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Professional and scientific societies impacting diversity, equity and inclusion in STEMM

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Published in
Frontiers in Education
Frontiers in Sociology

ISSN 1664-8714
ISBN 978-2-8325-3030-6
DOI 10.3389/978-2-8325-3030-6

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Professional and scientific societies impacting diversity, equity and inclusion in STEMM

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Citation

Segarra, V. A., Ramirez-Alvarado, M., Etson, C. M., eds. (2023). *Professional and scientific societies impacting diversity, equity and inclusion in STEMM*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-3030-6

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frontiers | Frontiers in Sociology

TYPE Editorial
PUBLISHED 04 July 2023
DOI 10.3389/fsoc.2023.1232770

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 01 June 2023
ACCEPTED 19 June 2023
PUBLISHED 04 July 2023

CITATION
Segarra VA and Etson CM (2023) Editorial: Professional and scientific societies impacting diversity, equity and inclusion in STEMM. *Front. Sociol.* 8:1232770. doi: 10.3389/fsoc.2023.1232770

Editorial: Professional and scientific societies impacting diversity, equity and inclusion in STEMM

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KEYWORDS

collective impact, equity, diversity, inclusion, professional societies, STEMM

Editorial on the Research Topic
Professional and scientific societies impacting diversity, equity and inclusion in STEMM

ProSs and collective impact

Professional and scientific societies (ProSs) are communities brought together by shared expertise, interests, practices, and sometimes even shared identities in the case of identity- or affinity-based ProSs. ProSs can serve as a home community to member scholars and practitioners in different stages of their career in a way that transcends geographical localization and home institution. The ways in which a ProSs serves its membership, its policies, practices, and programming have the potential to sculpt the composition of its membership and ultimately the workforce of the discipline(s) a ProSs represents. As scientists strive to build a global STEMM workforce that is as diverse and as inclusive as it can be, attention has turned to ProSs as possible agents of change toward building a STEMM workforce that is dynamic and representative of the populations and disciplines they represent.

ProSs working toward a diverse and inclusive workforce within their respective disciplines tend to leverage their resources in common ways, and often encounter similar challenges. The emergence of these common patterns motivated five ProSs in the biomedical and life sciences fields to come together in 2017 to establish the Alliance to Catalyze Change for Equity in STEM Success (ACCESS; NSF 1744098). ACCESS was established with the intent to examine and share best practices in areas such as travel awards to annual meetings, speaker selection, and involvement of undergraduate trainees in ProSs activities (Segarra et al., 2020a,b; Etson et al., 2021; Primus et al.). The task of identifying challenges and opportunities proved to be far more effective when sharing data across different ProSs, speaking to the impact that collective work can have on our individual communities.

Collective impact is a developing concept that uses broad cross-sector collaboration in order to achieve large-scale social change and combat the many issues that come with

its counterpart, isolated impact (Christens and Inzeo, 2015; Prange et al., 2016; Ennis and Tofa, 2020). Organizations harness collective impact not only to improve the success of their individual goals, but also to welcome new initiatives and ideas that can be integrated to create social change at a larger scale.

In this Frontiers Research Topic issue

To open the door to collaboration and collective impact, and to engage other ProSs in the conversation, ACCESS has set out to host this Frontiers Research Topic issue. In the sixteen articles that follow, you will find studies and stories that chronicle how ProSs in STEMM are striving to make their membership and scientific communities more diverse and inclusive. These include six articles presenting original research, one describing an educational intervention, two review articles, six perspective articles, and one opinion piece, and they are published in three Frontiers journals—Frontiers in Sociology, Frontiers in Psychology, and Frontiers in Education. This Research Topic of articles represents a variety of voices, including authors at all career stages within academia, as well as many who participate in the scientific endeavor from outside of that structure.

Although it may seem that ProSs are mainly focused on supporting relatively established scholars, the original research articles in this special topic reveal new insights into how participation in ProSs as early as their 1st year of study can support persistence in undergraduate STEMM education for women and members of other underrepresented groups (Smith et al.), not only by providing educational and networking opportunities, but also by increasing their feeling of belonging within the community (Campbell-Montalvo, Kersaint et al.). The importance of this sense of belonging is highlighted by the finding that students with sexual and/or gender minority identities benefit from participating in identity-focused organizations, even if those organizations do not provide as many educational and networking opportunities (Campbell-Montalvo, Cooke et al.). Indeed, many members of groups underrepresented in STEMM experience a conflict between the culture they encounter in educational and professional spaces, and their own identities, attitudes, and beliefs. Much of the research reported as part of this Research Topic explores those conflicts, including work investigating how attitudes and practices in STEMM fields are in conflict with Indigenous people's unique cultural and spiritual perspectives (Ingram et al.).

We believe that ProSs are uniquely situated to make use of findings like those reported in this Research Topic to provide leadership and drive systemic change that will result in standard practices that will be more inclusive. The final two research papers in our topic illustrate that quite well. One is a case study carried out by a small ProSs (the American Elasmobranch Society) representing a deep dive into their own efforts to create a more equitable and inclusive professional society. In addition to their analysis of membership demographics and honest evaluation of an attempted diversity initiative, the authors included a valuable discussion of broad range of potential actions, synthesizing recommendations from a variety of sources, that could be taken by any similar sized ProSs to better support diversity, equity, and inclusion goals (Shiffman et al.). The other describes the impact of a program developed by the Society for Developmental Biology that provided substantive research experiences to undergraduate students who are members of groups underrepresented in STEMM. They found that implementing the program resulted in significant impacts beyond the novice researchers who participated, and helped the society recognize and carry out needed changes in its leadership structure to better represent the needs of its members (Unguez et al.).

The benefits students can receive by having opportunities to participate fully in the community of science during their training period are further highlighted by other articles included in this Research Topic. Readers interested in curriculum intervention may find value in the report on the design and implementation of a biannual student-organized and student-led research conference for students already participating programs providing professional training to members of groups underrepresented in STEMM. This novel intervention goes beyond the typical model of providing coursework and laboratory experience to help students develop the confidence and leadership skills necessary to allow them to envision successful futures in academic science for themselves (Boehmer et al.). Readers looking for more ideas on how ProSs can support their student members may also appreciate the two review articles. One represents a collaboration among six ProSs (including the original five ACCESS ProSs), and presents an examination of the ways these ProSs use society sponsored program offerings to foster inclusivity and engagement of undergraduate scientists (Primus et al.). The other is focused on how student chapters of ProSs can provide students from groups historically underrepresented in STEMM with opportunities to become active members of the ProSs that organize them, at their own pace, as well as to receive the mentoring and support they need (Barnes et al.). In addition, readers will be reminded that the role of student-led organizations should not be discounted, as discussed in a student-authored opinion article (Youngblood et al.).

Rounding out this Research Topic, readers will find articles that share a variety of perspectives on the roles ProSs can play in efforts to reshape the STEMM community. Two provide retrospective reflections on the journeys ProSs have taken along the path to increasing diversity, equity, and inclusion over the lifetime of the organization in one case (Hays et al.), and over the course of a year of concerted effort in another (Segura-Totten et al.). Another perspective article reviews how ProSs report their efforts to support diversity online. In response to their observation that that these materials are often difficult to find, the authors created two webpages gathering them together, providing a valuable resource to our community (Haddad et al.). Yet another shares insights from a group of deaf and hard-of-hearing engineers, scientists, and clinicians on disability as an often overlooked component of diversity (Huyck et al.). The final two perspective articles address the need for tools to facilitate examination of the underlying mental models change leaders may need to address to maximize their ability to effect change (Leibnitz, Gillian-Daniel et al.), and to facilitate self-assessment of diversity, equity, and inclusion efforts at the society level (Leibnitz, Peters et al.).

We hope you will find ideas within these articles that resonate with your own experiences and that can serve as inspiration to continue your work toward a more inclusive and diverse STEMM workforce.

Author contributions

VAS developed a vision for the editorial and wrote the first draft. CME provided feedback and helped with the revisions. All authors approved the manuscript.

Funding

The creation of ACCESS was supported by the National Science Foundation (NSF; grant # 1744098). The NSF continues to support ACCESS work through a Leading Culture Change Through Professional Societies of Biology (BIO-LEAPS) grant (grant # 2134725).

Acknowledgments

We thank Jaelan C. Gabriel, Psychology major and Director of Inclusion of the Student Government Association at Goucher College, for contributions to our commentary on collective impact. We also thank the ACCESS members past and present.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Sociology

ORIGINAL RESEARCH
published: 31 May 2021
doi: 10.3389/fsoc.2021.671856

Social Capital From Professional Engineering Organizations and the Persistence of Women and Underrepresented Minority Undergraduates

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OPEN ACCESS

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Specialty section:
This article was submitted to Gender, Sex and Sexualities, a section of the journal Frontiers in Sociology

Received: *24 February 2021*
Accepted: *27 April 2021*
Published: *31 May 2021*

Citation:
Smith CAS, Wao H, Kersaint G, Campbell-Montalvo R, Gray-Ray P, Puccia E, Martin JP, Lee R, Skvoretz J and MacDonald G (2021) Social Capital From Professional Engineering Organizations and the Persistence of Women and Underrepresented Minority Undergraduates. Front. Sociol. 6:671856. doi: 10.3389/fsoc.2021.671856

Professional engineering organizations (PEOs) have the potential to provide women and underrepresented and minoritized (URM) students with social capital (i.e., resources gained from relationships) that aids their persistence in their engineering undergraduate programs and into the workforce. We hypothesize that women and URM students engineering students who participate in PEOs are more likely to persist in their engineering major and that PEOs contribute to their persistence by providing them access to insider information that supports their persistence. Each year for five years we administered surveys with closed- and open-ended items to examine the association between participating in PEOs and the persistence of a cohort of engineering majors from 11 diverse universities. We used logistic regression and thematic analysis to analyze the data. URM students who participated in PEOs and other engineering related activities were more likely to persist to the second year than URM students who did not (adjusted odds ratio = 2.18, CI: 1.09, 4.37). Students reported that PEOs contributed to their persistence by enabling them to network, reduce gender and race/ethnic isolation, and access professional resources. URM students should be encouraged to participate in PEOs beginning in their first year to increase their integration in their major, which we have found to increase their persistence.

Keywords: STEM degree persistence, equity, engineering education, professional engineering organizations, social capital

INTRODUCTION

The culture of engineering undergraduate degree programs is often unwelcoming and exclusionary for women and underrepresented and minoritized (URM) students, who are often subjected to overt sexism, racism, discrimination, stereotyping, and isolation (May and Chubin, 2003; Brown et al., 2005; McGee and Martin, 2011; Geisinger and Raj Raman, 2013; Seron et al., 2015; McGee, 2016; McGee, 2020). According to the National Science Foundation (NSF 2019), URM students in science, technology, engineering and mathematics (STEM) include Black/African American, Latinx, and American Indian and Alaskan Native men and women. The hostile climate of engineering programs and the feeling of not belonging in these programs are the main reasons that students identify for switching to non-engineering majors (as well as non-STEM majors) before graduation (Seymour and Hewitt, 1997; Tyson et al., 2007; Griffith, 2010; Hill et al., 2010; Ohland et al., 2011; Marra et al., 2012; Meyer and Marx, 2014; Rainey et al., 2018; Fink et al., 2020). This negative academic climate is a threat to efforts to make the STEM workforce more diverse, equitable, and inclusive.

Student involvement research has resulted in inconsistent findings about the benefits of student participation in PEOs and few are quantitative or mixed methods studies that examine the association with persistence. For example (Wilson et al., 2014), found that student participation in professional societies and other academic activities was positively associated with "self-efficacy and academic emotional engagement," but students who participated in women and minority organizations had "lower academic emotional engagement" than their counterparts who did not. They concluded that this lower emotional engagement is a coping mechanism where students practice detachment to curricula that has been traditionally shaped around the needs of the dominant group. Other research found students did not identify their participation in PEOs as important for their academic engagement (Allendoerfer et al., 2012) and found that students had levels of activity with their jobs and sports and less activity in PEOs (Simmons et al., 2018). In contrast, other studies have found that student participation in engineering PEOs, including the National Society of Black Engineers (NSBE) and the Society of Hispanic Professional Engineers (SHPE) provides social capital, supportive environments, and cultural enclaves that help students combat isolation, leading to greater on campus integration (Daily et al., 2007; Strauss and Terenzini, 2007; Martin et al., 2016; Ross and McGrade, 2016; Revelo and Baber, 2018). Several student involvement studies reveal that participation in and integration of co-curricular or extracurricular activities is one means of increasing persistence (Tinto, 1998; Astin, 1999; Berger and Milem, 1999; May and Chubin, 2003).

To bolster the methodological approaches used in previous qualitative studies, we use a mixed methods approach with a diverse student data set to investigate how women and URM students' persistence may be affected by the social capital acquired from their participation in PEOs. Social capital refers to the individuals in a person's social network and the resources that can be accessed through that network (Lin, 2001). For engineering students, such resources include access to professional role models and potential employers, opportunities to serve as leaders and develop leadership skills, enculturation into professional norms, and access to a network of like-minded peers who provide insight about which classes may be better to take, copies of past exams and other study materials (Smith et al., 2015).

Building upon Lin (2001), we focus on the relationships that student members cultivate with others in PEOs as a primary source of the social capital. Previously, we have differentiated between "participatory social capital", the capital gained by participants through the relationships they gain by participating in organizations that facilitate such networking (i.e. professional engineering organizations), and "network-based" social capital, the capital students access through social networks they have through their life and matriculation in their program more generally (i.e. family, professors) (Skvoretz et al., 2020; Puccia et al., 2021). Both types of social capital provide support, including that linked to direct forms of support to continue in STEM (i.e. travel awards, advice about what classes to take) as well as emotional support (i.e. advice about how to respond to negative treatment by others in STEM) (Puccia et al., 2021; Segarra et al., 2020). This research extends these prior findings by examining PEO participation rates across groups, how participation in various women- and race/ethnicity-focused PEOs in their first year of their engineering degree program affects women and URM student's persistence to their fifth year, as well as identifying the specific mechanisms through which student gain social capital through these organizations.

BACKGROUND

Persistence of Undergraduate Students

The persistence of women and URM students in engineering can be understood within the broader literature about the persistence of all undergraduate students. Astin's (1999) student involvement theory and (Tinto's 1998) theory of student departure assert that higher levels of student involvement and integration in campus life lead to improved student learning outcomes and persistence. Student involvement, according to Astin (1999), describes a student who is not only succeeding academically, but also "spends much time on campus, participates in student organizations, and interacts frequently with faculty members and other students" (p. 518).

Similarly, Tinto (1998) describes student involvement as "academic and social integration." Academic integration includes academic achievement and interaction with faculty and peers. Social integration primarily refers to the extent to which students socialize with peers and have feelings of fitting in. Tinto (1998) contends that this integration is a main influence on student persistence and is particularly crucial during the first year of college, when the attrition rate is the highest. Students must be motivated to commit time and become active participants in their academic and social college experiences (Tinto, 1998; Astin, 1999).

Scholarship on the persistence of women and URM students must attend to the different academic climate they experience compared to their majority peers, particularly when considering the potential role of PEOs in mitigating the effects of hostile climates on persistence. Often, members of the dominant group (i.e., White, Asian) are not aware of how race or gender affects other students' experiences and outcomes in undergraduate STEM programs (Dancy et al., 2020). Specifically, cultural ideologies associate men and masculinity with technical engineering skills (Dryburgh, 1999; Faulkner, 2000; Faulkner, 2009) and can result in interpersonal student behavior that restricts women's access to technical activities in lab and other engineering settings.

Likewise, STEM programs often prioritize individualistic and competitive cultures, which are attributes frequently associated with majority groups (Faulkner, 2009; Ong,et al., 2018; Secules et al., 2018; McGee, 2020). This results in mismatches between academic program cultures and the values of URM students, especially women of color, who may feel like they do not fit in STEM programs (Rainey et al., 2018) and report that their STEM experiences are explicitly impacted by race and gender (Dancy et al., 2020). Black students are disproportionately affected by their STEM programs' climates, given the societal pervasiveness of anti-Black microaggressions (Lee et al., 2020). Because the relationship between fitting into unwelcome academic climates and persistence is strong (Marra et al., 2012; Meyer and Marx, 2014; Rainey et al., 2018; Fink et al., 2020), investigations into how students gain social capital through PEOs to deal with poor academic climate are imperative.

Influence of Professional Engineering Organizations

Student chapters of PEOs are mechanisms by which engineering students can become integrated both academically and socially. Women- and race/ethnicity-focused PEOs, such as the Society of Women Engineers (SWE), the National Society of Black Engineers (NSBE), and the Society of Hispanic Professional Engineers (SHPE), contribute to students' identity development as engineers, to their persistence, and to their success in their engineering studies and subsequent careers (Goodman et al., 2002; Daily et al., 2007; Martin et al., 2016; Ross and McGrade, 2016; Revelo and Baber, 2018). They are often welcoming environments that reduce students' gender/ethnic isolation. They can also break down cultural barriers to integration in programs in which white men are the majority. In addition, they often serve as safe spaces where women and URM students can rebuild their confidence and motivation when they struggle academically (Meyer and Marx, 2014).

PEOs can provide women and URM students with familiar cultural environments that prioritize serving the community and collectivism over individualism and the academic competition that drives engineering programs (Seymour and Hewitt, 1997; Martin et al., 2016). These women- and race/ethnicity-focused PEOs can also offer women and URM students a "culture of support" and "motivation to succeed," which is associated with student persistence (Grandy, 1998; Suresh, 2006). Goodman and colleagues (2002) assert that by participating in PEOs and other support activities, women can build networks that create a community that makes them feel less isolated. They found that two-thirds of the women in their sample participated in PEOs to socialize with other women in engineering, and two-fifths of women did so because of the supportive environment. Daily and colleagues (2007) found that through its social network/connections, student leadership opportunities, and other activities (e.g., attending professional conferences for career fairs), NSBE creates a culture referred to as "luv." By participating in this culture, Black students acquire social capital that supports academic achievement and retention in their engineering programs. When considered collectively, the literature provides robust support for the vital role that PEOs, especially those that are gender- and race/ethnicity focused, can play in the persistence, especially for women and URM students.

CAREER ADVANCEMENT

For women and URM students, PEOs, particularly women- and race/ethnicity-focused PEOs (e.g., SWE, NSBE, and SHPE) are invaluable sources of social capital. This social capital is specifically intended to increase women and URM students' academic achievement and advance their careers, thus broadening their participation in engineering. To further these goals, women- and race/ethnicity-focused PEOs provide resource-rich environments in which collegiate members can access and activate insider knowledge and resources that would not be available to them otherwise. Because they are viewed as outsiders in engineering, women and URM students also participate in social interactions that support their integration and confidence in engineering. To determine how participating in PEOs affect women and URM students' engineering persistence, we investigated the following two research questions:

1. What is the relationship between participation in PEOs in year one and whether women and URM students persisted in their engineering degree programs in later years?
2. How do women and URM students believe that participation in PEOs contributed to their persistence?

The answer to research question 1 (RQ1) informs the association between participating in PEOs and persistence in engineering. The answers to research question 2 (RQ2) offer insight into the mechanisms through which social capital can influence persistence.

CONCEPTUAL FRAMEWORK

Originally (Bourdieu 1986), proposed social capital as primarily "connections" or access to a well-established network of useful relationships and material resources that benefit group members. Since then, social capital has been conceptualized in a variety of ways by numerous scholars (Coleman, 1988; Portes, 1998; Lin,

2001; Adler and Kwon, 2002; Bandiera et al., 2008; Korte and Lin, 2011). For example, Coleman (1988) described social capital as a function within societal structure, a group asset embedded in an individual's relationships. In contrast, Lin (2001) argues that the focus should be on the resources of individuals that benefit the group. Other scholars suggest that social capital in postsecondary education reproduces class and gender inequality (Holland and Eisenhart, 1990).

To study how an individual's social network contributes to their educational success, we adhere to (Lin's 2001) conceptualization that social capital "is captured in social relations and that its capture evokes structural constraints and opportunities as well as actions and choices on the part of the actors" (p. 3). Lin's conceptualization acknowledges that ascribed characteristics such as gender and race/ethnicity often create differences in access to social capital. Lin also asserts that individuals can achieve goals through activating social capital in "purposive actions" (2001, p. 60). Thus, our research examines students' social networks and the individuals in those social networks who influence their persistence in engineering. We also investigate how accessing and activating the social capital available in their social networks contribute to their persistence in engineering. Martin (2015) highlights the potential of "resource-rich networks" that do "not necessitate students knowingly mobilizing resources" because they "receive information and resources in routine exchanges" with the faculty and administration in engineering programs (p. 1180).

Because engineering is a field that white men have traditionally dominated, it has gained a reputation as a "closed club" (Ohland et al., 2011) where women and URM students are often treated like outsiders (Tate and Linn, 2005). Therefore, they are less likely to have the social relations (i.e. social networks) with individuals who are "insiders" and know about the "informal" pathways and resources that lead to success in engineering and other STEM fields (Seymour, 1999; Stevens et al., 2008). By cultivating these relationships, students acquire social capital that aids their persistence to degree attainment (Atman et al., 2008; Stevens et al., 2008; Shapiro and Sax, 2011). These relationships can further help women and URM students navigate the generally unwelcoming academic climate by creating culturally familiar and welcoming spaces that contribute to their persistence.

METHODS

Instrumentation

To answer the research questions, we developed five surveys that were IRB-approved and administered annually to a cohort of engineering undergraduates, beginning at the end of their first year of their program. The first survey measured the social capital students brought from high school and other pre-college experiences into their engineering programs. The four subsequent surveys, parallel in structure, measured the social capital acquired while students were enrolled in their engineering programs. Social capital survey items asked students (egos) about their participation in PEOs, professional societies, and other engineering-related activities and programs. Students were also asked to identify individuals who advised them to participate in PEOs and other activities, the extent of their participation, and how their participation contributed to their persistence (with this last item being the only open-ended item).

We created social capital items from the activities and resources that 31 stakeholders identified as beneficial for undergraduate success in engineering programs (Smith et al., 2015). These stakeholders were engineering faculty, advisors, graduate students, and undergraduates who participated in a *free listing* exercise, an anthropological qualitative research method. Free listing assumes that individuals 1) with extensive knowledge will provide more responses than those with less knowledge, 2) will list most familiar and meaningful responses first, and 3) will provide responses that reflect their local cultural knowledge (Weller and Romney, 1988).

The first (S1) and second (S2) surveys were pilot tested with a diverse sample of 30 engineering undergraduates who were not part of the study to refine each survey and increase its validity. We also conducted the *think-aloud* exercise (Smith et al., 2015) with S1 and S2, a verbal cognitive validation protocol, with a diverse sample of nine engineering undergraduates who were not part of the study (Martin et al., 2011). The students were asked to evaluate the survey, comment on item clarity, and suggest how unclear questions could be revised to be more explicit. Students read the questions and answers aloud while taking the online survey in a researcher's office. Researchers who engaged in this process observed the students' body language and listened to their comments as they cognitively processed their responses aloud. Feedback from the think-aloud exercise, which indicated several cognitive and minor structural issues, was used to revise the survey. Both refined surveys were then reliability-tested for internal consistency with 100 engineering undergraduates who were also not part of this study. Once we were confident in the reliability and validity of the items, the surveys were finalized. The third (S3), fourth (S4), and fifth (S5) surveys were modified versions of S2 that inquired about the students' experiences in the previous year so they were not tested and validated individually.

Study Sample and Data Collection

In spring 2015, engineering undergraduates were recruited from a population of all first-year students enrolled in the engineering programs at 11 universities located in three states and one U.S. territory. These engineering programs represent diverse learning contexts: five predominantly white institution (PWIs), three Hispanic-Serving Institutions (HSIs), two private PWIs, and one Historically Black College/University (HBCU). The engineering programs at these 11 universities had a total enrollment of approximately 5,854 first-year students in fall 2014. Each engineering program emailed their first-year students encouraging them to participate in our study. We sent three reminder recruitment emails with the link to S1 to all of these students over a period of two months.

Overall, 2,186 students of all genders and race/ethnicities completed S1. This sample represents a 37% response rate of the total enrollment in engineering programs at all participating

TABLE 1 | Number of Respondents, Broken down by Enrollment Status.

Survey	Respondents	Still enrolled	Eng. Grads	Switchers	Leavers	Non-eng. Grads
S1	1,252	1,252	–	–	–	
S2	1,252	1,003	1	232	16	–
S3	1,003	947	7	36	13	–
S4	947	883	36	17	11	–
S5	883	235	616	11	17	4

Note: This table excludes non-engineering majors and those lost to attrition; Eng. Grads = graduated with an engineering degree; Switchers = changed to a non-engineering major; leavers = left university; Non-Eng Grads = graduated with non-engineering degree.

TABLE 2 | Quantitative and Qualitative Data Sources.

Research Question	Quantitative and qualitative data source
Gender and race/Ethnicity	Survey 1 Items • Gender: Female; male • Race/ethnicity: American indian/Alaska native; asian (asian indian, Chinese, Filipino, Japanese, Korean, Vietnamese, other asian_____); black/Black; hispanic (cuban, mexican, mexican american, puerto rican, other hispanic or latino origin_____); native Hawaiian/Other pacific islander; middle eastern/North african/Arab; white; other ethnicity_____
PEO participation	Survey 2 Items In my first year as an engineering major, I participated in the following organizations/societies (select all that apply): 1) honor societies (e.g., tau beta pi [TBP]), alpha pi mu [APM]); 2) industry or discipline specific societies; 3) mexican americans in engineering and science (MAES) (e.g., bohique); 4) NSBE; 5) SHPE; 6) SWE; 7) other organizations/societies (to be specified); and 8) none
Research Question 1	Survey 2–5 Items • I am currently enrolled as an undergraduate engineering student: 1) yes; 2) no, I switched to a non-engineering major; 3) no, I am no longer enrolled at any university/college; 4) I graduated with my engineering degree; 5) I graduated with a non-engineering degree Survey 5 Items • In my first year as an engineering major, I participated in the [*insert identified organization/society*] because: 1) I was advised to participate by the [*insert alter in social network*] who most influenced me; 2) I was advised to participate by the other person(s) who influenced me; 3) my department/college assigned me to this activity; 4) and I decided on my own to participate • On a 4.0 scale, my grade point average at my current university is: _____ • In my first year as an engineering major, my employment status was (select all that apply): 1) did not work; 2) federal work study; 3) full-time employee; 4) part-time employee; and 5) summer/seasonal employment only • In my first year as an engineering major, the estimated number of hours that I spent on my studies outside of class meeting times (i.e., assigned projects, studying individually and with study groups) in a typical week was 1) <15 h; 2) 15–19 h; 3) 20–24 h; 4) 25–29 h; 5) 30–34 h; 6) 25–39 h; 7) 40–45 h; and 8) >45 h
Research Question 2	Survey 2 Open-ended Item • Please describe how your participation in [*insert identified organization/society*] has contributed to your progress as you pursue your engineering degree

universities. Students' statuses as an enrolled first-year engineering major were verified by an institutional representative from the engineering program at the 11 universities, as explained to students on the informed consent page presented before the survey items. We administered subsequent surveys (S2, S3, S4, and S5) to students who reported that they were still enrolled as engineering majors in the previous survey only. Each student who responded to S1 was sent a recruitment email with an assigned identifier that allowed us to link their responses across the five surveys. Over the course of the study, we lost 850 students (40% of the initial 2,186 sample) to attrition. The biggest loss was between S1 and S2, when 432 of S1 respondents failed to take S2. The number of students lost to attrition declined each year as the study progressed. However, there was a slight uptick in attrition in the response to S5 likely due to natural disasters that occurred during the period the survey was administered. Eighty-four respondents were excluded due to later determination based on their survey responses that they had never intended to pursue engineering as a major, specifically these students were computer science majors, which is not classified as an engineering field by NSF or the National Center for Education Statistics.

Table 1 presents the survey response and persistence data for the students in the sample after the administration of each survey. We administered S1 in spring 2015, and by then some students may have already switched out of engineering to non-STEM majors. We refer to these students as "switchers." This might explain the higher graduation rate of the students in our sample compared to the national rates (49% in our study graduated within five years vs. the 33% nationally who graduated within

four years, according to figures from 2011) (American Society for Engineering Education, 2017). However, we recognize that most statistics are on engineering degree attainment are based upon four years of data, whereas we have five years available. Alternatively, it may be that students who are more likely to stay in engineering decided to take the survey. Students who reported that they were no longer enrolled at university are considered "leavers."

Data Source and Analysis

The specific survey items used to answer the research questions are presented in **Table 2**. The gender (binary: woman vs. man) and race/ethnicity data (eight categories) collected in S1 were used for intersectional analysis with the exception of eight students who did not provide their race/ethnicity data in S1 (we used the information provided in S2).

To determine participation in PEOs, we analyzed responses to the S2 item that asked students to mark which of the six types of listed "PEOs/societies" that they participated in during year 1. As shown in **Table 2**, in addition to the six types of societies/organizations that they could choose from, students also had the option to select an "other organizations/societies" category where they could write-in the name of other organizations/societies, or to select an answer of "none". In reviewing the write-in responses to the "other organizations/societies," students mainly identified engineering-related organizations/societies such as Robotics club, sororities, and fraternities. Therefore, we aggregated all of these responses as "PEOs", acknowledging that student involvement or integration in any activity can contribute to persistence (Tinto 1998; Astin, 1999). A review of the responses to the "none" category revealed that some respondents participated in other activities, but in many cases, the description of these activities were vague or only tangentially related to science; therefore, we did not recode any of these responses.

To answer RQ1, we analyzed responses to items in S2-S5 that addressed enrollment status, reason for participation in PEOs, grade point average (GPA), employment status, and amount of study time. To answer RQ2, we analyzed responses to the open-ended item in S2 that asked students to describe how their participation in the PEOs that they identified contributed to their persistence in their engineering degree. We only included the responses of women and URM students who had graduated or persisted to their fifth year in our analysis. Although we asked students to think back to their first year in S2, which was administered in spring of the cohort's second year, some students wrote about their experiences participating in these PEOs during their second year.

Statistical Analysis

All statistical analyses were performed using the SAS version eight software (SAS Institute Inc., 1999). We express as percentages women and URM students' participation in PEOs in the first year of their engineering program. To examine the extent to which participating in PEOs is associated with students' persistence (RQ1), we performed logistic regression. This statistical method allows for modeling persistence, operationalized as a binary dependent variable (enrolled vs. not enrolled), as a function of participating in PEOs and other predictor variables without requiring that these variables are "normally distributed, linearly related, and have equal variance within each group" (Tabachnick and Fidell, 1996, p. 575). Because logistic regression assumes that the dependent variable varies as a function of the predictor variables, the logistic model calculates the probability of persisting, controlling for other variables, and expresses this probability as an adjusted odds ratio (AOR). Together with the associated *p*-values, the AORs are interpreted for the significant predictors in the models. The following five steps were followed to arrive at the model predicting persistence in year 2:

First, noting that our data set contained several potential covariates, the choice of variables to consider including in the model was guided by the literature review as detailed in our conceptual framework. The following four major classes of independent variables were included because of their potential theoretical and practical relationship to student persistence: 1) sociodemographic factors (i.e., being a woman vs. a man; being URM vs. white; being a URM woman vs. non-URM woman; and being at a minority serving institution [MSI] vs. non-MSI); 2) academic related factors (GPA [high ≥3.0, low ≤3.0]; amount of study time [high = spent >25 h on studies outside of class meeting times vs. less = spent <25 h]; how a student arrived at the decision to participate in a PEO [advised to participate by influencer or not, made own decision to participate or not]); 3) employment status (working fulltime, part-time, under federal work study, or summer/seasonal vs. not working at all); and 4) participation in PEO (women participating in PEOs vs. not; women in PWIs participating in PEOs vs. women in PWIs not participating in PEOs; URM students participating in a PEO vs. URM students not participating in a PEO; and being at a MSI and participating in a PEO vs. being at a MSI and not participating in a PEO). The dependent variable, persistence, was measured using enrollment status: students who indicated that they were still enrolled in their engineering major or had graduated with their engineering degree in S2-S5 were coded as "persisters" whereas those who indicated that they had switched to a non-engineering major or had graduated with a non-engineering degree were coded as "non-persisters."

Second, to aid the selection of variables to examine closely, we ran a correlation procedure. Whenever a set of variables were highly correlated, only one variable in each case was considered for further analysis so as to avoid multicollinearity. Third, we examined the bivariate relationship between persistence and each of these variables, using chi square test (p value of <0.05 was considered to be statistically significant). Fourth, beginning with the effect of sociodemographic factors and before arriving at the final model in year 2, we considered several models (not presented here), each time retaining only statistically significant covariates in the succeeding models. Finally, the overall fit of models tested were evaluated using the −2 log likelihood [−2LL] statistic (for nested models) and the Akaike information criterion (AIC) (Akaike, 1973) for non-nested models. These statistics are interpreted as follows: the smaller the −2LL, the better is the fit, and an AIC value closer to zero

TABLE 3 | Respondent Race/Ethnicity by Gender for Surveys 1, 2, 3, 4, and 5.

Race/Ethnicity	Survey 1		Survey 2		Survey 3		Survey 4		Survey 5	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
American indian	5	0	5	0	4	0	4	0	4	0
Asian	131	72	131	72	121	55	108	50	97	47
Black	40	26	40	26	26	16	25	16	20	16
Latinx	224	106	224	106	186	85	173	80	164	75
Middle eastern	13	4	13	4	11	4	11	4	9	3
Nat. Hawaiian	0	1	0	1	0	1	0	1	0	1
Other	7	15	7	15	6	14	6	14	4	14
White	393	215	393	215	301	173	286	169	267	162
Total	813	439	813	439	655	348	613	334	565	318

represents a better fit. Complementing the use of AIC and −2LL for assessing model fit, we used the likelihood ratio chi-square, a statistic that shows whether the model fits significantly than an empty model (i.e. a model not including any predictors). Once the best fitting model for year two was obtained, the analysis was repeated for year three–five so as to aid comparison of findings based on similar set of covariates.

Thematic Analysis

To determine how women and URM students acquire social capital, thematic analysis was performed on the responses to the open-ended S2 items that asked how participation in the PEOs, with a focus on SWE, NSBE, and SHPE, contributed to their persistence. Three members of the qualitative team coded the responses independently. After the first team member coded the open-ended data independently, the second team member reviewed the coded data, developed the codebook, and then coded the data independently. The third team member coded the data guided by the codebook. The first team member then reviewed all the coded data, the codebook, and finalized the coding based on the commonality of the themes coded by team members. The second and third team members then reviewed the coded data and codebook together (the first team member was unavailable). They discussed disagreements over coding and reached consensus by either assigning a response to the same code or doubling coding it. They then identified themes from the coded data by noting key terms that were repeated about participation in SWE, NSBE, and SHPE such as "helped," "gave," "community," "opportunity," and "friendships" (Braun and Clarke, 2006; Bazeley & Jackson, 2013). Along with the key terms, student descriptions of the social capital acquired from SWE, NSBE, and SHPE were grouped together by type. The analyses were based on frequency, patterns, and "keyness" (i.e., the extent to which the data captured concepts that are essentially related to our research questions).

RESULTS

Participant Characteristics

The gender and race/ethnicity of students who responded to each survey are presented in **Table 3**. Women are represented at a higher proportion in our sample than found nationally. They represented more than a third of the respondents in all five surveys (S1 = 35%; S2 = 35%, S3 = 35%, S4 = 35%, S5 = 36%). In 2015–2016 women were 19.2% (n = 104,033) of the 541,705 students enrolled in engineering (and engineering-related) majors (NSF, 2017). All women, including those who are not URM students (i.e., white, Asian), are included in analyses of women's responses. Likewise, URM students comprised a higher proportion of our sample (S1 = 32%; S2 = 32%, S3 = 32%, S4 = 31%, S5 = 32%) than they did of the national population of engineering undergraduates, where they comprise 16.5% (89,616) of the total of 541,705 (NSF, 2017). The likely reason for the high proportion of URM students is that we recruited participants from one HBCU and three HSIs. Another possible reason for the overrepresentation of women and URM students in our study is that the study's informed consent form explained that the goal of the study was to understand women and URM students' experiences in engineering. This focus may have encouraged women and URM students' responses and potentially discouraged responses from those not identifying as such. NSF does not count foreign nationals as URM students, but we included them in the reported race/ethnic groups.

Participation in Professional Engineering Organizations

Forty-nine percent (n = 612) of the 1,252 respondents to S2 indicated they had participated in a PEO during their first year in their engineering program. Of these 612 students, the highest proportion participated in industry-specific PEOs (43%), women-focused PEOs (31%), race/ethnicity-focused PEOs (20%), and other organizations/societies (22%), with honor societies having the lowest proportion of students (12%) (**Table 4**). A large percentage of women (42%) participated in women-focused PEOs whereas a quarter of URM students (27%) participated in race/ethnicity-focused PEOs. Of all the URM students in our sample, 55% of Blacks and 22% of Latinx participated in race/ethnicity-focused PEOs. Regarding respondents who were both women and URM, 69% of Black women and 17% of Latina women participated in race/ethnicity-focused PEOs. In contrast, half of white women (50%) and half (51%) of Asian women participated in women-focused PEOs.

TABLE 4 | Participation in Professional Engineering Organizations by Category, Gender, and Race/Ethnicity Intersection (Survey 2).

Category of Professional Engineering Organization	Total Students	Women	Under-represented minorities	Black	Hispanic	Black women	Latina women	White women	Asian women
	N	*n*	*n*	*n*	*n*	*n*	*n*	*n*	*n*
Industry-specific	264	90	95	9	84	1	25	46	11
Women-focused	190	183	33	9	24	9	20	108	37
Race/Ethnicity-focused	124	42	108	36	72	18	18	5	1
Other	136	53	25	2	19	4	8	30	9
Honor society	76	20	19	3	16	1	6	12	1

Persistence and Participation in Professional Engineering Organizations (RQ1)

Holding constant other factors, URM students participating in PEOs have increased odds of persisting to the second year than URM students not participating in PEOs have (adjusted odds ratio [AOR] = 2.18, CI: 1.09, 4.37). **Table 5** shows the prediction of enrollment across the 5 years and independent variables. However, women's participation in PEOs, women in PWI participation in PEOs, or attending a MSI and participating in PEO, are each not associated with persistence, ceteris paribus.

Overall, women are more likely than men to persist in third year (AOR = 3.09, CI: 1.19, 8.03) but not fourth or fifth year. Being an URM or URM woman is not associated with persistence from years two to five. However, being at a MSI is associated with increased odds of persistence in second year (AOR = 3.60, CI: 1.92, 6.76), but not years three to five. Other factors associated with increased odds of persistence include having a high GPA as opposed to a low GPA (second to fifth year); spending more time studying as opposed to less time (second and third year); and being advised to participate in a PEO by an influencer or deciding by oneself to participate (second year only) as opposed to not being advised to participate by influencer or not deciding by oneself, respectively. Working, as opposed to being unemployed, was associated with increased odds of persistence in second and third years but decreased odds of persistence in fourth year.

As noted earlier, some students participated in more than one PEO. For example, 29% of the women who participated in women-focused PEOs and 26% of the URM students who participated race/ethnicity-focused PEOs also participated in industry-specific PEOs. We examined whether participation in multiple PEOs vs. a single PEO made a difference in persistence but found that it did not. Thus, to present a more parsimonious model, we did not include this variable among predictors in our logistic regression.

Social Capital From Professional Engineering Organizations (RQ2)

Underrepresented and Minoritized Students in Professional Engineering Organizations

Thematic analysis of URM students' open-ended responses provides insight into the ways the acquired social capital from PEOs contributed to their persistence. Black and Latinx students described the social capital they accessed and activated due to their participation in NSBE and SHPE. The three primary forms of social capital were 1) academic and social integration through academic support, such as developing time management skills and tutoring, as well as social networking, such as meeting other students and engineers of color some of whom become friends and mentors; 2) connecting with industry internships and employment opportunities though attendance at national conferences; and 3) professional resources for career development such as improving leadership skills, resume writing, and interview skills.

Among the URM students who participated in PEOs in their first year, Black students (15 women and nine men) described how NSBE contributed to their success. The three Black students (1 woman and two men) explained that their participation in industry-specific PEOs reinforced their decision to pursue their engineering major and provided career opportunities and other activities through networking. Four Black women who also participated in SWE stated that through social networking they attended professional conferences and gained industry contacts and internship opportunities as well as a mentor. Two other Black women felt they did not gain anything by participating and one decided to stop participating in SWE and chose to focus her participation in NSBE instead.

Black students stressed that participating in NSBE reduced their isolation at PWIs. By participating in NSBE, they became part of a culturally familiar community whose membership was comprised of Black students and engineers who had similar engineering experiences. A Black man at a PWI wrote, "I feel that [NSBE] has connected me to other Black engineers and allowed me to remain close with some of the people from my [bridge program] cohort." A Black woman at a PWI agreed, "[NSBE] has helped me connect with people who are like me going through the same things." Several Black students explained that the social capital they accessed and activated by participating in NSBE in their first year continued to benefit them in their second year. A Black woman at a PWI reported, "in my first year of college [NSBE] introduced me to the importance of setting career goals. Now I am a sophomore . . . , I hold an elected position and will be attending the national conference in hopes of obtaining an internship or co-op. My academic performance has also improved." Another Black woman at a PWI explained:

> NSBE has helped me establish another family in the College of Engineering. I have gotten a lot of help preparing for career fairs and things of that nature

> from my peers in this organization. NSBE has also given me an opportunity to grow more as a person and learn a lot about leadership as I have moved up in the organization. It has provided me with tutors and great relationships that will help me well after I graduate.

A Black man at a PWI concurred, "NSBE gives me tools to develop time management skills, resume skills, elevator pitches and much more."

Latinx students described how industry-specific PEOs (45 men and 11 women) and SHPE (43 men and 11 women) contributed to their persistence as engineering majors. For Latinx students, industry-specific PEOs expanded their knowledge about their disciplines, provided information about the various careers available with their majors, as well as delivered critical sources of networking for internship and employment opportunities. For example, a Latino man at a PWI wrote:

> Being able to see the extent of the electrical engineering student body participating in IEEE [Institute of Electrical and Electronics Engineers] was inspiring and made me more eager to continue my studies. The topics covered in society meetings and events were slightly above my understanding, but made me more interested in a variety of EE topics.

Latinx students reported that SHPE provided access to professional resources and provided a familiar cultural environment where they could network and make friends with other Latinx students and engineers. A Latinx man at a PWI stressed the importance of cultural familiarity, "SHPE was a great way to maintain a sense of home while at university. Having a Hispanic culture with the engineering world made all the difference." Explaining the value of the relationships formed through SHPE, a Latina woman at a PWI shared:

> I began by rarely attending meetings to now being an active member. Attending the SHPE Conference this year has been one of the best decisions I have made this year by far. I collaborate with incredibly intelligent people from similar backgrounds who serve as role models and friends.

In addition to cultural familiarity, Latinx students explained how SHPE helped them develop professional skills. For example, a Latinx man at an HSI stated, "[SHPE] helped me develop my skills in time management and served as an excellent opportunity to meet people that already had experienced different types of situations at the university and hear how they solved them." A Latinx man at a PWI explained the value of the professional resources:

> Participation in SHPE has given me a lot of resources to be successful, such as resume critiques, private career fairs with only our organization. Furthermore, it allowed me to connect with students in my classes who I have become friends with and can rely on for help when I need it.

A Latina woman at an HSI concurred:

> SHPE has really helped me develop my leadership skills . . . Second year I started getting really involved with the community. Not only [did] I organize many activities during the semester, but I also got the opportunity to travel to Washington, DC for the National Science Bowl. It really has helped me with my communication skills as I approach recruiters, as well as create a resume and perform a good interview.

Overall, the responses to the open-ended responses reveal how URM students, and in particular, Black and Latinx students who represented the numerical majority of URM students in our sample, benefitted from participating in PEOs.

Women in Women-Focused Professional Engineering Organizations

Although we found no statistically significant association between women's participation in PEOs and persistence, women who participated in SWE reported acquiring social capital similar to that acquired by URM students who participated in race/ethnicity-focused PEOs. For example, women emphasized that participating in SWE reduced their gender isolation. They also noted that participating in SWE increased their confidence in their knowledge and abilities to succeed in their engineering programs and pursue successful careers as engineers.

Women reported socializing and networking with other women students (some senior to them), women engineering faculty, and professional women engineers with established careers at SWE events who talked about what it was like to be a practicing engineer. A white woman at a PWI stated, "having a professional society with women experiencing the same things as me really helped me gain confidence in my first year as an engineering student." A white woman at a PWI agreed, explaining:

> My participation in SWE has contributed to my progress to pursue my engineering degree by reminding me that even though engineering classes and events are dominated by males, females can still be loud and proud and make a difference in the engineering field. It is hard sometimes, but it is possible.

A white woman at a PWI concurred:

> It is encouraging to realize there are more women in engineering than you might think by just attending class. SWE is a great way to make friends and meet study-buddies with other girls when your classes are guy-heavy. They also have a mentorship program.

Through the relationships and interactions with other women in SWE, women form a community that provides emotional

support and a sense of belonging. These relationships also provide social capital by conveying critical insider knowledge about succeeding and persisting as a woman in engineering.

Describing the benefits of social networking, a white woman at a PWI stated, "as a member of SWE, I have attended various community events, received a mentor to help guide me through my degree, and have been to various industry networking events." The friendships with peers in SWE also provided invaluable academic and emotional support as noted by a white woman at a PWI:

> I currently hold an officer position and the friendships I have made through this Organization [SWE] are very rare. We study together. We hang out together. I have formed an amazing group of friends who all push each other to keep going. We all understand each other's struggles.

An Asian woman at PWI agreed about the beneficial resources available through SWE:

> I got to listen to speakers [who] come from companies I respect and learn what they look for in a student. Being a first year meant that I had plenty of space to shape the type of student I wanted to become.

For the women in our study, SWE was a critical source of social capital that, when activated, contributed to their persistence in a field where women students and faculty were few and far between.

SUMMARY OF RESULTS

In sum, we found that: 1) URM students participating in PEOs (including engineering-related activities) were more likely to persist to the second year than URM students not participating in them, and 2) women and URM students report that they acquire social capital from their participation in gender and race/ethnicity-focused PEOs through social networking, reducing gender isolation, reducing race/ethnic isolation, and accessing professional resources.

DISCUSSION

Our results align with (Astin's 1999) student involvement theory and (Tinto's 1998) theory of student departure, which posit that higher levels of student involvement and integration in campus life lead to improved student learning outcomes and persistence. Not determined by other studies, we found a significant relationship between URM students' participation in PEOs (including engineering-related activities) and their persistence to the second year compared to their third to fifth year. Additional research is required to understand this phenomenon. However, this finding suggests that establishing early connections to engineering may influence URM students understandings of expectation in ways that the diminishes the differences that may appear between them and their colleagues in later years.

Our analysis of the open-ended items provides additional evidence supporting prior research by highlighting a critical source of social capital for URM students who are traditionally excluded from engineering. Consistent with Martin and colleague's (2016) assertion, we found that race/ethnicity-focused PEOs serve as cultural enclaves on white PWI campuses. In addition to providing URM students with social capital, race/ethnicity-focused PEOs are also welcoming culturally familiar environments that cushion the cultural disruption of attending PWIs (Tierney, 1992). Consistent with Daily, Eugene, and Prewitt's (2007), we also found that NSBE is a critical source of social capital through its social networks because it creates a culture that contributes to academic achievement and retention of Black students in engineering. We extend this finding by reporting how students benefits from participating in race/ethnicity-focused PEOs to persistence.

Although we did not find a statistically significant relationship between participating in gender-and race/ethnicity-focused PEOs and engineering persistence, our qualitative findings are consistent with previous qualitative studies that found that URM students who participated in NSBE and SHPE and women who participated in SWE reported acquiring social capital that benefited their persistence (Daily et al., 2007; Goodman et al., 2002; Martin, et al., 2016; Martin et al., 2016; Ross and McGrade, 2016; Revelo and Baber, 2018; Strauss and Terenzi, 2007). Black students reported that NSBE was the primary source of social capital from PEOs while Latinx students identified both industry-specific PEOs and SHPE as their primary sources of social capital. Further, participating in race/ethnicity-focused PEOs reduces URM students' isolation, which is often exacerbated for URM women because of their dual minority identities related to gender and race/ethnicity. Participation in SWE increased the confidence of women who persisted to their fifth year in addition to reducing their gender isolation. This finding supports (Cech et al., 2011)' (2011, p. 658) claim that confidence is "important to students" behavioral and intentional persistence."

Our finding that URM students and women acquire social capital from PEOs, particularly women- and race/ethnicity-focused PEOs, is consistent with and reinforces (Lin's 2001) assertion that social capital is rooted in relationships and interactions with individuals engaging in agency for their benefit. Such relationships allow members to purposively activate social capital and receive it in "routine exchanges" (Martin, 2015, *p*.1180). As noted earlier, we refer to the social capital (i.e., the personal relationships/ties, social networks, and professional resources) attained through these organizations as participatory social capital (Author, 2020a). Researchers (Lin, 2001) assert that individuals gain social capital from the people directly in their network, and our findings indicate that students who enter an unfamiliar environment can establish relationships and gain social capital as they participate in organizations designed to provide this level of support, thereby extending their network and access to additional social capital.

TABLE 5 | Prediction of Enrollment in Year 2, Year 3, Year 4, and Year 5.

Variable	Year 2	Year 3	Year 4	Year 5
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Sociodemographic				
Women	1.49 (0.94, 2.36)	3.09 (1.19, 8.03)[a]	1.17 (0.82, 1.65)	1.13 (0.81, 1.58)
Underrepresented minorities (URM)	0.67 (0.39, 1.13)	1.42 (0.46, 4.41)	0.73 (0.47, 1.14)	0.79 (0.51, 1.22)
URM women	0.64 (0.33, 1.26)	0.82 (0.15, 4.36)	1.01 (0.61, 1.69)	1.01 (0.62, 1.66)
Being at a minority serving institution (MSI)	3.60 (1.92, 6.76)[a]	2.87 (0.79, 10.5)	1.57 (0.97, 2.55)	1.29 (0.81, 2.07)
Academic-related factors				
Current grade point average (high: ≥3.0; low: <3.0)	4.14 (3.30, 5.19)[a]	9.08 (5.99, 13.8)[a]	2.10 (1.76, 2.50)[a]	1.43 (1.21, 1.69)[a]
More study time vs. less study time	1.52 (1.14, 2.04)[a]	2.01 (1.14, 3.54)[a]	1.02 (0.83, 1.26)	0.96 (0.79, 1.17)
Decision to participate				
Advised to participate by alter/influencer (Yes = 1, No = 0)	2.76 (1.40, 5.43)[a]	1.17 (0.46, 2.97)	1.28 (0.86, 1.90)	1.07 (0.74, 1.54)
Own decision to participate (Yes = 1, No = 0)	2.96 (1.55, 5.66)[a]	2.05 (0.76, 5.51)	1.37 (0.94, 2.01)	1.16 (0.81, 1.65)
Employment				
Worked vs. unemployed	1.45 (1.13, 1.87)[a]	2.78 (1.77, 4.36)[a]	0.85 (0.70, 1.04)	0.73 (0.61, 0.88)[a]
Participation in PEOs				
Women participating vs. women not participating	0.50 (0.13, 1.84)	0.19 (0.02, 1.50)	0.66 (0.29, 1.52)	0.61 (0.27, 1.34)
Women in PWI participating vs. women in PWI not participating	1.52 (0.40, 5.75)	9.47 (0.99, 90.5)	1.65 (0.71, 3.86)	1.85 (0.82, 4.15)
URM students participating vs. URM student not participating	2.18 (1.09, 4.37)[a]	1.23 (0.28, 5.40)	1.09 (0.63, 1.88)	1.19 (0.70, 2.02)
Attending a MSI and participating vs. attending in MSI and not participating	0.78 (0.25, 2.48)	0.64 (0.10, 4.29)	1.20 (0.57, 2.52)	1.31 (0.64, 2.65)
Model fit statistics				
Akaike information criterion (AIC)	1,365.597	494.82	2,131.959	2,272.481
-2 loglikelihood (-2 L L)	1,339.597	468.82	2,105.959	2,246.481

[a]$p \leq .05$; *AOR (Adjusted Odds Ratio) indicate the likelihood of persisting to a given year as opposed to not persisting for a unit increase in a given independent variable, holding constant other variables in the model; AOR values greater than 1.0 denote a greater likelihood of a student persisting than not persisting for each unit increase in the independent variable; and AOR values less than 1.0 denote a lower likelihood of a student persisting than not persisting for each unit increase in the independent variable.*

Our findings also align with Martin and colleagues' (2016) that found that NSBE and SHPE provide ample opportunities for establishing mentoring and role model relationships and creating tight, "family like" bonds that last throughout students' college careers and beyond. For URM engineering students, the one key benefit of participating in race/ethnicity-focused PEOs is the opportunity to gain insider knowledge, a form of social capital. We found that the majority of students who joined race/ethnicity-focused PEOs did so because they were advised to do so by the most influential person in their social network.

Limitations

We acknowledge that capturing social capital retrospectively has the potential for recall bias when students are asked to "think back" to the prior year about their participation in SWE, NSBE, and SHPE. This retrospective approach examined whether levels of social capital at college entry change or remain stable over the first four years of an engineering program. However, given the short duration of time lapse (~1 year since the end of their first year), we expect their recall to be reliable overall.

Our sample size limited some intersectional analyses, and some variables were linear combinations of others and thus were not included in the list of predictors. Surveys 2 (S2) to S5 were administered to students who reported that they were still enrolled as engineering majors in the prior survey. As expected, the sample decreased with each subsequent administration of the survey. Despite this, 60% of the initial S1 engineering respondents (n = 2,102) completed all of the surveys (n = 1,252).

Finally, S1 was conducted in the spring 2015 semester when students were enrolled in the second semester of their first year. Because of this, our sample does not include any students who may have switched out of engineering after their first semester of enrollment in fall 2014. Therefore, our sample may underrepresent the percentage of switchers. Hence, we encourage researchers who may engage in similar studies to consider the potential impact on their data collection efforts. Specifically, obtaining information from students in their first semester of college enrollment may provide insights about other factors that influence their attrition.

Implications for Practice

Our results provide evidence to warrant further investment in race/ethnicity-focused PEOs such as NSBE and SHPE to aid URM students and ultimately promote diversity, equity, and inclusion in the STEM workforce. Specifically, advisors should encourage URM students to join and participate in PEOs beginning in their first year given the influence of such involvement to persistence. During their earlier years in the program, many engineering students are at highest risk for switching out (Meyer and Marx, 2014). Engineering programs should also partner with PEOs to 1) develop strategies to transform their culture so it becomes welcoming to women and URM students, and 2) sponsor campus events/activities that embrace and promote cultural diversity as a strength that can foster a sense of community for women and URM students (Tierney, 1992; Martin et al., 2016). We support and extend Martin and colleagues' (2016) call to action "for all engineering faculty—majority and underrepresented—to recognize the value of ethnic student organizations. . . and to explicitly support these organizations." Administrators can also financially support student participation in these PEOs, by paying member fees, funding travel to their professional conference, and the like. Faculty can collaborate with PEOs to provide research opportunities and career-oriented information. Doing so will support social capital

development for women and URM students and, ultimately, contribute to their persistence. Additionally, all PEOs, not just those that are women- and race/ethnicity focused, should prioritize ensuring that they are welcoming and inclusive to women and ethnic minority students (Campbell-Montalvo et al., 2020).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of South Florida Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

All authors contributed to the implementation of the research study and the development of this article. The lead writers were CS, HW, GK, and RC-M.

FUNDING

This research was funded by the Division of Human Resource Development at the National Science Foundation (Award 1664366).

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Conflict of Interest: Author EP was employed by the company Beta Research Associates, Author GD was employed by the company The MacDonald Research Institute.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Education

BRIEF RESEARCH REPORT
published: 07 October 2021
doi: 10.3389/feduc.2021.753488

Role of Professional Societies on Increasing Indigenous Peoples' Participation and Leadership in STEMM

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Indigenous people are the most underrepresented racial/ethnic group in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) in the United States. Most prior research suggests this trend is the result broadly of settler colonialism, and more specifically of cultural differences between students and school/university environments; poor academic preparation in K-12 schools; vague constructs of educational or vocational goals; insufficient financial aid; unwelcoming school and university environments; prejudice and racism; and social isolation. There is also a vast body of published work on the unique epistemologies and knowledge systems held by Indigenous peoples, which are only recently being acknowledged within mainstream STEMM communities. One potential reason for lower participation in STEMM programs and professions by Indigenous people that has generally gone unexplored relates to unique cultural and spiritual factors that could deter Indigenous people from STEMM fields. Our research investigates the range and variation of cultural/spiritual/ethical practical issues that may be affecting Indigenous people's success in STEMM. Our research provides valuable insights for policy and practices within higher education institutions and industry to provide flexible pathways for Indigenous people to reduce or eliminate barriers related to culturally- and spiritually-informed issues. In this paper, we explore how our findings can be used by professional societies to provide leadership to higher education institutions and industry in the area of changing some standard practices to be more inclusive of Indigenous people. An important mode of systemic change in STEMM fields is through professional societies that guide future practices in various STEMM disciplines.

Keywords: Indigenous, STEMM, professional society, culture, spiritual, barriers

OPEN ACCESS

Edited by:
Veronica A. Segarra,
High Point University, United States

Reviewed by:
Rebecca Campbell-Montalvo,
University of Connecticut,
United States
Rebecca Pollet,
Vassar College, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *04 August 2021*
Accepted: *22 September 2021*
Published: *07 October 2021*

Citation:
Ingram JC, Castagno AE, Camplain R and Blackhorse D (2021) Role of Professional Societies on Increasing Indigenous Peoples' Participation and Leadership in STEMM. Front. Educ. 6:753488. doi: 10.3389/feduc.2021.753488

INTRODUCTION

Although diversity, equity, and inclusion (DEI) have become a higher priority across STEMM fields, there is still much work to be done. This paper begins with the assumption that professional societies in STEMM fields have a critical role to play in this arena. While advances have certainly been made in the diversification of STEMM and the awareness of DEI among STEMM practitioners, teachers, and leaders, our research points to a generally unexplored phenomenon that impacts the participation of

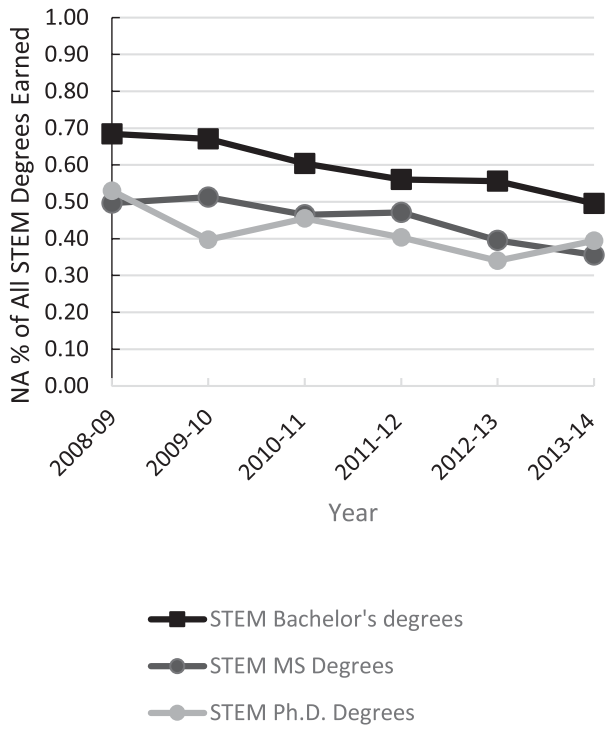

FIGURE 1 | The percent of AI/AN students in the United States earning STEM degrees compared to the total population between 2008 and 2014 (National Center for Education Statistics, 2016).

Indigenous people in STEMM pathways. In this paper, we explore how our research findings can be used by professional societies to provide leadership to higher education institutions and industry in the area of changing some standard practices to be more inclusive of Indigenous people.

Documented challenges for Indigenous students in higher education, as well as more specifically in science, technology, engineering, mathematics, and medicine (STEMM) fields are diverse. Indigenous people are the *most* underrepresented ethnic group in biomedical and health sciences (Diverse Issues in Higher Education, 2010). According to the National Center for Education Statistics (NCES), the overall percentage of baccalaureate degrees obtained by American Indian/Alaska Native (AI/AN)[1] undergraduates has decreased from 0.8 percent of the entire U.S. population in 2012 to 0.6% in 2015 (National Center for Education Statistics, 2016). There has been a similar decrease in STEM degrees awarded to Indigenous students since 2008, as shown in **Figure 1**.

Further, only 0.3% of all biology/biomedical degrees were conferred to AI/AN in 2015. This is compared to 1.6% of the entire U.S. population of AI/AN in 2015 (U.S. Census, 2016). Similarly, in 2015 the percentage of AI/AN receiving medical professional degrees (including MD, DDS, OD, PharmD, DO, DP, DVM, DC) in the United States was only 0.5% (National Center for Education Statistics, 2016). These statistics are significant because health care for many Indigenous people is received through clinics staffed mainly by the Indian Health Services (IHS). These clinics often have medical staff who are not from the local Indigenous community and are only located at these clinics for a short period of time, often to relieve debt associated with medical or other health school expenses (U.S. Government Accountability Office, 2020). These "short-timers," although well-intentioned, do not build sustainable health care capacity within the Indigenous communities. Thus, it is critical to increase the number of Indigenous students pursuing degrees in biomedical and behavioral sciences to fill this need to return to their communities and advocate for their people. The same is true for other STEMM fields as well: Indigenous communities need engineers, field researchers, and environmental scientists who are members of their community, understand the local needs and assets, and can leverage their expertise in ways that build capacity now and into the future.

The under-representation of AI/AN among those earning STEMM degrees reflects both extremely low participation rates and generally poor retention rates for Indigenous college students (Brayboy, et al., 2012; McClellan, 2005). These trends can be linked to settler colonialism and the concomitant marginalization, assimilation, and attempted genocide of Indigenous peoples–all of which manifest currently patterned systemic barriers such as cultural differences between students and school/university environments; poor academic preparation in K-12 schools; vague constructs of educational or vocational goals; insufficient financial aid; unwelcoming school and university environments; prejudice and racism; and social isolation. The body of work investigating challenges for Indigenous students and STEM disciplines has mainly focused on differences in the way Indigenous people interact with each other and their surroundings compared to non-Indigenous students, as well as the lack of culturally responsive educational practices in schools serving Indigenous youth (Castagno and Brayboy, 2008; Ingram 2009; Smith et al., 2014; Hadfield et al., 2016). Under-studied barriers in AI/AN education, particularly with respect to STEMM programs, include cultural and spiritual factors that could exclude AI/AN people from STEMM-related fields. One study of 96 students surveyed at Haskell Indian Nations University found that 38% of those surveyed would choose not to pursue a science major if they suspected that doing so would require them to disobey an important tribal taboo (Williams and Shipley, 2018). In our study, we also postulate that some standard practices in STEMM may be considered spiritually taboo by some AI/AN people. Further, the perceived non-acceptance of religion and spirituality within the scientific and engineering communities can accentuate the cultural differences between AI/AN people and STEMM educators and professionals (Weldon, 2007). The following are some examples of cultural and spiritual taboos for some AI/AN people that conflict with STEM practices: viewing of unique astronomy-related events such as eclipses or meteor showers, archaeological fieldwork of suspected Indigenous burial grounds, surveillance or dissection of

[1]The terms Indigenous, Native American, and AI/AN are used interchangeably in this paper.

specific animals, examination of human cadavers, genetics research, investigation of weather events such as lightning strikes, and assigning monetary worth to natural resources (Dorson, 1955; Bulow, 1991; Mathiasen, 2006). These cultural and spiritual taboos vary with respect to the tribe as well as the extent that AI/AN people engage in traditional practices. One goal of our research was to investigate if cultural and spiritual taboos constrain the recruitment and/or retention of Indigenous people in STEMM. Another goal of our research was to determine, if there are cultural and spiritual barriers for Indigenous people pursuing STEMM degrees and professions, how can these barriers be reduced to allow higher participation of Indigenous people in STEMM fields. It is this second goal that has direct relevance for STEMM professional societies.

An important mode of systemic and sustainable change in STEMM fields is through professional societies. Indeed, these societies have a broad scope and can leverage influence across STEMM fields in ways that other institutions may not be able. Professional societies provide a means for articulating codes of conduct and ethics within their membership (Perlis and Shannon, 2012). These codes serve to set standards, educate members on their professional obligations, and communicate standards to the public. In their discussion of the role of professional societies in STEM Diversity, Morris and Washington (2017) provide a list of strategies that professional organizations can take to improve diversity and inclusion in the STEM workforce. These include acknowledging racism within their society, developing partnerships with minority serving STEM professional societies, and facilitating leadership opportunities for underrepresented members. Given the focus of this special issue, we consider the implications of our research on leadership, policy, and practice within STEMM professional societies. More specifically, our purpose in this paper is to provide recommendations to professional societies on how our findings can be used to provide guidance to higher education institutions and industry leaders in the area of changing some standard STEMM practices to be more inclusive of Indigenous people.

METHODS

Although the purpose of this paper is not to present the results of our study per se, we provide a brief overview of our methodology and key finds in order to contextualize our recommendations for professional societies. Our project was guided by the following research objectives: 1) develop a culturally responsive theory about the ethical considerations faced by Indigenous students and professionals in STEMM fields, 2) develop a set of recommended best practices related to ethical challenges for Indigenous students and professionals in STEMM fields, and 3) develop a set of future research and policy issues related to culturally-informed ethical issues in STEMM for those working with Indigenous individuals and communities. We employed a blend of Grounded Theory and Critical Indigenous Research Methodologies to investigate the ethical considerations faced by Indigenous STEMM students and professionals in the western United States. Grounded Theory (Glaser and Strauss, 1967; Charmaz, 2006; Corbin and Strauss, 2008) is an inductive, iterative, and comparative methodology aimed at theory development. Critical Indigenous Research Methodologies suggest a set of guiding principles for researchers, including fore-fronting the inherent sovereignty and self-determination of tribal nations, honoring and building on relationships within and between researchers and community members, and pursuing research questions that will advance community needs and interests (Smith 1999; Brayboy et al., 2012). This project was developed with these principles in mind, and we continue to center them as we analyze and disseminate the results of the research.

Data collection was initiated with an online survey sent to two distinct participant groups: Indigenous post-secondary (undergraduate and graduate) students, and Indigenous professionals. The study was limited to the western U.S. in order to minimize the impact of the vast diversity of tribal nations in the U.S., as well as to leverage the connections the authors had in this particular geographic region. Using purposive sampling, Indigenous students and professionals were recruited through student and professional listservs, professional connections, and snowball sampling. A total of 408 participants met inclusion criteria and completed the survey (206 Indigenous professionals and 202 Indigenous students). Twenty-three Likert scale questions were asked on topics related to cultural identity. The scale used was 1–5, with 1 begin strongly disagree and 5 being strongly agree. The survey also asked questions about involvement with activities or tasks in their STEMM field that may be of concern to Indigenous people. The response to the questions probed how concerned the participants were participating in specific activities or tasks. Descriptive statistics, including frequencies, relative frequencies, means, and standard deviations (SD) were used to summarize descriptive characteristics, cultural characteristics agreement, and level of concern regarding STEMM activities among STEMM students and professionals, separately. Ordinal logistic regression was used to estimate the associations of cultural characteristic scores with level of concern about particular STEMM activities, influence of cultural identity and tribal affiliation on college and career decisions, and perspectives on Indigenous conflicts. All analyses were conducted using SAS V9.4 (SAS Inc., Cary, North Carolina). The survey concluded with two discrete open-ended questions. All qualitative (open-ended) survey responses were inductively analyzed using open coding methods, followed by focused coding using the constant comparative method (Corbin and Strauss, 2008; Glesne, 2010; Denzin and Lincoln, 2017).

A total of 203 students representing 78 tribes participated in the survey. **Table 1** shows that 27% were affiliated with health sciences, with lower proportions of participants in life sciences (22%), engineering (16%), mathematics (15%), physical sciences (11%), and computer sciences (6%). Almost 90% of student participants were younger than 30 years while most were female (57%), had completed some college (50%), grew up in a rural area (35%), and currently live in an urban area (20%). Over 60% of student respondents scored high (mostly agreed or

TABLE 1 | Descriptive characteristics among STEM students and professionals.

	Students (*n* = 203)		Professionals (*n* = 206)	
	N	**%**	***N***	**%**
STEM Discipline/Field				
Life sciences	45	22.2	47	22.8
Physical sciences	22	10.8	24	11.7
Engineering	33	16.3	45	21.8
Mathematics	31	15.3	21	10.2
Computer sciences	12	5.9	21	10.2
Health sciences	55	27.1	36	17.5
Other	5	2.5	12	5.8
Age				
18–22 years	97	47.8	7	3.4
23–29 years	82	40.4	44	21.4
30–40 years	22	10.8	103	50.0
41–50 years	2	1.0	41	19.9
>50 years	0	—	11	5.3
Gender				
Male	82	40.4	116	56.3
Female	116	57.1	90	43.7
Other	5	2.5	0	—
Education level				
Some college, no degree completed yet	102	50.3	11	5.3
Associate degree	20	9.8	18	8.7
Bachelor's degree	55	27.1	112	54.4
Master's degree	22	10.8	53	25.7
Professional or terminal degree	4	2.0	11	5.3
Other	0	—	1	0.5
Where participants grew up				
Urban	39	19.2	47	22.8
Suburban	44	21.7	34	16.5
Rural	70	34.5	67	32.5
Reservation	49	24.1	57	27.7
Missing	1	0.5	1	0.5
Where participants currently live				
Urban	102	50.3	110	53.4
Suburban	53	26.1	63	30.6
Rural	25	12.3	13	6.3
Reservation	22	10.8	18	8.7
Missing	1	0.5	2	1.0
Grew up on reservation and still live there	21	10.3	14	6.8
Grew up on reservation and live in a rural area	5	2.5	1	0.5
Grew up on reservation and currently live in an urban/suburban area	22	10.8	41	19.9
Grew up in a rural area and still live there	18	8.9	10	4.9
Grew up in a rural area and live on the reservation	0	0	2	1.0
Grew up in a rural area and live in an urban/suburban area	52	25.6	55	26.7
Cultural Characteristics Scale				
Low (disagree; 10–29)	26	12.8	41	19.9
Medium (neither agree nor disagree; 30–39)	48	23.7	88	42.7
High (agree; ≥40)	129	63.5	77	37.4
Cultural Characteristics Scale Components (proportion agree or strongly agree)				
I value the cultural practices of my tribe and/or Native community	167	82.7	141	68.8
I participate in cultural events within my tribal community when possible	154	76.2	130	63.4
I know some of my tribe's history	171	84.7	156	76.1
I can identify important leaders for my tribe	147	72.8	128	62.4
I can identify important social, health, political, or economic issues for my tribe	151	74.8	135	65.9
I believe it is important to maintain and/or revitalize our indigenous language(s)	163	80.7	128	62.4
I believe it is important to share information about my tribe with the children who are tribal members	168	83.2	127	62.0
My cultural identity is important to me	161	79.7	127	62.0
I learn from Native community elders	151	74.8	111	54.1
I consider myself a traditional tribal member	111	55.0	88	42.9

strongly agreed) on the cultural characteristics scale. A total of 206 professionals representing 76 tribes participated in the survey. **Table 1** shows that 23% were affiliated with life sciences, with lower proportions of participants in engineering (22%), health sciences (18%), physical sciences (12%), mathematics (10%), and computer sciences (10%). Almost 70% of professional participants were 30 years or older while most were male (56%), had a bachelor's degree or higher (86%), grew up in a rural area (35%), and currently live in an urban area (20%). As compared to students, fewer professionals scored high on the cultural characteristics scale (37%), with the majority (43%) scoring in the medium range. We acknowledge that participants represent a number of different tribes with different cultural and spiritual beliefs. We do not aim for broad generalizability; the project is designed to uncover themes, issues, and trends in the ethical considerations faced by Indigenous students and professionals in STEMM fields in the western United States.

RESULTS

Overall, our research found that Indigenous students and professionals face unique cultural, spiritual, and ethical conflicts in STEMM and they engage in thoughtful and intentional strategies to navigate those conflicts. Our data indicate that STEMM disciplines and work that involves human remains, genetics, tribal lands, or Indigenous sacred sites is often viewed as more ethically concerning for many Indigenous students and professionals compared to activities outside this scope. The navigational strategies used by both students and professionals include teaching others and leveraging their support, engaging in ceremonial practices to provide protection and correction when needed, being in the right mindset and/or acting in the right ways, and–for some–changing pathways altogether (Castagno et al., in press). By centering Indigenous students and professionals' voices and experiences, we can better understand how intentional, complex, and thoughtful their strategies must be. As one professional shared, "all people make choices dependent on their survival, we honor our ancestors by making choices that are based on our culture and spiritual journey." These journeys have much to teach STEMM leaders, faculty, teachers, staff, and employers, but the perhaps most important is the message from this experienced Indigenous STEMM professional: "I believe Indigenous people can do what is expected of them in their profession, but it may not be the in the same way." Since a full discussion of our findings is beyond the scope of this paper, we focus on a few results that have particular relevance for informing professional societies about how they can be leaders in the effort to broaden participation among Indigenous peoples in STEMM.

The first relevant result relates to the cultural characteristics scale we developed by summing Likert scale responses for the ten cultural characteristics questions shown in **Table 1** (listed as Cultural Characteristics Scale Components). The scale scores ranged from 10 to 50 where a score from 10 to 29 indicated generally low/disagreement, 30–39 indicated medium/neither agree nor disagree, and ≥40 indicated high/agreement. Importantly, this cultural characteristics scale is not meant to suggest an evaluative judgment or ranking of one's cultural identity; nor is it meant to suggest there are better or worse ways to be Indigenous. Instead, the cultural characteristics scale is intended as a way to capture a particular set of factors that may or may not collectively describe how one characterizes their Indigenous identity. This scale was not a feature of the research that we initially anticipated exploring, but after exploratory analyses of the survey, it evolved into a potentially important part of the narrative. As noted above, this scale is not intended to indicate any judgment about how individuals engage their cultural identities. But what it does provide is an important set of characteristics for universities and employers to better understand the importance of cultural identity for Indigenous individuals. The employment of cultural impact assessment, which has similarities to the cultural characteristics scale reported here, is used to understand the impact of culture and cultural activities with regard to interventions in economics, ecology, and society (Partal and Dunphy 2016). The cultural characteristics scale that we report provides context for the cultural identity of the survey participants allowing for improved interpretation of the results. Since many more students scored high on this scale (63.5 vs. 37.4 professionals scoring high, **Table 1**), it may be that employers will see more applicants and employees in the coming years who report higher levels of affiliation to their Indigeneity. Further, since a higher score on this scale correlates to higher odds of experiencing culturally-informed ethical conflicts in STEMM, we hope that the pathways to advanced degrees and desirable careers will evolve to be more culturally responsive with fewer conflicts for Indigenous people.

Another result of interest is that the particular field or subdiscipline of the participant does appear to make a difference in their reported experiences and perceptions. In one section of the survey, the participants were asked about concerns related to specific tasks associated with the STEMM fields (ranging from not concerned, somewhat concerned, and very concerned). **Table 2** lists the STEM tasks along with the percentages of the students and professionals who indicated that the task was very concerning. The percentages were determined by summing the very concerning responses and dividing by the total number of responses. The results indicated that among all participants, between 20 and 50% report being very concerned about every STEMM task listed in the survey that was part of their specific STEMM field. These are noteworthy numbers, even those at the lower end of the range. These results illustrate how some (non-Indigenous) individuals may consider these tasks to be part of the education process or tasks necessary for a particular discipline. However, an Indigenous individual may consider these tasks as a counter to their cultural or spiritual beliefs; thus, the individual must ignore their cultural or spiritual belief, navigate the task in light of their concern, or simply refuse to participate in the task. In a recent publication (Ingram 2021), we investigated the culturally-based barriers for Indigenous students and professionals in engineering fields. Many of the engineering participants identified difficulties being

TABLE 2 | STEMM task–percentages of very concerning responses.

	Students	Professional
Archaeological Field Work	21.1	18.6
Assessing Monetary Worth of Natural Resources on Tribal Lands	42.9	23.7
Being Near Human Remains	25.0	37.5
Commercial or Economic Development Efforts on Sacred Sites	38.5	37.8
Commercial or Economic Development Efforts on Tribal Lands	30.8	36.0
Designing Infrastructure on Tribal Lands	25.8	35.7
Discussion of Sacred or Ceremonial Knowledge	20.8	22.9
Dissection of Animals	29.0	20.5
Examining Human Cadavers	42.5	54.2
Genetics Research	33.3	34.0
Investigating Environmental Hazards on Sacred Sites	33.3	41.2
Investigating Environmental Hazards on Tribal Lands	44.8	41.0
Investigating Weather	30.0	28.6
Observing Animals in Clinical or Experimental Settings	26.2	18.9
Observing Animals in Natural Setting	22.4	19.7
Observing Medical Procedures on Animals	31.8	28.6
Observing Medical Procedures on Humans	6.8	20.7
Research on Indigenous Sacred Sites	31.3	40.6
Research on Tribal Lands	29.8	27.1
Research with Human Tissue Samples	36.7	32.6
Testing Infrastructure on Tribal Lands	31.3	22.6
Visiting Indigenous Ruins	25.9	25.0

Note: values provided as a percentage of very concerned responses divided by the total responses.

TABLE 3 | Association between cultural characteristics and perspectives on ethical concern for STEM activities among STEM students and professionals.

STEM activity	Students			STEM activity	Professionals		
	OR	95%	CI		OR	95%	CI
Archaeological field work of suspected Indigenous burial ground (*n* = 23)	**6.6**	**1.2**	**36.2**	Archaeological field work of suspected Indigenous burial ground (*n* = 43)	2.0	0.8	4.9
Visiting Indigenous ruins (*n* = 32)	**7.8**	**1.9**	**31.6**	Visiting Indigenous ruins (*n* = 52)	**3.4**	**1.6**	**7.3**
Designing infrastructure on tribal lands (*n* = 34)	**4.1**	**1.5**	**11.3**	Designing infrastructure on tribal lands (*n* = 60)	**5.0**	**2.4**	**10.3**
Testing infrastructure on tribal lands (*n* = 60)	1.8	0.9	3.5	Testing infrastructure on tribal lands (*n* = 68)	**3.7**	**1.9**	**7.1**
Assessing monetary worth of natural resources on tribal lands (*n* = 26)	1.8	0.7	4.6	Assessing monetary worth of natural resources on tribal lands (*n* = 40)	**3.3**	**1.3**	**8.1**
Commercial or economic development efforts on tribal lands (*n* = 27)	**3.3**	**1.0**	**10.8**	Commercial or economic development efforts on tribal lands (*n* = 51)	**2.5**	**1.2**	**5.0**
Commercial or economic development efforts on Indigenous sacred sites (*n* = 27)	**2.6**	**1.0**	**6.8**	Commercial or economic development efforts on Indigenous sacred sites (*n* = 45)	**2.2**	**1.0**	**4.5**
Research on tribal lands (*n* = 51)	1.6	0.8	3.3	Research on tribal lands (*n* = 60)	**2.1**	**1.1**	**4.0**
Research on Indigenous sacred sites (n = 17)	3.1	0.6	17.7	Research on Indigenous sacred sites (*n* = 34)	1.8	0.7	4.5
Investigating environmental hazards on tribal lands (*n* = 30)	**2.8**	**1.2**	**6.8**	Investigating environmental hazards on tribal lands (*n* = 40)	2.0	0.9	4.3
Investigating environmental hazards on Indigenous sacred sites (*n* = 26)	1.5	0.6	4.2	Investigating environmental hazards on Indigenous sacred sites (*n* = 36)	**3.0**	**1.2**	**7.9**
Hearing or discussing sacred or ceremonial knowledge outside of traditionally approved contexts (*n* = 30)	3.1	0.9	10.5	Hearing or discussing sacred or ceremonial knowledge outside of traditionally approved contexts (*n* = 40)	**3.8**	**1.3**	**11.3**
Dissection of animals (*n* = 74)	**2.4**	**1.2**	**4.7**	Dissection of animals (*n* = 46)	1.9	0.8	4.5
Observing animals in clinical or experimental settings (*n* = 64)	**2.2**	**1.1**	**4.5**	Observing animals in clinical or experimental settings (*n* = 54)	1.6	0.7	3.6
Observing animals in natural settings (*n* = 64)	1.3	0.7	2.6	Observing animals in natural settings (*n* = 70)	**1.9**	**1.0**	**3.3**
Observing medical procedures on animals (*n* = 48)	**2.9**	**1.3**	**6.5**	Observing medical procedures on animals (*n* = 28)	2.3	0.9	5.6
Examining human cadavers (n = 44)	1.3	0.7	2.7	Examining human cadavers (n = 27)	1.1	0.5	2.6
Being near human remains (*n* = 45)	1.6	0.7	3.4	Being near human remains (*n* = 24)	**5.2**	**1.1**	**24.1**
Research with human tissue samples (*n* = 53)	1.7	0.9	3.5	Research with human tissue samples (*n* = 48)	**5.7**	**1.8**	**17.7**
Genetics research (*n* = 53)	**4.0**	**1.8**	**8.9**	Genetics research (*n* = 51)	**2.7**	**1.3**	**5.5**
Medical procedures (*n* = 64)	1.3	0.6	3.0	Medical procedures (*n* = 59)	**2.2**	**1.1**	**4.3**
Investigating weather events (*n* = 32)	**0.3**	**0.12**	**0.9**	Investigating weather events (*n* = 42)	0.6	0.3	1.4

Abbreviations: Odds Ratio (OR); 95% Confidence Interval (95% CI).
*Items in **Table 3** that are in bold font are statistically significant.*

Indigenous in engineering fields that can be linked to cultural, ethical, and/or spiritual values that conflict with the U.S. majority population. The results suggested that engineering students have stronger concerns than the engineering professionals with participating in activities within the engineering field that they perceive to be in conflict with their cultural, ethical, and/or spiritual identities. These results could be interpreted in a few ways. One possible explanation is that more years of experience guide Indigenous professionals in their navigation of conflicts, which in turn, reduces their concerns. Another potential explanation is that professionals have more control over their work environment and thus can mitigate issues more easily than students. It may be, in fact, a combination of reasons that allow professionals to be less concerned with these types of conflicts.

And finally, we also found that when assessing the association between the cultural characteristics scale and perspectives on ethical concern for STEMM activities among students and professionals, a higher score on the cultural characteristics scale was associated with higher odds of concern regarding performing STEMM activities that are part of an individual's particular field (Castagno et al., under review). This correlation was true for all STEMM activities in our survey, with the exception of investigating weather events; although not all associations were statistically significant (**Table 3**). For example, the odds of finding visiting Indigenous ruins very concerning were 7.8 times (95% CI: 1.9, 31.6) among students with higher cultural characteristics scores compared to students with lower scores. Similarly, the odds of finding research with human tissue samples very concerning were 5.7 times (95% CI: 1.8, 17.7) among professionals with higher cultural characteristics scores compared to professionals with lower scores.

These findings of the cultural characteristics scale and the reported concerns in STEMM activities are particularly important given the need to open up science, scientific inquiry, and scientific innovation to additional and alternative ways of thinking and being in the world. In order for STEMM to leverage the knowledge and expertise of Indigenous people, the pathways need to evolve so that people do not have to engage in activities that conflict with who they are and the epistemologies, axiologies, and ontologies that have sustained their communities for generations.

DISCUSSION

The insights gained from this research should guide action on the part of leaders in STEMM fields in order to positively impact the participation of Indigenous people in STEMM fields. We suggest that professional societies, both disciplinary and those that support specific populations, can play a significant role in stimulating change within higher education and the professional workplace.

Disciplinary professional societies are structured to support members who identify with a specific discipline. This support is typically manifest as education and information in the form of journals, awards, and defining standards within the discipline (National Academy of Sciences et al., 2016). Disciplinary professional societies review trends in their specific disciplinary fields with respect to federal agencies, industry, and higher education. These societies are well-positioned to promote change within their disciplines through publications, policy statements, conferences, lectureships, and awards. In a variety of disciplines, professional societies lead the transformation of curriculum used to train the next STEMM generation, as well as develop policy around professional best practices in industry, federal agencies, and higher education. For example, the American Society for Engineering Education's (ASEE) mission is to advance innovation, excellence, and education for the engineering profession (American Society for Engineering Education, 2021). This organization provides input on engineering educational policy that, in turn, impacts curriculum for engineering students earning certified degrees. Likewise, the American Chemical Society - through the Committee on Professional Training - guides modifications to their certified chemistry degree as dictated trends within their field (American Chemical Society, 2021). Professional societies can also promote best practices and professional development in their disciplines for professionals and educators.

In many professional disciplinary societies, diversity, equity, and inclusion (DEI) issues are promoted through committees or subdivisions. For example, in the Ecological Society of America (ESA), the Committee on Diversity is focused on enhancing recruitment, training and retention of women and people of color in the ecological sciences and encouraging the equitable treatment and representation of all ecologists, regardless of gender, age, race, sexual orientation or cultural background (Ecological Society of America, 2021a). Additionally, some professional societies are not disciplinary-specific, but instead support members from specific populations, such as the American Indian Science and Engineering Society (AISES) and the Society to Advance Chicanos/Hispanics and Native Americans in Science (SACNAS). These societies focus on support of specific populations in a variety of disciplines to increase the diversity within these disciplines, such as science and engineering.

We applaud the efforts of both disciplinary and population-based professional societies on their efforts to address DEI issues, but there is still much more that can be done. In Stewart and Valian's (2018) discussion of gender and race schemas in higher education, they note that the values, norms, and ways of being of certain groups (generally White, male, straight, middle class, English-speaking, Christian groups) can be undervalued while others can be overvalued within organizations, and this often happens with little awareness by those in the organization. This is in part due to most people's tendencies toward homophily, which exacerbates the homogeneity among staff and especially among leadership within organizations. When these patterns of seeking out those who are similar to oneself and valuing particular values, norms, and ways of being are named and conversation is invited about the patterns, it is not uncommon to be met with denial or other forms of resistance. A common response for denying these patterns and attitudes is the comment "I don't see race (or color, etc.)," which is often referred to as color-blindness or color-neutrality, and it implies that race does not matter and that

everyone's lived experiences are the same. The result of this attitude is that people who do not acknowledge biases, do not believe they need instruction in DEI and, therefore, resist participation in any efforts to learn about DEI issues. Thus, strategies to best engage and inform the majority of people in STEMM, particularly those in leadership roles, must include a variety of approaches and must begin with understanding the common responses and forms of resistance to this work. Otherwise, efforts to address DEI issues will be limited to those who already understand the challenges, and can therefore be viewed as "preaching to the choir."

We have confidence that professional societies can play an important role in impacting changes that address attitudes and practices in STEMM fields that are in conflict with Indigenous people. We recommend that professional societies weave the findings from this study as well as other studies on barriers for Indigenous individuals entering STEMM into the fabric of their societal activities. The first step would be for the leadership of the professional societies to become acquainted with barriers that Indigenous people face in entering STEMM fields. As our research indicates, there are different cultural and spiritual conflicts for Indigenous people depending on the specific discipline. Understanding the types of cultural and spiritual conflicts within a specific discipline will provide a path for professional societies to develop strategies to address these conflicts. For example, in medical training, students are required to dissect animals and/or cadavers. Some synthetic animal models already exist and are being used in classrooms, such as the synthetic frog. Substitution of these types of synthetic models early in the educational training of Indigenous students may increase their likelihood of continuing in biology or medical career paths. This example leads to the recommendation to find alternate curricular approaches for teaching concepts that do not present conflicts for Indigenous students. It may be difficult for non-Indigenous educators to develop these alternatives on their own, but we encourage collaboration with Indigenous scholars and traditional knowledge holders. Once these alternative approaches are developed, the new curricular approach should be shared with educators through professional societies' journals, conferences, and websites as a resource to others. Educational practices and curriculum in STEMM fields do evolve over time, but these evolutions are often the result of new technology or changes in our understanding of best practices as determined by "evidenced-based research" in teaching. Professional societies can play an important leadership role in introducing changes based on research such as ours, as well as by providing resources and incentives to universities and STEMM educators to initiate change in their curriculum.

A more difficult recommendation for professional societies is to change the attitudes of their members toward disciplinary activities utilized for many years but that presents a conflict for some Indigenous people. One approach that is often taken by professional societies is to have symposia or special sessions at their national or regional conferences that are focused specifically on DEI issues. While this is an admirable use of resources for the professional societies, it is often attended by members that are already committed to addressing DEI issues, which means the impact on the larger professional society membership is minimal. Another approach that can be taken is to require members to attend mandatory DEI training. Studies have shown (Dobbin and Kalev, 2016) that diversity training rarely lasts beyond a few days after the training. We suggest in addition to DEI special sessions at professional society conferences, that Indigenous issues in STEMM be woven into keynote addresses and subject matter sessions in the context of gaining increased insights and participation of Indigenous peoples. Recently, there has been a movement among some disciplines to include Traditional Ecological Knowledge (TEK) as a framework for studying environmental and other complex STEMM challenges. The ESA has a TEK Section within their organizational structure that is tasked with stimulating research that incorporates TEK and participation of Indigenous people (Ecological Society of American, 2021b). The Wildlife Society has a Native Peoples' Wildlife Management Working Group as part of their societal structure (The Wildlife Society, 2021). Indigenous scholars provide an important example to non-Indigenous professional society members that having a diverse lens is an important contribution to their disciplines.

The final recommendation is to encourage the leadership of professional societies to work with Indigenous scholars and traditional knowledge holders on developing and disseminating policy statements that provide a pathway for change in education and professional practice to address concerns among Indigenous people. Policy statements are organization-level documents that prescribe acceptable methods or behaviors. A policy dictates how things are done within an organization. These statements guide the organization; they can be modified over time, which allows for advances for the organization. Policy statements focused on change associated with educational and professional practices that improve the participation of Indigenous people are important steps for inclusivity.

If scholars, leaders, educators, and employers in STEMM are genuine in their calls for broader participation from diverse people, these culturally-informed ethical conflicts must be addressed. The increasingly popular calls for more role models and mentors, affinity groups, and curricula that are relevant to Indigenous communities' needs are all important, but they will not change the high levels of concern many Indigenous people have about participating in certain activities considered to be standard practice in STEMM fields. Instead, consideration should be given to alternate activities or ways to navigate activities so as to minimize the cultural or spiritual conflicts for Indigenous people. An important approach is to seek guidance from Indigenous people themselves about culturally appropriate alternatives. These alternatives are not just beneficial for the Indigenous people who experience conflicts we describe in this paper; the alternatives would also open up new opportunities to learn and innovate for everyone in STEMM. Professional societies have a critical role to play in educating their memberships and leading these changes across the field National Academy of Sciences, 2005.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Northern Arizona University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JI and AC - development of project, funding, oversight of data collection, review of manuscript. JI development of manuscript. AC also contributed to the manuscript development. RC statistical analysis of data and development of data table. DB administration of survey and review of manuscript.

FUNDING

Funding support from the National Science Foundation Grant 1835108.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Education

PERSPECTIVE
published: 15 October 2021
doi: 10.3389/feduc.2021.755457

Supporting Equity and Inclusion of Deaf and Hard-of-Hearing Individuals in Professional Organizations

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Edited by:
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Reviewed by:
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Caroline Solomon, Gallaudet University, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: 08 August 2021
Accepted: 27 September 2021
Published: 15 October 2021

Citation:
Huyck JJ, Anbuhl KL, Buran BN, Adler HJ, Atcherson SR, Cakmak O, Dwyer RT, Eddolls M, El May F, Fraenzer J-T, Funkhouser R, Gagliardini M, Gallun FJ, Goldsworthy RL, Gouin S, Heng J, Hight AE, Jawadi Z, Kovacic D, Kumar R, Kumar S, Lim SR, Mo C, Nolan LS, Parbery-Clark A, Pisano DV, Rao VR, Raphael RM, Reiss LAJ, Spencer NJ, Tang SJ, Tejani VD, Tran ED, Valli M, Watkins GD, Wayne RV, Wheeler LR, White SL, Wong V, Yuk MC, Ratnanather JT and Steyger PS (2021) Supporting Equity and Inclusion of Deaf and Hard-of-Hearing Individuals in Professional Organizations. Front. Educ. 6:755457. doi: 10.3389/feduc.2021.755457

Disability is an important and often overlooked component of diversity. Individuals with disabilities bring a rare perspective to science, technology, engineering, mathematics, and medicine (STEMM) because of their unique experiences approaching complex issues related to health and disability, navigating the healthcare system, creatively solving problems unfamiliar to many individuals without disabilities, managing time and resources that are limited by physical or mental constraints, and advocating for

themselves and others in the disabled community. Yet, individuals with disabilities are underrepresented in STEMM. Professional organizations can address this underrepresentation by recruiting individuals with disabilities for leadership opportunities, easing financial burdens, providing equal access, fostering peer-mentor groups, and establishing a culture of equity and inclusion spanning all facets of diversity. We are a group of deaf and hard-of-hearing (D/HH) engineers, scientists, and clinicians, most of whom are active in clinical practice and/or auditory research. We have worked within our professional societies to improve access and inclusion for D/HH individuals and others with disabilities. We describe how different models of disability inform our understanding of disability as a form of diversity. We address heterogeneity within disabled communities, including intersectionality between disability and other forms of diversity. We highlight how the Association for Research in Otolaryngology has supported our efforts to reduce ableism and promote access and inclusion for D/HH individuals. We also discuss future directions and challenges. The tools and approaches discussed here can be applied by other professional organizations to include individuals with all forms of diversity in STEMM.

Keywords: Diversity & Inclusion, disability, hearing loss, professional organisations, peer mentoring

INTRODUCTION

A diverse scientific workforce leads to increased creativity and productivity by introducing a wider range of perspectives, experiences, and skill sets (Lindsay et al., 2018; Tilghman et al., 2021). Diversity is conventionally considered in terms of race, ethnicity, country of origin, linguistic background, socioeconomic background, gender, and/or sexual orientation. Despite its high prevalence in society, disability is often overlooked as a form of diversity (Santuzzi and Waltz, 2016; Dennissen et al., 2018; Gould et al., 2021). While the importance of cultural and ethnic diversity is widely acknowledged, it is important to consider the contribution that individuals with disabilities can make in science, technology, engineering, mathematics, and medicine (STEMM) (Bellman et al., 2018). As with other diverse groups, people with disabilities are underrepresented in STEMM (National Science Foundation, National Center for Science and Engineering Statistics, 2021).

Individuals with disabilities offer a unique perspective drawn from their experiences of living with a disability that can guide novel and innovative scientific progress or improve medical care for people with that particular disability. They frequently have extensive experience navigating healthcare settings as patients, utilizing creativity to overcome accessibility challenges, managing limited time and resources, and advocating for themselves and others with disabilities. This experience translates to valuable attributes such as better communication skills, persistence, empathy, planning, creativity, and adaptability (Hewlett, 2017; Accenture, 2018; Kristjansdottir et al., 2018; Lindsay et al., 2018; DeFelice, 2019; Kulkarni, 2020). Individuals with disabilities often know how to use assistive technology to increase their productivity (Hatton, 2014; Kulkarni, 2020), and some types of disability or neurodiversity have common attributes that might be helpful in and of themselves. For example, employees who are Deaf or hard of hearing (D/HH) may be less distracted by background noise and conversations (Hatton, 2014). Businesses who actively recruit and support individuals with disabilities often see higher revenue and better employee retention than businesses that do not (Accenture, 2018; Lindsay et al., 2018).

As defined by the United Nations' Convention on the Rights of Persons with Disabilities (2007), "Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments in which interaction with various barriers may hinder their full and effective participation in society on an equal basis with others." Scientists with disabilities face several hurdles to equity and inclusion (Brown, 2016; Brown et al., 2018; Brown and Leigh, 2018; Inckle, 2018; De Picker, 2020). In the context of STEMM education, disability equity refers to justice in the way that people with disabilities are treated, such that they have the same likelihood for educational and career success as individuals who are not disabled. Disability equity also extends to interpersonal relationships, where individuals with disabilities should be treated with the same respect as individuals who are not disabled. Inclusion of individuals with disabilities means giving them physical, social, and financial access to the same opportunities as individuals without disabilities, often through the use of accommodations. Physical access refers to whether a person with a disability can enter, move around in, and function in a physical space and whether they are able to interact with physical materials (e.g., posters, lab equipment). For D/HH individuals, physical access can be facilitated by using microphones, providing services like captioning, cued language transliteration, or sign language interpretation, and by providing quiet environments for conversations. Social access refers to being able to attend and participate in the informal social interactions (e.g., conversations, dinners, social hours) that can lead to research collaborations, employment, and leadership

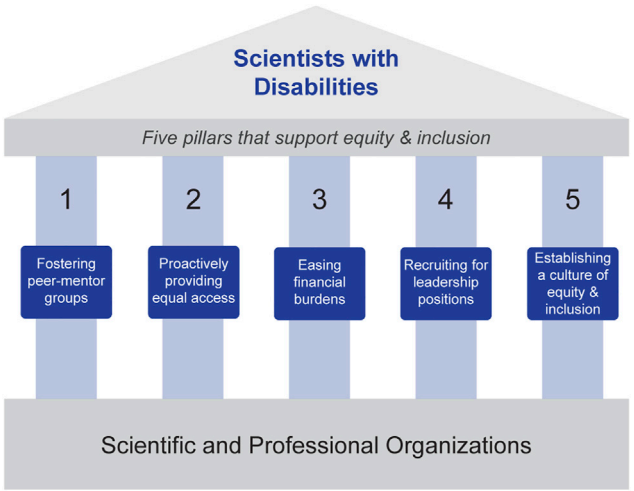

FIGURE 1 | The five pillars that Professional and Scientific Organizations can use to support equity and inclusion for scientists with disabilities. The Association for Research in Otolaryngology (ARO) has implemented these building blocks which have been successful in supporting their deaf and hard-of-hearing (D/HH) members.

opportunities. Social access is often a challenge for D/HH individuals who may be unable to hear in noisy conference halls or restaurants, or who may be exhausted from trying to hear at a conference and thus unable to attend evening events. Finally, financial considerations can limit both physical and social access. Many individuals with disabilities expend significant financial resources on health care and assistive technology. For these reasons, they sometimes cannot afford conference registration fees, travel costs, or educational expenses. Many interactions that are critical to career success occur at professional organizations' academic or scientific conferences. Given the key role professional organizations play in nurturing scientists and facilitating career growth for trainees, we believe these organizations can foster diversity by supporting efforts for recruiting and supporting individuals of diverse backgrounds, including those with disabilities. Indeed, there has been recent interest in how scientific conferences can be more inclusive (Oswald and Ostojic, 2020; Tzovara et al., 2021). We propose five pillars (see **Figure 1**) that organizations can use to better support their diverse members: 1) fostering peer-mentor groups, 2) proactively providing equal access, 3) easing financial burdens, 4) recruiting for leadership positions, and 5) establishing a culture of inclusion and equity. By adopting these pillars, professional organizations can lead by example, familiarizing their members with equitable treatment and inclusion of individuals with disabilities and those from other diverse backgrounds.

We are a group of more than 110 deaf and hard-of-hearing (D/HH) engineers, scientists, and clinicians, most of whom are active in clinical practice and/or auditory research (Adler et al., 2017). Our network was initially formed in 1992 at a professional society meeting for the Association for Research in Otolaryngology (ARO) and has continued to grow based on shared experiences at those meetings and in other STEMM environments. Typically, our group makes up 1% or less of attendees at professional conference meetings. Diversity networks such as ours have the potential to promote equity and inclusion if they directly address systemic inequalities in organizations, in addition to advancing career development and building community (Dennissen et al., 2018). We have worked with the organizational leadership of various professional societies to implement successful, practical strategies for improving accommodations, raising awareness, and promoting academic, research, and career development opportunities for diverse trainees. We discuss how one organization, ARO, has fostered a more inclusive and equitable environment for researchers with disabilities and provide five guidelines for other scientific or professional organizations to consider.

MODELS OF DISABILITY

Our peer mentorship network for D/HH individuals endorses a biopsychosocial view of hearing loss (defined below) that incorporates medical and social models of disability. While these disability models are not mutually exclusive, each model has distinct approaches to disability.

Medical models of disability address the physical differences associated with specific diagnoses and focus on preventing, curing, remediating, or accommodating the physical underpinnings of a given disability (Pelka, 2012). For D/HH individuals, this might involve genetic counseling about hereditary hearing loss, treatments to preserve or restore inner ear function, auditory rehabilitation through the use of hearing devices (e.g., hearing aids, cochlear implants), and promoting the individual use of assistive technology such as remote microphone technology and smartphone apps to provide automatic speech recognition and transcription. As scientists, engineers, and clinicians who study hearing and live with hearing loss, much of our academic labor falls into this category.

Social models of disability assert that some of the issues experienced by individuals with disabilities arise from the presence of societal or environmental barriers (Samaha, 2007). For deafness and hearing loss, addressing these barriers might include installing amplification systems that are compatible with hearing aids and cochlear implants, providing real-time captioning for all lectures and meetings by default, and providing interpreting and transliteration services (e.g., sign language interpreters, cued language transliterators, oral transliterators). Proponents of social models of disability often feel the language used to write and talk about disability should use "person-first language" (e.g., researchers *with disabilities*). This approach is meant to emphasize the personhood of individuals with disabilities and to avoid defining individuals and groups based only on their disability (Dunn and Andrews, 2015).

One type of social model, the diversity model, acknowledges that society and the environment can be inaccessible and exclusionary and also argue that people with disabilities form an important cultural group that contribute to society through their identity as disabled people (Andrews, 2020). This type of model recognizes that disabled people are culturally valuable

because of their experiences of living with disability, and not because they are able to "overcome"—or succeed in spite of—their disability. For example, extensive advocacy by the D/HH community during the 1960s through 1980s led to ubiquitous captioning of movies and television broadcast shows. Today, the majority of viewers who now use captioning for their own benefit do not have a hearing loss (Ofcom, 2006).

The diversity model perspective has long been held by the Deaf community (commonly designated by the capital "D" to indicate that it is specific cultural group differentiated from the broader D/HH community) who view hearing loss as a key part of their personal identity and often use sign language as a primary form of communication (Padden and Humphries, 1988). More broadly, disability culture includes individuals with any and all disabilities and encompasses values, arts, and political stances in addition to experiences of shared discrimination and prejudice (see Andrews, 2020; Mackelprang and Salsgiver, 2016; or Brown, 2002, for reviews). For example, the American Deaf community has developed poetry and storytelling techniques that leverage linguistic features unique to American Sign Language (Bahan, 2006; Sutton-Spence and de Quadros, 2014).

Diversity models of disability contributed to the rise of the field of critical disability studies, which focuses on how different diverse identities can intersect with disabilities and draws parallels between the disability rights movements and other civil rights movements (Andrews et al., 2019; Ginsberg and Rapp, 2017). This field has led to our current understanding of ableism, defined as the conscious or unconscious prejudice and discrimination towards disabled people (Andrews, 2020). Ableism takes many forms and can be harmful regardless of whether it stems from ignorance, negative attitudes such as viewing disabled people as burdensome or vulnerable, or from attitudes which on the surface seem more positive, such as viewing disabled people as inspirational or heroic (Andrews, 2020). For example, media profiles of successful disabled individuals in academia seldom acknowledge that the individual's disability can be an asset and not just something to "overcome" (e.g., Terry, 2019). Often, these narratives either ignore the challenges associated with disability entirely or assert that a scientist with a disability is noteworthy because they succeeded in spite of their disability. Ideally, these profiles would mention the challenges of being disabled and also include information on how their disability helped them to be more successful or a better scientist. Further, inspirational videos and articles of deaf children's reactions when their cochlear implant is first activated may objectify them and fail to provide adequate background regarding realistic benefits of the device and remaining challenges post-implantation.

Proponents of diversity models and the field of disability studies often advocate for the use "identity-first language" (e.g., D/HH scientists) which enables disabled individuals to express belonging and pride as members of a disabled community and to define what it means to be disabled instead of letting it be defined by negative stereotypes (Dunn and Andrews, 2015). The American Psychological Association (2020) states that both person-first and identity-first language are appropriate, and that authors should consider the preferences of the people who are being written about. In this article, we have elected to use person-first language when referring to disabilities in general (e.g., individuals with disabilities) and identity-first language when discussing the disabled community to which we belong (e.g., D/HH individuals).

Biopsychosocial models integrate aspects of individual, social, and diversity models of disability. Engel (1977) originally proposed a biopsychosocial model as a way of addressing an overreliance on a medical model in psychiatry, which ignored the "social, psychological, and behavioral dimensions of illness." Since that time, the model has been expanded and updated to apply to many areas of health, illness, and disability (Wade and Halligan, 2017). It was used as the basis for the World Health Organization's International Classification of Functioning, Disability, and Health (ICF), a framework for measuring individual- and population-level health and disability in 2001 (World Health Organization, 2001; Kostanjsek, 2010). At the time, the ICF was seen as progressive, because it included not only the biological underpinnings that give rise to disability (medical model), but also considered that the environment, society, and relationships can exacerbate or ameliorate disability (social model) and indicated that personal factors can also have a major impact on disability (diversity model). While personal factors remain underspecified in the ICF model, these factors could potentially include income, age, educational qualifications, and racial, gender, or LGBTQIA+ identity (WHO, 2011; Shaw et al., 2012; Nakkeeran and Nakkeeran, 2018).

The biopsychosocial model has the potential to be transformative because it acknowledges that there are limitations to our ability to address hearing loss and other disabilities through medicine. By combining medical, societal (i.e., environmental), and diversity considerations we can maximize opportunities for the success of disabled individuals. For example, combining cochlear implants (medical) with accommodations such as closed captioning and training of colleagues/teachers on how to facilitate communication (social) as well as introducing the disabled individual to other disabled peers (diversity) has a higher likelihood of success than any of these strategies in isolation.

DIVERSITY AND INTERSECTIONALITY

Hearing loss ranges from mild to profound. For example, an individual with mild hearing loss may experience difficulty understanding speech in noisy environments, whereas an individual with profound hearing loss may have little to no functional hearing. Communication modalities found within the hearing loss community can include audio-visual, where speechreading is combined with residual hearing, and visual-only, such as sign language and Cued Speech. The diversity of hearing loss etiologies and communication modes means the hearing loss community is heterogeneous and accessibility strategies for a particular individual (i.e., providing assistive listening devices) may not work for another individual.

Differences in the wording of questions across surveys makes it difficult to estimate the true prevalence of hearing loss

(Mitchell, 2006). Nevertheless, rough estimates suggest that approximately 15% of American adults report some trouble with hearing (Blackwell et al., 2012). Global data indicate that ~6-18% of the world's population live with some form of hearing loss (Olusanya et al., 2019). For comparison, these numbers are similar to the numbers for diabetes, which affects 13% of American adults (Centers for Disease Control and Prevention, 2020) and 9.3% of adults across the globe (International Diabetes Federation, 2019). Given its high prevalence, it is not surprising that the hearing loss community is inherently diverse. Hearing loss can occur in any individual regardless of race, ethnicity, gender, sexual orientation, socio-economic status, age, or other cultural background. This diversity can contribute to large disparities in terms of rehabilitative outcomes achieved by people with hearing loss. For instance, a child with hearing loss born into an affluent family may have better hearing outcomes due to better parental follow-up from newborn hearing screenings, early intervention such as speech therapy, and earlier access to hearing aids, cochlear implants, or assistive listening devices. A child born into a family of low socioeconomic status might not have access to the same resources (Holte et al., 2012; Ching et al., 2013).

There are strong parallels in the history and consequences of discrimination between individuals with hearing loss and other marginalized communities. Strategies developed to recruit and support members of the D/HH community in STEMM fields can serve as a template for efforts to recruit and support members of other historically disadvantaged or otherwise marginalized communities. The approach presented below is targeted towards D/HH individuals but can easily be adapted for the specific needs of other marginalized groups.

PROMOTING DIVERSITY

The Association for Research in Otolaryngology (ARO) is a scientific organization focused on hearing and balance research that was founded in 1973. In 1992, D/HH attendees at the ARO Midwinter Meeting formed an informal networking group dedicated to increasing the representation of D/HH individuals in hearing research. This group has grown to more than 110 members globally and has encouraged ARO to develop five pillars that support diversity and inclusion among their members (see **Figure 1**). These pillars are: 1) fostering peer-mentor groups, 2) proactively providing equal access, 3) easing financial burdens, 4) recruiting for leadership positions, and 5) establishing a culture of inclusion and equity. ARO is a model organization that has successfully implemented practices targeting all five pillars. Below, we provide examples for each that can be used as a framework for other STEMM professional and scientific organizations.

Fostering Peer-Mentor Groups

Informal interactions between marginalized peers have been shown to promote academic and social growth in higher education settings (Gurin et al., 2002; Tienda, 2013). Diversity networks have the potential to advance D/HH individuals in STEMM who are vastly underrepresented (0.13–0.19%) compared to the general population (11–15.3%; National Science Foundation, National Center for Science and Engineering Statistics, 2021). Over the last ~30 years, D/HH members and attendees of conferences relating to audiology, otolaryngology, and hearing science have established a distributed academic peer-mentorship network (Adler et al., 2017) to address this disparity. This peer-mentorship network is known as "Hearing Impaired members of ARO" (HI-ARO) due to its founding at an ARO meeting, though the group has expanded to include researchers and clinicians who are involved in hearing science but do not attend ARO meetings. HI-ARO has successfully recruited and retained D/HH scientists and clinicians, growing from three members in 1992 to more than 110 members in 2021. Unlike traditional mentoring, in which senior colleagues mentor junior colleagues in similar positions, peer mentorship refers to formal or informal mentoring among individuals who may be professional equals and/or have different types of jobs (Holbeche, 1996). Peer mentorship can be a valuable tool for underrepresented communities (Cree-Green et al., 2020; Williams et al., 2020) and individuals with disabilities (Hibbard et al., 2002; Thompson et al., 2020; Veith et al., 2006, for a review see: Hayes and Balcazar, 2008). Peer mentorship in our group is informal, occurring at group gatherings at professional society meetings (HI-ARO members comprised ~1% of total ARO meeting attendees in 2020, or 18 out of 1,798 attendees) and throughout the year *via* small personal meetings, email, Facebook (@deafearscience), Twitter (@earscience) and our website (www.deafearscientists.org). Most of the mentorship and interactions occur *via* email, which is ideal for a global group of individuals who often find written communication to be preferable to speaking and listening in a large group.

HI-ARO includes researchers at all career stages and STEMM disciplines, from trainees to senior scientists, medical students to clinicians, as well as audiologists and other leaders in healthcare and industry. HI-ARO members are highly diverse, spanning race, gender, nationality, socioeconomic status, religion, and disability (see **Figure 2** for a map of current members' locations worldwide). Members have a wide range of unilateral and/or bilateral hearing loss ranging from mild to profound with various etiologies. They use different communication modalities including oral, Cued Speech, and sign language. They may or may not use hearing devices and other augmentative technology. The rich diversity of HI-ARO has been instrumental in cultivating invaluable networking opportunities for D/HH trainees that provide support and guidance from peers and senior members, which is critical to personal and professional success. The diversity within the group has required the members to develop strategies that work equally well for all members, regardless of their mode of disability. For example, despite the large range of communication modalities, captioning was selected as the default method of access that is always provided at conferences. If individuals need other accommodations, such as a cued language transliterator, oral transliterator, or sign language interpreter, these can be requested separately.

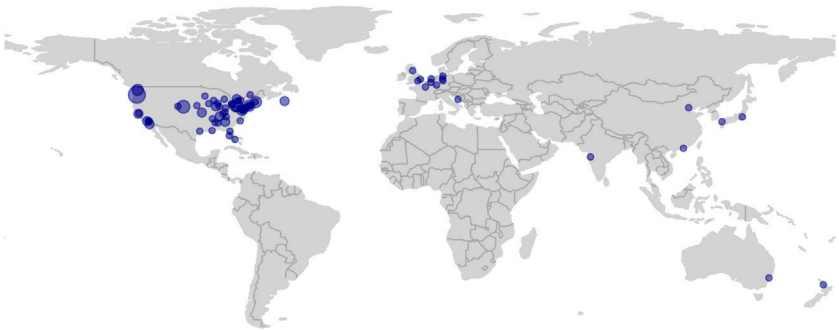

FIGURE 2 | HI-ARO is a diverse group with deaf and hard-of-hearing (D/HH) members from all around the globe. Each dot represents a city that has at least one member of HI-ARO. The dot size is scaled according to the number of members at that location.

Proactively Providing Equal Access

For scientists, engineers, and other researchers, attending national conferences is important for career advancement. It is at conferences that researchers learn about the work of others, present their own preliminary findings to the scientific community, and network for access to opportunities. However, effective communication can be challenging for attendees due to noisy conference halls, reverberant lecture halls, and suboptimal or inconsistent use of microphones (Atcherson and Yoder, 2002). For D/HH individuals in particular, these challenges can limit the benefits of attending conferences. Frequently, the D/HH attendee needs to personally contact, advocate for, or even explain their disability to conference organizers as they seek accommodations. Often the attendee needs to decide, well in advance of the meeting, what their exact schedule will be so accommodations can be arranged. Sometimes they must find strategies to facilitate communication on their own by carefully choosing listening locations, or using smart phone apps. This creates additional work and stress for D/HH individuals. Beginning ~20 years ago, ARO shifted from a *retroactive* approach (i.e., provided on request) to a *proactive* one where all podium sessions are automatically captioned regardless of whether accommodations were requested. This has not only benefited D/HH attendees but also attendees without hearing loss, especially for non-native English attendees and those who are fatigued after several hours of listening to podium presentations.

In recent years, ARO leaders created an accessibility committee made up of D/HH trainees and faculty to further improve accommodations. This has led to expanding captioning to small group meetings and workshops. Strategies for captioning poster sessions with automatic speech recognition apps and incorporating accommodations that are inclusive of other disabilities, such as color blindness, are being pursued. The widespread prevalence of captioning at ARO has provided D/HH attendees the ability to decide at the last minute what presentations they would like to see without having to worry about whether they would be able to follow the discussion. ARO is currently working on addressing acoustic issues in noisy poster halls by reducing the number of posters in a single room and spacing the posters farther out.

It should be noted that some individuals may need additional accommodations (such as a cued language transliterator or sign language interpreter). The registration form ARO uses has a specific field where registrants can describe the accommodations they need. ARO's management company will then reach out to the individual to set up the necessary arrangements.

Of particular relevance to many professional societies that host meetings within the United States is the Americans with Disabilities Act (ADA, 1990). The ADA prohibits discrimination against people with disabilities and requires that businesses open to the public, including nonprofit organizations, ensure that people with disabilities have equal access to all that they offer. The ADA typically applies to professional society meetings as they are open to the public (i.e., non-members can attend if they pay a registration fee) and are often partially funded by federal grants. Indeed, the National Institutes of Health (NIH) R13 and U13 funding mechanisms require that the proposal describe strategies for "involving the appropriate representation of women, minorities, and persons with disabilities in the planning and implementation of, and participation in, the proposed conference."

While the ADA requires equal access for these meetings, there is a difference between the professional society complying with the letter of the law, which places tremendous burden on the disabled individual to advocate for themselves and seek services and being proactive about reaching out to disabled attendees and securing accommodations for them. By being proactive about accommodations, professional societies can nurture and support diversity within their communities while avoiding potential conflicts between disabled individuals and conference management.

The optimal approach may vary from organization to organization. For example, ARO is aware that they have approximately 20 D/HH members from our group attending the annual meeting, along with an unknown number of attendees who may not wish to disclose their hearing difficulties. Thus, the proactive approach for ARO is to automatically arrange for captioning of podium talks, ensure assistive listening devices

are available and set up the conference facilities with the goal of improving acoustics. During the registration process, ARO captures information about additional access services that may be required. For other organizations who may feel they do not have a critical mass of D/HH attendees, they can still be proactive by including questions in the registration form to identify anyone who might need special support services. Inclusive practices such as captions and designing the conference with acoustics in mind benefit some members with age-related hearing loss, auditory processing difficulties, or other listening challenges (e.g., listening in a non-native language) but who do not self-identify as D/HH. Finally, being proactive can greatly increase the likelihood of increasing diversity in the organization by encouraging future participation of marginalized individuals.

Easing Financial Burdens

Increasing access to opportunities for diverse trainees with additional avenues for financial support is essential for cultivating personal and professional career success (Stevens et al., 2021). Many scientific and professional STEMM organizations, including ARO, have travel awards for trainees to attend conferences. For over a decade, the ARO Diversity Committee has used hearing loss status, and other disabilities, as an additional evaluation parameter for the Diversity Travel Award. This has since enabled D/HH trainees to receive financial support to attend conferences, furthering their scientific and professional growth and promoting equity for ARO trainees with disabilities.

Recruiting for Leadership Positions

The organizational committees of scientific and professional organizations provide an opportunity for trainees, faculty, and other members to take leadership roles within the organization. At ARO, D/HH trainees and faculty have been recruited to multiple committees, including Council, student-postdoc leadership committees, and those that target diversity and accessibility initiatives. For scientific organizations to practice true inclusion and equity, diverse members need to be in organizational and leadership positions. Diverse perspectives at the senior level can yield innovative approaches to drive the organization forward and encourage constructive changes that advance equitable principles. These experiences allow for D/HH individuals to gain the confidence to seek similar leadership roles at their home institutions.

Establishing a Culture of Inclusion and Equity

The five pillars described above have focused on how scientific organizations can support their diverse members. However, support should also come from other members. Here, organizations have an opportunity to provide tools for all members to learn from diverse perspectives so that they can reflect, grow, and start to advance and advocate for inclusion and equity in their professional and personal lives. ARO has hosted several events aimed at increasing awareness of diverse perspectives, addressing personal biases, and providing tools that help mitigate negative situations for marginalized attendees. These include events where notable individuals with hearing loss share their experiences, roundtable discussions for Women and Allies, networking events, and hiring outside facilitators to provide bystander training for all ARO members. From the point of view of scientific organizations, it can be difficult to assess whether progress has been made in establishing a culture of inclusion and equity. One way organizations can track progress is through anonymous surveys, where members can report whether they feel that the organization has or has not been successful in fostering inclusivity, identify areas of improvement, or voice concern if exclusionary conduct has occurred. This gives the organization an opportunity to improve in areas that are lacking, intervene if there is a problematic situation/person, and track progress of efforts over time. In addition, organizations can track the number of diverse individuals on society committees and leadership roles to ensure that representation is maintained and/or exceeded over time. It should be noted that in other fields, such as deaf education, certain conferences place great emphasis on accessibility. For example, D/HH individuals are included in the meeting planning and keynote presenters are chosen who are themselves D/HH. ARO is working to emulate lessons learned at these conferences by setting up an accessibility committee consisting of D/HH and other disabled individuals. In the past year, greater emphasis has been placed on inviting individuals with hearing loss, such as a deaf comedienne, to present at ARO-organized events.

Broader Impact

Over the last several years, an increasing number of D/HH clinicians and scientists have been presenting at auditory research conferences *via* posters and podium talks highlighting the need for expanded accessibility. Even within the field of hearing science and related clinical fields, some organizations still resist the need to accommodate a growing number of attendees with hearing loss. Nevertheless, the last decade has seen captioning at the biannual Conference for Implantable Auditory Prostheses (CIAP), the yearly American Cochlear Implant Alliance (ACIA) conference, the American Auditory Society annual conference, and the CI CRASH Midwest Mini-Conference on Cochlear Implants (hosted by University of Wisconsin-Madison). After three D/HH presenters had trouble understanding and answering questions at a CIAP meeting in the mid-2000s, one attendee declared that CIAP and related conferences should provide captioning. Since then, CIAP has received NIH funding for captioning which in 2019 benefited a record number of 13 D/HH attendees. By proactively seeking funding for captioning and providing access to all attendees, including those who are D/HH, these organizations stand out as truly being inclusive.

Our experience illustrates the proclamation from the Disability Rights Movement, "Nothing about us without us." D/HH scientists and clinicians should strive to be essential stakeholders in organizations that focus on hearing research and audiology so that the perspectives and experiences of D/HH individuals cannot be ignored. Moreover, equitable

access in educational and workplace settings, and at conferences, will help establish productive research trajectories and increased diversity in these settings.

For nearly 30 years, HI-ARO has worked with our professional organizations, especially ARO, to implement successful and practical strategies to increase inclusion of its D/HH members. With the guidance of our peer-network group, ARO leadership has continuously improved accommodations and provided essential support for academic, research, and career development success for D/HH members. ARO's support for equity and diversity has served and may continue to serve as a model for other conferences and professional organizations.

FUTURE DIRECTIONS

This article has described a highly successful model for promoting representation of D/HH individuals in hearing research. We have found that D/HH individuals have used their early career in hearing research, combined with mentorship from our group, as a stepping stone to other fields of study and medical specialties. This same support needs to be extended to inclusion of other disabilities, such as visual impairment, in their chosen field, and to the inclusion of D/HH individuals in STEMM fields beyond hearing research. Funding opportunities from the National Science Foundation (NSF 21-049, NSF 21-110) and the National Institutes of Health (R13, U13, R25) gives professional societies financial support to implement the five pillars, such as with conference costs (e.g., captioning) and mentoring activities.

The fact that the strong D/HH network arose in the auditory field is not surprising. After all, auditory researchers and clinicians understand communication challenges and many of us have been fortunate to have been mentored by normal hearing individuals who advocated for access within ARO. However, many other scientific societies have unfortunately not yet followed the lead of ARO. To fully realize equal participation of D/HH individuals in STEMM will require administrative champions in the leadership of other societies given the cost of assistive technology. The hearing research field is relatively small, and STEMM will benefit when D/HH individuals have full access to career opportunities in the field of their choice-not limited by the accessibility of the field or others' perceptions of what would be a "natural" choice based on their disability. Thus, the scientific community needs to come to this realization and do more for D/HH individuals across disciplines.

Professional organizations, including those that are not STEMM-focused, can include individuals with disabilities by inviting them to provide input on policies such as disability accommodations at scientific meetings. The COVID-19 pandemic provided an opportunity to reshape accommodations for those with disability when in-person conferences were shifted to virtual. For a virtual poster, a presentation is often recorded, without background noise, and can easily be captioned. Digital platforms can facilitate asynchronous text-based research interactions. This mode can be easier for many D/HH individuals and other individuals with disabilities than in-person sessions and conversations in noisy conference halls. Hybrid conferences adopting universal design approaches combined with remote manual correction and formatting of automatic captioning might proactively reduce isolation while still affording these benefits.

Another opportunity for professional organizations to foster diversity is to create mentoring programs for diverse middle school and high school students, including those with disabilities. Many students from historically excluded groups have the potential to succeed in STEMM fields but do not always receive the guidance and support needed to pursue those paths. Having a mentor who has faced similar challenges can bring confidence in learning and self-advocating and provide encouragement and inspiration. Existing models such as AG Bell's *Leadership Opportunities for Teens* (*LOFT*), Oregon Health Science University's *On Track OHSU!* and others (Pluth et al., 2015) provide a framework for adopting similar programs for STEMM outreach.

Our peer-mentorship network of D/HH engineers, scientists, and clinicians is foundational to our success in STEMM. Trainees have successfully transitioned to being leaders in academia, healthcare, and industry, often receiving significant research funding. Through this network we discuss the challenges we face and strategies to overcome difficulties. We also form a cohesive group to advocate for changes in our fields and at professional conferences to address the underrepresentation of individuals with hearing loss in STEMM. We believe that the adoption of this peer-mentorship network model by other underrepresented minority groups, and collaboration among and between peer-mentorship networks and professional societies, will drive changes that will promote diversity and equity in STEMM and other fields.

AUTHOR CONTRIBUTIONS

JJH, KA, and BB wrote sections of the manuscript and share first authorship. KA and BB generated the figures. All other authors contributed to the conceptualization of the paper, edited and modified the manuscript, and/or implemented the methods and policies described. In addition to those roles, JTR and PS provided guidance, leadership, and financial support and share final (senior) authorship. All authors contributed to article revision and read and approved the final manuscript.

FUNDING

JTR was partially supported by R25 NS107167 from the National Institute of Neurological Disorders and Stroke at NIH. PS was partially supported by P20 GM129762 from the National Institute of General Medical Sciences at NIH.

ACKNOWLEDGMENTS

We thank Dr. Monita Chatterjee, Dr. Amanda Lauer, and the ARO council for their helpful comments on the manuscript.

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Conflict of Interest: Author J-TF was employed by the company Bioglobe GmbH.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Education

PERSPECTIVE
published: 18 October 2021
doi: 10.3389/feduc.2021.755758

Enhancing Diversity in STEMM

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Professional and scientific societies can foster inclusive environments that can enhance the diversity of their respective fields and disciplines, but some associations are doing a better job than others. This paper reviewed more than a dozen professional associations and their efforts to support diversity as reported online in an effort to identify successful examples. It finds that resources generally fall into two categories: 1) Websites highlighting the accomplishments of specific individuals, which raise the profile of diverse practitioners in the field. 2) Membership associations that support under-represented communities within a particular field. This article will offer a review of the resources available and some recommendations for how professional associations can better enhance their support for diversity and inclusion in their fields.

Keywords: STEM—science technology engineering mathematics, diversity and inclusion, networks, professional associations, websites analysis

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *09 August 2021*
Accepted: *27 September 2021*
Published: *18 October 2021*

Citation:
Haddad MA, Jenkins T, Solivan B and Williams A (2021) Enhancing Diversity in STEMM. Front. Educ. 6:755758. doi: 10.3389/feduc.2021.755758

INTRODUCTION

STEMM (Science, Technology, Engineering, Mathematics, and Medicine) fields are notorious for their lack of diversity (Briggs, 2017; Jones et al., 2018; Botella et al., 2019), and professional associations are increasingly recognizing their responsibility to rectify this weakness in their fields. In the wake of the 2020 Black Lives Matter protests, every professional association we reviewed made some kind of statement related to supporting the movement, endorsing diversity, and/or taking responsibility for perpetuating racism in their fields.[1] A year later, the authors reviewed what they report they are doing. How are STEMM professional associations supporting diversity in their fields?

The authors performed a comprehensive review of more than twenty professional association websites (**Appendix** for full list) across a range of STEMM fields. We found that, with a few exceptions, most of the diversity-promoting resources in the STEMM professions were being offered by identity-based associations that focused on particular underrepresented communities within STEMM. In our review, we were surprised to discover that it was harder to find these resources than we had expected, and there was no single place where all relevant resources were gathered. To address this difficulty, we created two such resources: Diverse Faculty Listings and Scholar Networks).

After a brief overview of what we found in our review of the professional associations' online resources, we will discuss the two types of resources that we found directed towards STEMM professionals: those facilitating finding underrepresented scholars in specific fields and those supporting networking among professionals with a particular identity. For each type of resource, we will offer a few examples intended to highlight the range of resources and making note of groups that are supporting diversity in their respective fields.

[1]To give just four examples: AAAS CEO statement in support of #ShutDownSTEM, National Academies of Science statements, APS letter condemning racism, Royal Society of Chemistry statement.

OVERVIEW OF SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS, AND MEDICINE PROFESSIONAL ASSOCIATIONS' DIVERSITY EFFORTS

The first step in enhancing diversity is to demonstrate that people from all backgrounds can enter the field. It is very difficult to enter a field if you cannot imagine yourself in that field, and it is difficult to imagine yourself in that field if you have never seen anyone who looks like you practicing that profession. There is now considerable research documenting the importance of offering diverse role models, so students, faculty, and professionals can see people who look like themselves being successful in the field (Drury et al., 2011; Yonas et al., 2020; Steinke et al., 2021).

Not surprisingly, there is a wide range of ideas about what constitutes diversity. In our search, we limited ourselves to looking for 1) visible images of people who looked different from one another, 2) highlighted accomplishments of people who are generally underrepresented in STEMM fields (i.e., black, Latinx, LGBTQ+, women, etc.,), 3) evidence of gender and racial diversity in leadership, 4) programs that improved access, visibility, and provided career-enhancing opportunities for professionals from underrepresented identities. We recognize that these are not all-encompassing search criteria.

Four mainline associations stood out as positive examples of STEMM professional associations that appeared to have active and comprehensive efforts to enhance diversity in their fields. All four organizations had diverse images of professionals on their landing pages, and all listed extensive diversity initiatives. Their initiatives featured some combination of research contributions and profiles of professionals from diverse backgrounds, teaching resources designed to help with recruitment, explicit discussion of benchmarks related to progress on equity and inclusion initiatives, and other similar diversity-enhancing initiatives: American Association for the Advancement of Science, American Geophysical Union, American Society for Biochemistry and Molecular Biology, and the American Society for Cell Biology.

Finally, we examined the Board of Directors (or Board of Trustees) for each of the professional associations that we surveyed. Most associations had pictures of their current Board members listed on their websites, so it was possible to showcase the diversity (or lack thereof) among their leadership. Three professional associations we reviewed had multiple women and people of color among their top leadership: American Association for the Advancement of Science, American Chemical Society, and the American Medical Association. Two associations stood out because they had both diverse boards and they also had presidents who were people of color: American Society of Mechanical Engineers and the American Psychological Association.

In sum, some STEMM professional associations are making strong efforts to promote diversity in their fields. However, these efforts cannot reach everyone, and they are maldistributed across STEMM fields. It is not surprising, therefore, that groups of scholars and professionals from non-traditional backgrounds have formed identity-based organizations to support one another in their respective fields. It is these organizations, which are also professional associations, that are filling in the gaps left by the broader discipline-based professional associations. The resources supporting diverse professionals presented by these organizations generally fell into two categories: showcasing the talent of diverse professionals and connecting professionals from particular groups to one another in mutual-support networks.

SHOWCASING DIVERSE SCHOLARS

With the growing recognition of the importance of offering diverse role models in STEMM fields, several projects to highlight diversity in STEMM have sprung up outside professional associations. Diversify STEM Conferences offers a searchable of diverse speakers at STEM conferences as well as a mechanism for speakers to join their list and a pilot initiative for conference tracking. I Am A Scientist offers profiles of a diverse set of real-world scientists and educational materials to inspire students. The award-winning film Picture a Scientist, chronicles the journey of a new generation of women scientists and how they are working to make science more equitable and inclusive. #Ilooklikeanengineer offers a repository of selfies posted by diverse engineers, showcasing the large variety of professionals in the field.

Three identity-based professional organizations were among the best ones that we found for showcasing the talent of their members. Their websites enabled visitors to find speakers to give talks, collaborators for projects, or other professional networking purposes. The photos, bios, social media handles, and professional website links were all publicly available, making it easy for members and non-members alike to see and connect with STEMM scholars in specific fields from specific under-represented groups.

The Society for Advancing Chicanos/Hispanics & Native Americans in Science (SACNAS) is one of the oldest and most extensive groups that we found supporting underrepresented groups in STEMM. With more than 8,000 members in 118 national chapters, the organization has been active for almost 50 years. Its biography project includes numerous profiles of active professionals and graduate students and is searchable by discipline and ethnicity. In addition to publicizing the accomplishments of its members, the organization also offered a diverse set of professional support opportunities including annual conferences, webinars, leadership programs, and awards. It is also active in policy advocacy.

For reasons that were unclear to the authors, neuroscience as a field appears to be doing the best of all the STEMM disciplines at showcasing the contributions of diverse practitioners and facilitating access to those professionals. Women in Neuroscience has a keyword-searchable database of almost 2,000 professionals from around the world. Adding yourself to the database is free and easy. Black In Neuro also has a keyword searchable member directory that is full of talented (mostly young) professionals. In addition to the searchable member directory, the organization hosts an annual conference, networking socials, and themed workshops (e.g., salary negotiation, mentoring).

CONNECTING DIVERSE SCHOLARS

Most of the identity-based professional associations that we found were less focused on showcasing talent and were more

concerned with fostering professional success for their members. These groups generally offer services and support for members ranging from annual conferences and regular newsletters to legal and mentoring support. There are many, many of these groups across all of the STEMM fields, supporting different configurations of identity—professional intersections. We will highlight just a few of them here to provide an idea of the range of organizations available. We have gathered all of the diversity-supporting professional organizations that we could find in this listing of scholar networks.[2] Another good resource of organizations supporting underrepresented minorities in STEM is this list, maintained by Diversify STEM Conferences.

American Association of University Women (AAUW) is the oldest organization that we found supporting diversity in STEMM (and other) professions. Founded in 1881, AAUW has been active in supporting women's career advancement inside and outside of academia and has been particularly active in promoting national legislative agendas to support professional women. Its Strategic Plan 2.0 emphasizes equity and antiracism efforts and a focus on STEM. The organization is active in supporting women in STEM through its research, advocacy, and scholarships. Other well-established women-supporting organizations focusing on particular professions (e.g., Society of Women Engineers, American Women in Science, and Association of Women in Mathematics). These organizations all offer a wide range of support for members including professional networking, career mentorship, scholarships, etc.

Several well-established organizations supporting blacks in STEMM fields trace their histories to the 1970s (e.g., National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, Organization of Black Aerospace Professionals, National Society of Black Engineers, and National Society of Black Physicists). All of these organizations offer a sophisticated and extensive range of services from professional networking to leadership development to public policy advocacy and scholarships for promising students.

Similar well-established organizations exist to support other minority communities. SACNAS and The Society for Professional Engineers (SHPE) provide extensive support for Hispanic and Latinx professionals in STEM. The American Indian Science and Engineering Society supports American Indians, and the Society of Asian Scientists and Engineers offers similar supports for professionals of Asian heritage.

oSTEM (Out in Science, Technology, Engineering, and Mathematics) was one of the very few organizations that we found supporting the LGBTQ + community in STEMM. With student and professional chapters in cities around the world oSTEM offers a range of support services for its members including annual and regional conferences, mentorship and leadership programs, awards, and online links to other affinity groups and crisis-management resources.

All of the above organizations take organizational forms that mirror the well-established professional associations, with membership dues, boards of directors, annual meetings, theme-based committees, action plans, etc. More recently, several newer organizations have emerged with more fluid membership forms. These tend to have much more sophisticated websites, emphasize social network platforms as a way of connecting, and are more likely to be intersectional in their identity. Examples of these kinds of groups include Latinas in STEM, Blacks in Technology, and Out to Innovate.

Additionally, Twitter has become an increasingly common way for underrepresented scholars to organize among themselves. Many of these efforts have grown from Twitter-based conversations to full-fledged identity groups that hold conferences and offer a range of other professional opportunities for members. We did not perform a review of the Twitter space for this article, focusing instead on mainline professional associations, but we would like to offer a few examples here to illustrate how quickly these types of organizations are growing: Black Botanist Week, Black in Microbiology, Black in Astro, and Black in SciComm.

In sum, most of the pro-diversity professional support in STEMM fields that we found was located not in the mainline professional associations but rather in affinity-based groups that have been forming organizations that have provided mutual support, professional development, and advocacy for decades. Furthermore, new organizations are forming regularly to find innovative ways to support increased and increasing diversity in STEMM.

CONCLUSION AND RECOMMENDATIONS

Our review of STEMM professional associations' resources related to diversity has revealed that while all of them recognize their legacy of racism that has created the significant under-representation of women and people of color in their fields (as evidenced by the universal presence of statements in support of Black Lives Matter), they could be doing much more to help support diverse professionals in their fields.

Specialized affinity-based organizations have been formed to address the weaknesses present in the mainline associations. These affinity organizations are often modeled on the mainline professional associations and offer a range of traditional support for their members, such as annual conferences, networking, mentoring, and funding. A few also provide a platform to showcase the talent of their members. The newest groups take a less traditional organizational form and are more sophisticated in their use of technology, leveraging social media platforms to facilitate networking and career development.

Given our findings, we have three main recommendations for the mainline professional associations as they seek to realize the diversity goals articulated in their 2020 diversity statements.

1) Develop robust relationships with affinity groups already associated with your discipline. Of all the associations we reviewed, only the American Institute of Biological Sciences contained a link to a related affinity group (SACNAS) on its landing page (as a "featured member").[3] Many of these

[2]The authors would be delighted to add more resources to this website. Please email ofcd@wesleyan.edu if you know of an organization that should be added.

[3]The American Chemical Society (ACS) and the National Association for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) have had a long standing partnership, but it is not highlighted on ACS's web page.

affinity-based groups have decades of experience related to recruiting, retaining, and promoting professionals from under-represented backgrounds. The mainline organizations should take advantage of their experience and expertise and form mutually beneficial partnerships:
- Co-sponsor events and conferences
- Have designated slots on Boards of Trustees for affinity-group leadership, to ensure that their perspectives and experience are included in decision making
- Co-promote recruitment and teaching resources
- The mainline associations can use their greater financial resources to support activities of the affinity groups
- The affinity groups can use their greater access to students and professionals from under-represented groups to help the mainline associations recruit new members and access talented leadership.

2) Do more to showcase diverse members. Professional associations are all seeking to disrupt the stereotype that their fields are dominated by white men. However, if they have no pictures of any people on their websites and the few pictures that they do have do not show women or people of color, they are perpetuating that stereotype. Furthermore, to reduce macro and microaggressions directed toward professionals from non-traditional backgrounds, professional associations need to publicize and normalize the fact that people of all backgrounds are making important contributions to STEMM. Because contributions of underrepresented groups to STEMM fields have been ignored and discounted for centuries, professional associations must make extra efforts to publicize their talent and discoveries now.
3) Diversify association leadership and staff. Only a very few STEMM professional associations had visibly diverse boards of directors and even fewer had presidents who are women or people of color. As the previous sections make clear, numerous exceptionally talented professionals from diverse backgrounds exist in every single STEMM field. If professional associations are going to thrive in the 21st Century, they must diversify their leadership and incorporate the perspectives of a broader range of talent into their decision-making. As indicated in the first recommendation, one easy way to do this would be to create partnerships with affinity groups that are active in the field and have those groups send a representative to serve on the mainline association's Board of Trustees.

In sum, 1 year after their 2020 statements in support of diversity amidst the Black Lives Movement, many STEMM professional associations are not living up to their potential. There are thousands of women and people of color pursuing meaningful careers and making important contributions to all STEMM fields, but many are not yet well supported by their mainline professional associations. Some of the smaller, identity-based professional groups are filling in the gaps left by the mainline groups, but their efforts remain marginal to the activities of the field. The STEMM professional associations are very well positioned to use their institutional resources—financial, professional, and technical—to transform their professions and the broader society, making it more inclusive, dynamic, creative, and effective. Fundamental change will take a long time, but the small low-cost changes that we recommend above will go a very long way to promoting inclusion in STEMM.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this article and take full responsibility for its contents. MAH was responsible for most of the writing up of the analysis. TJ was primarily responsible for website gathering and analysis. BS was primarily responsible for analysis, technical expertise, and organization. AW was responsible for most of the literature review and policy recommendations. All authors were responsible for final editing.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX:

List of Mainline Professional Associations We Surveyed.
American Association for the Advancement of Science (AAAS)
American Astronomical Society
American Chemical Society (ACS)
American Geophysical Union
American Geosciences Institute (AGI)
American Institute of Biological Sciences (AIBS)
American Medical Association
American Physical Society (APS)
American Psychological Association
American Society for Cell Biology (ASCB)
American Society for Civil Engineers (ASCE)
American Society for Mechanical Engineers (ASME)
American Society for Microbiology (ASM)
American Statistical Association
Animal Behavior Society (ABS)
Association for Computing Machinery (ACM)
Association of Environmental and Engineering Geologists (AEG)
Biomedical Engineer Society
Federation of American Societies for Experimental Biology (FASEB)
IEEE Computer Society
Mathematical Association of America (MAA)
Society for Neuroscience

frontiers in Sociology

PERSPECTIVE
published: 27 October 2021
doi: 10.3389/fsoc.2021.755072

From Then to now: Diversity, Equity, and Inclusion in the Association of Southeastern Biologists

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The Association of Southeastern Biologists was founded in 1937 with the goal of increasing the contact and collaboration between scientists in the southeastern United States (US). With the exception of two years during World War II and one year during the COVID-19 pandemic, the Association has met annually to promote research and education in the biological sciences by providing a student-friendly networking environment. In recent years, the Association has placed an increased focus on diversity, equity, and inclusion among elected and appointed leaders, among participants in the annual meeting, and in the development of funding and other opportunities for students. This work prompted us to review the history of our Association, including periods of racial segregation and inequity, and focus on our current efforts to promote access and inclusion by students and scientists from myriad underrepresented groups. In so doing, the past provides us with the opportunity to cast a vision for the future of the Association. In this paper, we seek to share the journey of the Association of Southeastern Biologists in this regard so that we may be transparent, exposing the missteps and amplifying the successes of our organization. We envision this work as a first step toward creating a more open and inclusive scientific community for the future.

Keywords: scientific society, diversity, equity, inclusion, racism, segregation

OPEN ACCESS

Edited by:
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Reviewed by:
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Specialty section:
This article was submitted to Gender, Sex and Sexualities, a section of the journal Frontiers in Sociology

Received: *07 August 2021*
Accepted: *04 October 2021*
Published: *27 October 2021*

Citation:
Hays KA, Havran JC, Heard MJ, Morris AB and Ovueraye L (2021) From Then to now: Diversity, Equity, and Inclusion in the Association of Southeastern Biologists. Front. Sociol. 6:755072. doi: 10.3389/fsoc.2021.755072

INTRODUCTION

Professional societies play a critical role in disseminating scientific discoveries and forging collaboration among scientists. These organizations typically fall into two categories: 1) national or international organizations with large meetings that move across a broad geographical area or 2) smaller statewide and regional meetings and organizations. To our knowledge, since its founding in 1937, the Association of Southeastern Biologists (ASB) has been the only scientific association that spans the entire Southeastern US and is one of the largest regional, multi-disciplinary biological associations in the country. The ASB operates with the goal of increasing contact and collaboration between scientists in the region, representing biologists from many sub-disciplines, including student, faculty, and non-academic professionals. While the ASB prides itself on being a working association with an active and engaged membership, the past several years have served as a period of reflection on our growth and values, specifically as they relate to diversity, equity, and

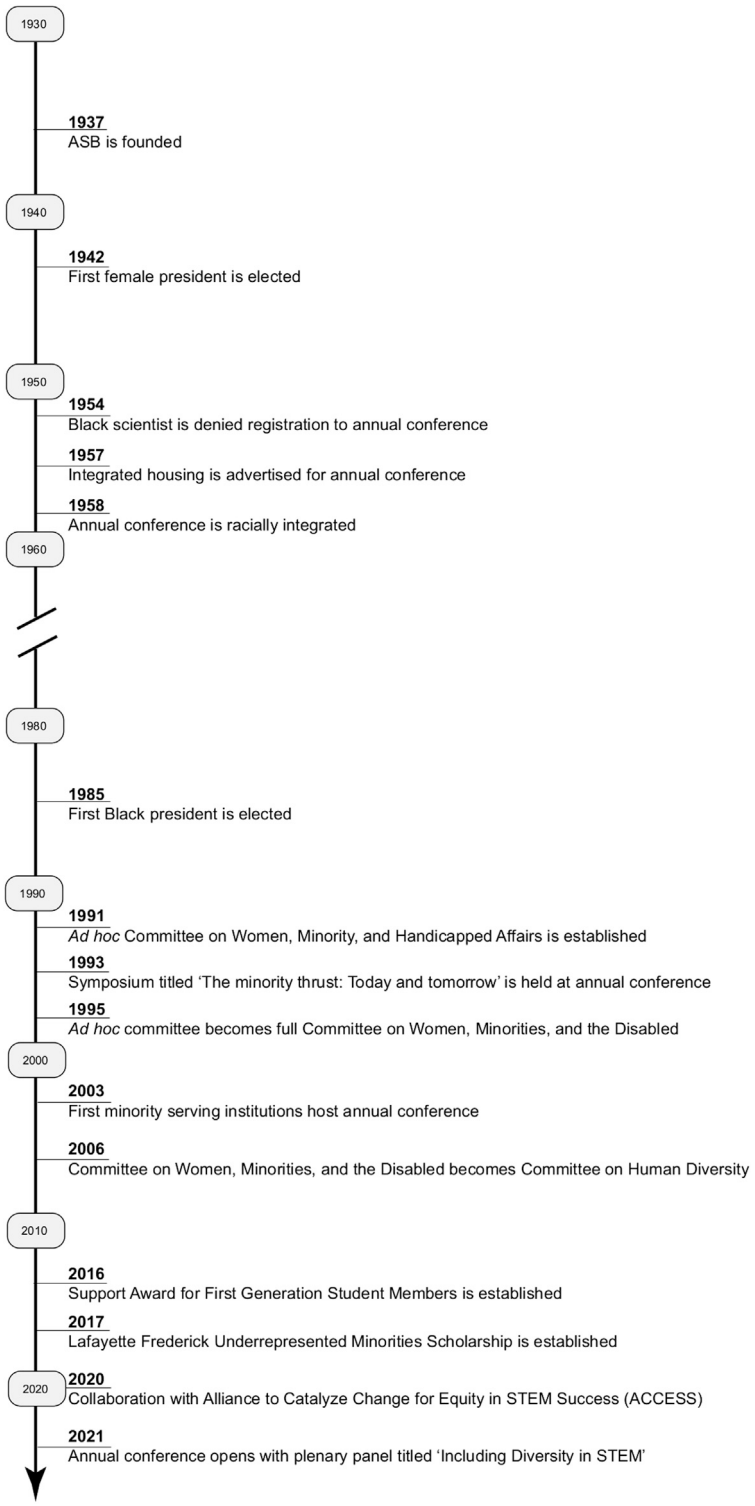

FIGURE 1 | A reconstructed history of the Association of Southeastern Biologists (ASB) highlighting events covered in this perspective.

inclusion. Upon reflection, we feel that the ASB, as a broad-reaching organization, is uniquely positioned to drive change not only within our own association but across academic institutions represented within the ASB, and our practice may serve as a model to other scientific societies.

As we in the ASB leadership reflect on our history (**Figure 1**), we encounter members who championed change and diversity to drive the Association forward during periods of conflict and challenge. We also recognize that increased diversity in membership does not by definition mean equity and inclusion, which are key goals of our association. In our reflection and in this paper, we seek to share the journey of the ASB by examining: 1) our early history as an organization in the segregated South and the role of members in keeping us afloat while driving change, 2) our contemporary history in which we are actively working to build diversity, equity, and inclusion into all aspects of our association, and 3) our recommendations for current and future leadership of the ASB to ensure that our association is an open forum for all biologists in the Southeastern US. For the purposes of this narrative, the terms minorities or underrepresented groups refer to those individuals who were historically excluded from participating in the scientific community as a consequence of their gender, race, ethnicity, sexual identity or ability; however, the historical records of the ASB often do not explicitly define these terms.

EARLY HISTORY

To better foster communication between biologists in the Southeastern US, the ASB was officially established as a scientific association at an invitational meeting at the University of Georgia in 1937 (Boyd, 1957). The inaugural meeting consisted of oral presentations on all aspects of biology, primarily from scientists in states that shared borders with Georgia (Boyd, 1957). The Association continued to meet annually in the spring, hosted by institutions in cities across the Southeastern US. The program evolved to include banquets, field trips, and awards to recognize outstanding research and meritorious teaching. None of the early meetings of the ASB were hosted by minority-serving institutions and no demographic records of meeting participants were kept in the early years of meeting.

Histories of the ASB (Boyd, 1957; Young, 1963; Flory, 1987) acknowledge the contribution of women to various aspects of association governance, with one taking on an outstanding role during the early years of the ASB. From 1943 to 1945, annual meetings of the ASB were put on hold during World War II (Young, 1963). At the last annual meeting before the war, Dr. Mary Stuart MacDougall of Agnes Scott College was elected President of the ASB. Dr. MacDougall was the sixth president of the ASB and the first woman to hold this position. With the assistance of the elected Secretary-Treasurer, Dr. Martin D. Young, Dr. MacDougall maintained the ASB while meetings were on hiatus (Boyd, 1957). She accomplished this through the reduction of annual dues and sending out newsletters to the membership, updating them on ASB affairs and the activities of members in uniform (Young, 1963). Dr. MacDougall's efforts to maintain the Association at a time when it very well could have dissolved have been applauded in several histories of the ASB (Boyd 1957; Young 1963). In his summary of the 25-years history of the ASB, Young (1963) expounded on the historical role of women in the association by mentioning how "women have served on various important committees and in general have had a prominent voice in the operation of the society". He mentions that this is "a shining example of integration".

In the 1950s, adherence to Jim Crow Laws would, unfortunately, limit participation of Black scientists in ASB functions. In 1954, Dr. James H.M. Henderson, a plant physiologist from Tuskegee University, was denied registration to the annual meeting held in Baton Rouge, Louisiana (Frederick, 2012). Dr. Henderson was Black, and the onsite representatives would not allow him to attend the banquet (Frederick, 2012). Dr. Henderson never participated in a subsequent ASB meeting, but continued his illustrious and internationally-recognized career (Henderson, 2001). Beginning in 1954, the annual meeting banquet would temporarily be put on hold based on the rationale that it was difficult to schedule the banquet around other conference functions (Boyd, 1957). While there is some lack of clarity related to the chronology of events in the 1950s, association records and oral accounts clearly indicate that, during this decade, the ASB followed Jim Crow laws that prevented communal eating. These choices prevented Black members from attending the banquet, which is now a pivotal component of the annual meeting. Beginning in 1957, notices began to appear in the ASB Bulletin about the location of integrated housing facilities for annual meetings (About our Tallahassee Meeting, 1957).

Racial integration of the ASB would not occur until the late 1950s. In 1958, Dr. Lafayette Frederick, a Black plant biologist then at Southern University in Baton Rouge, Louisiana, was recommended to attend the annual meeting of the ASB in Gainesville, Florida (Frederick, 2012). He took three students and two faculty members to the conference and secured housing in private homes for his female students (Frederick, 2012). He and his colleagues presented their research and attended the awards ceremony in an auditorium (Frederick, 2012). This event is recognized as the point at which the Association was racially integrated. Dr. Frederick continued to bring his students and colleagues to ASB meetings. Despite resistance that they faced during at least one social function, Dr. Frederick insisted that his students and colleagues continue to attend meetings of the ASB (Frederick and Williams, 2017). He persisted with his efforts and was eventually elected as ASB's first and only Black president in 1985 (Herr, 2012). Dr. Frederick would continue to be integral to the ASB's efforts to promote diversity in the organization, attending annual meetings until his death in 2018.

CONTEMPORARY HISTORY

A key turning point in the ASB's efforts in diversity, equity, and inclusion came *via* the 1990 American Institute of Biological Sciences (AIBS) Conclave of Presidents. The event, held in

Washington D.C., was attended by ASB President Frank Day. In his "A View from Here" column, Day (1990) stated "A specific societal issue that was extensively discussed at the conclave was the need to increase the involvement of minorities, women, and the disabled in our profession. Actions that ASB might consider are creation of a committee to address involvement of underrepresented groups and targeting local school kids with special programs in association with our annual meeting". While there is no indication that engagement with schools occurred, this call for a committee to address the needs of underrepresented individuals spurred the Association into several years of concerted action.

ASB members were involved in organizing and presenting at the 41st Annual Meeting of AIBS in Richmond, Virginia. Included in this meeting were a symposium, roundtable, and reception focused on minorities in biology (AIBS, 1990). In that same year, AIBS conducted a survey of 30 AIBS member and cooperating societies, 14 other life science societies, and seven organizations from other disciplines. The survey focused on the number of members who were women or minorities, the ability of societies to identify these members, and inclusion of events for women and minorities at annual meetings or in other settings. ASB was included in this survey, reporting a total membership of approximately 1,200 members. ASB was one of 65% of societies that did not identify the number of female members and 97% of societies that did not identify the number of minority members. While this survey did not indicate if ASB hosted specific activities or committees for women or minorities, no historical records of those appear to exist until 1991 (Blockstein, 1990).

In 1991, ASB President Frank Day appointed an *ad hoc* committee on Women, Minority, and Handicapped Affairs that was tasked with organizing "activities and programs which encourage and enhance the involvement of underrepresented groups in biology" (Day, 1991). The original committee was composed of Dr. LaFayette Frederick (Chair; Howard University), Dr. Margaret Gilbert (Florida Southern College), Dr. Elizabeth Blood (University of South Carolina), Dr. Beverly Collins (Memphis State University), and Dr. Geraldine Twitty (Howard University). In 1993, the committee hosted its first organized event at the 54th Annual Meeting in Virginia Beach, Virginia. The symposium, "The Minority Thrust: Today and Tomorrow", featured Dr. Clarice Gaylord, Deputy Director of the Environmental Equity Office with the U.S. Environmental Protection Agency. The committee scheduled symposia and workshops surrounding underrepresented groups in science, technology, engineering, and mathematics (STEM) fields fairly consistently through the late 2000s, at which time a shift was made to luncheons that often featured topical speakers.

Later in 1993, the ASB Place of Meeting Committee was tasked by then President Ken Marion to further the work of the Committee on Women, Minorities, and Handicapped Affairs by organizing an annual meeting at a minority-serving institution (Marion, 1993). Association records indicate that the committee transitioned from an *ad hoc* committee to a full committee in the mid-1990s, with the full committee being renamed as the Committee on Women, Minorities, and the Disabled (Committees, 1995).

In her message from the President, Dr. Pat Parr recounted the ASB's participation in the 1999 National Science Foundation President's Summit. According to Parr, the ASB and Ecological Society of America were the only two organizations of the 53 represented that had a committee focused on diversity and minority involvement. She stated, "Not only does ASB have wide representation from colleges, universities, non-academia, and disciplines, ASB has successfully demonstrated a commitment to support our students, improve education, recognize excellence, and encourage diversity" (Parr, 2000). When asked recently to reflect on the accomplishments of the committee in its first decade, Parr stated "What the committee achieved?—some positive but not enough, and not long lasting. We tried very hard to identify HBCU and community colleges in the area where ASB was meeting and send postcards and tried other ways to make personal contacts to get professors and students to attend" (P. Parr pers. comm., 2021).

In 2003, the ASB annual meeting was co-hosted by Howard University and Bowie State University in Washington, D.C., marking the first time that a minority-serving institution had done so. At that same meeting, the ASB Committee on Women, Minorities, and the Disabled hosted its first workshop focused on disability access titled "Accessibility of Online Teaching Materials". To our knowledge, no further workshops or symposia have focused on disability access.

In 2006, the Committee on Women, Minorities, and the Disabled was renamed the Human Diversity Committee to better encompass the breadth of diversity represented by the ASB membership. One major focus of the Human Diversity committee was to increase participation of first-generation and underrepresented students in the annual meeting. In 2016, the committee began awarding the Support Awards for First-Generation Student Members of ASB, which provides support for winners to attend the annual meeting. In 2017, the committee worked with the ASB Executive Committee, Dr. Lafayette Frederick, Dr. Luther Williams, and the Frederick family to create the Lafayette Frederick Underrepresented Minorities Scholarship, which provides one student each year with meeting registration, attendance costs, membership, and travel expenses. Since the inception of these awards, the first-generation and Lafayette Frederick Underrepresented Minorities Scholarships have supported thirty and three students, respectively. Upon analysis, the ASB leadership realized that while these awards that help underrepresented students attend the annual meeting are a good starting point on our journey to creating a more diverse scientific society, more work can be done to advertise these awards to both students and mentors.

Building and maintaining a scientific society that is truly diverse, equitable, and inclusive requires continual work and strategic planning to be successful (Olzmann, 2020; Tulloch, 2020). Therefore, over the past few years we have begun directed efforts to prioritize creating a more open and inclusive environment at our annual meetings. In 2020, to help facilitate this change and to evaluate our current practices, the ASB Executive Committee entered into a collaboration with the Alliance to Catalyze Change for Equity in STEM Success (ACCESS) via co-principal investigator and member of the ASB

Executive Committee, Dr. Veronica Segarra (High Point University). The goal of this effort was to determine how the ASB and other organizations select conference speakers that are representative of all members. Through this collaboration, ACCESS provided the ASB and other organizations with a list of best practices for how to foster inclusivity through plenary sessions at the annual meetings (Segarra et al., 2020).

Building on this work with ACCESS and their recommended best practices, the ASB Executive Committee chose to focus the plenary session of the 2021 annual meeting on diversity in STEM and how it relates to the ASB and biologists in the Southeastern US. The plenary session was titled "Including Diversity in STEM" (Association of Southeastern Biologists, 2021) and was moderated by an African American ASB Executive Committee member, Dr. Loretta Ovueraye, Vice Provost for Workforce Programs and Professional Learning at Miami Dade College. In the session, Dr. Ovueraye led a conversation with a group of ethnically and socially diverse individuals with science education and research backgrounds: Dr. Edward Moreira Bahnson from the University of North Carolina at Chapel Hill, Dr. Kelly Mack from the Association of American Colleges and Universities, Dr. Veronica Segarra from High Point University, and Dr. Selwyn Williams from Miami Dade College. Panelists discussed the meaning of diversity to them. Together, they described the particular disparities they see pertaining to diversity within biological institutions that limit our ability to recognize the range of diversity that already exists. This led to an exploration of the structures of higher education that have contributed to these systemic inequalities and the long-term consequences of ignoring diversity and inclusion in the STEM workforce. In a post-meeting survey, 45% of respondents indicated they were satisfied or very satisfied with the plenary session and no respondents indicated they were dissatisfied or very dissatisfied. One attendee commented, "ASB could make this available and become a leader in the efforts—there was so much realism and advice and perspective packed into this session. Truly, thank you for making this the opening session!".

This conversation gave us a blueprint for a more inclusive environment within the ASB to address the larger societal issue of underrepresentation of minority groups in STEM. Attendees who have impactful experiences like this can then influence policies and practices surrounding diversity, equity, and inclusion at their own institutions.

RECOMMENDATIONS MOVING FORWARD

This manuscript provides the ASB leadership a starting point for casting a vision for the future of our association. The process of developing this document has allowed us to dig deeply into our history and take stock of our strengths and weaknesses. Based on the events and experiences represented here, we have several recommendations for the ASB leadership moving forward, including: 1) complete a comprehensive strategic plan for the Association that clearly integrates diversity, equity, and inclusion throughout; 2) pursue an external assessment of the Association's diversity, equity, and inclusion activities; 3) increase engagement of members with disabilities to improve accessibility to both content and activities; 4) collaborate with HBCUs and other Minority Serving Institutions (MSIs) currently active in the ASB to strengthen and build additional partnerships; 5) engage first-generation and underrepresented students and their mentors in the application process for diversity, equity, and inclusion support awards; and 6) pursue external funding for mentorship activities.

CONCLUSION

The ASB was established in the segregated South, and it is clear that past actions of the Association caused harm to established and incipient scientists. Lasting social change must come from within, and it is guided by the actions of individuals. As we move forward, we recognize that there are still many more steps that the ASB must take in order to be truly supportive of all of its members. These efforts include working to be actively anti-racist, to provide support and mentoring opportunities for historically excluded students and faculty, to value and champion diversity within our scientific society, and to fight for equality and inclusivity in our communities. To truly achieve these steps, we acknowledge that we need to continue to be reflective, build on the expertise of scientists and individuals working to address diversity, equity, and inclusion issues within our association and more broadly, and to honor the legacy of our past heroes and champions within the ASB, including Dr. Mary Stuart MacDougall, Dr. Lafayette Frederick, and others who helped break down barriers that prevented the ASB from being a truly inclusive organization. In closing, we invite all members of the ASB and ASB's friends, partners, and affiliates throughout the Southeastern US to join us in these efforts.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

There are no grants or contracts associated with this work. Costs will be supported by the ASB.

ACKNOWLEDGMENTS

We thank Luther Williams for reviewing a portion of this document for historical accuracy.

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frontiers in Education

REVIEW
published: 03 November 2021
doi: 10.3389/feduc.2021.763908

Impact of Professional and Scientific Societies' Student Chapters on the Development of Underrepresented Undergraduate Students

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Undergraduate students from historically underrepresented groups (URG) in institutions of higher education with a focus on science, technology, engineering, and math (STEM) careers often lack the support, resources, and community necessary to succeed in their desired fields. Through mentoring, webinars, seminars, and various research presentation opportunities, national societies and "locally-based" institutional student chapters provide atmospheres in which URG undergraduates can develop the skills required for academic and professional careers in STEM. In addition, national societies and student chapters contribute to outreach activities aimed towards the public in order to foster interest in STEM, as well as to primary and secondary school students to help them develop competency in skills and areas that lead to successful STEM careers. While many of these societies have operated for decades, the onset of the COVID-19 pandemic proved to be an unexpected roadblock, creating difficulties in terms of maintaining community dynamics and overcoming limits on in-person meetings. Though the conditions were challenging, they allowed for new perspectives on problem-solving in the face of adversity. The pandemic promoted the development of creative ways by which institutions and national societies could continue to educate students virtually. In this review, we discuss the role of national societies and student chapters in providing URG students with resources and skills to succeed in STEM fields while incorporating them into a community of like-minded peers with similar experiences.

Keywords: STEM, professional societies, student chapters, underrepresented students, inclusion, diversity, academic success

OPEN ACCESS

Edited by:
Veronica A. Segarra,
High Point University, United States

Reviewed by:
Kellyann Jones-Jamtgaard,
Other, United States
Kirsten Block,
American Society for Biochemistry and Molecular Biology, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *24 August 2021*
Accepted: *15 October 2021*
Published: *03 November 2021*

Citation:
Barnes L, Grajales J, Velasquez Baez J, Hidalgo D and Padilla-Benavides T (2021) Impact of Professional and Scientific Societies' Student Chapters on the Development of Underrepresented Undergraduate Students. Front. Educ. 6:763908. doi: 10.3389/feduc.2021.763908

INTRODUCTION

A variety of historical, economic, and social factors have contributed to the underrepresentation of certain social groups in science, technology, engineering, and math (STEM) fields of study (Branchaw et al., 2020). This lack of diversity is most prevalent at the college-level of education, and in consequence, extends to the graduate school level (**Figure 1**). As a result, pursuing careers contingent on college-level degrees becomes a hurdle for aspiring minority scholars, as these environments appear less welcoming and at times unavailable to them. In recent years, professional and scientific societies have had increased involvement in efforts to promote

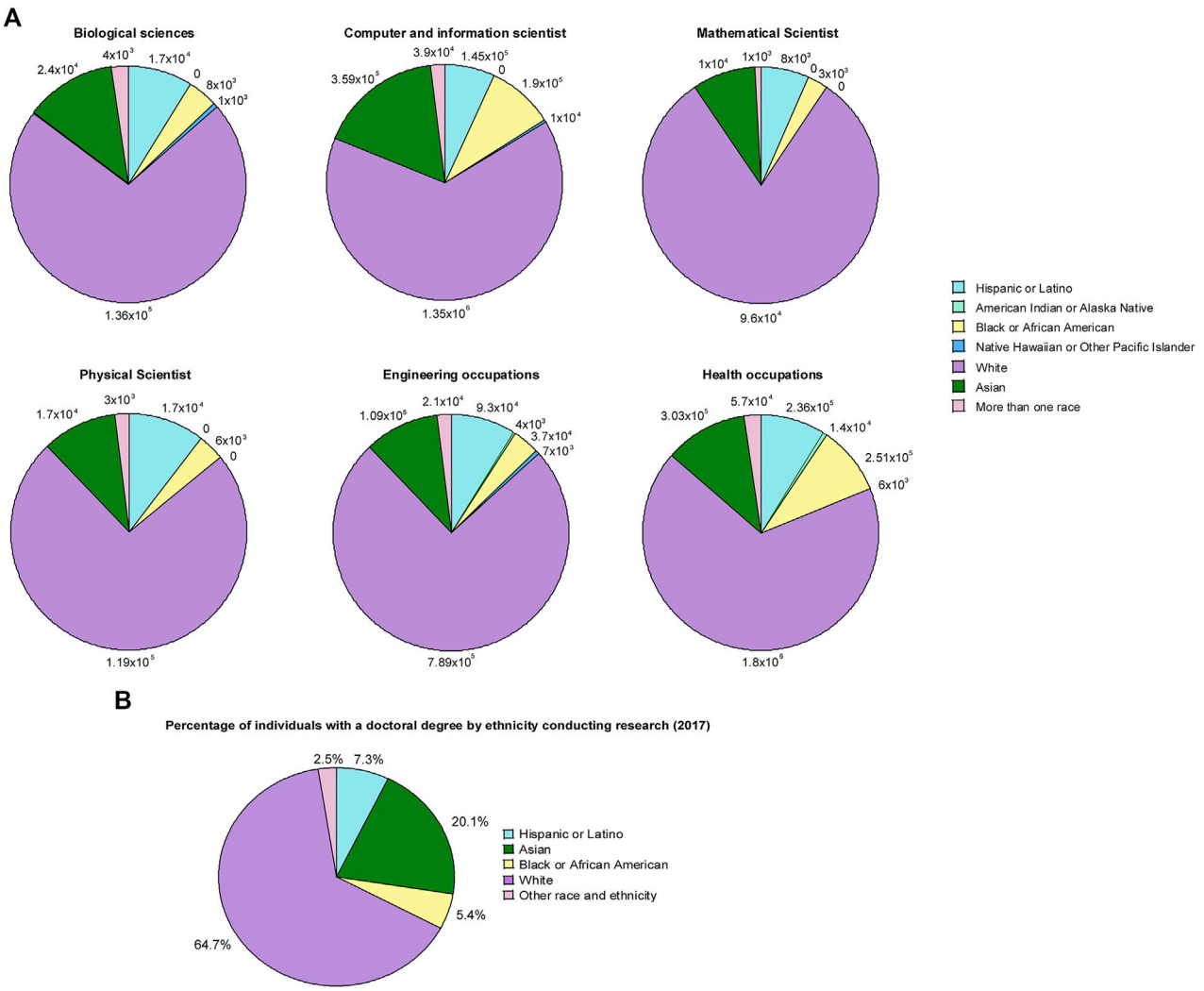

FIGURE 1 | Demographic distribution of professionals in the main STEM careers. **(A)**. Employed scientists and engineers with a bachelor's degree occupation, ethnicity, and race (adapted from https://www.nsf.gov/statistics/2020/nsf20300/#chp2 "Employed scientists and engineers, by highest degree level, occupation, ethnicity, and race: 2017"). **(B)**. Percentage of early career doctorates by ethnicity. Individuals who earned their first doctoral degree in the past 10 years and work at academic institutions and perform federally funded research and development centers (adapted from https://www.nsf.gov/statistics/srvyecd/#tabs-s).

diversity, equity and inclusion (DEI) in academia. There is an identified need to increase retention of minorities in colleges both at the student and faculty levels, as well as to ensure the completion of academic degrees (Vernon and Morris, 2017; Womack et al., 2020). Thus, a number of national organizations have committed to continuously create innovative opportunities for underrepresented groups (URG) of students (Vernon and Morris, 2017), e.g., the Society for Advancing Chicanos/Hispanics and Native Americans in Science (SACNAS), the American Indian Science and Engineering Society (AISES), the American Society for Biochemistry and Molecular Biology (ASBMB), the Annual Biomedical Research Conference for Minority Students (ABRCMS) hosted by the American Society for Microbiology (ASM), the American Society for Cell Biology (ASCB), the Biophysical Society, and the Sigma Xi Society. These major organizations have a long-standing record of supporting URG at the professional and personal levels by fostering communities that provide mentorship and support. This mission is the same throughout each student initiative, which are established by a variety of institutions all over the United States and are promoted via community outreach. There are different mechanisms by which these societies strengthen their communities (**Figure 2**), and these strategies are designed for distinct audiences, ranging from specific STEM fields to DEI efforts, such as the establishment of student chapters.

In this review, we focus on the use of URG student chapters of professional societies as tools that allow students to become active members of scientific and professional organizations while also receiving mentoring and support. Student chapters are an important component of professional societies, and they allow students to connect with the community directly. As such,

FIGURE 2 | Major scientific organizations that promote inclusion and diversity in STEM. Information on the mission, strategies, and summary of resources available to support general members and students' chapters (where applicable). Adapted from: https://www.asbmb.org/about; https://www.ascb.org/about-ascb/; https://www.sacnas.org/who-we-are/strategic-plan/; https://www.aises.org/about/our-mission; https://asm.org/About-ASM; https://www.biophysics.org/about-bps/mission-vision; https://www.sigmaxi.org/about/organization/mission.

student chapters have become part of efforts directed to make a difference within less privileged social groups. Oftentimes, these chapters reflect that large entities, such as scientific societies, realize that there is a social problem and are committed to solving such problems by connecting with local communities. However, these are not the only ways by which such organizations support students. Within these chapters, students can feel that they are part of something greater, beyond just participating in STEM activities at their schools. Events organized by professional societies and associated student chapters not only open the door to the scientific world, but also provide great networking opportunities for students to learn about and experience different professions and areas of research. Student chapters of professional and scientific organizations provide a forum in which students can expand their networks with experts in scientific fields and participate in professional and scientific development programs which ultimately may help them secure their first jobs. Student chapters also provide opportunities to develop leadership skills, as the students are in charge of proposing, planning, and executing diverse activities for their community. Such organizations allow the students to give back to the communities that fostered their growth. By organizing scientific outreach events, the students can reach out to the public as educators, ultimately enabling the students to learn how to share their knowledge with individuals outside the scientific community. These contributions to society are essential to raising awareness of common scientific and health problems, and they highlight the importance of STEM careers in hopes of promoting the next generation of professionals.

Student chapters are especially important to students from URG because they contribute to their gradual integration into the areas in which they are scarcely represented. Prior to these efforts, the absence of fellow minorities in STEM fields was often taken as a sign of an unwelcoming environment. National organizations seek to dismantle this conception, thereby encouraging and supporting minorities in their pursuit of STEM educations and careers. At an institutional level, undergraduate students regard chapters as cohorts of like-minded students with similar goals educational and community goals. Chapters are composed of aspiring scholars who seek to not only improve their current generation's opportunities in professional STEM fields but also those of future generations. In addition to this, faculty advisors serve as inspiration, guidance, and support for undergraduates as they traverse college life. Advisors and mentors provide students with examples of the professional experiences that college students may expect to have 1 day. In summation, each student chapter offers a support system to students by

TABLE 1 | Main awards offered to undergraduate students by the major scientific societies in the USA

Organization	Fellowship or award description
Society for Advancement of Chicanos/Hispanics and Native Americans in Science	•Travel scholarship $1,000 https://www.sacnas.org/what-we-do/conference/travel-scholarships/
The American Indian Science and Engineering Society	•Yearly Scholarships •Leadership Summit Registration Scholarships •AISES 3M Scholarship •AISES A.T. Anderson Scholarship •AISES Aristocrat/VGT Scholarship •AISES Burlington Northern Santa Fe (BNSF) Foundation Scholarship •AISES Chevron Scholarship •AISES Energy Scholarship, Mentorship and Workforce Development Cohort Program •AISES ExxonMobil Scholarship •AISES Intel Growing The Legacy Scholarship Program •AISES National Conference Travel Scholarships https://www.aises.org/students/scholarships •Chapter awards https://www.aises.org/students/college-chapter-awards
American Society for Biochemistry and Molecular Biology	•General resources https://www.asbmb.org/career-resources/awards-grants-fellowships •Student research award $1,000 https://www.asbmb.org/education/student-chapters/awards/undergraduate-research •Tuition scholarship $2,000 https://www.asbmb.org/diversity/undergraduate-scholarship •Trip to DC—inform policy makers on the importance of research https://www.asbmb.org/advocacy/capitol-hill-day •High/middle school student award for science fair project https://www.asbmb.org/career-resources/awards-grants-fellowships/science-fair •Outreach $500 https://www.asbmb.org/education/student-chapters/awards/outreach-grant •Outstanding outreach $500 https://www.asbmb.org/education/student-chapters/awards/outstanding-chapter
The American Society for Cell Biology	•Outreach award for $1,000 https://www.ascb.org/grants-awards/compass-outreach-grants/ •Public Engagement award $10,000–$35,000 •https://www.ascb.org/grants-awards/ascb-public-engagement-grants/
The Biophysical Society	•Travel scholarship $750 •Undergraduate Poster Award Competition and Image Contest https://www.biophysics.org/2022meeting/awards-competitions/travel-awards
Sigma XI	•Research Grant $1,000 for most science fields ($5,000 for astronomy) https://www.sigmaxi.org/programs/grants-in-aid
Additional useful resources	
RTK Environmental Group	•Scholarship $1,500 https://rtkenvironmental.com/about/scholarship/
Melissa StoneBerger Foundation	Scholarship •https://www.melissastonebergerfoundation.org/applying-for-a-scholarship.html
Connecticut Association of Latinos in Higher Education	Scholarship $1,000 •https://calahe.org/scholarship-eligibility
Hispanic American Cultural Council	Scholarship $2,000 https://hacc-chac.weebly.com/

providing a framework for and a professional community that fosters their success.

Although there exist several organizations that provide opportunities to minority students, several of which are listed above, SACNAS and AISES are the only organizations that have a clear focus on students from URG at not only an institutional level, but also at a chapter development level. While other societies such as ASBMB, the Biophysical Society, and Sigma Xi have vigorous student chapter programs, these chapters include membership from all demographics and do not have an explicit focus on supporting students from URG. Conversely, organizations such as the ASCB have developed a significant number of programs and activities to support scientists from URG at various career levels but lack student chapter programs.

Chapters organization is specified by each society. For instance, for the societies with primary focus on URG, there are 133 SACNAS chapters classified as student and professional chapters; while AISES chapters are divided into seven regions across the United States and Canada and are further classified into pre-college, college (195), and professional (19) and tribal chapters (3) levels. In general, these organizations provide support to their chapter membership to ensure successful

development. Common activities designed towards chapter development include examples on how to improve membership recruitment and retention, organize successful community outreach events, professional development activities and fundraising. Moreover, student chapters also constitute a network of other chapters, and frequently the members are eligible to chapter-exclusive opportunities developed by the national organizations.

In addition to these chapter-centered activities, the national organizations continuously adapt their conferences and websites to increase diversity and provide financial support to their membership (**Table 1**). In this regard, national societies rely on funding from a combination of national, institutional, and local sources, depending on the needs of the society. Major funding for these societies is given from organizations such as the National Institutes of Health (NIH) and the National Science Foundation (NSF), both of which award grants for the recruitment of students, planning of conferences and meetings, mentoring activities and training workshops, and the general promotion of faculty and student diversity in STEM (**Table 1**). Student chapters of SACNAS, AISES, and ASBMB can apply for funding *via* grants directly from the national society of which they are a part. However, in some cases, the student chapters may also apply to university student budget committees and student activities committees to fund the chapter, as they would for university-sponsored clubs. Chapters may also seek for external resources by organizing fundraising events, or by establishing partnerships with companies and organizations interested in sponsoring specific events, programs, and potentially awards. These contributions would enable to offer a wide variety of opportunities to their members.

URG student chapters are typically established due to an identified need for a strong network of peers and mentors to provide support for junior minority scientists both locally and nationally. Student chapters often increase their campus presence by collaborating with other student organizations to promote institutional awareness of the need for programs catered to students of URG. Students can also develop outreach programs aimed at K-12 students, allowing members to apply their knowledge while contributing to society by impacting the academic experiences of younger students. Inter-institutional collaboration among chapters also provides students with a larger support system and a broader perspective in their pursuit for professionalism and outreach opportunities. It is for these reasons that minority student chapters are important: they promote the integration and exploration of minorities in professional settings in which they are historically underrepresented.

IMPACT AND RELEVANCE OF PROFESSIONAL SOCIETY STUDENT CHAPTERS ON THE DEVELOPMENT OF UNDERGRADUATE STUDENTS

Frequently, students become active members of existing chapters or form new chapters because they have undergone challenges and identified needs from previous and current academic experiences. Opinions of undergraduate co-authors of this manuscript highlight the importance of student chapters at universities and colleges and frame the students' rationale for becoming active members of these organizations. Grajales commented that "as a first-generation student, much of the academic qualifications needed to continue my academic career were obscured. Looking back on my experience through high school, I wish I learned of the importance of standardized testing early on and had someone help me write my first resume and fill out financial aid paperwork. I believe these are tasks that minority students often realize late towards the end of their high school years as a result of their parents' lack of experience through the college-application process. Minority students need a mentor who has gone through the application process of college and beyond, teaching them the skills and actions necessary for ongoing growth in an academic and professional setting." Velasquez Baez expressed that "coming from a public-school background, I doubted my abilities to take on a STEM heavy schedule which inherently prevented me from reaching my full potential. I recall the time during my Biology Laboratory course when we were learning how to pipette. It was the first time I had ever placed my hands on any type of lab materials. However, most of the other students in my class had previous experience handling these tools. Although I wanted to learn and master how to properly pipette, I made mistakes during the learning process which lengthened our time completing the lab. Seeing the look of annoyance in my lab partners' faces, I decided to have them lead the lab. This experience made me feel as if I was behind and incompetent of doing basic lab work, hence I did not bother to begin looking for a lab/research opportunity on campus until I felt that I was better prepared." Velasquez Baez also stressed how these disparities make her feel continuously unprepared and that STEM student organizations for minorities have supported her throughout her college career.

The involvement of students that require support, as well as those who have experienced the benefits of organizations and societies, is an essential component of the successful development of chapters. As such, the presence and contributions of students with diverse backgrounds and life experiences are key for providing support to others. In this regard, Grajales commented "my involvement in SACNAS is important to me because it provides me with the opportunity to learn from others. SACNAS provides me with an environment where I am surrounded by like-minded individuals who want to learn from one another to better meet the needs of future generations. I believe that exposure to these diverse and empathetic environments is what allows student chapters to develop effective strategies to help future generations succeed in their journey through academia and beyond". Velasquez Baez expressed a similar sentiment of support and collegiality: "During my time at Wesleyan so far, I have been part of Wesleyan's Math and Science Scholars (WesMaSS) program, the Minority Association of Premedical Students (MAPS), and the SACNAS chapter. All have contributed to helping me advance in my future STEM-related endeavors. In all these organizations I have been able to connect and seek guidance from minority students and professors in order to help me transition from a

public-school background to a rigorous, STEM heavy schedule at Wesleyan. Participating at these organizations allows me to be part of a community (although small) where we share and learn from each other whether that means tips for studying for certain courses, overcoming imposter syndrome, or research/internship opportunities that are offered on and off campus." Thus, student participation and self-identification with these organizations may play a crucial role in the establishment of successful chapters and the development of supportive resources at an institutional level.

NATIONAL SOCIETIES AND STUDENT CHAPTERS PROMOTING THE DEVELOPMENT OF URG UNDERGRADUATE STUDENTS

Mentoring

Research has demonstrated that mentoring relationships are necessary for the academic success of URG students, as constructive feedback results in career success, commitment, and satisfaction in scientists at all stages (Crisp and Cruz, 2009). Engagement of undergraduate students in mentored scientific research experiences is associated with early development of research skills, critical thinking, and scholarly productivity. Experiencing a scientific laboratory environment is known to increase retention in STEM fields (Linn et al., 2015). However, mentoring is not restricted to only the development of scholarly skillsets; social and emotional support is a fundamental consideration while working with undergraduate students, highlighting the importance of competent faculty to advise them. Developing a sense of belonging and building confidence is essential to the successful transition into advanced scientific careers (Chemers et al., 2011; Lopatto, 2007; Thiry and Laursen, 2011). Professional societies provide avenues of support for these activities by offering fellowships and awards for undergraduates to partake in research experiences and present their research at national conferences (**Table 1**), which ultimately strengthens student interest, motivation, and academic performance (Lopatto, 2007; Russell, 2008; Eagan et al., 2013). For students from URG, mentoring plays a major role in enhanced commitment, resilience, and recruitment into graduate programs and other scientific careers (Nagda et al., 1998; Thiry and Laursen, 2011). Research suggests that minority students perform better when they are mentored by faculty from URG with whom they identify (Campbell and Campbell, 1997; Johnson-Bailey and Cervero, 2004; Blake-Beard et al., 2011). As such, professional societies and associated student chapters with a focus on URG might consider providing additional avenues for matching students with mentors of similar cultural backgrounds to whom they can better connect to maximize the benefits of participation. Thus, it is important that sociocultural diversity is considered when establishing mentoring interactions.

Meetings and Networking Events

Attending meetings, conferences, and other networking events is an important component of an individual's academic work that is essential when pursuing a career in STEM. These activities allow attendees to present their own research, learn from others in the field, collaborate with other colleagues, expand their networks, and seek potential job opportunities. This is a form of developing a professional identity and recognition in the scientific community, which can encourage young individuals to advance their careers (Womack et al., 2020). In addition, attendees can begin to develop and strengthen interpersonal, networking, and communication skills, all of which are important in academia, among other settings. These events are open to all students and professionals interested in STEM; however, they are predominantly geared towards and attended by graduate students and postdoctoral fellows rather than undergraduate students. A contributing factor is a lack of encouragement for undergraduate students to attend from their professors, as undergraduate educations typically set expectations for students to prioritize completing their degree and securing employment upon graduation, as opposed to promoting rigorous scholarship activities. Unfortunately, these issues are magnified for undergraduate students from URG, and as such, these students are less likely to build those connections and skills early on in their careers, placing them at an inherent disadvantage. To maximize the development of undergraduate students' professional skills, professors should encourage their students to attend these meetings and conferences.

While general meetings directed towards individuals from all backgrounds are beneficial, it is also important to address racial inequity and disparities that exist in the scientific community. For minority students and students from URG, it is often difficult to find the resources and support necessary to achieve future endeavors, especially as they aim for careers in competitive STEM fields (Estrada et al., 2016). Thus, meetings, conferences, and networking events should also be specifically geared towards minority students and actively encourage them to attend. Statistical information available for three of the largest conferences aimed at students from URG is shown in **Table 2**. In general, demographics show that the attendee population for these conferences is predominantly people from URGs. For instance, since 2016, the demographics of the national SACNAS conference comprised of 87–90% members belonging to URG and 10–13% members from non-minority groups (**Figure 3**; https://www.sacnas.org/what-we-do/conference/). **Figure 3** shows the general representation of various racial groups at SACNAS conferences over the past 5 years. For the past few years, the AISES National Conference has reported a consistent conference demographics comprised of 69% attendees from URG and 31% non-indigenous attendees, with a majority of college attendees (500–600 students; https://www.aises.org/about/financial-information). It is interesting that the demographic distribution has been consistent through this time, however, an important increase in the number of attendees can be noted for both conferences. Studies suggest that successful retention of diversity in STEM begins with representation, in which professionals from different ethnic and scientific backgrounds hold seats as panelists at meetings and conferences (Estrada et al., 2016; McGee, 2016; Hagan et al., 2020). For students from URG, having the opportunity to be in an interactive environment with successful individuals with whom they

TABLE 2 | 2020 Statistics for annual conferences focused on URG students in the USA.

Conference	Total attendees	Student presenters	First-time presenters	FGLI student presenters	FGLI student attendees	Exhibiting institutions
SACNAS 2020	5,767 attendees 27.3% Undergraduate; 14.4% Graduate	930	742	503	1981	346
AISES 2019	1916 attendees 78% undergraduate 11% Masters 12% Doctorate	518	N/A	N/A	N/A	633
ABRCMS 2020	3,980+ 51.4% undergraduate; 10.5% graduate students)	750	607	N/A	N/A	284

Sources: https://www.sacnas.org/wp-content/uploads/2021/03/SACNAS2020annualreport_FINAL321.pdf; https://www.sacnas.org/wp-content/uploads/2021/05/2020SACNAS_PostConferenceHighlights3.pdf; https://www.aises.org/about/financial-information; https://www.aises.org/sites/default/files/documents/2018-AISES-Annual-Report.pdf; https://www.abrcms.org/

FGLI, first-generation low-income.

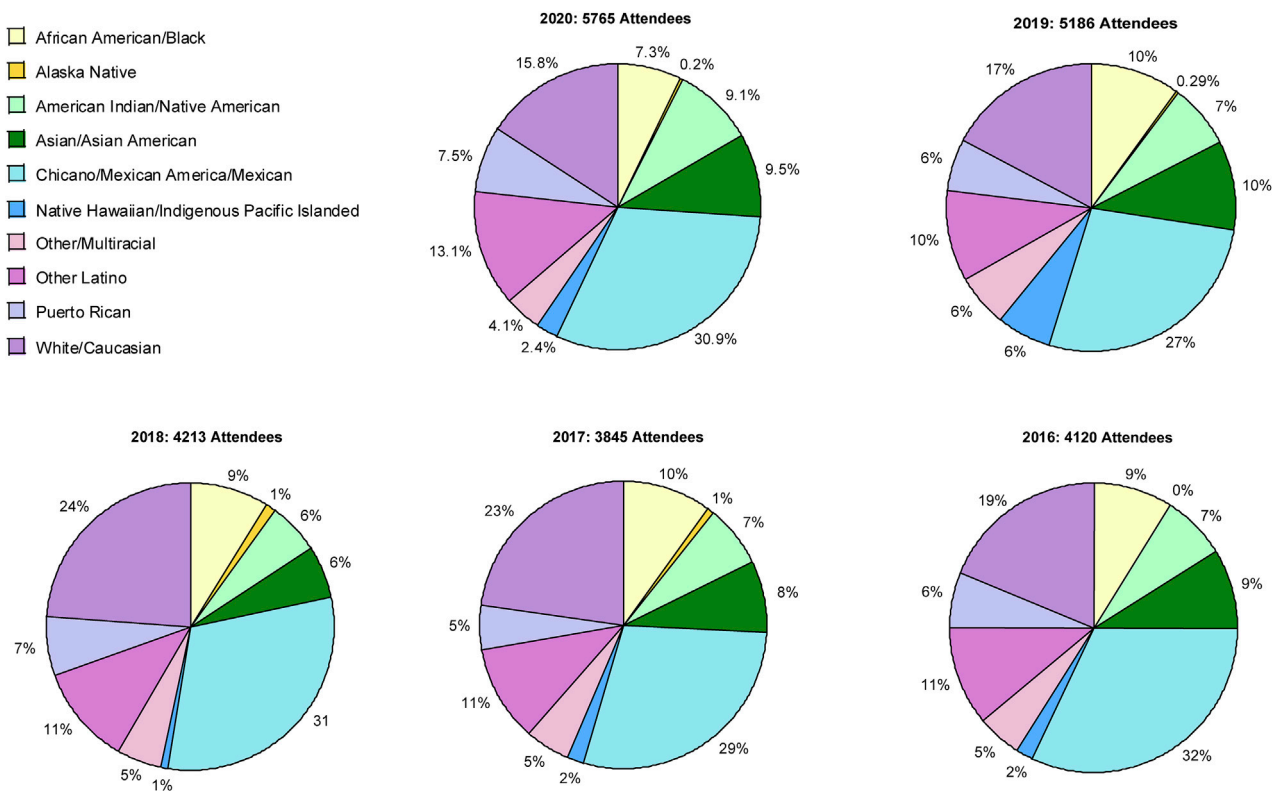

FIGURE 3 | Demographic information of attendees to SACNAS conferences from 2016–2020. The data presented was obtained from those attendees that reported demographic information. Adapted from: https://www.sacnas.org/what-we-do/conference/.

identify fosters a sense of community and belonging. In addition, building a network with peers and professionals can lead to job and funding opportunities as well as the identification of appropriate mentors that understand the needs of the students. As discussed above, a mentor that belongs to a similar URG as the trainee is likely to provide a stronger and more oriented perspective due to a sense of mutual understanding. While there is no specific information available on the statistics and demographics of mentors, judges, and panelists that participate in meetings and conferences, a recent article has discussed the relevance of the demographic composition of mentors and how it should match the demographics of the student attendees. This manuscript also highlighted SACNAS and ABRCMS conferences as having a focus on ensuring diversity in racial and ethnic identities across students, mentors, and board members (Hagan et al., 2020). Thus, representation at STEM conferences and other events can help foster the skills required for the future endeavors of minority students, as opportunities specifically targeted to these individuals contribute to advancing and maintaining diversity in STEM.

Planning and programming of conferences and meetings specifically designed for undergraduate students from URG may provide solid foundations for these individuals to pursue careers in STEM. Oftentimes, a large number of these undergraduate attendees have never been exposed to a conference environment before, and it is for this reason that providing venues in which these students feel safe and understood is so important. Meetings like SACNAS (**Figure 3**), AISES and ABRCMS gather an excellent sociocultural combination of professionals and trainees, allowing the community to connect and share common experiences in a way not often found at other meetings. Moreover, programming aimed at undergraduates requires a step back to highlight the big picture of STEM, presenting more general introductions to the various careers available to them as well as resources and steps to attain these careers. Programming including the personal experiences of panelists allows undergraduate students from URG to get a sense of typical career trajectories and help them avoid unnecessary setbacks during their career development. Programming of broader conferences–those open to trainees in general and can also include graduate students or postdoctoral fellows–are typically designed for individuals with a better understanding of STEM careers. In these cases, additional topics, such as explanations of and exposure to future opportunities (e.g., career fairs and job offers), management of interviews, deadlines, and funding resources available, should be considered to make the conferences more accessible to undergraduate students.

Professional Development

Increasing awareness regarding the insufficient academic preparation and limited opportunities for mentorship and exposure to scientific activities for students from URG has triggered innovative proposals to address the lack of representation in STEM. The recognition of these issues has increased the interest of national organizations to promote professional development during early academic years, with a particular focus on URG. Over the past few years, national organizations like SACNAS, ASBMB, and ASCB have focused on providing undergraduates from URG with professional development training, such as an understanding of and ability to apply skills that are key to future success in STEM careers and higher education environments (Hilty et al., 2019). In addition to targeted conferences and networking and mentoring events, several additional resources have been developed. Webinars offered to undergraduate students have also focused on individual career planning, public health in URG populations, and tools for overcoming discrimination.

Novel career opportunities are available to students. Discussions and panels organized by experts from different fields show the diversity of the STEM job market. Comparisons between careers in academia and careers in industry or policy, among other topics, are now frequent conversations that engage rising undergraduates in emerging scientific fields. While webinars supply information and guidelines for career planning and overcoming barriers in academic environments, seminars, often organized by faculty members, allow student members to gain insights into current research being executed by professionals in STEM fields who come from URG. Frequently, professional organizations provide services to members seeking jobs or internships, such as tips for interviewing and guidelines for building a successful resume. Through the creation of individual institutional chapters led by faculty mentors, undergraduates can also connect with other individuals from URG and work in collaborative atmospheres with their peers to organize events and seminars, as well as consult with faculty mentors. These resources supply undergraduates from URG with opportunities and skills that may not have been available previously due to language, financial, psychological, or other access barriers.

Undergraduates from URG report feeling stress related to the lack of representation in and understanding of their racial and cultural backgrounds by their educational institutions (Hurtado et al., 2002). Societies and chapters provide resources that not only take into account the various backgrounds of the members, but also cater specifically to students who have faced discrimination and struggled with a lack of diversity and inclusivity at their institutions that oftentimes result in limited opportunities available to the minority student population (Allen-Ramdial and Campbell, 2014). However, one issue that remains is that faculty from URG are often expected to assume the task of increasing diversity and inclusion at their respective institutions, regardless of the negative effects this may have on their work or well-being (Mahoney et al., 2008). This burden on faculty can be eased by the practice of cultural competence by non-minority undergraduates as they advance into professional settings. Cultural competence has been defined as a set of congruent behaviors, attitudes, and policies in professional environments, institutions, or agencies that enable effective work in cross-cultural situations (Cross et al., 1989). Cultural competence involves a concerted effort to adjust conventions to benefit the various cultural backgrounds that may not align with one's own. This is an essential practice in professional development for non-minority undergraduates in order to create a wholly welcoming environment for students from URG, both in their current academic settings and as practice for future professional positions. Cultural knowledge, which contributes to cultural competence, can be obtained by exposure to the traditions and perspectives that diverse individuals have as well as societal issues that they face. Webinars and events designed to promote sociocultural competence should not only engage members in efforts centered around their own backgrounds, but also increase interest and knowledge of issues pertaining to certain cultural backgrounds among those who do not personally identify with the webinar topic.

Mentoring opportunities that are designed with student needs in mind, and in which professional development and cultural competence are assessed, increase successful participation in STEM fields (King, 2013). Professional scientists that identify with this mission, such as faculty, chapter leaders and mentors, guest speakers, and webinar interviewees, offer an extended community to undergraduate members from URG. These networks provide the trainees with diverse perspectives, such as personal experiences in STEM, guidelines on how to navigate academia, and expectations for future career endeavors. The

diversity of opportunities and activities offered by national organizations and local chapters creates a supportive atmosphere for undergraduates from URG through supplying resources and personal and professional guidance, all of which increase self-efficacy. Self-efficacy, or one's confidence and belief in their capacity to succeed in a task or field, can be increased by a supportive environment and by witnessing others from similar backgrounds succeeding in that environment (Mourad et al., 2018).

Webinars and workshops that focus on scientific writing and presentation guidelines provide skills to undergraduates that will further them in their STEM academic and professional paths. Seminars and interviews with professionals from URG in STEM fields allow undergraduates to see individuals from similar backgrounds succeeding in STEM. With these examples, the students may be able visualize a path for themselves in STEM that they had not been able to prior.

Development of leadership skills is also an important component of student participation at institutional chapters. Leadership involves guiding as a group in order to accomplish goals shared by the group as a whole (Northouse, 2013). The process of learning is maximized when an individual fully participates in an activity or process, as opposed to simply watching as others do so (Lave and Wenger, 1991). Therefore, undergraduate chapter members are encouraged to serve on the chapter board. These individuals are involved in decision-making regarding chapter events, community outreach initiatives, fundraising, and involvement in regional and national meetings. Participation of undergraduates as chapter board members allows them to hone leadership skills as they relate to STEM fields and their research. Undergraduates serving on chapter boards fulfill these tenets by making decisions as a unit to accomplish specific goals. In the case of chapters with a focus on diversity and inclusivity in STEM, students seek to help individual members from URG to reach personal and scientific goals and practice professional development and technical skills. However, to fully achieve diversity and inclusion, chapters that serve URG must also consider the participation and views of non-minority students in order to promote institutional equity. Serving on a chapter board provides undergraduates with a way to move from learning through listening and watching as others carry out leadership roles such as leading webinars and seminars, to learning through actively engaging in processes such as planning, decision-making, and peer-reviewing as they relate to chapter activities.

A student chapter's organizational structure is typically determined by the size and specific needs of the group. However, in most cases there are necessary officer positions: president, vice president, secretary, and treasurer. The time of election and duration of service of these officers is decided by the students and chapter members. Ideally, these roles will be taken for one or more semesters to allow the student to fully immerse themself in the culture of the chapter, learn the roles associated with the positions, and develop a successful program of activities during the academic year. The typical positions necessary to establish the chapter board represent different kind of responsibilities and require diverse set of skills by the students in charge. For instance, the president is the leader and manager of the student chapter affairs. In general, this individual directs chapter meetings by following a planned agenda, appoints responsibilities, approves any chapter expenses, and represents the chapter publicly as needed. The president may also coordinate work with other institutional or external organizations or delegate this to another board member. The vice president performs the duties of the president when absent or at their request. This officer helps to coordinate meetings and programs and may represent the chapter at institutional or external meetings. The secretary keeps records of chapter activity, helps in advertising events, and is in charge of taking minutes at chapter meetings. The records and participation of the secretary are fundamental to completing annual reports requested by the national organizations. Finally, the treasurer holds the record, reports the chapter income and expenses, and prepares an operating budget when funding is available so that the chapter activities may be planned accordingly.

Student chapters are also spaces in which members can receive feedback on presentations, perform community outreach, engage in social events, and participate in smaller scale regional meetings. Additional resources that national organizations and chapters provide, and which are essential to scientists from URG in training, include support for those seeking jobs or internships during their undergraduate years. An example tailored to students from URG is the "Career Insights" tool on the SACNAS website (https://careercenter.sacnas.org/career-insights/) with which members can view statistics for a particular occupation, such as average annual wage, employment rate, and average education level held by those in that career. Webinars and articles are also offered with tips for successful resume building and interview techniques. These tools can be utilized by undergraduates to begin planning both their academic and professional journeys to maximize the potential of succeeding in a specific career path. Job searching is a process that often requires significant connections within an institution, as well as financial resources to which undergraduates from URG may not have access (Segarra et al., 2020). The availability of webinars, seminars, and mentorship provides resources and prepares undergraduates from URG to succeed in the job market and in internship opportunities. Professional development is a key component of the academic career of any undergraduate student, but especially so for undergraduates from URG, who may not have had access to the resources that allow the practice and maintenance of professional development skills. Thus, through mentorship and leadership programs, meetings, job seeking tools, webinars, and seminars, national organizations and institutional chapters provide an ideal atmosphere for professional development in undergraduates from URG.

NATIONAL SOCIETIES AND URG STUDENT CHAPTERS GIVING BACK: PROMOTING COMMUNITY AND INSTITUTIONAL DEVELOPMENT

Community development has been broadly defined as "a process where community members come together to take collective action and generate solutions to common problems"

(UNTERM, 2021). The goal is to achieve sustainable development and provide opportunities to promote equity and social justice. In this regard, student chapters can make a significant impact on the education and empowerment of people outside of their institutions by organizing public activities related to academic training. Similar to the goals proposed within academic institutions, chapters with a focus on URG provide real life examples to members of the community regarding how marginalized people may find an avenue to succeed in STEM professions. Activities are targeted to specific social sectors and planned accordingly to maximize the delivery of the messages. Thus, chapter members must understand and learn how to work with specific groups of individuals. Two of the most common problems encountered by the URG community is implicit bias and imposter syndrome (IS), which pose social and personal challenges. These challenges highlight the importance of URG student chapters in educating the community, as it is likely that several members of these organizations may have been exposed to these problems and therefore possess the necessary background and understanding to help others overcome these issues.

A number of definitions have been used to describe implicit bias. The Kirwan Institute defines it as "attitudes or stereotypes that affect our understanding, actions, and decisions in an unconscious manner. Activated involuntarily, without awareness or intentional control. Can be either positive or negative. Everyone is susceptible" (Staats et al., 2017). Yale's Poorvu Center for Teaching and Learning recognizes implicit bias as the "unconscious attitudes, reactions, stereotypes, and categories that affect the behavior and understanding of various social groups" (Yale Poorvu Center for Teaching and Learning, 2021). Implicit bias has a diverse set of impacts on social interactions in a variety of settings. The implications of implicit bias in academic settings result in assumptions by instructors about students' learning behaviors and their capability for academic success (Yale Poorvu Center for Teaching and Learning, 2021). Studies have shown that such presumptions have a significant negative impact on affected students, oftentimes impeding student growth (Staats et al., 2017). These issues also exist in professional settings in a wide range of environments, such as medical fields, in which the quality and frequency of healthcare services available to minority ethnic groups may be negatively affected (Blair et al., 2011). Given these examples, it is clear that implicit biases can severely limit and even incapacitate the development of individuals from URG in various facets of life. As such, studies have devised methods by which individuals can combat implicit biases, including but not limited to the following (TP Institute, 2021; Yale Poorvu Center for Teaching and Learning, 2021).

- Self-assessment of implicit biases: promotes reflective teaching that offers formal and informal strategies for considering one's own habits. A number of individual tests are available, and instructors can choose to take an online self-assessment to identify their biases (Moon, 2011; TP Institute, 2021).
- Encourage mindfulness: fosters an inclusive environment that supports development of sensitivity and self-awareness.
- Soliciting feedback from external observers: invites individuals to provide honest feedback on your behaviors and how they impact those around you.

Imposter syndrome, also called imposter phenomenon, is loosely defined as feelings of fraudulency and self-doubt (Bridgette et al., 2015). Many individuals who suffer from IS often undermine their own accomplishments, as they believe that they are attributed to external factors such as luck, charm, or network (Bridgette et al., 2015). This feeling is prevalent among high achieving individuals, and even more so among those who undergo significant stress and/or aim for perfection (Bridgette et al., 2015). Studies have shown that IS is highly prevalent in individuals who pursue higher education due to the combination of high expectations and the competition that students undergo in a short period of time (Ramsey and Brown, 2018). For students, stress is a significant factor in IS since it is often difficult to balance academics, personal life, and additional responsibilities (Ramsey and Brown, 2018). In addition, perfection is not a reasonable expectation. When the student is not satisfied with their work, it can lead to a lack of self-confidence and provoke them to work harder and longer in order to achieve something that is not attainable. Intense feelings of IS can be detrimental to the individual's success, as it can lead to burnout, anxiety, and depression (Parkman, 2016), resulting in an increased likelihood for the student to lower their standards and fail to reach their full potential. Therefore, IS often causes students from URG to drop out of school, or even prevent them from pursuing higher education at all, which contributes to the difficulty institutions have in retaining students (Parkman, 2016).

Studies describe a strong prevalence of IS within URG, such as first-generation and ethnic minority students, as they have reported higher levels of stress and depression as well as a lower sense of belonging compared to continuing-students (Bridgette et al., 2015; Le, 2019). First-generation students are individuals who are the first in their family to pursue higher education, whereas continuing-students have family members who have earned at least a bachelor's degree (Redfort and Hoyer, 2017). The differences among the two groups include many barriers that students from URG more commonly face, such as economic instability, decreased family contribution, and lack of cultural support. First-generation students are more likely to come from low-income families and are subsequently highly dependent on grants, scholarships, and employment to afford their education (Postsecondary National Policy Institute, 2021). As such, there is increasing interest within professional societies to support for first-generation, low-income students (**Table 2**). However, finding, applying, and working for these opportunities takes essential time away from focusing on school and striving for academic excellence. For many graduate schools and programs, students majoring in STEM are expected to have research experience in order to be considered competitive applicants and increase their chances of acceptance (Varsity Tutors an Education Blog, 2021). The average number of hours per week for a research position is 15–20, but many positions require more

or less time depending on the field of research. According to the Center for First-Generation Student Success, first-generation students work more hours per week (20 h) while enrolled in school than their continuing-generation counterparts (12 h). Therefore, the time commitment for a research position is oftentimes unfeasible for first-generation students, especially if it is unpaid or low-wage, on-campus jobs. Therefore, first-generation students are more likely to pursue a job off-campus compared to continuing-generation students (Center for First-generation Student Success, 2021). The lack of economic stability is a significant barrier to the future endeavors of many low-income students who must provide for themselves, especially in comparison to their continuing-generation peers.

First-generation students are less likely to have the resources and emotional support from their families required for success in competitive fields. While emotional support from peers is an important element, colleagues of first-generation students may not understand the hurdles and responsibilities that this group of students has faced. This increases the pressure for students, who must balance family duties with their education. Most parents project expectations on their children based on their own experiences. A parent with an educational background is more likely to have an expectation that their children attend college and secure a reputable career in comparison to a parent who has little to no educational background (Brooks-Terry, 1988). Without a college background, parents of first-generation students may underestimate the rigor of attending college, leaving their children without sufficient emotional support. There may also be an increased sense of guilt in first-generation students, who may feel that they should be prioritizing their family over their education (Brooks-Terry, 1988; Chelsey et al., 2021). Other hurdles may include high levels of stress due to being the first in the family to pursue higher education, and not feeling satisfied with how far they have come despite the barriers they have faced. The lack of emotional support often leaves students discouraged and lowers their expectations, resulting in longer than average times to degree completion. All of these factors contribute to higher levels of stress, depression, and IS.

In many college institutions, especially those that are predominantly white, there are limited resources for first-generation and minority students, such as funding and student groups that provide emotional support and representation. Even if these resources are made available to students, first-generation students are less likely to take advantage of on-campus resources, leaving them at higher risk for IS (McGuffey et al., 2019) due to feelings of unworthiness and the fear of not meeting expectations in classes. A plausible preventive measure against these issues would be to address IS at an early age, as this feeling amplifies with time. Hesitancy to take advantage of tutoring services, reach out to professors, or pursue other forms of academic help can lead students to work on assignments for longer than necessary or even underperform. First-generation students are also less likely to take advantage of mental-health services for similar reasons. As an additional contributor, mental health is an unknown subject within the culture of many ethnic groups. Many first-generation students have been told by their families and communities to keep pushing forward and that what they feel is only temporary, which may further deteriorate their mental health in the long run (Aklin and Gómez, 2017; Bailey et al., 2019).

It is evident that economic stability, family contribution, and lack of emotional support are all common barriers among students from URG that increases the risk of IS, placing them at a greater disadvantage in the pursuit of higher education compared to continuing-generation students. Despite these barriers, there are manners in which students and college institutions can prevent IS from significantly impacting academic success. Institutions should prioritize the formation of student groups that promote representation among different ethnic groups, as well as provide emotional and cultural support similar to those which scientific societies tailored to minority students provide. For example, SACNAS and ABRCMS both offer resources to address and help their students overcome IS. SACNAS's "Insights to Success" webinar series (https://www.sacnas.org/what-we-do/webinars/) allowed diverse professionals in STEM fields to share their experiences and the lessons learned facing different challenges in order to move beyond IS, among other personal challenges. Similarly, ABRCMS has a blog in which professionals share their experiences and strategies to overcome these barriers (https://www.abrcms.org/index.php/education-training/blog). National conferences for these and other scientific societies, as well as workshops and seminars, commonly offer resources with a focus on IS and other relevant personal topics.

Student chapters can also help their membership manage IS. Development of IS workshops that focus on how to self-identify the main features of IS and provide advice and strategies to cope could help combat IS in students. Existing workshops developed by experts in the area typically consist of an initial informational presentation on IS followed by group exercises and discussions that facilitate intimate interactions and allow attendees to overcome or manage this syndrome. Representation should also exist within faculty, as faculty from URG can serve as mentors for underrepresented students and have a positive influence on their sense of belonging and recognition of their own abilities (Ramsey and Brown, 2018). Providing mental health services for all is another way to relieve feelings of IS in students from URG, as addressing mental health can allow students to understand the root causes of IS and manage feelings of self-doubt and incompetence. Discussions of ways to manage failures are particularly useful, as experiencing failure is a universal experience that everyone will encounter throughout their life-time (Mind Tools, 2021). Lastly, counseling for time management, studying habits, and other useful skills would also be beneficial for students, and could result in increased confidence and decrease the likelihood of anxiety, depression, and other mental health issues (Wang and Wang, 2018). IS continues to be a prevalent research topic, as it has a significant impact on many lives. Thus, it is important for individuals and institutions to keep up-to-date with data that provide potential resolutions for IS in order to effectively help students in their education and career endeavors.

Overall, students that join institutional chapters seek to assist others in advancing their careers in science and overcoming academic and personal challenges. Chapters with a focus on

URG intend to foster an inclusive environment for minority students within the institutions. As students from URG embark on their journeys through college, they may feel intimidated by a white-dominated student body. The underrepresentation of people with whom they identify allows for thoughts of doubt to manifest: "do my peers think I am less capable?" or "have other minority students come this far only to drop out and will that be my fate, too?". To combat these intrusive thoughts, student chapters promote social events such as ice cream socials, movie nights, and picnics to provide a safe environment in which students can express themselves and speak openly of their cultures. At these chapters, the students can express their experiences navigating academia in pursuit of professional degrees. In addition to social support, some national organizations and chapters may be able to provide students with economic support, helping to alleviate financial stress and decrease the number of students from URG who forgo the opportunity to attend college due to financial constraints. Some examples of current major funding sources are listed in **Table 1**. However, these funding sources do not help to alleviate the financial constraints of attending college, but rather create opportunities to strengthen their professional skills and develop a network, among other features.

NATIONAL SOCIETY CHAPTERS AND THEIR IMPACT ON LOCAL COMMUNITIES

Studies suggest that students lose interest in STEM fields over time (Chung, 2019). Specifically, this low level of interest among older students is characterized by three factors: STEM being perceived as too challenging; a poor perception of scientists and their personal and social lives; and the lack of accessibility to enrichment opportunities (Chung, 2019). In response, scientific and professional national organizations have been developing innovative ideas to eliminate these stigmas that loom over STEM communities. To combat these notions, community-based outreach initiatives have been developed and have proven to be an essential component of STEM education (Chung, 2019). National organizations have attempted to dispel the notion of "nerdiness" so often attributed to STEM students, as young trainees realize that they may soon be in their positions. Community outreach also helps young students realize the various potential STEM avenues of exploration that would otherwise be unknown to them. This assists students in fully understanding the diversity of career options available to STEM professionals, thereby enticing them to further consider STEM careers. In fact, it is vital that outreach programs acknowledge the versatility of job opportunities offered by STEM careers, as young students often neglect the various opportunities encapsulated by it (Chung, 2019). Further fueling students' resistance to considering STEM careers is the blockage of scientific curiosity imposed by physical and financial barriers. Severe inequities in resources impact future generations of college students. Taking this into consideration, it is critical for national organizations to serve as entities that offer educational STEM resources, especially for those communities that lack the funds to provide them for their student bodies. As such, for these national organizations to be most effective, they must target communities that do not already have access to the resources necessary to host early STEM exposure opportunities.

The dissemination of information through college students has proven to make a large impact on how appealing STEM careers appear to young students, as young students are able to identify with the college students. Moreover, college students are often perceived as being more approachable than college faculty, who can appear intimidating to young students. For this reason, efforts to increase the representation of any demographic in STEM must consider community engagement between current college students and younger generations of students.

K-12 students also directly benefit from outreach activities coordinated by student chapters with a focus on URG. Student chapters aim to stimulate curiosity and incentivize exploration of STEM-related fields of study so that students will hopefully engage with the material for reasons beyond academic requirement as they progress in their studies. The encouragement of active participation within student chapters serves to plant the seed of scientific interest in younger generations, enabling them to consider more broadly the various fields encompassed by STEM and begin to develop an idea of what careers they are interested in pursuing. In general, high school outreach programs aim to assist both students preparing for the college application process and those in the midst of it. Offering innovative and state-of-the-art workshops is also important, as these workshops can entice young students and provide advice on how to optimize their time and resources in high school that may contribute to sculpting stellar college applications. Oftentimes, high school students are unaware of the temporal proximity of college applications or of the requirements of their preferred schools. These "blind spots" in high school students can be remedied by enabling interactions between high schoolers from URG and college students from URG, and doing so can set the students up for academic success through sharing personal and academic experiences.

Student members of national organizations that promote academic excellence for students from URG in STEM are largely characterized by their ambition and dedication to making an impact on their communities. These students are able to share their knowledge and experiences in order to enrich themselves and those who follow in their footsteps with respect to navigating their academic and professional careers. Thus, in order to increase the number of students considering careers in STEM, there need to be programs set in place that address the issues outlined above. Taking these factors into consideration, faculty and staff should be participate in seminars that stress the importance of seeking the involvement of college students in leading conversations with younger students regarding STEM, both as a major and as a future career path. By educating the

general public about issues that hinder the growth of STEM professions, a methodology can be set in place to actively and effectively combat these issues.

COVID-19 PANDEMICS TAUGHT US NEW STRATEGIES. CHAPTERS CONNECTING REMOTELY BRINGS BETTER OPPORTUNITIES

With the COVID-19 pandemic keeping students isolated from each other, the opportunity to develop meaningful relationships with others has been greatly limited. Under necessary restrictions put in place, it was no longer possible to walk through college campuses and interact with others in in-person classes or study sessions, and most facets of human interaction were relegated to meetings through a computer screen. This transition to a digital social sphere left many first-year students struggling to develop friendships, as most college freshman do. More broadly, shifting educational programs and conferences to an online setting created a steep learning curve for most. This led to suboptimal communication processes, oftentimes resulting in the loss of audience attention. All in all, the pandemic paused all sorts of traditional social interaction.

Despite the lack of normalcy, the COVID-19 pandemic pushed standing institutions into adopting new forms of communication. Although the adjustment to these new standards was difficult, it was because of the pandemic that educational programs diversified the means by which they distribute information. In many situations, this transition to a more digitized world increased the feasibility and timeliness of social interactions. For example, having meetings online forced students to adopt a strict itinerary, allowing them to better organize themselves in their day-to-days. This transition also benefitted some student-tutor interactions, as students no longer needed to leave the comfort of their dorms and homes to receive support from professors. This shift also provided faculty with a wealth of student resources, as the eligibility to serve as a tutor was no longer limited to students in the immediate area of the educational community. Significantly, many of the changes that arose in the wake of COVID-19 onset appear to be in the process of becoming permanently adopted techniques. While perhaps the most notable change is the revitalized need for upholding high standards of hygiene in all social spaces, the newly established residence of digitized professional social interactions has also made a great impact. For many, remote meetings are not only a fleeting phenomenon, but a standard by which to organize professional communication in the future. However, despite current efforts to make STEM available under these challenging conditions, students from URG may be at a disadvantage compared to their non-minority peers. Students from URG may lack access to computers, internet, or technological tools used in remote meetings. Thus, personal challenges again may affect how these individuals engage with the virtual world. It is important for institutions to ensure that all students, regardless of racial background, have access to this technology at home.

The COVID-19 outbreak revitalized attention to research and health; however, disparities in the latter increased over the pandemic. The CDC commented on this issue, highlighting that social and racial injustice has "unequally affected many racial and ethnic minority groups, putting them at more risk of getting sick and dying from health complications" (Centers for Disease Control and Prevention, 2021). It will be interesting to see the development of young trainees from URG as a community effort to eliminate these social injustices.

FUTURE DIRECTIONS: HOW NATIONAL SOCIETIES AND CHAPTERS ARE ADAPTING TO CHANGE AND PROBLEMS

The COVID-19 pandemic has been a lesson for national societies in problem solving and streamlining programs and events in order to most effectively allow communication and learning among undergraduates from URG. The transition of many annual conferences from in-person to virtual seminars and research presentations bodes well for the overcoming of challenges that national societies may encounter in the future. Over the past year, student chapters have had to surmount the limits on their ability to meet in person and host activities and events that foster a continued sense of community within their institutional chapters. Exposure of the work that national societies and chapters perform to the public will not only increase awareness of the need for inclusivity and diversity in STEM, but also strengthens community, institutional, and national support via funding and donations.

CONCLUSION

The ability to bring together students of diverse backgrounds but with common experiences in their STEM education journey results in the formation of communities both within individual institutions and nationally, as well as building personal, academic, and professional confidence. National societies and institutional student chapters with a focus on diversity and inclusion in STEM are fundamental players in the development of this network. They not only promote the development of essential skillsets in students from URG, but also foster public interest in STEM and provide early STEM education for K-12 students. Equally as important is the diversity of the faculty that lead these conversations with the students, as students are more likely to believe in and follow advice given from with a person with whom they identify. Increasing the diversity of these educators also maximizes the opportunity for student engagement, as educators of different backgrounds appeal to students of different demographics. Promoting diversity of educators helps students from URG to not only overcome challenges related to STEM engagement, but also overcome personal challenges, such as imposter syndrome and implicit biases. As such, the impact of national societies and student chapters transcends that of educational information services and extends into the motivation and inspiration for younger trainees.

Efforts and opportunities for students from URG provided by these organizations should be focused on helping these students navigate domains that may otherwise have appeared too daunting or beyond their reach.

AUTHOR CONTRIBUTIONS

DH and TP-B conceived of and designed the research; LB, JG, and JVB compiled and analysed data; LB and JG prepared figures and tables; LB, JG, JVB, and TP-B drafted the manuscript; all authors edited and revised the manuscript; all authors approved the final version of the manuscript.

FUNDING

LB received the 2021 Undergraduate Research Award from ASBMB during the period that this manuscript was developed. DH is supported by NIH grant R25GM113686. TP-B. is supported by NIH grant R01AR077578.

ACKNOWLEDGMENTS

The authors are thankful to Dr. Cat McCann and Dr. Monserrat Olea-Flores for their critical comments on this manuscript.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Education

OPINION
published: 02 December 2021
doi: 10.3389/feduc.2021.755176

Student-Led Organizations Advocating for Inclusivity in Healthcare and Healthcare Professions

Lauren Youngblood, Cherokee Kim, Katie Qiu and Monifa Williams*

Highlights from the Joining Hands in Healthcare Club, High Point University, High Point, NC, United States

Keywords: diversity, equity, inclusion, student, minority, mentor, healthcare, community

INTRODUCTION

Joining Hands in Healthcare club was founded at High Point University (HPU) in 2020. Membership to the club is open to all students pursuing health care professions across the undergraduate, graduate, and post-graduate programs at HPU. Currently, membership is made up of undergraduate students in the Exercise Science program, as well as Pharmacy, Physical Therapy, Physician Assistant, and Athletic Training graduate students. To date, there are thirty-nine active members of the club. According to research conducted by the U.S.

Department of Health and Human Services, Health Resources and Services Administration, and National Center for Health Workforce Analysis in relation to the profession of Physical Therapy. . . 22.2% are split between Black, Asian, Hispanic, American Indian/Alaskan Native, Hawaiian and other Pacific Islanders, and other races. (HRSA Health Workforce, 2017) The mission of Joining Hands in Healthcare club is to provide a sense of community and support in order to improve the wellbeing, mental health, grades, and prosperity of racial and ethnic minority students pursuing healthcare professions at High Point University.

BRIDGING THE GAP/CURRENT INITIATIVES

This club has been a platform in which the student officers have been able to bridge the gap between undergraduate and graduate students pursuing healthcare professions. The club has organized several events in order to promote conversations between members as well as post-graduate professionals. Various health care workers, all identifying as minorities, were asked to speak on virtual panels pertaining to different topics. These topics included "Changes in clinical practice since the COVID-19 pandemic and how students can adapt" as well as "Transitioning from student to healthcare professional and overcoming imposter syndrome." Between the two events, a total of fifty-five people attended. Through these panels, students were able to gather virtually which helped to stimulate discussions amongst one another. Both the panelists and students offered unique perspectives on methods to navigate the topic at hand, as well as techniques on coping with current social dilemmas. Holding these virtual events throughout the global COVID-19 pandemic has provided a sense of community for members, evidenced by comments of appreciation made during the panel and feedback from those who attended. These environments allowed students to feel comfortable and safe in sharing their difficulties and resolutions knowing others have experienced similar situations.

Currently, club officers are working closely with faculty members to highlight the significance of recognizing implicit biases and discrimination, as it not only can have detrimental impacts on the

OPEN ACCESS

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Reviewed by:
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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *08 August 2021*
Accepted: *21 October 2021*
Published: *02 December 2021*

Citation:
Youngblood L, Kim C, Qiu K and Williams M (2021) Student-Led Organizations Advocating for Inclusivity in Healthcare and Healthcare Professions. Front. Educ. 6:755176. doi: 10.3389/feduc.2021.755176

success, mental health, and general well-being of minority students, but also can impact minority patient care. In order to collaborate with faculty to highlight the importance of the effects of implicit biases and discrimination within an institutional setting, the club is looking to host a student-led panel with faculty members in attendance. The student panel and attendees will address and discuss their personal experiences with microaggressions in professional and academic settings in order to raise awareness of this common experience within minority populations. Other notable initiatives will include community outreach events that look to serve and educate marginalized groups within the immediate area surrounding High Point University. Through this outlet, it is our mission for students to find better success and confidence in becoming a minority professional.

DISCUSSION

In addition to the local success of health professional students, Joining Hands in Healthcare's ongoing goal is to advocate for minority communities. The Health Professionals for Diversity Coalition asserts that we can effectively improve the health outcomes of racial and ethnic minorities by "increasing the diversity of the healthcare workforce. (Health Professionals for Diversity Coalition, n.d)" They further explain that minority health care workers that identify as Asian American, Hispanic, and Native American often are more likely to practice within marginalized and underserved communities. By improving the diversity within the healthcare workforce, we can better address health disparities experienced by racial minorities. It is interesting how the current trend within the U.S. population is becoming more diverse, and yet the healthcare workforce does not reflect this trend. For example, research conducted by the U.S. Department of Health and Human Services, Health Resources and Services Administration, and National Center for Health Workforce Analysis workforce analysis shows that 77.8% of Physical Therapists are white. (HRSA Health Workforce, 2017) The lack of diversity among healthcare workers may pose difficulties for minorities seeking resolution to health issues as minority individuals often seek out healthcare professionals that are similar to their own identity. The importance of the framework of the Joining Hands in Healthcare club is imperative not only to the success of students, but to the longevity of minority individuals.

When investigating the reasons as to why the healthcare workforce lacks diversity, one of the key reasons according to research by Toretsky, Mutha, and Coffman at the Health force Center at UCSF was the "lack of racially/ethnically concordant mentors" with a student's identity. (Toretsky et al., 2018) As a result, students who identify as a minority often have difficulties balancing academics and being advocates for their communities. As a club, Joining Hands in Healthcare has provided a support system and mentorship opportunities. Members aid and provide advice to one another on how to cope with the unique societal struggles that accompany being a minority while also being a student. This mentorship system within the club has been a pillar of student success in educational and personal aspects of member's lives. Future implications of Joining Hands in Health Care could serve as a channel for the APTA *PT Moves Me Ambassador* Program. The *PT Moves Me Ambassador* Program is aiming to "Raise awareness of the profession of physical therapy. Recruit the next generation of physical therapists and physical therapist assistants. Increase diversity within the applicant pool, and ultimately the profession." (American Physical Therapy Association, n.d.) The goal of Joining Hands in Health Care is largely aligned with such a program (American Physical Therapy Association, n.d.).

CONCLUSION

As evidence highlights, healthcare professionals of color are underrepresented in the workforce for various reasons. To aid in improving the longevity of minority individuals and provide a space where racial and ethnic minority students feel welcomed and able to succeed, clubs such as Joining Hands in Healthcare are necessary to provide support and mentorship. The emergence of these programs may lead to improvements in diversity within the healthcare workforce, prosperity and wellbeing of minority students, and healthcare outcomes for minority communities. We will aim to provide community outreach, leadership, networking opportunities, and mentorship to break the barriers limiting prevalence of underrepresented minorities in healthcare. Our hope is to encourage other universities and healthcare programs to begin initiatives similar to that of Joining Hands in Healthcare in order to support students of color and promote diversity, equity, and inclusion.

AUTHOR CONTRIBUTIONS

LY and CK contributed to the organization, construction, and development of the first draft of the manuscript. KQ and MW wrote sections of the manuscript and contributed to revision and editing of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Education

CURRICULUM, INSTRUCTION, AND PEDAGOGY
published: 07 December 2021
doi: 10.3389/feduc.2021.774070

Motivating Self-Efficacy in Diverse Biomedical Science Post-baccalaureate and Graduate Students Through Scientific Conference Implementation

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OPEN ACCESS

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *10 September 2021*
Accepted: *18 November 2021*
Published: *07 December 2021*

Citation:
Boehmer KR, Boschen De Souza SL, Doles JD, Lachman N, Mays D, Hedin KE, Dornink CA, Maher LJ and Lujan J (2021) Motivating Self-Efficacy in Diverse Biomedical Science Post-baccalaureate and Graduate Students Through Scientific Conference Implementation. Front. Educ. 6:774070. doi: 10.3389/feduc.2021.774070

Tactics to increase the number of underrepresented (UR) students in biomedical research PhD training programs have not yet translated to UR faculty numbers that reflect the diversity of the United States. Continued interventions are required to build skills beyond those that result in placement into a PhD program. We hypothesize that successful interventions must build skills that give UR students foundations for confident self-efficacy in leadership. We seek interventions that allow UR students to envision themselves as successful faculty. We posit that development of such skills is difficult in the classroom or laboratory alone. Therefore, novel interventions are required. As part of the NIH-funded Post-baccalaureate Research Education Program (PREP) and Initiative for Maximizing Student Development (IMSD) at the Mayo Clinic Graduate School of Biomedical Sciences, we designed and implemented a unique intervention to support development of student leadership skills: a biannual student-organized and student-led national research conference titled "Scientific Innovation Through Diverse Perspectives" (SITDP). This initiative is based on the concept that students who actively live out realistic roles as scientific leaders will be encouraged to persist to scientific leadership as faculty. Here we describe the motivation for, design of, and outcomes from, the first three pilot conferences of this series. We further discuss approaches needed to rigorously evaluate the effectiveness of such interventions in the future.

Keywords: underrepresented and minority groups, education - active learning, conference participation, self-efficacy, diversity & inclusion

BACKGROUND AND RATIONALE FOR THE EDUCATIONAL ACTIVITY INNOVATION

The National Institutes of Health define UR populations in the research enterprise of the Unites States as individuals *1*) from specific racial or ethnic groups (e.g., Blacks or African Americans, Hispanics or Latinos), *2*) with disabilities, *3*) from certain disadvantaged backgrounds (e.g., first generation college graduates, raised in rural areas), and *4*) who are women, especially those in the aforementioned categories (National Institutes of Health, 2019). These individuals are less likely to be enrolled in graduate school programs (National Institutes of Health, 2020a), receive PhDs (National Institutes of Health, 2020b), and receive research project grants (National Institutes of Health, 2020c; National Institutes of Health, 2020d; National Institutes of Health, 2020e). Research indicates that there are key targets for intervention to increase diversity amongst research faculty.

First, early intervention to improve diversity in the research workforce appears critical. For example, in the case of women, those lacking enrichment support during their early-career faculty phases are less likely to achieve senior faculty ranks (Holliday et al., 2014; Lopez et al., 2014; Paulus et al., 2016) and have lower network reach, measures of productivity such as h-indices, and publications (Budden et al., 2008; John et al., 2016; Bernard, 2018; Schrouff et al., 2019). Others have noted the importance of intervention for UR students during undergraduate learning experiences as well as during the transition from post-doc to tenure track faculty (Meyers et al., 2018). Second, undergraduate research experience, NIH-funded programs to increase diversity, conference participation, mentorship, and institutional cultures of commitment to UR students are the activities deemed critical for enrichment of UR learners toward the goal of persistence in careers in biomedical research (Martinez et al., 2018). Specific activities such as internships in career exploration where students spend significant time in an on-the-job experience in a desired field and academic career coaching, which focuses on guiding learners through career planning steps and professional development activities have been used towards developing UR student self-efficacy (Williams et al., 2017; Schnoes et al., 2018).

Furthermore, UR student success is correlated with identity as a career scientist, a self-perception that is more holistic than simply reflecting competence to conduct experiments (Kim-Prieto et al., 2013). As a result, we hypothesized that successful interventions must build skills that give UR students foundations for confident self-efficacy in *leadership*. These interventions allow UR students to envision themselves as successful faculty. We posit that development of such skills is difficult in the classroom or laboratory alone.

Toward that end, our aim was to create a platform for developing critical thinking and leadership skills outside of the classroom and laboratory settings. To accomplish this, the joint Postbaccalaureate Research Education Program (PREP) and Initiative for Maximizing Student Development (IMSD) at the Mayo Clinic Graduate School of Biomedical Sciences pioneered a "Scientific Innovations Through Diverse Perspectives (SITDP)" conference series, *organized by students*, to cultivate relevant scientific leadership skills not taught in the classroom or laboratory. This effort was supported with funding from the National Institute of General Medical Sciences (NIGMS) of the NIH, the Mayo Clinic College of Medicine and Science, the Mayo Clinic Office for Education Diversity, Equity, and Inclusion, and the Mayo Clinic Graduate School of Biomedical Sciences.

To our knowledge, the SITDP conference is the first intervention of its kind to specifically use the execution of a student-led conference to develop leadership and scientific self-efficacy for UR students. While PREP and IMSD programs have a long-standing history, to our knowledge their application has focused on traditional scientific development of scholars through mentorship in the lab setting, writing and presentation skills practice, and partaking in coursework (McGee et al., 2012; Remich et al., 2016). Literature reviews focused program characteristics of initiatives designed to increase UR student participation in STEM and other health-related disciplines appear to focus more on individual skill development, even when interventions are conducted in a group or cohort setting (Kirui and McGee, 2021; Ureña et al., 2021). Other interventions that are conducted in group settings and centered on fieldwork activities have also been described and may also increase UR student persistence, self-efficacy, and science identity (Bowser and Cid, 2021).

As such, our aim in this brief report is to describe the overarching learning frameworks underpinning SITDP, specific activities carried out to plan and execute the conference, early evaluation of the first three iterations of the activity, and future directions for the program to be considered by institutions wishing to adopt similar offerings for UR students.

PEDAGOGICAL FRAMEWORKS, PEDAGOGICAL PRINCIPLES, AND COMPETENCIES UNDERLYING THE EDUCATIONAL ACTIVITY

The conceptual framework for SITDP can be described as one of experiential learning within the socio-cultural context (Yardley et al., 2012; Mukhalalati and Taylor, 2019). Specifically, we sought to create an experience in which students were explicitly given full leverage to organize themselves as a scientific conference planning committee and to collaboratively envision, plan, and implement all conference activities within a given budget and time frame. The involved student leadership team is offered guiding advice by a lead faculty coach on request, but ultimately students are given full latitude and responsibility as decision-makers. This empowerment builds on other coaching strategies that have been designed to augment mentoring for UR students by enhancing identity formation, self-efficacy, and the building of cultural capital (Williams et al., 2016). The socio-cultural context of the activity is both the graduate school within an academic medical center, as well as standard cultural norms of academic conferences (e.g., various kinds of presentations and networking activities).

LEARNING ENVIRONMENT, LEARNING OBJECTIVES, AND PEDAGOGICAL FORMAT

The SITDP Conference has convened every other year led by Mayo Clinic IMSD and PREP students in the summers of 2016, 2018, and 2020. The 2016 and 2018 conferences occurred as traditional live conferences involving travel, housing, and hospitality. The 2020 conference was delivered virtually in the context of the COVID-19 pandemic. While the 2020 conference could have been canceled, the student planning committee demonstrated significant resilience in choosing to continue the conference and pivoting the fully in-person design to a virtual format using the commercial Zoom teleconferencing platform with a lead time of only ~4 months. Planning committee meetings were conducted in person during 2016 and 2018. In 2020, these meetings began in-person and shifted online in March 2020. Conference planning commenced late fall of the years 2015, 2017, and 2019 respectively.

Student organizational approach: Student leadership teams for the conferences are self-selected from participants in the PREP and IMSD programs at Mayo Clinic. These programs are NIH-funded initiatives designed to increase UR student participation in the biomedical sciences with PREP focusing on pre-professional training of post-baccalaureate students and IMSD focusing on students during their first two years of graduate school training. Mayo Clinic's joint PREP/IMSD program intentionally mingles both student groups with the goal of mutual near-peer mentoring. Participants meet weekly to cover diversity and resilience curriculum and to practice scientific presentation and critique skills. During a regularly scheduled meeting, IMSD and PREP faculty introduced the concept of the SITDP student-led conference, including proposed dates, actions required for successful carry-out of the conference, and benefits of participation to learners' development and curriculum vitae. Students are asked to indicate their interest in participating in planning committee activities and those interested are invited to a separate meeting led by a faculty coach to discuss timelines, responsibilities, and direction more specifically. Topics covered in the initial two hour planning include: planning tasks (e.g. venue selection, speaker invitations), potential planning committee roles (e.g., chair/co-chair, budget director, sub-committee leads), selection of a conference theme, and a schedule for planning committee meetings. Student committee members are provided the conference dates and the budget, and otherwise given full control over other conference activities. Students determine committee roles and sub-committee organization, and vote to establish their committee framework. While the exact committee format was different from year to year based upon student-organization, committees generally include two co-chairs that oversee planning sub-committees, which take on individual tasks such as speaker invitations, venue and catering, social activities, travel, and budget. Committee scheduling is dictated by students but generally starts with weekly full committee meetings in the early planning stages, followed by less frequent full committee meetings as sub-committees are established and meet on their own schedule. As part of their responsibilities, planning committees are expected to document their processes and workflow to develop templates and best practices for subsequent teams.

Faculty coaching: Faculty coaches and administrative staff offering support and guidance are drawn from members of the PREP and IMSD leadership team, with the leadership team growing over the 6-year time frame to include more faculty from UR backgrounds to serve as faculty role models. Faculty coaches possess significant experience in organizing scientific conferences and attend all committee meetings during early conference planning and then approximately monthly after planning roles and sub-committees are established. Faculty coaches remain available by electronic communication and for *ad-hoc* meetings as needed. Attention is given to ensuring student empowerment, leadership, and negotiation so that faculty and administrators maintain only resource roles.

Conference content: The conference theme and the agenda is organized entirely by the student leadership, and as such differed between years. However, the conference maintains structures familiar to scientific meetings, including plenary lectures and panels given by invited speakers, oral and poster presentations by students attending the conference, workshop activities on diversity and resilience topics, and social activities such as a conference dinners and networking lunches. Planning committee members are encouraged by faculty coaches to reflect on their best conferencing experiences and work towards designing a conference that aspires toward their unique vision of an ideal scientific meeting. In-person conferences commenced late afternoon/evening on a Friday and included a full agenda morning to evening on Saturday. For the virtual format, to prevent teleconference fatigue, the schedule was abbreviated to the Friday evening and a half-day of sessions on Saturday.

The specific learning objectives for SITDP conference activities involving UR biomedical research students are:

1. To foster a unique experience for UR students to build identity as leaders in a culturally relevant activity for their future as scientists.
2. To increase the self-efficacy of UR students through self-directed problem-solving, negotiation, and planning tasks required to conduct a scientific conference
3. To strengthen career-relevant social networking of UR students both amongst themselves, with coaches on the leadership committee, and with student and faculty conference participants from other institutions during both planning and conference phases.

RESULTS TO DATE AND ASSESSMENTS

In all three instances the student-led SITDP conferences proved feasible and successful. Even under the most challenging circumstances in 2020, students were able to accomplish all three learning objectives. The conferences attracted 65, 56, and 60 attendees in 2016, 2018 and 2020, respectively. To date, students led the evaluation of the conference based upon attendee feedback. This included a different student-developed survey after each of the conferences. In 2016, all questions were formulated as open-ended questions with qualitative responses from attendees. Prompts included items such as "Tell us what you thought about the student panel" and "what did you think about the diversity discussion?" In 2018, the post-course survey was shifted to a

quantitative format, with only three qualitative questions to indicate the most beneficial aspect of the conference, future session suggestions, and additional comments. Quantitative questions asked participants to rate their satisfaction with various aspects of the conference such as registration, conference content, and the conference's usefulness to their current and future careers. The 2020 survey similarly was mostly quantitative, asking attendees to express their level of satisfaction with each of the sessions, as well as the opportunity to elaborate on opportunities for improvement in the conference in future years.

Because of the differing questions and format across post-conference surveys, pooled analysis across years was not possible, and this presents an opportunity for future evaluation improvement of this program. Of what could be summarized through the analysis of the attendee surveys of content and format it is concluded that most conference attendees learned about the SITDP conference from PREP and IMSD program directors of invited institutions. Feedback was strongly positive across all 3 years with approximately 90% of attendees endorsing that the conference met their expectations for a scientific conference and that they would recommend the conference to colleagues.

We recognize the need to formalize critical evaluation of this novel method for increasing student self-efficacy. Specifically, in future conference years attendee survey questions must be standardized, using past student-created surveys as a guide, such that conferences can be compared across years. Further, there is a need for evaluating the effect of the intervention on student leaders compared to those that do not participate in the SITDP conference process. While randomization is not possible due to the self-selection of participants into the planning committee, administering a survey measure to all PREP/IMSD students both pre- and post-conference is possible, and would offer insight into the unique effect of the SITDP conference leadership in isolation of participation in IMSD/PREP generally. We suggest a few key metrics that may be valuable be measured immediately pre- and post-conference. These include general self-efficacy (Scholz et al., 2002), student perceived achievability and perceived desirability of an academic career as measured previously by Williams et al. (Williams et al., 2016), student sense of belonging within the academic community (Trujillo and Tanner, 2014), and science identity (Trujillo and Tanner, 2014). Should programs wish to evaluate the skills of the faculty coach, which is typically different from the students' main mentor(s), it is suggested to use a validated scale such as the Mentoring Competency Assessment (Fleming et al., 2013). Qualitative study of student experience in the process through conducting individual interviews and/or focus groups may also yield insights into the unique aspects of this intervention otherwise not captured through surveys. However, qualitative research is a time- and resource-intensive activity, so careful design of such study is required. Further, an in-depth qualitative evaluation of the program is likely feasible for a single conference, whereas quantitative evaluation is better suited for longitudinal study.

Importantly, the Mayo Clinic SITDP conference developed a network of contributing allied programs that participated jointly. These allies included students and faculty from University of Chicago and Northwestern University. In fact, enthusiasm for the learning objectives and outcomes was such that these institutions hosted a similar conference in 2019 and are considering and proposing comparable activities in complementary years. The Mayo Clinic IMSD/PREP plans to host a 2022 meeting and continues to seek expansion of the program through additional outreach. The program remains committed to continued collaboration with other programs seeking to conduct similar initiatives.

DISCUSSION ON THE PRACTICAL IMPLICATIONS, OBJECTIVES, AND LESSONS LEARNED

In the first three instances of the novel SITDP conference, we found that a completely student-led conference was both feasible and valuable. In this sense, these conferences have served as pilots. Armed with these experiences and preliminary data, future SITDP conferences hosted by the Mayo Clinic IMSD and PREP programs will focus on coherent strategies for longitudinal evaluation of enrichment efficacy. Such evaluation should include controlled quantitative and qualitative assessment of impacts of student planning committee participation, specifically focusing on advanced leadership skill sets not otherwise gained through traditional mentored laboratory and classroom experiences. As such, our program recommends thoughtful collaboration with skilled education assessment professionals to develop instruments and an advanced plan for qualitative evaluation of student experiences and quantitative evaluation of student self-efficacy, perceived career cultural capital, and identity as scientists before and after the planning experience. It would be important to establish standardized evaluation approaches that can be applied longitudinally over multiple conferences across years, and with the potential to review long-term impacts on biomedical science careers of participants. Consideration should be given to identification of control groups that do not experience the SITDP planning enrichment to judge outcome impacts.

CONCEPTUAL, METHODOLOGICAL, ENVIRONMENTAL, OR MATERIAL CONSTRAINTS

We urge other programs seeking to enhance UR student learning to pursue novel and experimental activities such as SITDP. It is worth noting that the leadership team that proposed and provided coaching for the student SITDP planning experience benefitted from many years of previous experience working with UR students, conference planning, and material resources through NIH funding and generous institutional support of PREP and IMSD initiatives. Significant funding is required to support in-person conference planning and execution, especially when catering, student and speaker travel funds, and speaker fees are involved. Planning must include consideration of how many of the conference costs are to be covered from registration fees. The SITDP budgetary footprint was significantly smaller for the virtual version of the conference. As is being discovered for all modern science conferences, there are certain irreplaceable aspects of in-person conferences, such as impromptu

networking, but additional favorable cost factors must be considered as mitigating. Virtual or hybrid models may also be more feasible for new or young programs, as well as those with significant budgetary constraints for other reasons.

In summary, the Mayo Clinic Graduate School of Biomedical Sciences scientific conference planning exercise as a leadership enrichment for UR biomedical research students has been a success. When linked with an appropriate evaluation plan, this activity creates a unique and transferable template for developing self-efficacy.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

KB is the first author of the manuscript. LL is the last, senior author of the manuscript. All other authors contributed to the conduct of the SITDP conferences and preparation and approval of the manuscript.

FUNDING

The SITDP conference was proposed as an aim of the NIGMS funded award number R25GM 75148-15. Additional funding for conference expenses and personnel time were supported by Mayo Clinic's Office for Education Diversity, Equity, and Inclusion, the Mayo Clinic Graduate School of Biomedical Sciences.

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Conflict of Interest: The handling editor declared a past co-authorship with one of the authors JLL.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Education

PERSPECTIVE
published: 08 December 2021
doi: 10.3389/feduc.2021.780401

Chronicling the Journey of the Society for the Advancement in Biology Education Research (SABER) in its Effort to Become Antiracist: From Acknowledgement to Action

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Edited by:
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Reviewed by:
Ginger Shultz, University of Michigan, United States
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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: 21 September 2021
Accepted: 02 November 2021
Published: 08 December 2021

Citation:
Segura-Totten M, Dewsbury B, Lo SM, Bailey EG, Beaster-Jones L, Bills RJ, Brownell SE, Caporale N, Dunk R, Eddy SL, García-Ojeda ME, Gardner SM, Green LE, Hartley L, Harrison C, Imad M, Janosik AM, Jeong S, Josek T, Kadandale P, Knight J, Ko ME, Kukday S, Lemons P, Litster M, Lom B, Ludwig P, McDonald KK, McIntosh ACS, Menezes S, Nadile EM, Newman SL, Ochoa SD, Olabisi O, Owens MT, Price RM, Reid JW, Ruggeri N, Sabatier C, Sabel JL, Sato BK, Smith-Keiling BL, Tatapudy SD, Theobald EJ, Tripp B, Pradhan M, Venkatesh MJ, Wilton M, Warfa AM, Wyatt BN and Raut SA (2021) Chronicling the Journey of the Society for the Advancement in Biology Education Research (SABER) in its Effort to Become Antiracist: From Acknowledgement to Action. Front. Educ. 6:780401. doi: 10.3389/feduc.2021.780401

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The tragic murder of Mr. George Floyd brought to the head long-standing issues of racial justice and equity in the United States and beyond. This prompted many institutions of higher education, including professional organizations and societies, to engage in long-overdue conversations about the role of scientific institutions in perpetuating racism. Similar to many professional societies and organizations, the Society for the Advancement of Biology Education Research (SABER), a leading international professional organization for discipline-based biology education researchers, has long struggled with a lack of representation of People of Color (POC) at all levels within the organization. The events surrounding Mr. Floyd's death prompted the members of SABER to engage in conversations to promote self-reflection and discussion on how the society could become more antiracist and inclusive. These, in turn, resulted in several initiatives that led to concrete actions to support POC, increase their representation, and amplify their voices within SABER. These initiatives included: a self-study of SABER to determine challenges and identify ways to address them, a year-long seminar series focused on issues of social justice and inclusion, a special interest group to provide networking opportunities for POC and to center their voices, and an increase in the diversity of keynote speakers and seminar topics at SABER conferences. In this article, we chronicle the journey of SABER in its efforts to become more inclusive and antiracist. We are interested in increasing POC representation within our community and seek to bring our resources and scholarship to reimagine professional societies as catalyst agents towards an equitable antiracist experience. Specifically, we describe the 12 concrete actions that SABER enacted over a period of a year and the results from these actions so far. In addition, we discuss remaining challenges and future steps to continue to build a more welcoming, inclusive, and equitable space for all biology education researchers, especially our POC members. Ultimately, we hope that the steps undertaken by SABER will enable many more professional societies to embark on their reflection journeys to further broaden scientific communities.

Keywords: inclusion, diversity, antiracism, biology professional societies, professional development

INTRODUCTION

On May 25th, 2020, Mr. George Floyd was murdered by a police officer in Minneapolis (Bryson Taylor, 2020). This was not the first high-profile murder of a Black man by police in Minnesota-in 2016, Mr. Philando Castile was killed near Minneapolis (Smith, 2017). However, building on a history of racial injustices nationwide and the Black Lives Matter movement, the death of Mr. George Floyd in 2020 catalyzed national action in all parts of society, including the sphere of higher education. The location of these incidents was particularly relevant to the Society for the Advancement of Biology Education Research (SABER), an international organization of discipline-based biology education researchers, because its annual meetings had been held in Minneapolis since its inception in 2011. The historical and continuing racial violence in Minneapolis (Nathanson, 2010) sparked a conversation about whether SABER should continue to hold its meetings in this city. This in turn led to a much broader discussion related to systemic racism and the perception by some of SABER's members of a lack of existing support and inclusion towards members of color. This event paved the way for SABER's journey of acknowledging and reflecting on systemic racism.

In this essay, we describe SABER's actions in direct response to Mr. George Floyd's death, discuss the impact of these actions, and articulate SABER's long-term goals for addressing systemic racism both within the society and broader academic structures. The goal of documenting this process is to show how a professional society could be mobilized in response to an event that heightened long-standing issues of racial justice and equity, and how the resulting journey led to tangible evidence of positive change in a year. We hope that the reflections in this essay will serve as a general guide to other professional societies that are grappling with how to address issues related to racism, diversity, equity, and social justice.

Positionality of Authors

We are writing this essay on behalf of SABER, but it brings up an important question as far as who constitutes SABER and who can speak on behalf of an organization of hundreds of people, all of whom have a different history and set of experiences and perceptions of the organization. We acknowledge this challenge and hope that our shared contribution can help describe the collective efforts of the society, but we know that voices are missing. We tried to identify people who contributed in specific ways to these 12 actions and invited them as authors. Our team cannot speak about the experiences or perceptions of all SABER members, but the authors identify as white, Latinx, Black, Southeast Asian, East Asian, South Asian, multiracial, Immigrant American, women, men, non-binary, genderqueer, LGBTQ+, first-generation college graduate, continuing generation college graduate, non-traditional student, parent, caregiver, chronically ill, living with a disability, religious, non-religious, and associated with the military (Smith-Keiling et al., 2020). We represent graduate students, postdoctoral scholars, university staff, tenure-track faculty, tenured faculty, and non-tenure-track faculty including lecturers. Some of us have held leadership positions at the highest levels of SABER, including the Steering and Executive committees, others have served as committee chairs, committee participants, abstract reviewers, event facilitators, or as general attendees of the conference.

The Origins of SABER and its Lack of Representation of People of Color

More than a decade ago, the need emerged for a new professional society focused on biology education research. More biologists and biology educators were engaging in discipline-based education research, yet there was not a single meeting where everyone could attend to present their work. Discipline-based education researchers in fields like physics, chemistry, and geoscience in the United States could attend one or two professional society meetings. However, the sub-disciplinary nature of biology - with over 64 different professional societies (e.g., American Society for Plant Biologists, American Society for Microbiology, American Society for Cell Biology) - made it impossible for all biology educators to attend a single cohesive biology meeting. Many of these sub-disciplinary biology societies had some sessions focused on education research, although there were often very few organized talks and posters, making it difficult to justify the expense of attending the entire meeting.

In response to this need, SABER was founded in 2010. In the first year, a group of 29 invited biologists and biology education researchers convened at the University of Minnesota in Minneapolis to lay the groundwork for the society (Offerdahl et al., 2011). The new SABER society exclusively focused on biology education research, and its unofficial slogan of "Show me the data" emphasized the need for systematically collecting evidence to make instructional decisions within biology courses. Given the social contexts of the issues that some SABER members attempt to address, "data" here are inclusive of that derived from both qualitative and quantitative approaches to experimental design (Lo et al., 2019). We also note that our students are more than just sources of data and consider the impact of our research on their lives and education.

The first annual meeting of SABER was held in 2011 at the University of Minnesota in Minneapolis. Every in-person meeting thereafter was held at this same location because it was logistically convenient and also kept the meeting costs affordable. Specifically, free access to meeting rooms at the university and the low cost of food kept the registration costs relatively economical in comparison to other education or scientific meetings. The availability of a major international airport, convenient mass transportation, student dorms and hotels within walking distance of the meeting, and the central location of Minneapolis with respect to the east and west coasts of the US made travel costs less expensive. Lower costs for attendees reduced the financial barrier posed by a typical meeting attendance and thus made attending SABER relatively financially inclusive.

The first seven meetings were primarily organized by one of the founders of SABER. In 2017, the inaugural steering committee, which was composed of eight people, was formed to create bylaws, organizational structure, and hold the first elections. This steering committee made diversity and inclusion key components of the bylaws and goals of the organization, and visibly posted both the society's goals and a diversity statement on the organization website. Reflective of these priorities, the Diversity and Inclusion Committee (**Table 1**) was the second SABER-wide committee to be formed in 2018, after the Abstract Review Committee. The first president, president-elect, secretary, and treasurer were elected in 2019. Although SABER has held 11 annual meetings that have attracted thousands of people, it is still a young society with no paid staff, composed exclusively of volunteer leaders and committee members, and with a formal structure that has only been in place for two years.

Most scientific professional societies have a history of racial exclusion and continue to grapple with issues of inclusion and diversity within the membership (Cech and Waidzunas, 2019; ASM Diversity, 2020; Lee et al., 2020; Segarra et al., 2020b; Ali et al., 2021; Carter et al., 2021); the ubiquity of this problem illustrates its systemic nature. Steps to address racial inequity are specifically important for professional societies because these societies ought to provide a platform for individuals from minoritized backgrounds to share their research and build a network for their continued professional success (Morris and Washington, 2017; Segarra et al., 2017; Lee et al., 2020; Segarra et al., 2020b; Harris et al., 2021; Madzima and MacIntosh, 2021). SABER, like other professional societies, has struggled with a lack of representation of People of Color (POC), including in leadership positions. The 29 scholars who were invited to the initial meeting of the organization were all white-presenting[1]. The

[1]We capitalize Black and People of Color (POC) but not white in this manuscript. This is in accordance with current Associated Press (AP) style standards that recognizes that there is a shared history, culture, and discrimination based on skin color for Black individuals or People of Color, but there is not the same shared experience for white individuals. Further, white is not capitalized to avoid legitimizing white supremacist beliefs. However, there is disagreement here and some scholars and organizations advocate for white to be capitalized (https://apnews.com/article/entertainment-cultures-race-and-ethnicity-us-news-ap-top-news-7e36c00c5af0436abc09e051261fff1f).

TABLE 1 | SABER committees involved in antiracist initiatives.

Name of committee or group	Committee focus and composition	Status
Diversity and Inclusion	Focus: To ensure SABER continuously works to become an inclusive, safe, and equitable society that benefits from diverse perspectives and voices Composition: 10–15 active members, including two co-chairs. Membership is open to anyone in SABER and there is no restriction on committee size	Permanent
Diversity and Inclusion Action Group on Place and Racial Justice	Focus: Action group was created after the murder of Mr. George Floyd to specifically address how the society could work to become more aware of issues of racial injustice, work towards making the society more anti-racist, and consider the location of the society meetings (*see* Sense of Place sub-committee) Composition: An email was sent to the society listserv inviting anyone to participate, and as a result 25 individuals joined this group	Temporary
Executive	Focus: Day-to-day management of the society Composition: SABER Past-President, President, President-elect, Treasurer, Secretary	Permanent
Keynote Speaker	Focus: Invite keynote speakers to the annual SABER national meeting who broaden the perspectives of the community and enhance the quality and impact of our work in biology education Composition: Eight members including chair and co-chair	Permanent
Mentoring	Focus: Establish flexible and inclusive resources and structures to support the professional and social development of SABER members. Implement strategies to *1*) welcome and orient new members, *2*) support members in furthering their expertise in research methods, and *3*) help members build networks of personal mentoring relationships appropriate to their needs and career stage Composition: 11 members including two co-chairs	Permanent
PEER Network Special Interest Group	Focus: *1*) provide career support for individuals who identify as PEERs, *2*) foster communication and research collaborations among SIG members, *3*) integrate the PEER Network into the larger SABER community so SIG members are part of the larger conversation, and *4*) create structures that support full participation by all community members Composition: Individuals who identify as PEERs and allies	Permanent
Sense of Place	Focus: Subcommittee of the Diversity and Inclusion Action Group on Place and Racial Justice. Discussed issues related to the physical location of the SABER conference in the context of social justice and antiracism and related their recommendations to the SABER membership and the Executive Committee Composition: 16 individuals including POC, Minneapolis residents, and individuals at different career stages from different types of institutions	Temporary

Committees are arranged in alphabetical order. Temporary committees were established in response to the events that followed Mr. George Floyd's death to address specific issues related to equity and inclusion in SABER. These committees were meant to lead to more permanent SABER infrastructure to carry out long-term actions.

founders of SABER, seven out of eight of the steering committee members, and the majority of committee chairs have been white-presenting, including the two inaugural co-chairs of the Diversity and Inclusion Committee. All of the elected officers in the first round of elections were white. Further, even though no demographic data were collected on race or ethnicity before 2020, an overwhelming majority of attendees at the annual conference have been perceived as white. It is important to point out that the reasons for these observations are complex and potentially the result of the intrinsic racial composition of the SABER membership that mirrors the national trend of faculty in science, technology, engineering and mathematics (STEM) fields (Miriti, 2020; National Science Foundation, 2021). In this article, we define POC as individuals who identify as members of racial and ethnic groups that have been traditionally marginalized. This denomination includes, but is not limited to, individuals who identify as Asian, Black, Latinx, and Indigenous. We focus on marginalization rather than underrepresentation because certain racial and ethnic groups, while not underrepresented in STEM, still experience marginalization (Siy and Cheryan, 2013; Yip et al., 2021).

Indeed, the lack of racial and ethnic diversity in the membership and leadership of SABER reflects a wider issue within STEM, both in the workplace and in academia. The lower representation of certain groups in STEM extends from the college level through the attainment and retention of academic faculty positions (Allen-Ramdial and Campbell, 2014; Hassouneh et al., 2014; National Science Foundation, 2021; Pew Research Center, 2021). Moreover, diversity in the workforce and in academia is not reflective of the ethnic and racial composition of the US (Allen-Ramdial and Campbell, 2014; Li and Koedel, 2017; Morris and Washington, 2017; Martinez-Acosta and Favero, 2018; Miriti, 2020; National Science Foundation, 2021). Factors that influence the observed underrepresentation of racial and ethnic minorities in STEM are varied, and include the lack of access to research experiences at the college level, paucity of mentorship at different career stages, and the creation and perpetuation of institutional environments around race that range from apathetic to repressive (Mahoney et al., 2008; Villarejo et al., 2008; Peralta, 2015; Valantine and Collins, 2015; Whittaker et al., 2015; Zambrana et al., 2015; McMurtrie, 2016; Swartz et al., 2019; Folkenflik, 2021; Gosztyla et al., 2021). Interestingly, a climate survey of the membership of the American Physiological Society (APS) revealed unwelcoming environments across different sectors, including private corporations and academia,

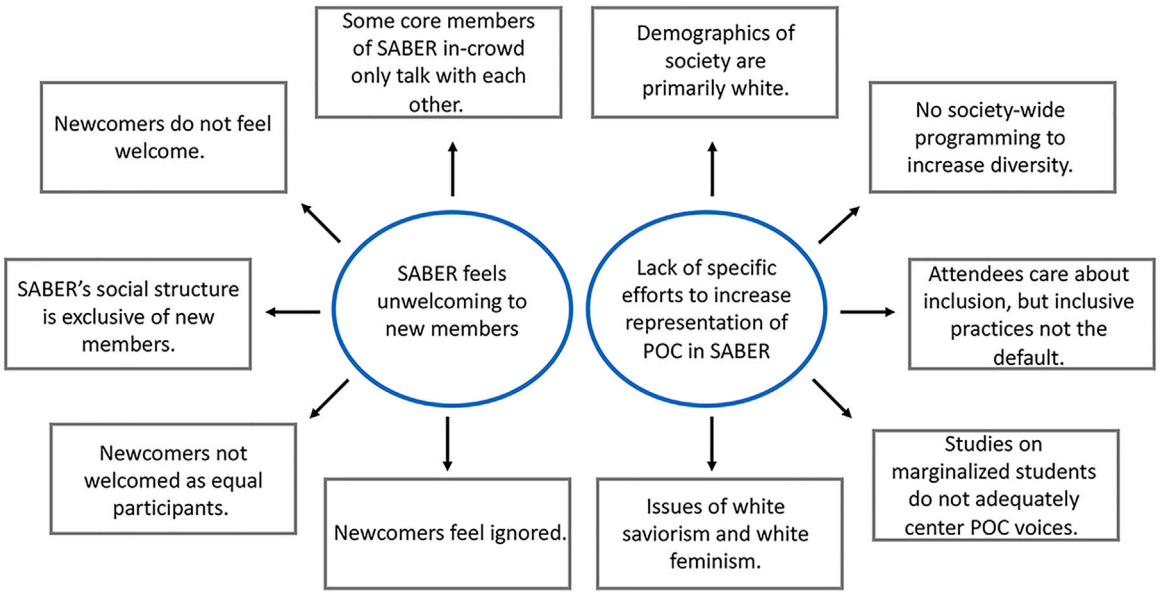

FIGURE 1 | Themes derived from SABER attendee survey responses from 2019 in response to the question: "In what ways has SABER not fully practiced diversity, equity, and inclusion?" Themes are shown in blue circles and sample comments from these themes are shown in squares.

highlighting that issues with inclusion are pervasive in society (ASM Diversity, 2020). Even though there are many initiatives aimed at increasing diversity, these often fall short when implemented in academic STEM spaces that are not supportive and inclusive (Puritty et al., 2017).

Responses from a SABER post-conference survey in 2019 indicated that many members of SABER saw a lack of racial representation in conference attendance and leadership as a problem, and that first-time SABER attendees did not feel included at SABER (**Figure 1**). For example, some survey respondents felt as though SABER was an exclusive clique, and if they were not part of the in-group, then they were dismissed and ignored. Further, survey responses commented that there was seemingly a lack of awareness in the research being presented at SABER of critical frameworks and issues facing Black students and colleagues. For example, it was noted that the majority of the biology education research on Students of Color focused on achievement gaps, using deficit framing of comparing white students to Students of Color, and did not focus on racism (Ladson-Billings, 2006), institutional barriers to minoritized students, or critical race theory (Ladson-Billings, 1998) as a way to understand the experiences of these students. In addition, survey responses reflected that many members supported measures to increase representation in SABER, such as establishing travel funds specifically for conference attendees who identify as POC.

In response to the survey results, members of the Executive and Diversity and Inclusion committees (**Table 1**) decided to: *1*) track the demographics of registrants for the annual meetings starting in 2020 to better characterize the racial composition of SABER, *2*) compare the demographics of abstract submitters and accepted abstract presenters to identify any inequities in abstract acceptance that should be addressed, and *3*) establish and support the Mentoring Committee, to address issues of inclusion for newcomers (**Table 1**). Further, the Diversity and Inclusion Committee generated a list of ideas to address additional issues from the survey responses, but none of the ideas were transformed into tangible actions during the 2019–2020 academic year. Thus, although the leadership of SABER had taken initial steps to address issues of inclusion and diversity, the majority of the actions described in this article resulted from conversations and discussions in the summer of 2020.

To begin addressing issues of lack of support and inclusion, the "SABER Buddies" program was instituted to build community among new SABER attendees. The Diversity and Inclusion Committee suggested the name and the Mentoring Committee implemented the structure of the program. This initiative paired multiple new or returning attendees with mentors who had previously attended SABER, forming groups of four to seven people. Small group mentoring was used in an effort to provide new attendees with multiple contacts and ease potential social and logistical pressures. Mentors were asked to meet with attendees and help introduce the conference to them; attendees were encouraged to ask mentors questions and some of these conversations even led to new collaborations. The SABER Buddies program was so well-received that it was implemented again in 2021 and is being extended into a yearlong mentoring program. In addition to the Buddies, virtual game nights were hosted in SABER 2020 and 2021, and in SABER West in 2021. These virtual game nights were designed to help graduate students and postdoctoral fellows to meet and interact.

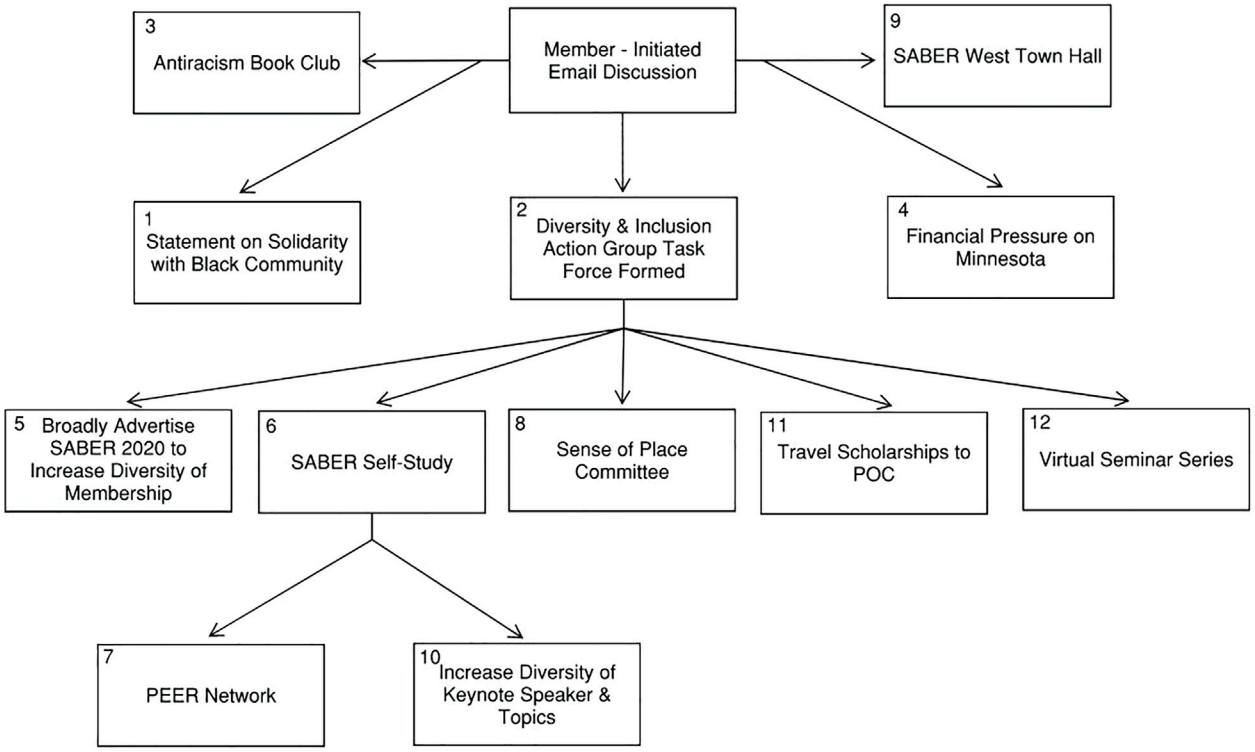

FIGURE 2 | Actions taken by SABER to increase inclusion. Actions are numbered according to the order in which they appear in the text. The arrows indicate which actions led to other initiatives.

The Impetus for Change: Mr. George Floyd's Murder

As protests began nationwide in response to Mr. George Floyd's murder (Bryson Taylor, 2020), SABER, like many other scientific professional societies, was silent on the issue until a Black member emailed the SABER listserv. The call for justice in support of those who have experienced racially-motivated trauma created a sense of urgency and propelled a flurry of emails about whether the conference should continue to be held in Minneapolis given the local history of systemic racism there. This tragic event and the resulting email exchanges on the SABER listserv served as a catalyst for SABER to self-reflect on its previous inaction on systemic racism, to recognize that systemic racism pervades nationally but manifests in different ways, and to determine what changes needed to be made to the organization to make it more inclusive.

Response of the SABER Community

Within three weeks of Mr. George Floyd's murder, SABER's Executive and Diversity and Inclusion committees worked together to: *1*) create a public statement of solidarity with the Black community, *2*) send a letter to entities in Minnesota to financially pressure them to end police brutality, and *3*) initiate a task force open to anyone in the SABER community called *Diversity and Inclusion Action Group on Place and Racial Justice* (**Table 1**; **Figure 2**, actions 1, 2 and 4). These initial actions, coupled with the email discussions resulting from Mr. George Floyd's murder, ultimately led to additional actions (**Figure 2**, actions 5–12). Importantly, while some of the discussions and activities related to these actions included all members of the society, some of the activities were first steps towards involving and amplifying the voices of POC members of SABER. For example, many of the actions that derived from conversations within the *Diversity and Inclusion Action Group* (**Figure 2**, actions 5–8 and 10) were shaped by the perspectives and suggestions of POC SABER members on how to best address issues of equity and inclusion. The creation of an online environment for difficult dialogues on how to tackle issues of inclusion in SABER was important for the creation of initiatives that responded to POC members' needs. These 12 actions are described in detail below, including what has resulted from the action.

Action 1: Published a Statement of Solidarity With the Black Community

Given that members often look up to professional societies to model what is appropriate and accepted in the field, the silence of an organization can inadvertently indicate approval or neutrality about an issue or event, even if that event runs counter to the goals of the organization (Settles et al., 2020). As such, it can be useful for professional societies to make formal statements about

TABLE 2 | Statement of solidarity with the Black community.

The Black community in the United States deserves to feel safe no matter where they are. However, events in recent weeks remind us how systemic racism and biases threaten that safety. We as an academic community stand in solidarity with the Black community against these tragic injustices, and we are committed to finding ways to ensure our community is safe and welcoming. As a biology education organization, we are specifically committed to supporting our students and colleagues who are in pain and hurting because of these senseless acts of violence against Black Americans.

Since its inception, SABER has been graciously hosted by the University Minnesota-Twin Cities in Minneapolis. However, as a society, we need to reckon with our lack of awareness and action pertaining to the longstanding racial injustices across the country, and particularly in Minneapolis - injustices that resulted in the murder of George Floyd and violence against countless other Black Americans. One of the stated goals of our organization is to "strive for an inclusive community," part of which requires us to better understand and respond to the ways in which these longstanding racial injustices impact the lives of our students, members, and colleagues. Moving forward, we commit as a society to educating ourselves and taking anti-racist action in the places where we convene, whether that be in Minneapolis or elsewhere. Furthermore, we will fight against systemic racism to better understand the potential struggles of our students and colleagues, particularly if we do not share their racial identities. A first step to address these injustices is to increase our understanding of these inequalities and how our own biases are potentially contributing to these issues. We have compiled a suite of resources that can help us:

Suggested Articles:

- 75 Things White People Can Do for Racial Justice
- White Privilege: Unpacking the Invisible Knapsack
- Who Gets to Be Afraid in America?
- The American Nightmare
- Scientists push against barriers to diversity in the field sciences
- Race matters

Podcasts:

- Seeing white series within Scene on Radio
- Code Switch

events or issues, particularly when they affect marginalized groups within the organization, so that the organization does not appear to ignore the situation.

The SABER Executive Committee felt a response was needed to the events surrounding Mr. George Floyd's murder. However, they were aware of their positionality as white individuals and for that reason relied on the Diversity and Inclusion Committee, which included POC, to take the lead in drafting a statement indicating SABER's explicit solidarity with the Black community. This statement highlighted SABER's support for the Black community, particularly students and colleagues in biology, and an acknowledgement of the society's current lack of awareness and action regarding racial injustices, even though a stated goal of the society was to strive for an inclusive community (**Table 2**). The statement, which was reviewed and edited by the member who first emailed the listserv, the SABER Diversity and Inclusion Committee, and the SABER Executive Committee, was then posted on the society website and sent to everyone on the society listserv.

Even though the statement promised specific commitment to raising awareness of issues of racism and taking antiracist actions, it was in many ways written from the point of view of a white majority organization with white majority perspectives. As such, the statement intentionally recommended resources focused on what white people could do for racial justice and how to unpack white privilege. While unintentional, the language of the statement subtly positioned the organization as distinct from the Black community (thereby erasing the presence of SABER members who identify as Black), by standing in solidarity with the Black community and committing for white individuals to learn about the struggles of students and colleagues from minoritized backgrounds. In addition to providing educational resources to the membership on issues of diversity and racism, it is important for SABER to center minority voices in ways that consider them as rightfully present with legitimized membership in the organization (Calabrese Barton and Tan, 2020). Because of the perceived timely need of producing a statement and the concern about silence being interpreted as lack of compassion, there was not enough time to solicit extensive feedback from a diversity of perspectives on the statement, which may have identified some of these problems beforehand. Nonetheless, this statement represents an important first step for the society to acknowledge its history and reckon with potential future actions. We share the imperfect nature of the SABER statement of solidarity not as an indictment of those who worked to show their support of minoritized individuals, but as a way to alert readers who care about issues of racism and social justice to the importance of including a variety of individuals with different perspectives when crafting a document meant to represent the stance of the entire membership of a society.

Notably, many other scientific societies, institutions of higher education, and private corporations also responded to the events surrounding the death of Mr. George Floyd by posting statements of solidarity with the Black community (Staff A. P., 2020; August et al., 2020; Bertuzzi and Patel, 2020; Staff E., 2020; Samuelson et al., 2020; Schloss et al., 2020). Some of these statements had similar issues as SABER's statement and others were critiqued for committing to efforts that were largely symbolic and short-term (Belay, 2020; Bumb, 2020; Weiser, 2020). However, the SABER membership saw their statement of solidarity not as the end of their pledge to address systemic racism and racial injustices, but as the first step. The remainder of this manuscript describes 11 additional steps that were taken to transform this pledge into actions to pave the way towards concrete changes in the society's practices, policies, and composition.

Action 2: Pressured Minnesota Financially to Stop Police Brutality

Professional societies can bring hundreds to thousands of people into a city, creating revenue for transportation, lodging, and restaurants. This financial influence can be used as an agent of change, as when organizations boycotted North Carolina when it enacted anti-transgender policies (Jenkins and Trotta, 2017). SABER held its annual meeting in Minneapolis for eight consecutive years, bringing thousands of visitors into Minneapolis. In an effort to exert a political impact by using its financial influence, SABER sent letters to the governor of Minnesota, the mayor of Minneapolis, the CEO and manager of the hotel where conference participants typically stay, the director of operations for the catering company that has supplied food for the conference dinners, the deli that had supplied lunches, and the chief of the Minneapolis police. The letter stated that SABER would stop meeting there if it did not see evidence of justice and changes in Minnesota law enforcement. An excerpt demands that:

"We need to see tangible evidence of action for justice for Mr. Floyd and of changes in Minnesota law enforcement. Such changes would include de-escalation training for police, firing of police who violate human rights, and implicit bias training for all government officials, police, and other public servants. These actions will allow its citizens of color to feel protected, not threatened, by police. We need to see the requests, needs and perspectives of your Black communities in Minneapolis and Minnesota honored."

The letters had three concrete demands: justice, to the extent it could be achieved, for Mr. George Floyd, changes in Minnesota law enforcement, and honoring the requests, needs, and perspectives of Black communities in Minnesota. We have included the complete letter that was sent to the governor in the **Supplementary Materials**.

SABER did not hear back from anyone who received the letters, so it is impossible to discern the letter's impact. That said, the society was part of a broader social movement to demand change in the Minneapolis Police Department. The society followed what happened concerning justice and reform in Minneapolis over the next year to see whether our demands were met. While justice for Mr. George Floyd can never be fully served, all four of the police officers involved in his death were fired and charged with either second-degree murder or aiding and abetting second-degree murder. Notably, police officer Derek Chauvin was found guilty of second-degree unintentional murder, third-degree murder, and second-degree manslaughter and sentenced to 22.5 years in prison. In terms of changes in Minnesota law enforcement, while initial protests in Minneapolis were often met with a seemingly violent police presence, the city of Minneapolis did invoke plans for police reform (Office of Police Conduct Review, 2021), which included new disciplinary processes and body worn camera policy changes, as well as requiring officers to use the lowest level of force to safely engage a suspect. However, there is concern about whether this reform is sufficient or meaningful. Much work still needs to be done in terms of honoring the requests, needs, and perspectives of Black communities in Minnesota and across the US. Black people continue to die at the hands of the Minneapolis police force (Hargarten et al., 2021), what reforms to enact remain contentious both overall and within the Black community (Janzer, 2021), and everything is occurring within a national framework that greatly limits police accountability (Carlisle, 2021).

Action 3: Organized How to Be an Antiracist Book Club to Foster Awareness

Professional societies can serve as sources of information for its members. The initial statement from SABER (action 1) indicated that SABER committed to becoming more knowledgeable about how biases contribute to racial injustices. The email conversations on whether the SABER conference should continue to meet in Minneapolis spurred two SABER members to organize and facilitate a virtual book club to discuss Dr. Ibram X. Kendi's book *How to Be an Antiracist* (Kendi, 2019) and how to consider its principles in our STEM teaching and research. The initial call resulted in 49% of the SABER membership (286 individuals) expressing interest in joining a virtual learning community. Twenty nine facilitators led different sections with a total of 191 participants. The two organizers met with facilitators across three separate meetings prior to the start of the book club to talk about the format and share sample discussion questions and facilitation tips (*see* **Supplementary Materials**). Each discussion group met three to five times during the summer of 2020. The organizers convened at the end of the summer with 13 of the 29 facilitators (others could not meet due to scheduling conflicts) and debriefed ways to improve this process and gauge interest in future book club discussions. Some groups continued to meet and discuss other books and media focused on racism (e.g., *Race after Technology*, Benjamin, 2019). Given the predominantly white membership of SABER, it is important to acknowledge the tendency for white communities to join book clubs when Black trauma occurs in lieu of taking actionable steps to address racism from a position of privilege (Johnson, 2020). For this reason, during discussions facilitators specifically asked participants to identify antiracist action-oriented goals they could implement at the individual to institutional levels. Actions articulated included: identifying specific changes to course content, facilitating workshops on inclusive teaching practices, attending conferences such as NCORE (National Conference on Race and Ethnicity), creating departmental antiracism working groups, advocating for more equitable admissions and hiring practices, applying for funding to support antiracist initiatives, and writing letters to administrators about creating more inclusive institutional environments. Due to the way it was organized, the book club helped increase awareness and focus conversations toward actionable change in the SABER community.

Action 4: Formed a Diversity and Inclusion Action Group on Place and Racial Justice

To immediately respond to the issues of race and social justice that arose during the email conversations resulting from the

murder of Mr. George Floyd, the Diversity and Inclusion Committee created the *Diversity and Inclusion Action Group on Place and Racial Justice* task force (**Table 1**) to focus on two goals. The first was to identify issues of "place" that create a sense of safety, or lack thereof, to members of SABER who identify as POC in consideration for future conference locations. The second was to assess actions that SABER and its members could take to promote awareness of and action surrounding racial justice.

This task force convened to develop concrete recommendations that would be conveyed at the SABER 2020 meeting that was happening within a month. A group of 25 people participated in a series of meetings and online discussions to try to address current challenges for POC in SABER. The group collectively brainstormed steps that could be enacted in the short-term (over the following weeks) and long-term (within the year) to begin addressing these issues. They generated seven ideas (**Figure 2**, actions 5–8 and 10–12) that the SABER community enacted and which are described below. The action group dissolved after the summer 2020 meeting because the intent was for it to be a temporary task force that would lead to more permanent SABER infrastructure to carry out the long-term actions.

Action 5: Advertised SABER 2020 Conference Broadly to Increase Representation of POC and Build Community During the Conference

With conferences forced to go online due to the COVID-19 pandemic, the annual SABER meeting was not held in Minneapolis and instead was delivered as a free virtual conference held every Friday in July 2020. Cost is a motivating factor for individuals who attend research conferences (Sarabipour et al., 2021). For this reason, the SABER leadership and the action group saw the virtual conference as a unique opportunity to promote inclusion by alleviating financial pressure. The free nature of the virtual conference might attract people who had never attended the SABER meeting, including participants from institutions that are not research-intensive (Sarabipour et al., 2021). Attracting new attendees from diverse types of institutions might in turn result in an increase in the representation of POC at the conference particularly because research-intensive institutions, which were currently overrepresented in the membership of SABER, tend to have less diversity in their faculty ranks (Vasquez Heilig et al., 2019).

The group identified a number of listservs and emails to contact about the 2020 SABER conference: American Society of Microbiology, Council for Undergraduate Research, National Institute on Scientific Teaching, CUREnet, CC BioINSITES, HHMI Inclusive Excellence Awardees, IRACDA, SACNAS, CCB FEST, SABER West, Sigma Xi, AAAS Community Board, and Research on STEM education (ROSE) Network (*See* **Supplementary Materials** for more information about these organizations). While some of these organizations are specifically for POC, others were leveraged by the social networks of people in the action group to try to broaden awareness of the conference. Additionally, SABER used social media to promote the conference, initiating the SABER Twitter and Instagram accounts.

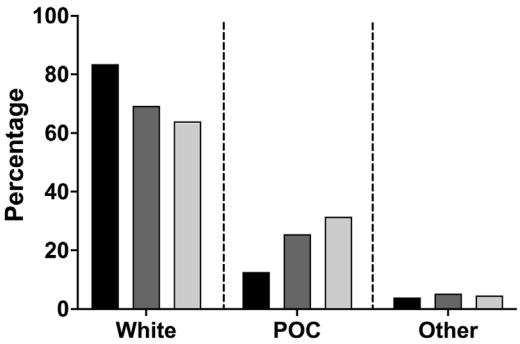

FIGURE 3 | Demographic composition of SABER 2020 conference attendees. Black bars represent individuals who had attended five or more SABER conferences as of 2020. Dark grey bars represent individuals who had attended two to four SABER conferences as of 2020. Light grey bars represent first-time SABER attendees.

As a result of these actions, the number of people who participated in SABER in 2020 was nearly double the number who participated in 2019. While we did not collect data on the racial and ethnic breakdown of SABER attendees prior to 2020, the percentage of POC who attended SABER in 2020 was 24.3% (307/1264) and in 2021 was 25.9% (174/673). Additionally, the fact that 24% of attendees in 2020 were POC is encouraging given the perception from the 2019 survey responses that POC attendance was much lower. The 2020 and 2021 rates of POC attendance could be explained by at least two alternative hypotheses: *1*) the number of POC who attended SABER increased from 2019 to 2021 in part due to some of the actions taken, or *2*) the 2019 perception that the percentage of POC in SABER was much lower than 24% did not match actual POC attendance. POC individuals can be "invisible" in professional situations, either because they physically pass for white and may not be perceived as POC, or because they are simply not seen as professionals (Morris and Washington, 2017; Settles et al., 2020). Thus, while it is possible that POC representation in SABER drastically increased from 2019 to 2021, we cannot discount the latter explanation without baseline demographic data. Notably, in 2020, 63.5% (803/1264) of SABER conference registrants were first time attendees and 27.4% of these first time attendees were POC compared to 18.9% of non-first timers (**Figure 3**). In 2021, 39.2% (264/673) of people were new attendees and 31.4% were POC compared to 22.3% of non-first timers (**Figure 3**). These numbers suggest that SABER has attracted a more diverse membership in recent years and supports the hypothesis that the number of POC who attended SABER increased from 2019 to 2021. Overall, the racial demographics of SABER are similar to those of other biology professional societies: a 2019 study of the APS membership conducted as part of the STEM Inclusion Study and a climate study conducted by the American Society for Microbiology (Cech and Waidzunas, 2019; ASM Diversity, 2020) indicated that 28% of respondents were Asian, Black or Latinx.

TABLE 3 | Major self-study findings from July 2020, including progress to date and future plans to address recommendations.

Major recommendations derived from self-study in July 2020	Progress made by July 2021	Future plans to be accomplished by July 2022
To increase access and representation		
• Increase advertising, maintain virtual aspects of SABER, and create travel awards to support underrepresented individuals • Ensure that there is representation in the conference speakers, including keynote speakers	• The Diversity and Inclusion Committee created and circulated a flyer for the 2021 SABER meeting to broaden attendance of POC • The keynote speaker committee consulted with the Diversity and Inclusion committee on the phrasing of the "call for committee members" in fall 2020 to encourage a diversity of people to express interest and join the committee • The two SABER 2021 keynote speakers were POC scholars who spoke on issues of racism and equity	• Establish a travel fund for POC who are first-time attendees to attend the annual meeting • Participate as an exhibitor at SACNAS and ABRCMS to advertise SABER at these organizations to increase participation from POC
Support and mentor POC to maintain them in SABER and to help them enter leadership roles in SABER	• Creation of the PEER Network (SABER's special interest group for POC - *see* Action 7 below) as a way to create community for POC SABER members. PEER Network members who were new to SABER received fee waivers for the 2021 virtual meeting • The Executive Committee recruited POC in SABER to run for elected office. Two elected officials to SABER's Executive Committee in 2021 were POC, including the President-elect • The Diversity and Inclusion committee leadership that was previously exclusively white was diversified to include POC	• Continue PEER Network community-building and networking activities • Begin advocacy efforts to further amplify POC voices in SABER
Consider a range of potential meeting locations beyond Minneapolis, specifically closer to regions with HBCUs or higher populations of POC and identify opportunities for outreach within local communities at any location	• Identified an additional location for the SABER annual meeting	• A survey was sent out to the SABER membership in the fall of 2021 on potential locations for the SABER 2022 conference • The Executive Committee will identify opportunities for outreach with local communities of color in a meeting location
To build community and belongingness		
• Host informal gatherings during the meeting • Offer affinity group space to interact at the meeting • Increase professional development activities	• SABER 2021 included a virtual game night and activities for graduate students and postdocs in training, affinity groups during the meeting, and SABER buddies, a mentoring program that pairs new attendees with senior SABER members	• Affinity groups will meet during the SABER conference at a designated time that does not conflict with other mentoring programs or events. Promoting affinity group meeting schedules will continue
• Provide people new to biology education research and/or SABER opportunities to meet people, get feedback, and build connections	• Poster presenters had an option of requesting a senior SABER member to attend their poster to get feedback on their project. 34 poster presenters opted into this program and 40 senior SABER members offered to attend their posters	• The mentoring program will transition from participation during the SABER meeting to year-round
To promote greater awareness of diversity and inclusion issues		
• Collect evaluation data related to diversity and inclusion and use these data to make decisions • Increase diversity literacy through programming, including speakers on research in diversity and inclusion	• Evaluation data were collected in 2020 and 2021 after the conferences • SABER hosted 15 virtual seminars throughout the 2020–2021 year focused on diversity and inclusion to help broaden awareness of these issues • The SABER West 2021 conference hosted a Diversity, Equity, and Inclusion Town Hall (Action 9) • The two SABER 2021 keynote speakers were POC scholars who spoke on issues of racism and equity	• Continue to collect evaluation data using a post-conference survey • Virtual seminar series on diversity and inclusion will continue in 2021–2022

Action 6: Conduct a Self-Study of Issues of Systemic Racism Within SABER With a Trained Facilitator

To better understand how SABER as a professional society could help support POC within SABER, the *Diversity and Inclusion Action Group on Place and Racial Justice* task force conducted a self-study of the organization and dedicated time during the 2020 annual meeting to help accomplish this objective. We were mindful of the positionality of the facilitator of the self-study during the selection process since we wanted someone who was external to the society and who had relevant personal experience. We therefore invited Dr. Kecia Thomas, a Black scholar who is an expert in the organizational experiences of minority groups and the psychology of workplace diversity, to facilitate this self-study. This self-study included: *1*) a pre-conference survey that asked participants to share their thoughts about SABER's strengths, weaknesses, and barriers for promoting diversity and inclusion, *2*) a presentation by the expert facilitator about the importance of diversity in professional organizations, *3*) engaging in affinity groups over two weeks to discuss questions related to diversity and inclusion, and *4*) having the facilitator convey the results of the self-study to SABER attendees. The pre-survey allowed individuals to anonymously share their thoughts and ideas with the facilitator, and the affinity group leaders summarized the discussions from their groups and shared these with the facilitator. The affinity groups included the following categories: POC, LGBTQ+ individuals, individuals with disabilities, religious individuals, women, community college faculty, primarily undergraduate institution faculty, postdoctoral scholars and graduate students, undergraduates, mentors for graduate students and postdoctoral scholars in biology education research, and an open group for anyone to join. The presentation by the facilitator was intended to broaden awareness about issues of diversity in an organization. It highlighted definitions of diversity and inclusion (Downey et al., 2015), diversity resistance in organizations (e.g., silence regarding inequities, diversity is too time consuming, discrediting ideas of individuals who are in the minority (Thomas, 2008; Segarra et al., 2020b)), implicit biases and reinforcing of negative racial stereotypes (Wheeler et al., 2001), privilege of majority identities, and the "otherness" of being in the minority.

After evaluating the pre-survey responses and the affinity group responses, particularly those from marginalized groups, the facilitator summarized the key findings. The three most prominent findings are listed in **Table 3**. Many of the recommendations were focused on increasing representation and supporting POC in SABER, building community and belongingness, and promoting greater awareness of diversity and inclusion. Notably, many of the recommendations aligned with ideas that the action group had already identified and was making progress on, but importantly these recommendations were derived from the broader SABER community. In **Table 3**, we also highlight how the SABER community is addressing these recommendations and what future plans are intended to be accomplished by July 2022. It is important to mention that conversations during the self-study and within the action group acknowledged that even when other locations were being considered as options for future SABER conferences, we had to bear in mind that systemic racism is nationally found. For this reason, the action group recommended focusing on identifying meaningful opportunities for outreach with local communities of color in future meeting locations (**Table 3**). For a copy of the pre-conference survey questions or the discussion questions in the affinity groups, *see* **Supplementary Materials**. For a video of the complete summary of the self-study results, *see* this link: https://saberbio.wildapricot.org/2020-July-24-Anti-Racism-Summary.

SABER attendees were surveyed after the 2020 meeting. On average, respondents said that they agreed with the statement, "I found SABER's 2020 national meeting to be equitable and inclusive." Some participants noted that SABER had done more specifically on diversity and inclusion within the society and at the conference, and many noted a positive shift from previous years. Many participants mentioned that they appreciated the work done by the racial justice action group, the self-study, the affinity groups, the buddy system for new attendees, and the online free and accessible format. Even though respondents noted that there was room for improvement in terms of the overall lack of diversity in SABER, they appreciated that it seemed like SABER was acknowledging this problem and making concrete actions to rectify it for future meetings.

Action 7: Establish a People of Color Special Interest Group Within SABER

During conversations within the *Diversity and Inclusion Action Group on Place and Racial Justice*, the idea emerged that building a community for SABER members who identify as POC would be an important early step in making the professional society more inclusive. This community would also help to address the overarching feeling of exclusion that many SABER members who identify as POC had voiced. Three members of this action group volunteered to lead the creation of the community. Since SABER already had in place special interest groups (SIGs) as a tool for individuals with similar interests and identities to connect (e.g., LGBTQ+ special interest group, Physiology special interest group), it made sense to use this existing framework to build a community for individuals who identify as POC. Initially, the group was termed the Black, Indigenous, People of Color (BIPOC) SIG. However, the SIG was eventually renamed the PEER Network after conversations between members revealed that the term PEER (Persons Excluded because of their Ethnicity or Race, (Asai, 2020)) better reflected the identity of individuals in the group (**Table 1**). The first meetings of this SIG coincided with the two self-study affinity group sessions during the July 2020 SABER meeting. More than 20 people met as part of this group during the conference. The general consensus after these meetings was that the SIG should be a community that met throughout the year and had an online space for PEER members to network, collaborate, and grow professionally.

After the July 2020 SABER meeting, the group leads designed and distributed a survey through the SABER email listserv to help

shape the direction of the SIG and to collect contact information for individuals interested in joining the group. The results of this survey showed that individuals were most interested in participating in: *1*) journal clubs on articles related to inclusiveness, diversity, and antiracist pedagogical practices, *2*) mentoring groups, *3*) social check-in meetings, and *4*) regular meetings to discuss topics of importance to PEERs. Other priorities mentioned in the survey were increasing the visibility of PEERs within SABER, building research collaborations, mental health resources, fundraising, and the creation of a PEER SIG listserv. During this time, we received several emails from individuals asking to join the SIG who do not identify as PEERs but who wanted to be involved in advancing the role of PEERs in SABER. Since, as a group, the members of the network wanted to make it an inclusive space, we decided to leave it open to allies who are not PEERs, and we publicized this in emails to the SABER listserv and during PEER SIG meetings. The PEER Network met as a group twice in the fall of 2020. These initial meetings led to the creation of six subgroups: *1*) Happy hour, *2*) Journal club, *3*) Mentoring (modeled after the SABER-wide "SABER Buddies" program), *4*) Safe space (this is the only subgroup that is restricted to individuals who identify as PEERs), *5*) Website, and *6*) Writing buddies.

Another top priority was to establish an online presence within SABER to enhance the visibility of PEERs, attract new members, and facilitate collaborations. To accomplish this, we solicited and found a volunteer to build a webpage for the PEER Network. The webpage (https://saberbio.wildapricot.org/PEER-Network) contains a description of the goals of the group as well as its mission. In addition, it contains an announcement section, information on the subgroups, a community discussion forum, and contact information for joining the PEER Network and the subgroups. The design and content for the webpage was refined using member feedback.

An early challenge we encountered was how to publicize the existence of the PEER Network within SABER to reach out to members who did not know of its existence. One of the SIG leads advocated to the SABER leadership for society-wide announcements to be made during the 2021 annual meeting, and we designed a slide that members could share at the end of their talks to provide information on the network. We plan to conduct a roundtable discussion on the PEER Network during future SABER meetings to continue to internally publicize the existence of this SIG. An area in which we have not made as much progress as we anticipated is in establishing research collaborations within members of the network. Moving forward, we are considering creating a research mentorship program and establishing research working groups following successful models that are focused on inclusion and equity (Pelaez et al., 2018; Reinholz and Andrews, 2019; Campbell-Montalvo et al., 2020).

Currently, the PEER Network SABER SIG has 105 members out of 582 SABER members (18% of the SABER membership). These numbers provide evidence for the tremendous need for community among SABER POC members. The creation of this group has provided fertile ground for important discussions related to diversity and inclusion within SABER. Our meetings have offered a way for individuals who identify as PEERs to connect and share their experiences. Perhaps most importantly, the creation of this SIG gave PEERs a collective voice within SABER that was previously unavailable. During the summer of 2021, two members of the PEER Network were elected to the offices of President-elect and Secretary of SABER. During our most recent meetings, discussions organically arose about how to further amplify PEER voices by beginning advocacy efforts in SABER.

Action 8: Initiated Sense of Place Committee to Discuss the Physical Location of the Conference

The impetus for the formation of the *Diversity and Inclusion Action Group on Place and Racial Justice* task force was the discussion about where to hold the annual conference and whether it should be held in Minneapolis. For this reason, a sub-committee of the task force was the Sense of Place Committee (**Table 1**), which intentionally included POC, Minneapolis residents, and individuals at different career stages from different types of institutions. The final committee was composed of 16 people and met in three rounds in July 2020 to discuss issues related to the physical location of the SABER conference and Minneapolis specifically. Representatives from the committee shared their advice with the SABER community at the last session of the 2020 SABER conference.

Although the original intent was to discuss how to choose a physical conference location in a way that would honor SABER POC, the conversation broadened with the realization that every major city in the US has racial tensions and systemic racial inequities. The committee did weigh the impacts of registration and travel costs, the logistical challenges of moving to a new location, and previous incidents of racial violence in certain places. However, the discussion expanded to focus on how the SABER community could engage in a more meaningful way with local communities of color, including Minority-Serving Institutions (MSIs), Tribal Colleges and Universities (TCUs), and Historically Black Colleges and Universities (HBCUs). Notably, the committee did not recommend against going back to Minneapolis, as long as progress was made towards racial justice and police reform that reflected the demands stated in the letter we sent to the city (*see* action 2). There was broad support for keeping a part of the meeting virtual, instituting travel scholarships for POC, and intentionally partnering with local communities of color. This could include speakers addressing local issues of social justice relating to education, being thoughtful about who we are financially supporting (e.g., Black-owned catering companies), and engaging explicitly with local Students of Color through fee waivers and special sessions.

Action 9: Hosted a Town hall on Inclusion at SABER West 2021

Beginning in 2017, the University of California, Irvine has been home to SABER West, an annual regional conference aimed at

providing faculty, staff, and students who seek to improve biology education and conduct education research with an opportunity to engage with the SABER community. While built upon SABER's focus on biology education research, SABER West has been dedicated to increasing diversity and inclusion by fostering the professional development of biology researchers and educators from community college and other non-research-intensive institutions, a population that is underrepresented at education research conferences. This goal is made explicit by a unique meeting format that includes workshops to promote the development of attendees' research skills and assist with the implementation of evidence-based teaching practices, as well as multiple sessions to foster collaborative research or pedagogical connections between 2-and 4-year affiliates.

The exacerbation of existing inequities by the pandemic and the national call for higher education to re-evaluate its anti-Black and anti-POC policies after Mr. George Floyd's death led SABER West organizers to reiterate the need to make diversity, equity, and inclusion in conference spaces a priority. In response, the conference organizers met consistently to reflect on these priorities and to assess whether we, as a field, were critical of our own roles in perpetuating inequality and inequity, especially centered on race and ethnicity.

To start to address the need for actions to increase diversity and inclusion in the SABER West conference, as well as to begin an open dialogue on these issues, the online SABER West 2021 conference convened a panel of diverse individuals for a virtual Town Hall aimed at identifying challenges and practices that result in marginalizing conference spaces. This Town Hall happened in place of a traditional keynote address. Panelists gathered participant insights into the climate of STEM education conferences through a pre-conference survey. This survey asked about participants' general thoughts on STEM education conferences, motivations and barriers for attendance, and how the conference organization, programming, and structures impact climate (Mair and Thompson, 2009; Mair et al., 2018; Garcia et al., 2019).

During the Town Hall, panelists identified and presented the themes that arose from the survey responses: *1*) Monetary and physical barriers to conference attendance that can be marginalizing for individuals with families or those who work at institutions with less professional development support, *2*) First- or second-hand experience with discriminatory behavior at STEM education conferences, resulting in unwelcoming climates, *3*) Physical spaces or programming that has not been designed with individuals with disabilities in mind, and *4*) A lack of representation and inclusion of individuals and researchers from 2-year colleges, HBCUs, and Tribal Colleges, resulting in reinforcement of academic hierarchies where participants from 4-year research-intensive institutions often comprise the overwhelming majority of conference attendees. These themes highlight participants' perceptions of the different barriers to inclusion that can be present in conference spaces.

Panelists viewed their contributions to the Town Hall as giving a voice to and elevating the experiences of those who have been marginalized in these conference spaces. This event was envisioned as a starting point to characterize the current participant experience of STEM education conferences and provide information for SABER West organizers, SABER as a whole, and the broader STEM education research community, to develop ways to create more inclusive conference space.

Action 10: Increase the Diversity of Keynote Addresses for the SABER 2021 Conference

The majority of invited keynote speakers throughout the history of SABER including the 2020 conference have been white, even when their talks have addressed racial justice. The visibility of invited speakers can send implicit messages about the culture of an organization, and who should be listened to (Tulshyan, 2019; Hagan et al., 2020). The demographic composition of speakers at conferences can also affect the self-efficacy of participants by modeling what a successful researcher looks like and which producers of knowledge are viewed as legitimate (Hagan et al., 2020; Settles et al., 2020). A survey of the SABER community conducted by the Keynote Speaker Committee (**Table 1**) in 2019 indicated a clear interest in inviting a scholar for the 2020 annual SABER conference to talk about their research around issues of equity, inclusion, and racism, with implications for our own instructional practice. At the SABER 2020 conference, Dr. Elizabeth Canning shared her work on social-psychological interventions to support historically and currently marginalized students. The Keynote Speaker Committee developed a community survey to get an input about SABER community preferences for the 2021 keynote speaker. This committee intentionally conferred with the Diversity and Inclusion Committee on the content and wording of the survey to make the survey as inclusive as possible. Feedback from both the 2020 conference and the community survey for the 2021 SABER conference indicated a sustained interest in learning from scholars in the area of equity, inclusion, and racism and a recommendation to invite a POC as the keynote speaker. This specific action was addressed by the Keynote Speaker Committee; in 2021, the two invited key speakers included a Black woman, Dr. Saundra McGuire, who spoke about her research on metacognitive strategies for increasing STEM student success, with an anti-deficit lens on improving equity in the classroom, and a South Asian man, Dr. Niral Shah, who spoke about his research using poststructuralist frameworks to understand how racism affects the STEM learning experiences of students from minoritized groups.

Action 11: Provide Travel Scholarships for People of Color to Attend SABER 2021

Given that cost is often a motivating factor for attending a research conference (Segarra et al., 2020b), the action group recommended increasing representation of POC at SABER by offering funding to defray the cost of conference attendance to first-time conference attendees. This was also highlighted in the post-conference survey responses in 2019 and findings from the 2020 SABER self-study. Since SABER 2021 was online again due to COVID-19, the only

TABLE 4 | Summary of talk titles, speakers, and live attendance for the SABER virtual inclusion seminar series.

Title	Format of presentation	Speaker	Live attendance
Fall series: A call to action: Striving for racial justice in academic biology			
Race REALLY matters	Discussion	David Asai, Howard Hughes Medical Institute (HHMI)	964
Actionable steps toward equity in STEM	Discussion	Starlette Sharp, Penn State University John Matsui, UC Berkeley	712
Lessons from a hot spring: Authentic transformation in the higher education classroom	Discussion	Bryan Dewsbury, University of Rhode Island	444
Language Matters: Considering racial microaggressions in science	Discussion	Colin Harrison, Georgia Tech	722
But is it really "just" science? Engaging critical race theory to unpack racial oppression with implications for Black student science engagement	Research talk	Terrell Morton, University of Missouri	699
Black women and belongingness: An interrogation of STEM education as a white, patriarchal space	Research talk	Nicole Joseph, Vanderbilt University Luis Leyva, Vanderbilt University	391
An exploratory investigation of the experiences of Black immigrant women in undergraduate STEM	Research talk	Meseret Hailu, Arizona State University Brooke Coley, Arizona State University	250
Spring series: A call to action: Striving towards inclusion in academic biology			
Interrogating the center of STEM education	Discussion	Cynthia Bauerle, James Madison University	345
Addressing students' basic needs with a culture of caring during the pandemic	Research talk	Sara Goldrick-Rab, Temple University	257
Structural racism, institutional transformation, and diversifying the STEM faculty	Research talk	Kimberly Griffin, University of Maryland	352
The influence of kindness and community in broadening participation	Research talk	Mica Estrada, UC San Francisco	279
Systemic disadvantages for LGBTQ professionals in STEM	Research talk	Erin Cech, University of Michigan	346
Land of milk and "honey": Confronting gendered experiences in field research	Research talk	Katie Hinde, Arizona State University	330
Nature-culture relations and engaging multiple ways of knowing	Research talk	Megan Bang, Northwestern University	318
Beyond information: Walking the path of truth, reconciliation, and liberation to make academic biology more inclusive	Discussion	Mays Imad, Pima Community College	222

cost was registration. SABER offered registration fee waivers to individuals in the PEER Network who had not attended SABER previously. Additionally, the ROSE network offered waivers to attendees, with an emphasis on individuals who identified as POC, first-time attendees, community college faculty, and people from primarily undergraduate institutions. While we have not yet implemented a specific travel funding mechanism to increase POC attendance at the SABER national meeting, we have plans to establish a permanent travel award program for POC who are first-time SABER attendees.

Action 12: Host a Year-Long Virtual Seminar Series to Broaden Awareness of Issues Related to Systemic Racism in Academic Biology

To help promote awareness of issues of systemic racism, SABER hosted a year-long seminar series focused on making academic biology more inclusive, with the fall term speakers specifically focused on racial justice (**Table 4**). Importantly, the speakers were experts and scholars in issues around diversity, equity, and inclusion; the speakers were intentionally not scholars of color working in other areas of research, thus avoiding the common and taxing assumption that all people of color are experts in research about inclusion (Applewhite, 2021). The intended audience for the seminar series were biologists and biology educators. To broaden the reach of the series, SABER members at 42 different institutions advertised the series to their biology departments. The series was highly attended and attendance ranged from 222 to 964 people. All talks were recorded and posted on the SABER website for later viewing (at https://saberbio.wildapricot.org/Diversity_Inclusion).

All speakers in the fall 2020 series were POC, and all speakers in the spring 2021 series were women or genderqueer. The focus of the fall seminar series was on building awareness of issues related to racial injustices, particularly experienced by Black individuals, and the spring series broadened the scope to include inequities faced by LGBTQ+ individuals, low-income students, Indigenous students, and women. It was especially important to broaden the types of inequity discussed in the spring 2021 series because the effect of oppression can be amplified in individuals who identify with multiple marginalized identities (Crenshaw, 1991). Some of the seminars were general discussions on topics that academic biologists may not be familiar with but ought to be aware of, including examples of systemic racism, how supposedly neutral language used to describe individuals can be offensive, and how racial microaggressions can create unwelcome and threatening situations in academic settings. The majority of the seminars were research presentations highlighting qualitative and quantitative data that demonstrated inequities in academic environments, and

most of the work was done through the lens of critical frameworks. Notably, all of the research presenters were outside the SABER network of biology education researchers: we intentionally brought in new ideas and perspectives by identifying scholars outside of SABER who were working on issues related to diversity and inclusion. Most of the speakers were trained in sociology, psychology, and schools of education (as opposed to discipline-based education research), so they brought a different lens and scholarly focus to this work and to the SABER community.

Several institutions hosted their own local discussion groups to debrief the talks and consider how they could incorporate the ideas at their institution. Some of these have led to the formation of equity and inclusion committees or diversity, equity, and inclusion proposals to higher levels of administration. The series was so well-attended that SABER will continue to hold the series in the 2021–2022 academic year with an additional six talks focused on inclusion.

DISCUSSION

These actions are just the first steps for SABER to grapple with systemic racism and were not intended, nor expected, to fully make the society antiracist. We acknowledge that organizational change takes time and coordinated effort. Further, we know that it is easy to revert to what is comfortable or familiar, which can make change temporary if it is not accompanied by structural changes to ensure diversity, equity, and inclusion. SABER is not unique in the challenges it faces in terms of equity and inclusion: other biology professional societies, which are older and more established than SABER, also face similar issues. For example, a report published by ASM's Diversity, Equity and Inclusion Task Force noted that, while the society has demonstrated a commitment to diversity through initiatives like graduate fellowships to students of color, outreach activities to bring attention to issues of social justice and racism, and providing its staff with antiracism and anti-discrimination training, there remains a lack of diversity in leadership positions, and a significant proportion of ASM POC members feel that they do not have a voice within the society (ASM Diversity, 2020). Black and Latinx members of American Physical Society reported feeling marginalized in the workplace more often than other groups (Cech and Waidzunas, 2019).

Several practices can promote long-term and sustained changes to increase diversity, equity and inclusion: *1*) centering voices from individuals who are underrepresented so they can help guide the direction, mission and vision of the organization, *2*) supporting efforts to promote diverse representation in leadership positions, *3*) mentoring programs to retain underrepresented individuals within the organization, and *4*) reaching a critical mass of individuals from diverse backgrounds within the organization (Allen-Ramdial and Campbell, 2014; Morris and Washington, 2017; Piggott and Cariaga-Lo, 2019; Segarra et al., 2020b; Madzima and MacIntosh, 2021). The 12 actions described in this article have initiated the process of long-term change by taking steps towards giving a voice to POC (through the creation of the PEER Network SIG, diversification of keynote speakers at the SABER annual meeting, and the creation of a seminar series focused on inclusion with speakers from marginalized identities), increasing diversity in the leadership of SABER, establishing mentoring programs for new and POC SABER members, expanding the networks through which the SABER conference is advertised, and providing financial support to POC to attend the SABER conference. To continue this process, we hope to enact the following measures: *1*) expand current efforts to establish a welcoming environment for POC through mentoring programs and opportunities to network and socialize (Madzima and MacIntosh, 2021), *2*) increase fundraising efforts to augment the financial capacity of SABER to provide support to members of groups underrepresented in the society (e.g., conference registration waivers, travel funds), *3*) continue and expand current efforts to reach new constituencies of individuals who might benefit from joining SABER, and *4*) examine all aspects of the SABER organization and conference through a diversity lens to ensure it is inclusive, equitable, and a welcoming environment for all members (Ali et al., 2021). We are interested in increasing POC representation within the SABER community and bringing our resources and scholarship to reimagine education as an equitable, antiracist experience. To this end, in the future the society might address this goal by initiatives including, but not limited to: *1*) the incorporation of special sessions on classic liberatory education frameworks within the annual SABER meeting to learn from other cross-disciplinary scholars engaging in education and equity work (e.g., Gay, 2002; Giroux, 2010; Givens, 2021) and *2*) SABER-sponsored programs that work *with* educators on social justice pedagogy at the postsecondary and secondary level, perhaps following the model for professional development developed by SABER West. The second of these would be crucial in developing a pathway and culture of inclusive discipline-based education research long before these careers are chosen at the graduate level.

We acknowledge that there is not a "one size fits all" approach to the journey of a professional society towards being more inclusive and equitable, and that change should be driven by the specific needs and challenges of a particular group of individuals. For this reason, we envision that SABER as a society should: *1*) continue the reflections and conversations that began in earnest during the 2020 self-study, *2*) continue to collect demographic data to investigate existing inequities and to make informed decisions about better supporting individuals from minoritized identities who are members of SABER, and *3*) keep communication open through forums and surveys that both give a voice to all members and serve to "check in" on the success (or lack thereof) of initiatives geared to increase inclusion and diversity (Cech and Waidzunas, 2019; ASM Diversity, 2020; Segarra et al., 2020b; Madzima and MacIntosh, 2021). As a society, we are making steady progress towards these goals: *1*) the Executive Committee is planning to facilitate the attendance of POC

faculty and faculty at MSIs, TCUs, and HBCUs at the 2022 SABER conference through awards that include funding for travel and a registration waiver. Beyond attracting a more diverse set of participants to the SABER conference, we are planning inclusive ways to support these individuals by making them an integral part of the conference activities through the PEER Network and the mentoring buddy system; *2*) the Diversity and Inclusion Committee and the PEER Network SIG will annually survey the SABER membership and the members of the SIG, respectively, to collect data on existing inequities and the success of current initiatives and to inform future actions; *3*) we will continue to collect demographic data society-wide through an annual SABER survey, and *4*) the Diversity and Inclusion Committee is reaching out to past POC SABER participants to inquire about reasons they have not returned to SABER conferences, in an effort to identify barriers to participation.

Several climate reports and reflections by STEM professional societies have proposed the following recommendations to increase diversity and inclusion: *1*) establishing and fostering open communication with members from minoritized groups, *2*) providing greater and continued support and agency to POC individuals to not only retain them within the society, but to build a welcoming environment that these members see as valuable to them, *3*) promoting greater diversity in positions of leadership reflective of the racial and ethnic composition of the society, *4*) conducting yearly surveys of the membership to track the progress made towards inclusion and diversity, *5*) engaging in outreach activities to support diversity on a wider scale, and *6*) integrating programming on diversity and inclusion in conferences (Cech and Waidzunas, 2019; Segarra et al., 2020a; ASM Diversity, 2020; Bell, 2020; Segarra et al., 2020b; Womack et al., 2020; Ali et al., 2021; Madzima and MacIntosh, 2021). The findings and recommendations of these climate surveys largely mirror the initial efforts to increase inclusion by SABER as well as those activities planned to sustain the initial work. There is one notable difference: the actions described in this manuscript arose organically through the work of many SABER members, and were not the product of a small group of people. The grassroots movement that began with the horrific death of a man at the hands of a police officer galvanized the membership of SABER and catalyzed change in our group within the span of a year. It is essential for scientific societies to identify ways in which they have neglected their POC members before taking action to rectify issues of inclusion and racism (Ali et al., 2021). Recognizing with humility our shortcomings but utilizing the urgency of this event to propel change, we as a professional society know we are not alone in this endeavor as institutions across the nation and globally have also been seeking more profound steps toward lasting change. We hope that the process of open communication, iterative changes to organizational policy and initiatives, and a data-based approach to examining the success of SABER's actions will allow the organization to keep equity as not only a core value but also a lived philosophy.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Materials**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

SR and MS-T conceived of the design of the manuscript. All authors participated in the writing of and editing of the manuscript. SR & MS-T - lead for PEER • BD sent the initial email, gave a talk in the series, co-organized book club on how to be an antiracist • SML is the current President of SABER and contributed to the Sense of Place committee and the SABER West town hall (second author) Alphabetical: • EB - posted solidarity statement, letters, and other D&I content on SABER website • LB-J - active D&I committee member • RB - served as a facilitator for the 2020 SABER book club *How to Be an Antiracist* • SB - helped lead the action group and the seminar series • NC - led sense of place committee, led initial creation of PEER • RD - participated in sense of place committee, member of mentoring committee 2019–2020, host of SABER game nights 2020 & 2021 • SE - initiated the letters to the governor • MG-O - active D&I committee member • SG - led keynote committee and made sure to incorporate recommendations from action group • LG - D&I committee active member • LH - headed up mentoring committee.

FUNDING

We would like to thank Arizona State University's HHMI Inclusive Excellence Award, Arizona State University's Research for Inclusive STEM Education (RISE) Center, University of California Santa Barbara, SEISMIC collaboration, and Community College (CC) BioINSITES for funding the seminar series, as well as all of the speakers, people who introduced the speakers, hosts at institutions who helped to advertise the series, and all of the attendees. Finally, we are grateful for the financial support of SABER and the ROSE network grant (National Science Foundation Research Coordination Networks in Undergraduate Biology Education Grant No. 1826988 to SR) to help support fee waivers and National Science Foundation Grant No. 2109356 to SML and JKK to support some of the seminar speakers and future initiatives.

ACKNOWLEDGMENTS

These actions would not have been possible without some funding and substantial time and effort by dedicated volunteers. We are grateful to so many people in the SABER community who have spent countless hours – and continue to do so – to try to make SABER more inclusive. Special thanks go out to the volunteers of the action group, the volunteer facilitators for the affinity groups, the members of Sense of Place Committee, the members of the Diversity and Inclusion Committee, the members of the Keynote Speaker

Committee, the members of the Mentoring Committee, and the members of the Executive Committee whose leadership allowed us to make immediate changes, alter the programming of the summer conference, and fund the self-study out of SABER's budget. We appreciate all of the people who participated in the self-study, including those who completed surveys, attended an affinity group, or watched the presentation on diversity. We are grateful to the people who volunteered to facilitate the book club discussions and appreciate the people within the SABER community who attended the discussions.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.780401/full#supplementary-material

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frontiers in Education

ORIGINAL RESEARCH
published: 25 January 2022
doi: 10.3389/feduc.2021.755471

The Influence of Professional Engineering Organizations on Women and Underrepresented Minority Students' Fit

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OPEN ACCESS

Edited by:
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Reviewed by:
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University of Colorado Boulder, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: 09 August 2021
Accepted: 29 November 2021
Published: 25 January 2022

Citation:
Campbell-Montalvo R, Kersaint G, Smith CAS, Puccia E, Sidorova O, Cooke H, Wao H, Martin JP, Skvoretz J, MacDonald G and Lee R (2022) The Influence of Professional Engineering Organizations on Women and Underrepresented Minority Students' Fit. Front. Educ. 6:755471. doi: 10.3389/feduc.2021.755471

Our work focuses on women and underrepresented minority (URM) students' cultural models of engineering success (CMES) or beliefs about doing well in engineering. Because of its consequential effect on persistence, we pay special attention to the fit domain of CMES—student feelings of belonging in their engineering program. We examine 1) how student fit is affected by participatory social capital (i.e., participation in professional engineering organizations [PEOs] that have as part of their mission a goal to assist students in their STEM education and careers), as well as 2) the factors that affect students' decisions to participate in PEOs. Due to the traditional prioritization of majority norms in engineering programs, women and URM students' CMES may conflict with the cultures manifested in engineering departments. Analysis of interviews with 55 women and URM engineering students shows that PEOs, particularly gender- and race-focused PEOs, affect students' feelings of fit. PEOs affect student fit positively and primarily through expressive social capital—emotional support wherein students feel they fit in because PEOs provide a sense of community and opportunities to be around successful women and URM engineers. PEOs also allow students to build instrumental social capital, such as academic and professional skills, including networking and knowledge development. Encouragement from others and their desire to be around people like themselves played a central role in students joining PEOs. However, students identified time, financial, and fit issues that discouraged them from participating in PEOs. This investigation illuminates how socially distant others from PEOs affect student fit, extending previous work which uncovered how more proximal others affect fit as well as previous work finding that URM students participating in PEOs were more likely to persist in their engineering program. Research, theory, and practice applications are presented.

Keywords: social capital, belonging, STEM-Science Technology Engineering Mathematics, women, black students

INTRODUCTION

For the last half-century, researchers have investigated differential declaration and persistence rates in STEM majors across groups, including gender and racial/ethnic groupings. During this period, studies tended to locate differences in STEM declaration and persistence within an individual's characteristics, such as their interest or ability (e.g., Goldrick-Rab, 2006; Faulkner, 2009; Cech et al., 2011). In addition, many of these studies used the pipeline model, which focused on how individuals and groups moved through education into careers (Metcalf, 2010). More recently, scholars have found that individual variables, such as aptitude and interest, do not alone account for STEM declaration and persistence (Acker and Feuerverger, 1996; Seymour, 1999; Margolis, et al., 2000; Summers and Hrabowski, 2006; Sax, 2008; Hill, et al., 2010; Shapiro and Sax, 2011). Therefore, researchers who aim to explain STEM persistence have shifted their focus by adopting structural explanations that take into account broader social forces, such as discrimination, economic inequality, and the limited representation of women and underrepresented racial minority (URM) students in the STEM curriculum, to explain the lower proportions of women and URM engineering students and workers (McGee, 2020; Campbell-Montalvo et al., 2021). For instance, student participants in the landmark Seymour and Hewitt (1997) study cited disappointment with the culture of the field or reduced confidence as reasons for leaving STEM. Weston (2019) bolstered Seymour and Hewitt (1997) and found that lack of fitting in socially due to program structure or difficulty finding assistance to address problems were reasons students decided to leave STEM. Thus, the structure of university and department program culture, including STEM norms, has been shown to be a factor in retaining students.

We posited that there may be structural incongruities between the understandings of women and URM students about how to do well in engineering and institutional norms manifested in engineering department culture (Smith et al., 2015). Students' understanding of how to do well in engineering, dubbed Cultural Models of Engineering Success (CMES), includes student understanding of how they fit in their engineering program (Smith et al., 2015). Traditionally, engineering program norms prioritize the experiences of dominant groups, which impacts the ability of engineering departments to attract and retain a diversity of students (Goldrick-Rab, 2006; McGee, 2020).

Echoing Weston (2019) that highlights the importance of assisting students in addressing problems encountered in their STEM degree programs, other research reveals that students linked their disappointment with STEM majors to a lack of advice received from specific influential people in their degree programs, such as engineering professors (Nyquist et al., 1999; Marra et al., 2012) and advisors (Prieto et al., 2009; Sutton and Sankar, 2011; Schmidt, et al., 2012). Social network analysis allows researchers to map relationships between students and such influential people. In such cases, students are referred to as the "ego" and comprise a focal point, while the influential people to whom student relationships are mapped are known as the "alters" (Burt, 1982; Lin, 1999; Son and Lin, 2012; Tulin et al., 2018). Students, including Black women in mathematics fields (Brown and Josephs, 1999; Morganson et al., 2010; Borum and Walker, 2011; Evans et al., 2011; Joseph et al., 2017; Leyva et al., 2021), who have access to homophilous alters (i.e., same-gender alters, same-race alters) receive culturally sustaining guidance when they experience obstacles and affirmation, which aids their persistence in the often unwelcoming STEM climate (Campbell-Montalvo et al., 2021). Studies that examine the intersection of STEM department culture, women and URM student values, and social capital from alters who can help mitigate dissonance between department culture and women and URM student values offer insight into the structural factors shaping engineering persistence. Our research shows that women and URM students benefit from access to resources and advice from alters in students' social networks (i.e., network-based social capital), as well as alters in the organizations in which they participate (i.e., participatory social capital) (Skvoretz et al., 2020; Campbell-Montalvo et al., 2021; Puccia et al., 2021; Smith et al., 2021). For example, Puccia et al. (2021) identified the role network-based social capital garnered from parents' advice played in students' declaration and persistence in their engineering majors. Parental advice included statements indicating their belief that their child could graduate with their engineering degree or encouraging them to persist even when their program became difficult. Likewise, Campbell-Montalvo et al. (2021) found that students' feelings of fit in engineering, especially Black students' feelings of fit, improved as they received advice from people in their social networks, including parents, high school teachers, and other alters. In such cases, alters explicitly warned students that others in engineering would negatively prejudge them because of their gender and/or race. Students who received such warnings were better able to negotiate fit when they experienced microaggressions and/or felt excluded. Similarly, based on interviews with 38 Black and Latinx engineering students, Johnson showed that ties that Black and Latinx students make with engineering peers of color "helped offset the psychosocial burden of ethnoracial marginalization experienced on a predominantly white campus and provided important academic support" (2018, p. 15). Collectively, these studies suggest that homophilous alters help students identify processes of marginalization, which in turn, helps students resist them (Secules et al., 2018).

Participatory social capital refers to advice from people students meet by participating in STEM professional societies, such as Professional Engineering Organizations (PEOs), including those that are gender-focused (i.e., Society of Women Engineers [SWE]) or race/ethnicity-focused (i.e., National Society of Black Engineers [NSBE] or the Society for Hispanic Professional Engineers [SHPE]). Researchers have reported the value of PEOs to women and URM students, highlighting the role that participation in PEOs plays in reducing their feelings of isolation due to being numerical minorities (Espinosa, 2011; Ong et al., 2018; Campbell-Montalvo et al., 2021; Smith et al., 2021), and increasing URM students' persistence in their program (Smith et al., 2021). In our previous work, we analyzed two rounds of survey responses from ~2,186 engineering students, in which half of the participants

engaged in PEOs (Smith et al., 2021). We found that Black and Latinx students who participated in race/ethnicity-focused PEOs (such as NSBE or SHPE) were more likely to persist in their engineering program (i.e., still be enrolled) in their second year than Black and Latinx students who did not participate in such organizations. Similarly, in a previous study using interviews with 44 diverse engineering juniors and seniors, the majority of women and URM students believed that their connections through their memberships in professional societies contributed to their persistence by providing resources such as free tutoring and information about professors' teaching and exam styles (Borman, et al., 2010; Chanderbhan-Forde et al., 2012). The documented impacts of participatory social capital are relevant to informing research and structural approaches aimed at broadening participation in STEM, particularly for Black engineering students who, when compared to women and Latinx students, had the highest rates of involvement in gender- or race/ethnicity-focused PEOs (Smith et al., 2021) and who experience some of the worst STEM department climates (Campbell-Montalvo et al., 2021).

At this juncture, what remains unclear is how PEOs promote student persistence in STEM by reducing isolation or developing students' sense of fit, and whether PEOs mainly do so through the same mechanisms as network-based social capital (i.e., warnings of discrimination) similarly across groups. Thus, the goals of the present study are to elucidate the mechanisms through which PEOs and engineering persistence are related, including the effect of PEOs on student CMES (particularly fit) across groups, and investigate the factors that encourage or dissuade students from joining PEOs. We draw on interview data from 55 women and URM engineering undergraduate students to answer the following research questions:

(1) Across groups, how does participating in PEOs affect students' CMES?
(2) What factors affect students' decisions to join or not to join PEOs?

We aim to extend research at the nexus of STEM persistence, professional STEM societies, social capital, and fit/sense of belonging by investigating the development of fit through participatory social capital. Insights from this study can be used by universities and STEM professional societies to develop intersectional interventions and extend their efforts (both in student chapters and the parent organizations), offer encouragement and justification for participating in these societies, and support efforts to reduce obstacles to participation to help students take advantage of documented benefits of joining PEOs.

Theoretical Perspective: CMES (Fit) and Social Capital

By examining the patterned ways in which PEOs affect students' feelings of fit based on the ways students negotiate the engineering department's culture with the values they bring, we situate our work within 1) the fit domain of CMES, a particular type of cultural model of education (Smith et al., 2015), and 2) social capital theory (Lin, 2001), specifically participatory social capital as described in Skvoretz et al. (2020). Cultural models are how people structure their cognitions about their life experiences in particular areas, such as gender or education (D'Andrade, 1995; Shore, 1996). Cultural models are different from regular knowledge because they are (to an extent) shared among groups and can differ between gender and racial/ethnic groups (Holland and Eisenhart, 1990; Mukhopadhyay, 2004; Fryberg and Markus, 2007; Fryberg et al., 2013). Broader society and particular people with whom an individual comes in contact, such as family members and teachers, shape individuals' cultural models. Cultural models are internalized and mediate how individuals interact with others (Strauss and Quinn, 1997). CMES includes the groups of assumptions and ideologies people have about how individuals in schools interact and should behave (Fryberg and Markus, 2007; Fryberg et al., 2013). Specifically, CMES relate to how students understand engineering education and the people involved in the schooling process, including their understandings about how to be a successful student, how relationships between instructors and students function, and the role of education in personal development (Fryberg and Markus, 2007; Fryberg et al., 2013; Smith et al., 2015).

The CMES domain of "fit" is of particular interest as a potential influencer of engineering persistence. Fit refers to a person's sense of belonging, including feelings of inclusion or welcome (Campbell-Montalvo et al., 2021). Such feelings may vary in engineering contexts, such as the lab or the classroom (McGee, 2020). We conceptualize fit as a structural outcome experienced by students who feel welcomed or like they belong based on their STEM department or program culture. Fit is affected by the environment cultivated by a STEM department's policies and actions, patterns in social relations (e.g., microaggressions), and identities (e.g., the underrepresentation of women and people of color among engineering faculty). However, fit is not considered an individual characteristic rooted in a student's abilities to match "correct" norms and values. Instead, feelings of fit are a consequence of how well universities and engineering programs make spaces for, include, and validate a range of students (Campbell-Montalvo et al., 2021). Because engineering and STEM cultures are not founded upon the cultural experiences and traditions of women and people of color, resulting in the anti-blackness of STEM (Bullock, 2017; Cedillo, 2018; Martin et al., 2019; Vakil and Ayers, 2019; Nxumalo and Gitari, 2021), women and URM students may be less likely to fit in engineering and STEM programs (Goldrick-Rab, 2006).

Social capital theory explains how individuals access resources through webs of connections to people that enable them to accomplish goals that they might not have accomplished on their own (Lin, 2001; Van der Gaag and Snijders, 2005; Lin, 2008). Social capital is relational, meaning that knowledge and skills are transmitted through relationships between people in the same network. Due to social inequity and patterns in social interaction, social

capital may differ based on an individual's gender, age, and ethno-racial background (Skvoretz et al., 2020). Thus, we use the terms 'network-based social capital' and 'participatory social capital' to locate one's access to social capital by how they are situated in relation to other people in a social context, which may determine how and what type of resources are received. In network-based social capital, alters are connected to an individual through that person's daily life, and include family members, peers in the same major, professors, and the like (Skvoretz et al., 2020). Because of their potentially closer social proximity, network-based alters may be more able to offer resources unique to the individual, such as advice about classes or emotional support (Borman et al., 2010; Chanderbhan-Forde et al., 2012; Campbell-Montalvo et al., 2021; Puccia et al., 2021). Participatory social capital is specific to an individual's involvement in an organization, such as a PEO, that has as part of its mission a goal to make resources available to its members (Skvoretz et al., 2020). Students can access various resources based on the PEOs they choose to join and through the department of their major. Alters from PEOs, who may not be in the individual's social network and might be less socially proximal, may often offer advice about classes and career-related skills (Smith et al., 2021).

Within social capital, it is also essential to distinguish the types of resources and support provided to students, including instrumental social capital and expressive social capital (Puccia et al., 2021). Instrumental social capital is activated when an individual gains new resources specific to a goal (e.g., academic advising, help with homework). Expressive social capital is the support and encouragement provided to support an individual's emotional wellbeing (e.g., reassurance before an exam) (Van der Gaag and Snijders, 2005). Expressive social capital is likely a primary driver of improvement in fit given the emotional and relational characteristics of fit and the potential of expressive capital to offer emotional support needed in the STEM environment, often unwelcoming to marginalized students (Campbell-Montalvo et al., 2021). Puccia et al. (2021) found that both the instrumental and expressive social capital provided by parents was influential in women and URM students' declaration of an engineering major. Smith et al. (2021) found that participation in PEOs provided instrumental and expressive social capital, which was beneficial to women and URM students because it led to 1) academic and social integration, including gaining a sense of belonging or fit; 2) connections with potential employers; and 3) opportunities to develop professional and career-related skills. Overall, expressive and instrumental social capital positively garnered through participating in PEOs affected the chances that women and URM students would stay in their engineering programs.

In (Campbell-Montalvo et al., 2021), which involved the same sample of 55 students as in the current study, we showed how acquired network-based social capital helped students feel they fit because alters warned women and URM students, particularly Black students, that they would experience discrimination. These warnings helped students understand these events when they happened and cope, thereby preventing a loss of fit. However, that study focused primarily on the influence of network-based social capital. Likewise, while Smith et al. (2021) showed PEOs helped students stay in STEM, it did not model the mechanisms through

TABLE 1 | PEO participation and participant characteristics of interviewees (n = 55).

PEO participation	Race/Ethnicity	Gender	University type
AIAA	White	Woman	PWI 1
AIChE	White	Woman	PWI 2
ASCE	Latinx	Man	PWI 3
ASME	Black	Man	PWI 2
ASME	Middle Eastern	Man	PWI 2
ASME, ASCE	White	Woman	PWI 1
NSBE	Black	Man	HBCU
NSBE	Black	Man	HBCU
NSBE	Black	Man	PWI 1
NSBE	Black	Man	PWI 2
NSBE	Black	Man	PWI 2
NSBE	Black	Man	PWI 2
NSBE	Black	Woman	HBCU
NSBE	Black	Woman	PWI 1
NSBE	Black	Woman	PWI 1
NSBE	Black	Woman	PWI 2
NSBE, ASCE	Black	Man	PWI 1
NSBE, IEEE	Black	Woman	PWI 2
SAE	Black	Man	HSI
SHPE	Latinx	Man	HSI
SHPE	Latinx	Man	PWI 1
SHPE	Latinx	Man	PWI 2
SHPE	Latinx	Man	PWI 2
SHPE, IEEE	Latinx	Man	PWI 3
SWE	White	Woman	PWI 1
SWE	White	Woman	PWI 2
SWE	White	Woman	PWI 3
SWE, AIChE	White	Woman	PWI 1
SWE, AIChE	White	Woman	PWI 2
SWE, ASCE	Latinx	Woman	PWI 1
SWE, BMES	White	Woman	PWI 1
SWE, SHPE, ASCE	White	Woman	HSI
No	Black	Man	HBCU
No	Black	Man	PWI 2
No	Black	Woman	HBCU
No	Latinx	Man	HSI
No	Latinx	Man	HSI
No	Latinx	Man	HSI
No	Latinx	Man	PWI 1
No	Latinx	Man	PWI 2
No	Latinx	Man	PWI 2
No	Latinx	Man	PWI 2
No	Latinx	Man	PWI 2
No	Latinx	Man	PWI 3
No	Latinx	Woman	PWI 1
No	Latinx	Woman	PWI 2
No	Middle Eastern	Man	PWI 1
No	Middle Eastern	Man	PWI 2
No	Other	Man	HSI
No	Other	Man	PWI 3
No	Other	Woman	HSI
No	White	Woman	PWI 1
No	White	Woman	PWI 2
No	White	Woman	PWI 2
No	White	Woman	PWI 2

which PEOs were beneficial to students, such as through fit or other variables, to understand the levers causing the observed effectiveness of PEOs in persistence for URM students. To address these gaps and complement earlier work, we investigate how different social locations of social capital (i.e., network-based, participatory) offer varying forms of social capital (i.e., instrumental, expressive) that can influence fit to impact persistence across groups.

METHODS

Participants

We interviewed a subsample of the 2,186 engineering students who were first-year students in 2014 and who completed a survey as part of our larger longitudinal research project (see Skvoretz et al., 2020 for a description of the larger survey project). To recruit the 55 women and URM students we ultimately interviewed, we contacted students from five of the 11 universities who participated in our research. The five universities included three Predominantly White Institutions (PWIs), one Hispanic-Serving Institution (HSI), and one Historically Black College/University (HBCU). We selected these universities because they represented a mix of students and contexts. In Puccia et al. (2021) we describe processes through which we determined which survey participants we would recruit for interviews; briefly, we contacted students with higher and lower levels of social capital based on their first completed survey.

A total of 55 students agreed to be interviewed. Thirty-two interviewees participated in PEOs, of them, 12 participated in NSBE, six in SHPE, and eight in SWE. Students' participation in PEOs was not a selection criterion. Interviewees included women of any racial/ethnic grouping as well as URM men. Their demographics were Latinx (15 men, three women), Black (11 men, six women), White (0 men, 14 women), Middle Eastern (3 men, 0 women), and other ethnicity/race (2 men, one woman). Forty-two of the interviewees were from the three PWIs, eight from the HSI, and five from the HBCU. Interviews were conducted during 2015, when participants were either finishing their first year or entering the second year of their engineering program. Interviewee characteristics, including PEO participation, are shown in **Table 1**.

Interview Protocol

Our semi-structured interview protocol was designed to answer our research questions about how CMES and social capital affect students' persistence in their engineering programs. Interview protocols were customized to each participant using their earlier survey responses about their alters. For example, we asked how people they identified on the previous survey (see Skvoretz et al., 2020) contributed to their persistence in engineering, and whether students followed advice from these mentors and how that advice helped them in engineering. We also asked students how they fit into their programs, given their gender and racial/ethnic identities. The students were additionally directly asked whether they participated in professional societies and, if so, why they did or did not participate in them. We similarly asked students about the actions they had taken to be successful engineering majors. These items and additional probes yielded responses from students in which they described participating in PEOs and how it affected them. We asked participants to share examples during the interviews and used "tell me more" prompts to increase the amount of detail elicited (Bernard, 2011). Items from the interview guide included the following:

(1) Can you give me an example of something that [the person they identified on their survey] said or did that influenced you during your first year as an engineering undergraduate?
   (a) How did you act on this advice?
   (b) How did this advice contribute to you remaining an engineering major?
(2) As a [insert their self identifications from the survey], tell me how you fit into your engineering department.
(3) Do you participate in any: study groups, research, communication with professors (e.g. office hours, networking), internships, or professional societies/ organizations?
   (a) Why or why not?
(4) What have you done in college to be a successful engineering major?

Two Black women and one white woman conducted the interviews. If possible, we matched participants with interviewers of the same race/ethnicity as the participant. This study was conducted following protocols approved by the University of South Florida Instructional Review Board[1], including gaining signed informed consent from participants. Interviews lasted 1 hour or less, and most were conducted in person on campus. However, seven were conducted via videoconference for students unable to meet in person. Interviews were audio-recorded and transcribed verbatim. Participants received a $25 Amazon gift card for their time.

Data Analysis

We used thematic analysis to find themes in the interview data based on previous research, patterns that emerged, and the data's relationship to the key components of the research questions (Braun and Clarke, 2006). A codebook was developed with primary and sub-codes using the literature on fit and social capital and the interview guides. After independently reviewing the interview transcripts, five members of the research team engaged in a group discussion to achieve consensus about the codes and their definitions. We refined the codebook through several iterations and discussions, and established intercoder reliability (both described in detail in

[1]The study was initiated at University of South Florida and was later transferred to the University of Connecticut. The researchers were permitted to continue the study based on the protocols approved by the University of South Florida based on an authorization agreement between the two universities

Puccia et al., 2021). Two team members coded the 55 interviews, and another team member entered the codes into the program QSR NVivo 11.0. These steps above comprise the first phase through which this data was analyzed wherein all interviewee comments about professional societies were organized during the coding process into one code, "Participated or did not participate in professional societies." Before we commenced with coding, the team agreed to apply this code to any salient mentioning of societies, and then further analyses would be undertaken to tease out additional trends.

Two research team members undertook the second phase of coding. They first read through all the interview data excerpts to which the "Participated or did not participate in professional societies" code had been applied. They then grouped these excerpts based on the frequency of occurrence, keyness to the research questions, or in relation to the reviewed literature, which resulted in the following preliminary themes emerging at this stage:

- Benefits of joining PEOs
  - Skills and collaborative benefits of getting involved (gaining experience, responsibility, leadership, etc.)
  - Knowledge benefits from PEO events, conferences, and learning from members
  - Networking and connection benefits
  - Job and professional advantages (e.g., getting an internship or job, having professional and career security and success)
- Reasons to join
  - Reputation of PEOs
  - PEOs helping with certification
- Participation, how people got involved in PEOs
- Barriers to participation in PEOs
  - Time constrains, conflict in schedules, other priorities
  - Readiness to be involved
  - Finances, cost
  - Did not take societies seriously or believe they were helpful (i.e., already had an internship)
  - Lack of interest or willingness to get involved, skepticism
  - Student perception that they would not be welcome at the PEO
- Things to do to be a successful engineering major (e.g., time management, studying, sleeping enough, working hard, scheduling, balancing work with pleasure, joining a PEO)
- Fit in engineering and in PEOs
  - Sense of belonging
  - Diversity
- Relationships with others
  - Mentor/mentee programs

Afterward, in the third phase, one of these two team members and a different team member further organized the data grouped in these above themes. In this phase, the researchers compared our current findings to the results of previous studies utilizing the same population and from which the participants of this study were selected (Puccia et al., 2021; Smith et al., 2021). In Smith et al. (2021), we performed inferential analyses on the larger pool of the 2,186 survey respondents and found that race/ethnicity-focused PEOs improve engineering persistence for URM students. We were also able to determine the types of social capital provided by these PEOs by thematically analyzing open-ended survey data. These types of social capital guided the final phase of data analysis for the present article and include the following types:

(1) "academic and social integration through academic support, such as developing time management skills and tutoring, as well as social networking, such as meeting other students and engineers of color some of whom become friends and mentors;
(2) connecting with industry internships and employment opportunities through attendance at national conferences; and
(3) professional resources for career development such as improving leadership skills, resume writing, and interview skills." (Smith et al., 2021, p. 8)

In Puccia et al. (2021), we analyzed the same 55 interviews as in the present study, highlighting the instrumental (e.g., direct advice about accessing resources and strategies) and expressive (e.g., emotional support) social capital provided by parents. In this study, we drew upon the operational definition of expressive social capital for engineering students (Puccia et al., 2021), to identify themes focusing on how PEOs and alters provided emotional support through various mechanisms to help students persist in engineering, which are presented in the findings section.

In sum, because we recruited interview participants from the same pool of 2,186 survey participants described in Smith et al. (2021), our analysis sought to add nuance to previous findings and buttress the transferability of the findings from Puccia et al. (2021). Thus during analysis, we prioritized instances related to how PEOs enable students to network, how PEOs reduce isolation related to gender and race/ethnicity, and how PEOs provide access to professional and emotionally supportive resources, because such instances were identified as important in Smith et al. (2021). We then related these explanations to the notion of instrumental and expressive social capital identified in Puccia et al. (2021).

RESULTS

Regarding the fit domain of CMES (the first research question), we found that PEOs provided 1) expressive social capital, wherein students felt they belonged, primarily because they saw others like themselves in large numbers, and 2) instrumental social capital, wherein students gained valuable academic and professional skills, indirectly promoting their feelings of belonging in engineering. First, students discussed how PEOs provided a sense of community and allowed them to be around others like themselves and see them succeed in engineering. This provided students "a family" with whom to talk about a "shared struggle." Students' feelings of fit were further increased as they established friendships and gained validation

from their PEO. Second, PEOs provided students with instrumental social capital, including academic support and access to internships and employment by building professional networks, often with people like themselves. Students also developed leadership and time management skills through experiences in their PEOs.

Regarding our second research question, students provided three common reasons for joining PEOs. First, they were encouraged to do so by teachers, mentors, peers, and others in their social network. Second, they desired to join a community of people from the same racial/ethnic background. Third, they were motivated by opportunities to network with professional engineers and peers. In particular, connecting with homophilous alters was crucial reason why students wanted to join PEOs, and race/ethnicity-focused PEOs are a good source of them for URM students. Finally, students also recounted obstacles that inhibited them from joining or fully participating in PEOs. These included time constraints and scheduling conflicts, financial concerns, or a lack of fit.

Expressive Social Capital: Community and Seeing Other People Like Yourself in Engineering

The main expressive social capital finding related to how:

- Participation in PEOs provided women and URM students access to (often homophilous) others from whom they received expressive social capital that aided them in fitting in their engineering program.

Women- and race/ethnicity-focused PEOs allowed student members to be around others in engineering like themselves, which improved their fit as they navigated the field of engineering, a field traditionally dominated by white men. Specifically, alters students met through PEOs helped them feel like they were part of a community of people with whom they could discuss their struggles and find solutions to obstacles. In addition, being around others with similar characteristics aided students in making sense of the negative treatment they received from others. Ultimately, these homophilous alters helped students feel they belonged in engineering.

Women, particularly women who were not Black, identified SWE as a common source of support. For example, a Latinx woman at a PWI expressed that engineering is a field dominated by men and that joining SWE made it "a little bit more inclusive" for her:

> SWE makes engineering a lot smaller. It makes it easier to relate to all these people and be able to understand the things that you're going through and understand the struggles that even women feel in this kind of area.

Likewise, when asked if the resources provided by SWE offered a sense of camaraderie, a white woman at a PWI discussed the PEO's newsletter.

> Yeah, definitely. They do also send out a newsletter about a prominent woman engineering in the world, and they give a backstory on her and sometimes they'll mention other engineers here at my university.

When asked a follow-up question about whether that newsletter helped her feel like she fit in or had a more established place as a woman in engineering, the woman agreed:

> I think, yeah, a more established place as a woman in engineering. Especially as the years progress and women in STEM programs becomes more prominent, I definitely think that's how I feel. Maybe not necessarily like, 'Oh I fit in,' but it's like, 'I belong here whether other people [see that or not].'

Women who did not participate in SWE for various reasons, such as already participating in gender-focused opportunities or not "being into clubs," also acknowledged that SWE often benefits its members. For instance, a white woman at a PWI acknowledged that other women may feel encouraged by such societies, "I don't think that I could be a part of another all-female thing [in addition to my Women in Science and Engineering learning community], but I know that it's encouraging for [them]." Likewise, a white woman at a PWI shared that she had not participated in SWE much because "she is not into clubs" but she thinks that joining a club is beneficial for other students who need support. She said, being in PEOs "could be helpful if you're struggling being a woman [in engineering], . . . if you're struggling with coping and being in college."

URM students, particularly Black students, noted the importance of joining a race/ethnicity-focused organization. For example, when asked about the role that NSBE has played in her experience in her engineering program, a Black woman attending a PWI described the PEO's essential role in securing her fit:

> Oh my gosh, huge role . . . just having that family, that community, that support system is, it's almost essential. NSBE has given me mentors, role models, encouragement.

Likewise, a Black woman at a PWI said NSBE is "like a family" in a way that "just blends well," and she enjoyed making shared memories with NSBE peers.

Other Black students talked at length about their attraction to NSBE because it was specifically inclusive of Black engineers. For example, a Black woman at a PWI shared:

> I feel like I fit well . . . especially because there aren't a lot of black people at all in engineering so when I see, at least at the NSBE meetings, when you see all the people that are doing it, it definitely is like, 'Okay there's other people just like me doing it'.

Further discussing how seeing other Black students succeeding in engineering creates a feeling of fitting into engineering and pride

in being one of those students, a Black woman attending a PWI described her perceptions of NSBE. NSBE conferences and events provided a sense of "comfort." She shared:

> The people that you meet, the amount of people that you meet at [the] conference [. . .] When you go to [the] conference it's National Society of Black Engineers, it's mainly Black engineers. And it's nice to see how many are really pursuing the same major, the same field actually, so that's comforting. And because there's not many of us, that's the main reason why [you participate], to see more of you pursuing what you do.

A Black man at a PWI specifically connected his participation in NSBE to his fit, noting that "there's even a society, a whole society of Black engineers, so I think we fit in pretty well [in my department]." Although a less pronounced theme, Latinx students connected participation to SHPE to feelings of inclusion as well.

> Sometimes it's a little weird [in my engineering department], but there's organizations like SHPE and fraternity where I don't feel so alone. Compared to high school, I had more Hispanic friends, and here I don't have many . . . Sometimes I just don't know if it's being homesick or missing talking Spanish or something, it feels a little off, I guess.

Together, these excerpts highlight how gender- and race/ethnicity-focused PEOs helped students fit into engineering, and how they were particularly helpful in white women's and Black students' fit. These PEOs are designed intentionally to serve people of specific groups who have shared experiences based on their gender, racial, and ethnic identities.

Instrumental Social Capital: Academic and Professional Knowledge and Networking

In their interviews, students discussed what they thought it took to be a successful engineering student and how their PEOs supported them in that endeavor. The main instrumental social capital findings related to:

- Alters met through PEOs helped students develop time management skills, which is crucial in excelling academically.
- PEOs provided mentoring opportunities where students were coached on what to expect, encouraged, and provided access to resources, such as study groups.
- PEOs provided students with socialization experiences, including practicing a range of professional skills, like communication norms and leadership opportunities.
- PEOs sponsored networking activities that provided access to people that could be useful in a student's career path later or academic path now.
- PEO events, such as conferences and job fairs, where employers actively sought students to hire, directly aided students' current career development.

In discussing how PEOs helped them manage their time, participants shared how alters met in PEOs helped them learn how to make time to support a healthy balance between self-care, school efforts, and participating in other activities. For example, a Black woman at a PWI shared that NSBE's mission included three components: "excelling academically, succeeding professionally, and positively impacting the community." The student described how she brings those three components into her life as she manages her various responsibilities and roles:

> I get better every year, especially with time management . . . I make sure I get sleep because that's really important. I lay off coffee. I talk to my teachers, my professors—the relationships with them—I go to office hours, I make that extra effort to make sure that I'm not behind in classes. I get tutoring. I tutor unofficially in the community with NSBE, just volunteering there and I'm a mentor now.

These skills of taking care of oneself and being one's best academically are important for persisting in a challenging major. However, developing skills like time management can be difficult. Therefore, the PEOs encouraged students to practice managing their responsibilities.

Integrating instrumental and expressive social capital, a specific aspect of PEO programming that supported the development of academic skills occurred through mentoring programs. Many PEOs offer mentor programs in which a student who is further along in their program is paired with a student in the early stages of their program. For example, a white woman at a PWI described how her mentor from the American Institute of Chemical Engineers provided encouragement regarding her classes:

> He helped me see what was coming the next semester because he'd already been through it . . . He knew the struggle. So just being able to talk to him about it and [him] being like, 'Oh, well this class is going to be really difficult, but you can do it because I did it . . . He was more someone that I could talk to about the struggle that is chemical engineering just because he'd already been through it.

Likewise, a white woman at a PWI stated that being part of PEOs and having a study group working on particularly difficult academic tasks are essential to be a successful engineering student. She shared:

> I've joined the study groups, . . . [in my fraternity] it gathers all these biomedical engineers together and it gives you the older people that have had a lot more experience in these classes that I'm taking now or have

> experience with internships and jobs and things like that. They have a lot of really good advice to give to us younger kids, I guess I'm an upperclassman [now] technically, but like, I still feel like they can teach me so much. So having that has been like a really valuable resource too.

Similarly, a white woman at a PWI described her experience learning over time. She said:

> I didn't recognize how important being in organizations, forming study groups, and getting leadership positions was. I didn't recognize how important it was to work with other students to pass your classes and plan an event for your club, so I wasn't in a lot of organizations. When I came here, I joined and it's a really good support system.

In addition to academic knowledge and skills, participating in PEOs provided students with socialization experiences tied to developing professional skills relating to norms of communication, appearance, and leadership. For example, a Latinx man at a PWI described his experience in SHPE developing a range of professional skills:

> We do everything from professional workshops to social events. You want to get the club members interacting with each other, but you also want to do professional workshops. Like we have conference . . . So we held a conference readiness workshop beforehand on how to introduce yourself to someone, how to approach someone, what to have your resume look like, how to dress, how to present yourself, what to talk about, what not to talk about, how to act throughout the conference. So that's professionalism, interview workshops, all sorts of things like that.

In another instance, a Black man at a PWI discussed how being the publications chair of his NSBE chapter provided leadership practice that would help him in his future career. He said:

> It's a great experience, it gets me experience being a leader and a servant leader . . . For me, being a servant leader is important because I want to do project management when I go in the workforce. So being a leader and understanding everybody's different gifts and being a servant to them and also leading them is something I believe in doing . . . so I want to build myself up for that.

For a Black man at a PWI, his role as a leader in the American Society of Mechanical Engineers impressed potential employers. He reflected:

> I'm taking on more leadership roles than most people in my field. I've talked to employers at career fairs and events hosted by ASME. They tell me, 'Oh wow, you've done a lot in your early years.' I'm like, 'Yeah, I thought that's what you're supposed to do.' He told me, 'Oh no, not a lot of people actually do that.' So, I'm standing there, 'Oh, okay. I guess I'm ahead of the game right now, that helps me stick out.'

Likewise, a Latinx man at an HSI mentioned "moving up" in SHPE to become a regional leader and developing a campaign to get elected. Similarly, a Black man at HSI described how the Society of Automotive Engineers "decided that I was fit to be a leader already" despite starting "off knowing nothing about cars."

Students built professional relationships through PEO-sanctioned networking activities helpful in their later career and current academic path. Connecting with professional engineers provided students access to career opportunities and advice. For example, a Black woman at a PWI shared that through NSBE, students "go to networking events, talk to company representatives and hand out their resume." Likewise, a white woman at a PWI described:

> SWE definitely does offer a lot of resources and they do offer networking sessions for the community or the society. They give us a lot of heads up about events happening on campus, so that's beneficial.

Similarly, a Black woman at a PWI benefitted from NSBE without attending every event. She said:

> Even last year when I wasn't going to every NSBE meeting necessarily, I still got emails about the corporate events, so I'd go to those . . . It's honestly when I have time . . . Right now, there's a lot of random events, you can just kind of go to whatever, but networking—whenever there's a company I'm interested in I'll go.

In another example, a Black man at an HBCU mentioned that attending NSBE meetings was helpful. When asked to explain how it was helpful, he identified that it facilitates his communication with various organizations beneficial to his persistence in his engineering program. He especially highlighted the role of NSBE in supporting him in this regard with people who were similar to himself:

> I mean, it's networking skills. It's a bunch of other engineers that are also Black as well, [in the] same boat, go to my university, so that's how it's helpful. You can network very well, and just because you're in the same major as them, they're willing to help you. They're like, 'Oh c'mon, you need help with computing? Come here.'

In sum, PEOs created opportunities for women and URM students to network with professional engineers, often of the same gender or race/ethnicity, which enabled professional relationships supporting fit to form.

Participating in PEOs provided access to opportunities and experiences that aid in imminent career development, such as

allowing students to meet professionals and potential employers who were hiring or seeking interns. For instance, a Black woman at an HBCU, who was the treasurer of her university's NSBE chapter, stated that participating in such clubs gave her access to internships and networking opportunities:

> I cannot stress enough sources, sources, getting involved. If you get involved in a lot of the engineering clubs, those help a lot because you can get internships, you can talk to corporate people. If you go to the fairs too, you can talk to jobs and they'll help you too.

Students felt confident that their PEO would help them land a good job. For example, a Latinx man at a PWI described his experience with SHPE:

> All these kids … now they work for major companies—Exxon, Goldman Sachs, Lockheed Martin. Every single person in SHPE got a job . . . They knew what to do, they knew how to play the game, they knew what you had to do to get through, to get by and they had the best advice to give in my opinion. It's thanks to them, thanks to SHPE, thanks to my friend introducing me to SHPE, that's what's made the difference.

A Latinx man at a PWI also discussed the benefits of SHPE and ASME in employment. He said:

> A lot of my friends who have gone to SHPE, [American] Society of Mechanical Engineers meetings, they've had opportunities to tour the local beer factory, study how machines work at the local theme park . . . so if you go to SHPE you have a higher chance. I mainly went to SHPE for local meetings and just having my name out there.

In another example, a Black woman at a PWI shared, "I received 90% of my internship offers because of NSBE … Through conferences and networking with the people there." In addition to networking to land job interviews, a white woman at a PWI discussed how her PEO mentor recommended an internship and provided support during the interview process.

> I signed up for the mentor/mentee program through AIChE, and my mentor actually had the internship before me. He had quit because he was entering his senior year, it was just too much. They were like, 'Well do you have any friends who would like this internship?' And he's just like, 'Well, my mentee would really like this internship', and so I just had to send my resume and then they hired me.

These examples show the range of instrumental social capital, which intersects with expressive social capital, gleaned from participating in PEOs.

The Main Reasons for Joining PEOs Were Expressive: Encouragement From Others and Wanting to be Around People Like Oneself

The two main reasons students offered for why they joined PEOs include:

- They were encouraged to do so by alters.
- They wanted to join to be around people like themselves, particularly people who were similar to them racially.

First, students learned about and received recommendations to join PEOs from teachers, parents, friends, professors, mentors, resident advisers in engineering living-learning communities, and alters in a range of other settings, including classes, festivals, career fairs, and other events for first-year engineer students. For instance, a Black woman at a PWI said, "A former student advised me to join NSBE . . . and then I did. And then it was just it's like a family, so I like it." A Latinx woman at a PWI also shared how her mentor encouraged her to get involved in discipline- and gender-focused societies, saying, "She's a civil engineer and I'm a civil engineer, so she was influencing me to join American Society of Civil Engineers, join SWE. I've acted on her advice." A white woman at a PWI discussed the major role of her resident adviser and of her engineering living-learning community in general in her awareness and involvement in PEOs:

> We had a mentor and an RA that were both experienced engineering students, so they told us about every single organization and what they did and what their purpose was so that's where I heard about most of them. They also had an event at the beginning of the year where all of the organizations came to our floor and talked to us.

Second, in addition to identifying the advice of others to join PEOs, URM students were drawn to join race/ethnicity-focused PEOs, such as NSBE, because they offered a cohort of similar students with whom a student could experience the engineering program. Many students wanted to join because of the importance of seeing people "like themselves" succeed, which made them feel empowered in their studies and career and feel that they fit. For instance, a Black man at a PWI joined NSBE during his freshman year when he wanted to be part of a community of Black engineers. He described his experience:

> It's [my experience in NSBE that's] cool. I wanted to get in extra-curricular groups and just have a well-rounded college experience because I just didn't want to be in the books. So, I joined NSBE because its National Society of Black Engineers, and so they're engineers that are Black and just like me and going through the same struggles. I like just going to those meetings, and then also being a part of an officer position.

When comparing NSBE and SWE in terms of effectiveness of their outreach to students, a Black woman at a PWI discussed

how her Black and white friends might choose a PEO based on such criteria as having "people like me", field focus, or availability of scholarships. She shared:

> I think some people just do NSBE, but my Black friends are all in NSBE. My white friends, I have one who's in a business frat because she just wants to do business, but then some of them are in SWE. So, I think you should have one engineering thing, at least that you're in. I might do SWE, I know SWE had scholarships that I haven't looked at and SWE since it's all women, I think it has a little bigger reach.

These excerpts highlight how a student's identity and the need to seek others with similar identities encouraged students' participation in PEOs.

Reasons for Not Joining PEOs: Lack of Time, Money, or Fit

Most students who did not participate in PEOs expressed an interest in participating, but often offered one of three main reasons for not joining a PEO:

- Students had an already packed schedule full of classes, commute time, or a job.
- The cost of dues was too high.
- Students were concerned that they would not fit in at the PEO because they did not yet have enough engineering knowledge or the environment may not have been welcoming.

The main time-related obstacles to participating in PEOs mentioned included course load, commuting, or having a job. For instance, when discussing how his academic workload prevented him from joining PEOs, a Latinx man at a PWI shared, "My sophomore year, I was focused on research and classes. There's not enough time in the day to do everything." Similarly, a Latinx man at an HSI was not able to add any PEOs to his schedule, despite being interested in them. He shared:

> There are a lot of clubs. There was a fair here last month . . . with a lot of engineering clubs. A lot seemed really interesting . . . But because I was taking a lot of higher level classes, I didn't want to get into them because I was already pretty swamped studying.

Similarly, a Black man at an HBCU prioritized studying over attending PEO meetings: "Nothing against them, don't get me wrong. They're helpful and all. It's just . . . I'm not going to go to every single meeting because I could be studying during that meeting." Further, a Latinx man at a PWI described that his classes coincided with the meeting times. He said:

> SHPE helps, [but] I don't go to their meetings often enough because I usually take calculus at night . . . SHPE meetings, nine out of ten times, will be during those class times. The professor's office hours fall at the same time, too. I would go to four SHPE meetings out of fifteen because those are the meetings that work with my schedule.

Commuting compounded the issue of having limited time. A Latinx man at a PWI stated:

> I didn't really go to any meetings last year, especially since I commute 30 minutes a day . . . Sometimes their meetings are at night and my classes are during the day, so I leave campus and then I don't really feel like driving all the way back, it's a long drive.

Similarly, a white woman at a PWI was limited in her ability to participate in SWE's activities because of the distance between the campus location where classes were held and where SWE holds its activities and events. She explained:

> I'm part of SWE. I haven't participated too much with them because their meetings are every other week on Wednesday at seven . . . Since the engineering campus is off campus, it was always too much to go to my car and drive there.

Students who hold jobs while going to school have an additional time constraint. For example, a Latinx man at an HSI discussed how it was tough for him to be a successful engineering student because he worked part-time in a warehouse since he began his studies 2 years ago. He discussed how his day was already full:

> I don't have time to be in a clubs because I have a job. Since my job takes a good chunk of my day, I can't spend a lot on anything else other than the three core things: going to school in the morning, working in the afternoon, and studying at night.

Other students were in a similar situation. A white woman at a PWI is not a member of any clubs "because I work as well as I'm taking a lot of credits in the semester, so I didn't think that I would have time to spend at the societies, but I will be doing that in the fall." Similarly, a Black man at a PWI explained that his lack of involvement was due to having an internship in his first year of college.

Financial reasons influenced students' decisions to join a PEO. A Latinx woman at a PWI noted that whether she joins SHPE or not "depends on how much I can work and how much my mom can work as well." A white woman at a PWI explained that the cost associated with being a PEO member made her think about how many hours of work she would need to afford it. Further, a white woman at a PWI shared, "I did actually go to a meeting at SWE, and then I didn't want to pay national dues."

In addition, students' desire to participate in PEOs were influenced by their feelings of fit. Some students were concerned about whether they were ready to join PEOs given their knowledge and experience in engineering. For example, a man identifying as 'other' race or ethnicity (specifically, Chinese and Nicaraguan) at an HSI said that he was not interested in joining PEOs "because I still don't feel like I have the skills to really be in there. I haven't

completed that many classes." When discussing her interest in joining a PEO, a Latinx woman at a PWI had similar views and assessment of her knowledge and readiness to be a member of a PEO. She explained:

> I probably will join junior or senior year. Right now, I don't know that much about engineering. But once I can actually start more engineering-based classes, then maybe I will feel more like into being into the club and 'Oh, I can help in this club.'

A Latinx man at an HSI similarly remembered his first visit to one of the organizations and not being able to absorb the content:

> I don't recall much of it because my mind wasn't ready to learn. My interest was not in what they were saying, so it just went right over my head. I didn't absorb everything, my mind was closed at the time.

In other cases, prospective PEO members, at times, did not feel like they fit into the PEO due to their intersectional identities (i.e., being a URM student in SWE, being a light-skinned Latinx student in SHPE). For example, for a Latinx woman at a PWI, SWE felt competitive and she did not feel included:

> I haven't been as involved as I want to be in SWE, but SWE is kind of just a huge seminar body with all these women in it. We kind of just talk about struggles and like things like that . . . I don't know, whenever I went to a SWE thing, I didn't feel as included as when I went to like other things. I haven't felt that . . . I feel like a lot of the women, they're very competitive compared to men, which is really interesting.

A Latinx man at a PWI did not join SHPE because he felt he might have to perform Latinidad in a particular way given his intersectional identities (i.e., a Puerto Rican with blue eyes who speaks "unaccented" English).

> So, my family's very Puerto Rican . . . but I mean I have no accent . . . I don't look Puerto Rican, I have blue eyes . . . I'm not a member of any societies, I've considered joining but I don't really - I mean I see the usefulness for a lot of people, it's not something that I want to do. Like even though, SHPE, even though I consider myself Hispanic, I feel uncomfortable in groups like that.

These remarks show the factors that impacted student participation in PEOs and their ability to reap the benefits associated with PEO participation.

DISCUSSION

In sum, previous research revealed positive impacts of joining PEOs, reporting that not joining a race/ethnicity-focused PEO is associated with a decreased likelihood of continuing in an engineering major for URM students (Smith et al., 2021). Yet, the specific levers through which PEOs, as participatory social capital, may promote fit and reduce isolation were not entirely clear compared to the more clearly identified levers of network-based alters who can provide warnings of discrimination to promote fit (Campbell-Montalvo et al., 2021). Therefore, this study's primary goal was to understand better the mechanisms through which participation in PEOs affects persistence, focusing specifically on the CMES domain of fit. We highlighted how PEOs affect persistence mainly through expressive social capital that supported improved feelings of fit, like when students saw many people like themselves doing engineering. We also found that the provision of instrumental social capital was particularly well received by women and URM students in women-focused and race/ethnicity-focused PEOs because it was provided by homophilous alters (Brown and Josephs, 1999; Morganson et al., 2010; Borum and Walker, 2011; Evans et al., 2011; Joseph et al., 2017; Campbell-Montalvo et al., 2021; Leyva et al., 2021). In short, this study reveals how students become connected to PEOs, and how PEOs provided students access to instrumental and expressive social capital delivered by people with similar characteristics that affected fit consequential in persistence.

This study focused on students' CMES (i.e., their notions of what they needed to do to be successful as engineering students, including feeling that they fit) and highlighted their agency in locating and accessing resources (i.e., PEOs and the people in them) needed to enhance their feelings of fit. PEOs, particularly gender- and race/ethnicity-focused PEOs, have as part of their mission a goal to help students fit in and build their academic and professional capabilities to promote their success in STEM. What is particularly powerful about gender- and race/ethnicity PEOs is their acknowledgment that the STEM environment can be unwelcoming for women and URM students, and that participation in a supportive community can mitigate that feeling. We conclude that within the context of incongruities between women and URM students' CMES and institutional culture (Smith et al., 2015), PEOs play a vital role in encouraging students' persistence in engineering through expressive social capital affecting feelings of fit.

Because women and URM students encounter a less welcoming environment and see fewer people like themselves, expressive social capital provided by race/ethnicity-focused and women-focused PEOs provides added value because it provides access to homophilous alters who are successful in engineering. Engaging with homophilous alters with whom they could learn, discuss struggles, and share common experiences positively influenced students' feelings of fit. Obtaining social capital from homophilous alters was most beneficial because of the shared identities, perspectives, and comfort/trust between the ego and alter. This finding reinforces results from previous studies that highlight the importance of students having alters with whom they can consult when they experience difficulty in their engineering programs (Weston, 2019). These alters help students name and resist processes of marginalization (Secules et al., 2018; Campbell-Montalvo et al., 2021).

PEOs also provide instrumental social capital, including academic and professional skills, networking, and knowledge development opportunities. They help students develop professionalization skills and gain awareness of disciplinary

norms (e.g., how to talk, dress, or engage in ways accepted in the field). We acknowledge that foundations of disciplinary norms are grounded in the values of majority groups, and these norms and values are often assumed to be neutral (McGee, 2020). However, efforts should be made to address how institutional norms are often rooted in the values of majority groups. While STEM culture will not be changed overnight, making information about disciplinary norms explicit informs students and permits them to be more knowledgeable about actions that can be taken to impact how others perceive them, contributing to their feelings of fit and potentially leading to engineering persistence. Although industry- and discipline-based PEOs are valuable sources of instrumental social capital, we highlight how social capital provided by homophilous alters in women-focused and race/ethnicity-focused PEOs interacts with the academic climate and nature of inequality experienced by women and URM students.

Although participatory social capital may comprise less direct social relations between students and alters than the relationships established between students and alters in network-based social capital, it may accomplish similar outcomes, especially for marginalized students when they are receiving it from people like themselves. We found that participatory social capital helped women and URM students make sense of the treatment they received from others and improved their feelings of fit. We posit this social capital is especially beneficial for Black students. Indeed, it is likely that the higher rates of NSBE participation (Smith et al., 2021) are connected to the more pronounced threats to fit experienced by Black students (Campbell-Montalvo et al., 2021). Black students' increased tendency to seek assistance helpful in fit can be understood given STEM's anti-Blackness (Bullock, 2017; Cedillo, 2018; Martin et al., 2019; Vakil and Ayers, 2019; Nxumalo and Gitari, 2021).

Skvoretz et al. (2020) reported that students from various ethnic/racial groups enter their engineering programs with differing levels of social capital. Further, Blosser (2020) highlighted the role of initial social capital in developing more social capital useful in STEM success. We showed the crucial role of homophilous alters in students' persistence and acquisition of additional capital. Given the limited number of women and URM in engineering departments, the reactions to students' intersectional identities that can make it difficult for them to access capital open to some of their identities, and the differential treatment marginalized students may experience, it is vital to address existing gaps in social capital. If these gaps are not filled, students may be less likely to benefit from advice to take advantage of available resources such as PEOs, despite evidence that women and URM students will more often experience stereotype threats than their majority peers. Our study revealed that students joined PEOs because they were encouraged to do so and desired to be around people who were like themselves. However, some students could not take advantage of these opportunities because of obstacles that need to be addressed, such as inconvenient meeting times and the cost of dues.

Implications for Institutions

Results from this study offer insights to augment university and engineering degree program efforts to attract and retain women and URM engineering students, particularly by harnessing PEOs to help support them and provide development opportunities. PEOs are a vital part of university efforts to broaden participation in STEM. In particular, universities should consider how PEOs can bolster or supplement engineering programs. Because of their impacts on students, universities and departments are encouraged to increase their relationships with PEOs and support student engagement in them. Increasing students' access to PEOs is paramount. To be inclusive, universities should attend to potential barriers to participation, such as when and where meetings and events occur and how to provide nontraditional and commuter students access. Additionally, departments can consider ways to reduce financial barriers to participation, such as covering the cost of students' dues.

Other strategies can be addressed programmatically. Programs such as engineering bridge programs, design teams, PEOs, and other valuable opportunities for students to build social capital and improve feelings of fit should be widely available and accessible (Campbell-Montalvo et al., 2021). Additionally, departments can encourage students to engage with PEOs by requiring them to explore their benefits by attending a few meetings, including exploring race/ethnicity- or gender-based PEOs as appropriate. Such experiences can provide students insights about resources and role models early on in their programs. Because we found that alters influence participation in PEOs, advisors in engineering programs can play a pivotal role in encouraging students, particularly students of color, to participate in PEOs. Students should be encouraged to participate early (e.g., first semester) to benefit from access to such resources fully. Our study also revealed that students benefit when they have access to homophilous alters. This reinforces the need to have a diverse engineering faculty that includes professors and advisors who are women and/or people of color.

Data from this study showed that PEOs might not be equally welcoming to all students, whether because students feel they lack engineering content knowledge or are concerned that they will not fit into the society. Professional societies can use this information to support changes in organizational culture and help make their programming more accessible (Campbell-Montalvo et al., 2020). We suggest that PEOs consider implementing an assessment and improvements of their programming as needed with an eye on diversity, equity, and inclusion (Peters et al., 2021).

Implications for Research

While this study advanced understandings about how PEOs affect engineering persistence, additional research is still needed. For example, students' pre-college socioeconomic backgrounds may be an important factor to consider in their PEO participation. Previous research has shown that Black and Latinx students' pre-college experiences may influence their ability to integrate into engineering programs at PWIs (Johnson, 2019). Indeed, such experiences could have influenced why students in our study participated in PEOs and in which PEOs they chose to participate. Although our sample included students enrolled in different types of university contexts (e.g., PWIs, an HBCU, and an HSI), we

did not address the role of university context in this study. However, we found that Latinx students talked far less about the benefits of participation in PEOs. It might be that Latinx students in our sample, particularly Latinx men, had higher rates of fit in their engineering degree programs, particularly if enrolled at an HSI (Campbell-Montalvo et al., 2021). Although we assert that PEOs are valuable for helping marginalized students fit into engineering programs, additional research is needed to undercover the influence of various university settings (e.g., HSIs and HBCUs with students from a range of racial/ethnic groups) on several factors including pre-engineering fit and social capital.

Campbell-Montalvo et al. (2021) showed that network-based alters, who are arguably more well known to students and have potentially closer social proximity, offered more personal advice about students' identities and how others would react to them. In the current study, participatory social capital improved fit by making role models accessible, allowing students to see people of similar characteristics achieving, permitting them to engage in discussions about engineering obstacles and how to overcome them, and helping them to receive professional and academic advice. Collectively, both network-based and participatory social capital are crucial for students' fit, and offer complementary resources helpful in STEM persistence. As noted in Johnson (2019), additional research is needed to determine the extent to which these findings are patterned in engineering and STEM, and how these types of social capital and CMES articulate for particular students. For instance, can having lower levels of network-based social capital be mitigated by participatory social capital? Does this differ across gender and ethnic/racial groups? What is the relationship among the varying levels of fit, types of social capital (network-based, participatory), and other forms of social capital (instrumental, expressive), and how do these relationships affect persistence? How do differences in fit and social capital within and between groups' pre-college experiences affect persistence?

Additionally, studies are needed that disaggregate data within categories, including those that disaggregate within URM categories and offer intersectional analyses for women of color. For example, Smith et al. (2021) found that URM students participate in PEOs at different rates—Black students participate in NSBE at higher rates than women in SWE and Latinx students in SHPE. So, conducting analyses that combine students from the various demographic groups may hide important differences. Similarly, we found that network-based alters (Campbell-Montalvo et al., 2021) and participatory social capital (i.e., participation in NSBE) played an important role in Black student persistence in engineering (Smith et al., 2021). Considered together, these findings suggest that using the URM as an all-encompassing category may obfuscate results, particularly as they relate to Black students, and reduce the efficacy of recommendations to support broader STEM participation. Likewise, other research reveals the challenges of using Asian as an umbrella category. For example, Kang et al. (2021) noted that such practices contribute to the gross underrepresentation of southeast Asian students, such as Filipino, Hmong, Cambodian, and additional students.

Our finding related to influences on students' decision to participate in PEOs raises additional questions. For example, do the sources of advice to join particular PEOs differ across gender and ethnic/racial groups? How does the availability of alters (including whether they are homophilous) affect the receipt of such advice (see Johnson, 2019)? Answers to such questions can provide insights about social processes, including how the entry social capital of Black students interested in STEM affects their ongoing acquisition of social capital and its influence on fit, and persistence. A focus on Black students is warranted given their low representation in STEM, especially compared to other groups (i.e., women, Latinx students), and existing societal and STEM notions of anti-Blackness. Answering these additional questions could be valuable in informing theory and practices relating to STEM persistence across groups.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of the need to preserve participant confidentiality. Requests to access the datasets should be directed to rebecca.campbell@uconn.edu.

ETHICS STATEMENT

This study involving human participants was reviewed and approved by the University of South Florida Institutional Review Board. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RC-M and CS conducted the interviews in this research. RC-M, GK, CS, EP, and JM developed the interview analysis protocol for this research. RCM and EP coded the interviews. OS and HC, under the direction of RC-M, led the analysis. RC-M, OS, and HC drafted an initial version of this manuscript. All authors provided intellectual contribution in project development, research methods, analysis, and writeup. GK and HW provided additional writing and revision efforts.

FUNDING

This material is based upon work supported by the National Science Foundation under Grant #1664366 and Grant #1432297.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Sociology

ORIGINAL RESEARCH
published: 02 February 2022
doi: 10.3389/fsoc.2021.762836

Increasing Diversity in Developmental Biology

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The demographic profile of the scientific and biomedical workforce in the United States does not reflect the population at large (https://ncses.nsf.gov/pubs/nsf21321/data-tables; www.census.gov), raising concerns that there will be too few trained researchers in the future, the scope of research interests will not be broad enough, gaps in equity and social justice will continue to increase, and the safeguards to the integrity of the scientific enterprise could be jeopardized. To diversify the pool of scientists, the Society for Developmental Biology (SDB) developed the *Choose Development!* Program—a two-summer immersion for undergraduate students belonging to underrepresented (*UR*) populations in STEM to join the research laboratory of an established SDB member. This research-intensive experience was augmented by a multi-tier mentoring plan for each student, society-wide recognition, professional development activities and networking at national meetings. The strengths of the *Choose Development!* Program were leveraged to expand inclusion and outreach at the Society's leadership level, the Board of Directors (BOD), which then led to significant changes that impacted the SDB community. The cumulative outcomes of the *Choose Development!* Program provides evidence that community-based, long-term advocacy, and mentoring of young *UR* scientists is successful in retaining *UR* students in scientific career paths and making a scientific society more inclusive.

Keywords: diversity and inclusion, developmental biology, undergraduate research, choose development, summer research program

OPEN ACCESS

Edited by:
Veronica A. Segarra,
High Point University, United States

Reviewed by:
Fadie Coleman,
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Specialty section:
This article was submitted to Gender, Sex and Sexualities, a section of the journal Frontiers in Sociology

Received: *23 August 2021*
Accepted: *22 November 2021*
Published: *02 February 2022*

Citation:
Unguez GA, Bennett KL, Domingo C and Chow I (2022) Increasing Diversity in Developmental Biology. Front. Sociol. 6:762836. doi: 10.3389/fsoc.2021.762836

BACKGROUND

"*In Diversity There is Epistemic Strength*"—Helen Longino

It is not news that Science, Technology, Engineering and Math (STEM) disciplines are severely lacking wide representation from people belonging to non-White, ethnic and cultural groups of scientists (Tilghman et al., 2021). Efforts to increase diversity and inclusion in STEM fields are motivated by various concerns - a concern for equity and social justice (Byars-Winston, 2014; Coleman, 2020), and a concern for increasing the pool of scientists that are prepared to address contemporary needs in biomedicine, science and technology (Coleman et al., 2010; National Academy of Sciences 2011; Benish, 2018). Importantly, there is growing evidence that when scientists from diverse backgrounds and with unique experiences work together, a wider range of approaches to problem-solving are proposed and often more creative and groundbreaking

solutions emerge (Hong and Page, 2004; Valentine and Collins, 2015). Our efforts to increase diversity in developmental biology and related fields are motivated by these factors. However, a fundamental concern intrinsic to scientific inquiry, is the reduction in objectivity in the scientific process and interpretation of data when our scientific community is less diverse. A key safeguard against this, is to have investigators from different backgrounds, experiences, ethnicity, sex, age, nationality, and so on, working on problems from different perspectives, using different methods and model systems. In other words, as Helen Longino (Longino Helen, 1990) and other philosophers and historians of science (Martin, 1991; Harding, 1992; Oreskes, 2019) have argued, if the diversity of the scientific community increases, the objectivity in generating new data and in its interpretation increases, leading to knowledge that is more reliable.

Science is an inherently a social endeavor that is affected by personal experiences (Longino Helen, 1990; Oreskes, 2019). These biases influence decisions on what, who and how to approach questions to find "truths" about our natural world. As in all disciplines, developmental biology has not been immune to narrow viewpoints supported by data generated from a largely homogenous community comprised of White males. Women and other marginalized groups have been largely left out, both in terms of being part of the scientific community and in the research process itself. Although, recently the number of White women scientists in developmental biology is currently similar to that of men, the consequences of this exclusion can be observed in the sexism underlying scientific accounts of reproductive biology and the roles of egg and sperm in fertilization (Longino Helen, 1990; Martin, 1991; Harding, 1992) or in the use of embryological and evolutionary findings to support sexism and racism such as those found in the eugenics movement (Longino Helen, 1990; Martin, 1991; Harding, 1992; Gilbert, 2001, 2021). Because values play an inevitable role, increased efforts to safeguard against current and future undetected biases leading to erroneous theories necessitates a scientific community with a rigorous peer review process that allows for criticisms and corrections influenced by differences in disciplinary experience as well as cultural and social viewpoints that comprise a diverse community of scientists within peer review groups.

Scientific societies are central to more than the peer review process. Professional societies organize and sponsor conferences that allow scientists to present their findings, vet new scientific ideas, and challenge those that are not sufficiently supported by evidence. These venues are invaluable platforms for all attendees to expand their disciplinary knowledge, meet, interact and form new professional networks, and create opportunities to pursue new scientific questions. These communities of scientists are one standard for how scientists work together not only to exchange and scrutinize ideas, but also to advocate and influence the science that will be subsequently published, presented nationally and internationally, and funded. Given the influence of scientific societies on the direction of scientific endeavors, the demographic of their membership is a serious concern to the success and collective impact of scientific research on society (COSSA, 2008; Madzima and MacIntosh 2021; Rushworth et al., 2021).

It is important to highlight differences between the demographics of the resident population in the UnitedStates in 2019 to the demographics in the STEM workforce (https://ncses.nsf.gov/pubs/nsf21321/data-tables). These data show that in 2019, the percent of Hispanics/Latinos in the UnitedStates was 18.45% but only 8.76% were employed (age 75 years or younger at full- and part-time status) in STEM fields. Representation of Black/African Americans and American Indian/Alaska Natives in STEM fields (6.89 and 0.32%, respectively) was also lower than their representation in the country (12.54 and 0.74%, respectively). In contrast, in 2019 Asians made up 13% of our STEM workforce, which is 2.25 times their representation in the UnitedStates population (5.76%). The representation of Whites, Native Hawaiian/Pacific Islander, and persons with disabilities working in STEM fields (68.45, 0.28 and 12.78%, respectively) was greater or somewhat closer to their representation in the country (60.11, 0.18 and 13.2%) than Hispanic/Latinos, Black/African Americans or American Indian/Alaska Natives.

In 2008, a consortium of various scientific organizations met to discuss the role of scientific societies in enhancing the diversity of those engaged in the sciences (COSSA, 2008). Their top recommendation was for scientific societies to make recruitment and retention of underrepresented (*UR*) scientists a goal, work with their membership and funding agencies to develop and sustain effective new initiatives, and monitor their impact aimed at broadening participation (COSSA, 2008). In 2012 the Society for Developmental Biology (SDB) was invited, along with a dozen or more other scientific societies, to a retreat sponsored by the National Science Foundation (NSF) BIO-Integrative Organismal Systems "Broadening Participation" initiative to discuss how NSF could work with scientific societies to increase the diversity in STEM. SDB was one of three scientific societies funded to test their pilot programs. In 2013, with funding from NSF, SDB established the *Choose Development!* Program.

The *Choose Development!* Program is focused on the recruitment and long-term retention of undergraduate students belonging to *UR* groups into a society of developmental biologists. The SDB *Choose Development!* Program provides fellows with a research-intensive experience equipped with a multi-tier mentoring plan, community-wide recognition and inclusion at national meetings, and continued tracking of their career progression. The early success of this program (Scientia, 2017) led to continued financial support from the SDB Board of Directors and donations from individual SDB members. Recently the National Institute of Child Health and Human Development (NICHD) has awarded a new grant to SDB to continue and expand this program given its success. Here, we report the outcomes of the *Choose Development!* Program as well as the positive effects on changing the infrastructure of the SDB and the diversity of its membership.

METHODS

Advertisement and recruitment of students and faculty for the *Choose Development!* (CD!) Program consist of contacting

attendees at the annual meetings sponsored by the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) and Annual Biomedical Research Conference for Minority Students (ABRCMS) which target undergraduate; also by wide dissemination of flyers to the membership and through the SDB website, and at the SDB's regional and national meetings every year. Active recruitment targets undergraduate students belonging to *UR* populations in STEM and attending a wide range of institutions (Junior Colleges, Primarily Undergraduate Institutions, etc.). Students and faculty complete separate applications that are due in early spring. These applications are made available through the SDB website (www.sdbonline.org/choose_development#Application). A three-person CD! leadership committee reviews all student and faculty applications and selects Fellows based largely on their academic performance, scientific curiosity, and interest in pursuing a research experience in developmental biology or related field. The students selected for the programs are referred to as CD! Fellows. Faculty are selected based on their record in mentoring students from diverse backgrounds, summer availability and research activity. Fellows are then matched to selected faculty based on mutual research interests and the Fellow is supported during two consecutive 10 weeks summer research internships.

Each Fellow is required to attend and present their summer research data during their second summer internship at the national SDB conference. Throughout their tenure in the program, Fellows are provided with multitude of professional development workshops and networking opportunities set up by the SDB that allow them to meet established developmental biologists via Zoom and in person when feasible. Various survey metrics have been used to assess the learning gains in scientific knowledge, understanding of the research enterprise, communication skills, attitudes towards pursuing graduate degrees and remaining in scientific research by the Fellows. The program has continued to seek updates from the Fellows after their CD! support. Mentors are surveyed to assess their mentoring experience, skills and attitudes in participating in the *Choose Development!* Program and its impact in their lab. This feedback is taken into consideration and modifications to the program are made each year to continue to improve the experiences for the Fellows.

RESULTS AND DISCUSSION

SDB was founded in 1939 as the Society for the Study of Development and Growth. In 1965, the name was changed to the Society for Developmental Biology. It took 35 years before the first woman, Dr. Elizabeth Hay, was elected president of the society in 1974 and 81 years to elect a president of Latino ethnicity, Dr. Alejandro Sánchez Alvarado (https://www.sdbonline.org/sdb_past_presidents). A voluntary survey of its membership in 2013 showed that individuals belonging to *UR* groups—Hispanic/LatinX, Native Hawaiian or Pacific Islander, Black or African American, American Indian or Alaska Native made up only about 10% of the SDB compared to 45.11% of the UnitedStates population (Table 1.2 in NCES Report, 2019). Members of the SDB Board recognized a need to increase the diversity of their membership, including *UR* groups and individuals with disabilities, across all academic levels. The drive to meet this goal led to the development of a comprehensive program called *Choose Development!*, which was established with funding by the National Science Foundation from 2013 to 2017 (https://www.sdbonline.org/choose_development). Here, we describe each of the society-wide initiatives (**Figure 1**) that has enhanced recruitment and engagement of established SDB members and has expanded inclusion of a wider range of scientific and social topics at our annual meetings that support diversity and inclusivity of all SDB members across social, cultural, ethnic and academic status, and institutional categories.

Core Activity: A Two-Summer Research Intensive Experience and Presentation at the SDB Annual Meeting

Recruitment of Students Belonging to Underrepresented Groups to the Developmental Biology Community

Over the last 40 years many programs have been created to encourage *UR* individuals to pursue careers in science, engineering, and mathematics. Thus far, the assessment of short-term interventions to broaden participation in STEM has yielded low returns (see "Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads" by NAS, 2011). A major challenge of these programs is helping *UR* students to see themselves as successful scientists. This is largely due to insufficient mentoring, lack of peer support, and a near absence of role models that represent the communities that these students are from (Sasso, 2008; Carnevale et al., 2011).

Recognizing that a strong research training experience in a laboratory setting that encouraged cooperative training and independent thinking had to be complemented with a strong and long-term mentoring support group (Handelsman et al., 2005), SDB developed the *Choose Development!* Program. This program provides a 2 year 10 weeks summer research immersion by *UR* undergraduate students in laboratories of established SDB members and encouraged by a strong multi-tier mentoring team throughout their tenure in the program and into their graduate programs. This multi-tier mentoring team is comprised of the Academic and Lab Mentors (see below) and the CD! leadership team. The training and mentoring structured around each Fellow were designed with the goal of increasing their professional network, sense of belonging in the community of developmental biologists, and likelihood of persisting in the sciences—an approach that has been validated by various groups since the inception of *Choose Development!* (NAS, 2011; Estrada, 2014; Estrada et al., 2016; Carpi et al., 2017; NAS, 2017; Martinez et al., 2018; Sellami et al., 2021).

UR students from 2 years Colleges, Primarily Undergraduate Institutions (PUIs) and Research (R1 and R2) institutions (**Table 1**) are encouraged to apply to this program. The SDB

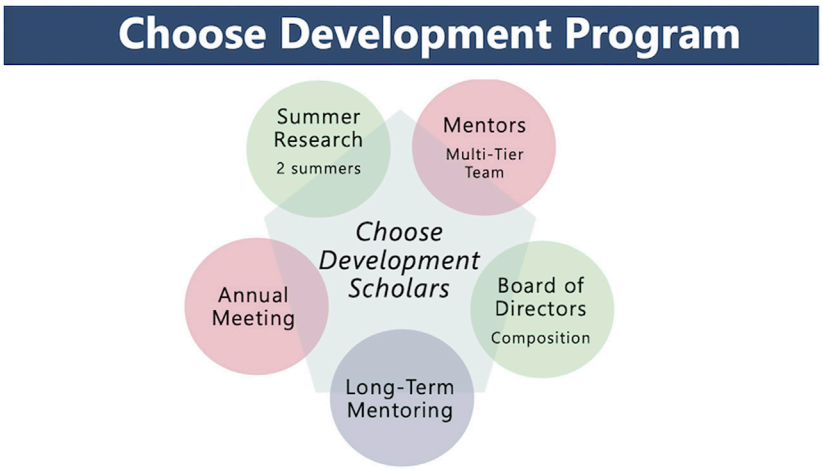

FIGURE 1 | Transformation of the Society for Developmental Biology into a more diverse and inclusive scientific society through a comprehensive research-intensive experience and long-term mentoring of undergraduate students.

TABLE 1 | Demographics of *Choose Development!* fellows (2013–2020).

	American Indian	African American	Hispanic / Latino	Hawaiian / Pacific Islander	Female / Male	Students with disabilities
2-years College	-	-	2	-	1 / 1	-
PUI	-	2	1	-	2 / 1	-
R1 and R2	1	8	20	1	17 / 11	3

PUI: primarily undergraduate institution.
R1 and R2: research intensive university; Research University.
Some students self-identified as multi-racial or multi-ethnic.

sponsored tables at national SACNAS and ABRCMS meetings where candidates were recruited for this program. In addition, CD! was presented to SDB members at their regional and annual meetings, in mailings to the entire membership, postings on websites of sister scientific societies, flyers sent to Minority Serving Institutions (MSIs), and direct communication with representatives who lead minority research training programs at their institutions.

As described above, undergraduate students who are beginning their sophomore or junior years with 2 years remaining in their baccalaureate degree are recruited through active outreach. The preferred applicants are those who belong to an *UR* group in STEM and are full-time students in good academic standing (minimum GPA of 3.0) who provide evidence of a strong interest and commitment towards pursuing a career in developmental biology or any related field as per their personal essay, research interests and letters of reference. Students from institutions where research experience is difficult to achieve are preferred, if academics are acceptable. Students with special needs are encouraged to apply, and a host lab that can provide the needed facilities sought. The cohort of Fellows chosen has ranged from ten to five, with the smaller numbers in years of limited bridge funding. This program has invested funds from the SDB, NIH and NSF on each Fellow's team. The expenses include summer stipends for the Fellow, housing allowances when needed, and registration and help with travel funds to the annual meeting in the second year for the Fellow and a Mentor.

Once selected, the Fellows were matched with the lab of an established SDB member with shared research interests and a strong record of mentoring *UR* students in their research group. These SDB members could be at or away from the Fellow's home institution. SDB members who wish to mentor a CD! Fellow also completed an application and underwent a thorough review. After each team is in place, Fellows and Mentors attend pre-summer workshops to ensure compliance with all programmatic requirements prior to starting their research projects. Upon joining their summer lab, Fellows are asked to make videos of their summer research experience in collaboration with their Academic Mentors. This activity bolsters the Fellow-Mentor relationship and communication from the beginning of their summer experience. These videos are uploaded to the SDB website and are used during the national meeting to introduce the Fellows to the entire society (https://www.sdbonline.org/choose_development_fellowvideos). During the summer, Fellows are required to complete and discuss an Individual Development Plan (IDP) with their Mentors. The IDP helps the Mentor become aware of the Fellow's career goals, their experiences and assets, as well as the disciplinary training and professional skills needed by them to achieve their career goals.

TABLE 2 | Academic/ professional status of *Choose Development!* fellows with Bachelor's degree.

Total with BS /BA	Doctoral program	Master's program	Medical school	Gap year app Grad	Industry	Unknown
30	15 (50%)	4 (13%)	3 (10%)	4 (13%)	2 (7%)	2 (7%)

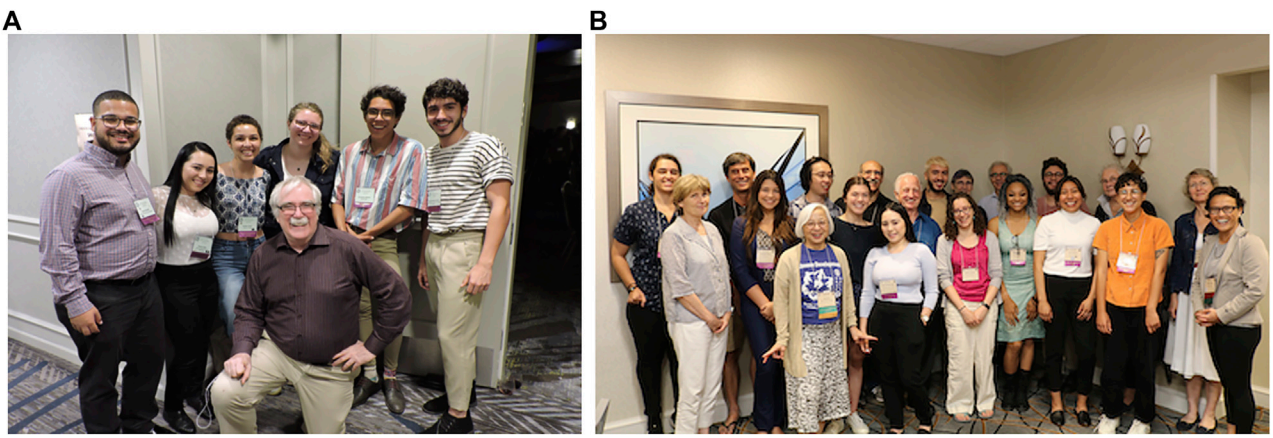

FIGURE 2 | (A): *Choose Development!* Fellows at the 2018 SDB Annual Meeting meet Nobel Laureate Dr. Eric Wieschaus (center). Fellows from left to right: Evan Brooks, Alexis Camacho-Avila, Amber Rock, Caroline Pritchard, Christian Wilson and Josean Reyes Rivera. **(B)**: *Choose Development!* Fellows at the 2019 SDB Annual Meeting lunch with renowned developmental biologists. From left to right: Lindsey Hernandez (2018); Ruth Lehmann; Richard Behringer; Adriana Vélez (2018–2019); Ida Chow; Qinan Hu (Lab Mentor); Talia Hart (2015); Martin Chalfie; Alexis Camacho-Avila (2017–2018); Mario Capecchi; Josean Reyes Rivera (2016, 2018); Rebecca Green (Lab Mentor); Brigid Hogan; Doug Melton; Grace Jean (2018); Davys Lopez (2013); Diana Ramirez (2018–2019); Christiane Nuesslein- Volhard; Amanda Neves (2018); Lilianna Solnica-Krezel; Graciela Unguez. Martin Chalfie, Mario Capecchi, and Christiane Nuesslein-Volhard are all Nobel Laureates; Ruth Lehmann, Brigid Hogan, Doug Melton and Lilianna Sonica-Krezel are all members of the National Academy of Science and SDB past presidents.

Outcome #1: Choose Development! Increased the Number of Underrepresented Undergraduates and Students With Disabilities Entering Graduate Programs in Developmental Biology

Between 2013 and 2020, *Choose Development!* accepted 33 undergraduate Fellows to its program. To date, 30 of 33 Fellows (91%) accepted into the Program have obtained their baccalaureate degree. As shown in **Table 2**, 19 (63%) of those that graduated have entered a graduate program in developmental biology or related biological fields (including one MD/PhD). In addition, 3 (10%) have entered medical school, two (7%) are employed in science-related fields, four (13%) have taken gap years to submit a more competitive application to graduate schools, and two (7%) have not responded to our annual surveys. Despite the relatively small number of Fellows to date, these are very high outcomes given both the graduation rates (91%) and persistence in science or science-related careers (80%, **Table 2**: all Fellows except those taking a gap year or are unresponsive).

Incorporation of Choose Development! Fellows into the SDB at Annual Meetings

An important part of this program is the opportunity for the Fellows to showcase their summer research accomplishments by presenting a poster at the subsequent year's SDB annual meeting. This activity provides the opportunity to welcome the Fellows into the community of developmental biologists. They also meet the Board of Directors at a reception exclusive for these Fellows. This is an important event as it provides the Fellows with access to the SDB leadership as well as an opportunity for the leadership to understand the impact of the program on the Society. Each year at the annual meeting the Fellows are also introduced to the community through different social events that include the opening reception, closing banquet, and a luncheon with distinguished, award-winning developmental biologists, including Nobel Laureates and members of the National Academy of Science (**Figure 2**). Their videos have often been shown during the meeting. The objective is to provide them with a sense that they have access to and support from the leaders in the developmental biology field as well as a sense that they can rely on the Society for long-term mentoring support. The long-range goal of the *Choose Development!* Program is for these students to flourish in the welcoming environment of the Society throughout their scientific careers. Such a system-wide commitment from a scientific society is both innovative and rare.

> "*I think it has been very successful like again, walking around with (SDB faculty), her introducing me to everybody has been very, very helpful. I mean I am*

FIGURE 3 | Screen picture of a weekly Zoom meeting with 2021 *Choose Development!* Fellows and guest, former SDB President and Noble Laureate Dr. Martin Chalfie. **(A)** Martin Chalfie, Marsha Lucas (SDB Publications and Communication Director), Jose Segura Bermudez, and Talia Marc. **(B)** Jahmiyes Wright, Richard Behringer (*Choose Development!* Program Coordinator), Christian Torres, and Katerine Norton. **(C)** Zach Mayne, Isabella Higgins, and Graciela A. Unguez (*Choose Development!* Program Director).

getting really great resources and networks. And so it's kind of fun because from going from the person I was in high school to where I am now is kind of . . . it's still kind of surreal how supportive everybody has really been." --Former Fellow

Complementary Activity 1: Long-Term Networking, Mentoring and Tracking

To ensure continued communication and tracking of our CD! Fellows, the SDB has explored several online platforms that allow individuals to share documents and set up networking and mentoring discussions. For example, between 2014 and 2016, a *listserve* for each group (i.e., Academic and Lab mentors) and Fellows (current and former), was generated in Trellis, a former online networking platform connecting different scientific communities provided by the American Association for the Advancement of Science. This allowed communication among current and former Mentors and Fellows so they could network and learn from each other as they transitioned out of the program and into graduate programs. Since 2017, the program has moved to the online Zoom platform to hold these meetings. This platform was essential to keep the Fellow-Mentor teams in contact during the summer of 2020 due to the COVID-19 pandemic. Online network forums are excellent sources for ongoing interactions between Fellows and Mentors and between Fellow-Mentor teams and the CD! leadership for evaluation purposes that lead to evidence-based modifications of the program. An innovative alternative to face-to-face introduction of the Fellows was started in 2020 by current program coordinator Dr. Richard Behringer, who recruited Nobel Laureates in the field, former and current SDB presidents and editors (current and former) of the official SDB journal *Developmental Biology* to meet current Fellows at weekly 1 h meetings during their 10 weeks summer research internship (**Figure 3**).

At these meetings, guests presented the Fellows with a wide range of professional trajectories and personal stories. The Fellows were provided many professional, research and networking opportunities. These weekly meetings proved effective in enhancing the Fellows' circle of practitioners in the field, many of whom looked like the Fellows themselves and/or had cultural and geographical backgrounds similar to those of the Fellows. Moreover, these focused online scheduled meetings have provided Fellows from Primarily Undergraduate Institutions and Minority Serving Institutions with a considerably greater source of input and feedback from established developmental biologists, and a more expansive professional network available to these students than what they otherwise experience.

Complementary Activity 2: *Choose Development!* Partners With the International Marine Biological Laboratory Embryology Course

Along with the two-summer research-intensive program, selected CD! Fellows were provided with the opportunity to visit the world-renowned Embryology Course at the Marine Biological Laboratory in Woods Hole, Massachusetts. Each summer, one or two Fellows were chosen to spend 1 week immersed in the course. This expanded their knowledge of developmental biology and new experimental techniques, while also providing an opportunity to network with national and international colleagues. To date, a total of ten Fellows have participated in

this unique training opportunity. This exposure and integration of the Fellows into the wider national and international developmental biology community gave them a strong identity along with a supportive professional network of developmental biologists. Three of the Fellows who attended the Embryology course were invited to become course assistants for the Embryology Course in subsequent years. This additional experience cemented their sense of belonging with the developmental biology community beyond SDB, and all three Fellows are now pursuing their doctoral degrees.

Complementary Activity 3: Implementation of Multi-Tier Mentoring Approach to Enhance the Training of Novice and Not-So-Novice Developmental Biologists

One of the most vital aspects to the success of this program is the multiple-tier mentor team format incorporated into the research and professional training of CD! Fellows. Each Fellow is assigned an Academic Mentor (Primary investigator/head of lab) and a Lab Mentor (postdoctoral fellow or an advanced graduate student) at the research lab. In turn, Academic and Lab mentors have a Master Mentor, an SDB member with extensive experience and record of training underrepresented students and postdocs in her/his lab, with whom to share concerns, request advice and discuss best practices in mentoring. In addition to exposing Mentors to inclusive communication skills and providing them with strategies to build an inclusive and culturally sensitive lab environment, the Lead Mentor facilitates discussions on implicit biases and approaches to optimize the sense of belonging in the lab of all Fellows.

Choose Development! provides all mentors, especially the senior faculty with a training workshop before the Fellows start the internship in their labs and at least one follow-up meeting to discuss programmatic issues and research progress of their Fellow. The feedback from these workshops has provided informed guidelines for best practices in mentorship which are disseminated to all SDB members and other scientific societies (e.g., Society for Neuroscience and AAAS) through meeting poster presentations. Because each Fellow must also be assigned a Lab Mentor, this program also offers professional development training to these early career scientists with the objective of providing them networking opportunities within the SDB community and skills essential for their careers as independent investigators. Incorporation of Lab Mentors has also elevated the awareness and reassurance of the Academic Mentors of their responsibility and role in cultivating these tiers of mentorship. Mentor workshops organized during the annual meetings give Academic and Lab mentors an additional opportunity to share and listen to other mentors' experiences and obtain advice from more senior mentors. These active group discussions also encourage Mentors to share strategies to manage priorities and responsibilities in the lab.

The multi-tiered mentoring approach offered to Fellow-Lab Mentor-Academic Mentor teams is a unique approach in CD! and reinforces the culture of good mentorship practices that benefit the mentors and results in positive consequences for all the Fellows. A specific focus for Lab mentors is the honing of the following skills: 1) lab management and interpersonal skills, 2) communication skills, and 3) time management skills. In post-summer surveys, Lab Mentors commented on the structured multi-layer mentoring approach, which primarily manifested in positive impacts on their own growth as mentors, scientists, and communicators (**Table 3**). Academic Mentors reflected on how their communication style and skills impact the attitudes and prospects of undergraduate students continuing onto a graduate program (**Table 3**).

> "*My participation was highly beneficial to my mentoring skills. My Fellow had a disability that I had little understanding of. This experience really taught me to explore different learning and communication styles with my mentees and to use campus resources, such as careers and disability advisors to manage expectations and career goals.*"—Former Lab Mentor

> "*I am very grateful to be a participant in the Choose Development program. I think it is a wonderful initiative that is already having a tangible impact on student fellows and mentor participants. I look forward to more positive outcomes that will inevitably result from this program.*"
> Former Academic Mentor

This mentor training plan has established the infrastructure within a national scientific society to support and foster the scientific enrichment of *UR* undergraduate students to successfully enter a graduate program and remain in the scientific research fields related to developmental biology. The introduction of this program to the SDB community raised awareness and appreciation for the benefits of good mentoring at all levels and of training a diverse population of future scientists. An atmosphere of inclusivity in the laboratories and classrooms is essential to foster and retain students who come from underserved and underrepresented populations. For their commitment and work efforts, all Mentors are recognized publicly at the annual SDB meeting for the commitment they have made to providing strong mentoring roles for the SDB Fellows. Several mentors have also participated in education workshops by sharing their experiences. Many established and not-so-established developmental biologists throughout the country who served as mentors or met the Fellows have since adopted the philosophy of long-term advocacy and mentorship.

Outcome #2: Choose Development! Fellows Co-Author Presentations and Publications Based on Their Research Projects

A science identity is not complete until students fully participate in all aspects of professional scientific culture. This means they must understand the values of the profession they are joining and appreciate that their research is not complete until it is disseminated to the public through presentations at scientific meetings and/or publications. All CD! Fellows actualize the

TABLE 3 | Impact of *Choose Development!* program on academic and lab mentors—some insights.

Lab mentors	Academic mentors
The lab mentor continued to gain experience in mentoring students, in particular *organizing experiments to maximize the output of the mentee*. It also helped the lab mentor *think more deeply about his project*, by having discussions with the mentee.	I realized that undergrads greatly value *having discussions with me about the process of applying to graduate school*. . .
The Lab Mentor had to *learn how to manage his own time better*, so that he would be able to help manage the SDB Fellow.	Alerted me to my need to articulate aspects of science as a career that I may not be conveying well to all students - *the process, the rewards, the frustrations* - in addition to the nuts and bolts of the science. . .
The postdoc became *far more engaged in her own project*. She let the Fellow go with an aspect of the project that has fueled the next set of her experiments.	The Embryology course and the SDB meeting. . . showed [my SDB fellow] a wider world outside of my lab and our immediate environment. . . promoted his independence and inspired him to take more control over his project. *In the future I will promote these types of opportunities more*
Interacting with our Fellow really *brought his lab mentor out of her shell*. Having to support him and seeing his interactions with me *have given her more confidence in her own work and interactions with others in the lab*.	Figuring out how *to teach her to communicate effectively*
The Lab mentor *developed many new strategies for working with students with difficulties*. She was very inventive in some of the things she came-up with - and most of them did really help and I think will be useful to him in all aspects of his life.	It gave me the opportunity to *develop new strategies for mentoring students with difficulties*.

TABLE 4 | Research publications with data from *Choose Development!* fellows research projects.

2020
Martinez-Gómez, J., Galimba, K.D., Coté, E., Sullivan, A., Di Stilio, V.S. 2020. Spontaneous homeotic mutants and genetic control of floral organ identity in a ranunculid. *Evolution and Development* Special Issue (November 12, 2020). https://doi.org/10.1111/ede.12357
Hu, Q., Aviles-Velez, A., and Wolfner, M.F. 2020. Drosophila Plc21C is involved in calcium wave propagation during egg activation. *Micropublications Biology*
Hu, Q., Duncan, F.E., Nowakowski, A.B., Antipova, O.A., Woodruff, T.K., O'Halloran, T.T., Wolfner, M.F. 2020. Zinc dynamics during Drosophila egg maturation and activation. *iScience* 23(7): 101275.
Fellows acknowledged: Adriana Aviles-Velez and Lauryn Worley
2019
Wang, T.N., Clifford, M.R., Martinez-Gómez, J., Johnson, J.C., Riffell, J.C., Di Stiliio, V.S. 2019. Scent matters: differential contribution of scent to insect response to flowers with insect vs wind pollination traits. *Annals of Botany* 123(2), pp. 289–301
2018
Galimba, K.D., Martinez-Gómez, J., Di Stiliio V.S. 2018. Gene duplication and transference of function in paleo AP3 lineage of floral organ identity genes. *Frontiers in Plant Science*, 9, p. 334
Anna I Vickrey, Rebecca Bruders, Zev Kronenberg, Emma Mackey, Ryan J Bohlender, Emily Maclary, Raquei Maynez, Edward J Osborne, Kevin P Johnson, Chad D Huff, Mark Yandell, Michael D Shapiro. 2018. Introgression of regulatory alleles and a missense coding mutation drive plumage pattern diversity in the rock pigeon. *eLife* e34803. doi: 10.7554/eLife.34803
S. Basu, I. Barbur, A. Calderon, S. Banerjee, A. Proweller. 2018. Notch signaling regulates arterial vasoreactivity through opposing functions of Jagged1 and Dll4 in the vessel wall. *Am J Physiol Heart Circ Physiol*
Salinas-Saavedra, M., Rock, A.Q., and Martindale, M.Q. 2018. Germ layer specific regulation of cell adhesion: insight in to the evolution of mesoderm. *eLife* 7:e36740. doi: 10.7554/eLife.36740
Dubuc, T.Q. *, Stephenson, T.B.*, Rock, A.Q., and Martindale, M.Q. 2018. Hox and Wnt Pattern the First Primary Axis of an Anthozoan Cnidarian before Gastrulation. *Nature Communications* 9(1): (2018/05): 2007
2017
Pekar,O., Ow, M.C., Hui K.Y., Noyes, M.B., Hall, S.E., Hubbard, E.J.A. 2017. Linking the Environment, DAF-7/TGFβ signaling and LAG-2/DSL ligand expression in the germline stem cell niche. *Development* 144(16). pp. 2896–2906.
Fellow Acknowledged: Jesus Martinez-Gómez
2015
Sharma, P., Arazona, O.A., Lopez, D.H., Schwager, E.E., Cohn, M.J., Wheeler, W. and Extavour, C. 2015. A conserved genetic mechanism specifies deutocerebral appendage identity in insects and arachnids. *Proc Biol Sci*, Jun 7:282 (1808):20150698. doi:10.1098/rspb.2015.0698

NOTE: name of fellow in bold; name of Academic Mentor underlined.

experience of being an active contributor to the production of scientific knowledge and its dissemination by submitting abstracts of their work and presenting it at poster sessions at the SDB Annual Meetings (2014–2020). Many of the 33 Fellows have also presented their research at the annual meetings of other scientific societies including SACNAS, ABRCMS, and the American Society for Cell Biology. Some Fellows have also been able to "professionalize" their summer research experience by engaging in the peer review and publication process of their results. To date, a total of 11 publications have involved the research conducted by Fellows, with nine publications having a Fellow as a co-author and two crediting Fellows in the acknowledgements for including research from their two research summers (**Table 4**). These accomplishments exemplify the level of dedication and commitment of the Academic Mentors toward the training and education of the Fellows, as well as the dedication and motivation of the Fellows.

Complementary Activity 4: *Choose Development!* Spurs SDB Leadership to Better Represent Its Membership Needs

Restructure of the Board of Directors: Elected Office and Committees

Introduction of the CD! Program has led to expansion of inclusion and outreach of various groups within the Board of Directors (BOD). Specifically, the BOD approved the addition of three electable officers that would represent graduate students (2019), postdoctoral fellows (2020), and faculty at Primarily Undergraduate Institutions (PUIs, 2019) (https://www.sdbonline.org/board_of_directors). The first elected graduate student representative was a CD! Fellow, who recently received her PhD from Stanford University) and is now a postdoctoral fellow at UCSD in a developmental biology lab. Addition of these three new elected representatives to the BOD has greatly contributed to the BOD's diversification, and most importantly, the contributions of the BOD has led to an expansion of inclusive activities that have influenced the structure of the SDB regional and national meetings

In 2012, two of fourteen BOD members and one out of nine members of two standing committees had *UR* status. Since inception of the CD! Program, SDB has elected its first Hispanic/Latino President (2019) and five BOD members that identify as African American or Hispanic/Latinos. In 2017, the Inclusion and Outreach Committee (IOC) was formed to oversee the design and implementation of program activities that promote "Development for all". The goal of this campaign is to continue to message that SDB welcomes and supports anyone interested in developmental biology and related disciplines (https://www.sdbonline.org/ioc#mission). The IOC in conjunction with the SDB's Professional Development and Education Committee (PDEC) has organized special symposia at the national annual meetings on unconscious bias, scientific bias, and mental wellness. The IOC also coordinates the offering of 1 h small group discussion led primarily by BOD members on topics requested by the SDB membership. These topics have included the following themes: networking for undergraduate and graduate students, applying to graduate schools and postdoc positions, preparing for academic and non-academic jobs, mentoring for trainees and faculty at all career stages, support for LGBQT+ members, and optimizing teaching and research at different types of institutions.

Outcome #3: Changing Trends in Demographics of the SDB Membership

An increase in the number of SDB members that "look" like the Fellows will provide a more inclusive environment that facilitates the sense of belonging of the Fellows—an outcome that is essential for their progression and retention in the field of developmental biology. In 2012, the demographics from an SDB membership survey (voluntary participation) showed White members made up 78% of total respondents. Data from a more comprehensive database on the 2020 SDB membership shows a 9% decrease in the percentage (69%) of Whites compared to that in 2012 (**Table 5**). The total percent membership made up by underrepresented groups was similar in both 2012 (14.5%) and 2020 (14.43%). In these voluntary surveys, an increase was seen in the Hispanic/Latino membership (7.2 versus 9.30% in 2012 and 2020, respectively) and a decrease in members with disabilities (4 versus 0.016% in 2012 and 2020, respectively). The largest change was in the members that checked the "Other/Undisclosed" category—it more than doubled between 2012 (7.5%) and 2020 (16.06%).

Broadening the representation of the SDB leadership has increased the active outreach to underrepresented scientists across the country to be speakers at regional and annual meetings. It has also led to an increase in *UR* candidates to the Nominating Committee for elected positions on the BOD. Collectively, the *Choose Development!* Program spurred the SDB to work towards maximizing the effectiveness of inclusion and diversity initiatives and promoting greater representation and participation in the Society by individuals belonging to *UR*

TABLE 5 | Demographics of the SDB membership (based on voluntary membership responses in 2012 and 2020)

	African American	American Indian	Hawaiian / Pacific Islander	Hispanic / Latino	White	Other / Undisclosed	People w/ Disabilities	Total
2012	16 (2.3%)	7 (1%)	0	49 (7.2%)	531 (78%)	51 (7.5%)	27 (4%)	681 (survey)
2020	52 (2.9%)	22 (1.2%)	5 (0.02%)	168 (9.30%)	1,242 (69%)	289 (16.06)	29 (0.016%)	1799 (database)

TABLE 6 | Demographics of trainees (undergraduate, graduate and postdocs) in the SDB

Year	Undergrad and Grad	Hispanic	Non-Hispanic	Undisclosed ethnicity	Black/ African American	American Indian	Pacific Islander	White	Asian	Undisclosed race	Disability disclosed
2013	473	46 (9.72%)	369 (78.01%)	58 (12.26%)	16 (3.38%)	8 (1.69%)	4 (0.85%)	307 (64.90%)	91 (19.24%)	68 (14.38%)	8 (1.69%)
2014	571	51 (8.93%)	428 (74.96%)	92 (16.11%)	20 (3.50%)	9 (1.58%)	3 (0.53%)	311 (54.47%)	166 (29.07%)	85 (14.89%)	7 (1.23%)
2015	588	74 (12.79%)	444 (75.91%)	70 (11.90%)	23 (3.91%)	11 (1.87%)	1 (0.17%)	357 (60.61%)	134 (22.79%)	82 (13.95%)	4 (0.68%)
2016	660	69 (10.45%)	514 (77.88%)	77 (11.67%)	31 (4.70%)	8 (1.21%)	2 (0.30%)	412 (62.42%)	135 (20.45%)	94 (14.24%)	7 (1.06%)
2017	594	75 (12.72%)	470 (79.12%)	49 (8.25%)	28 (4.71%)	13 (2.19%)	6 (1.01%)	348 (58.59%)	155 (26.09%)	79 (13.30%)	10 (1.68%)
2018	583	75 (12.86%)	471 (80.79%)	37 (6.35%)	29 (4.98%)	9 (1.54%)	4 (0.69%)	360 (61.75%)	135 (23.16%)	69 (11.84%)	10 (1.71%)
2019	601	79 (13.14%)	471 (78.37%)	51 (8.49%)	35 (5.82%)	16 (2.66%)	5 (0.83%)	376 (62.56%)	137 (22.80%)	69 (11.48%)	10 (1.66%)
2020	703	104 (14.79%)	548 (77.95%)	51 (7.25%)	36 (5.12%)	18 (2.56%)	3 (0.43%)	412 (58.61%)	173 (24.61%)	99 (14.08%)	11 (1.56%)
2021*	602	112 (18.60%)	441 (73.26%)	49 (8.14%)	33 (5.48%)	12 (1.99%)	3 (0.50%	334 (55.48%)	158 (25.26%)	94 (15.61%)	13 (2.16%)

groups. One of the most encouraging indicators of effective efforts by the entire SDB is the increase in the diversity of the undergraduate and graduate students joining the SDB since the inception of the CD! Program in 2013 (**Table 6**). Among these trainees, the percentage of Hispanics has doubled from 9.72% (2013) to 18.60% (2021). Although not as dramatic, the number of Black/African American (3.38 to 5.48%), American Indian (1.69 to 1.99%), and students with disabilities (1.69 to 2.16%) have also increased (**Table 6**).

The cumulative outcomes of the CD! Program to date (**Tables 2**, **3**) strongly support the positive impact of community-based long-term advocacy and mentoring of *UR* undergraduates in retaining students in a science career. Moreover, this Program has raised awareness and appreciation of the benefits reaped by all members across the entire SDB community when it champions structural changes that allow the inclusion and support of a diverse population of scientists into the Society. The high retention of CD! Fellows in scientific careers exemplifies an optimal convergence of highly dedicated and motivated *UR* students with a scientific community that is committed to support their successful research training and education. Although we highlight some promising outcomes, much work must still be done to ensure that these young scientists-in-training persist through the ranks of the academy. In order to ensure that the scientific process serves our nation and our society well, we must capitalize on the collective talents that people from all ethnic and cultural groups can bring to bear in solving the mysteries of the natural world.

Academic researchers are part of a society composed mostly of non-scientists who fund, participate in, benefit from, and in some cases are the subjects of scientific research. At the heart of the scientific endeavor is the conviction that when new knowledge is produced, these findings and their interpretations are reliable. This process warrants that research practitioners engage in a rigorous peer review process wherein scientists engage in presenting their findings, vetting ideas, and rejecting those that are not sufficiently supported by evidence prior to the publication of reports to the public. Because values play an inevitable role, diversifying our scientific community will more likely increase social practices of criticism, and corrections will detect unexamined assumptions, blind spots and inherited biases. But the need is even more fundamental because a diversity of ideas, which can originate from ethnic, cultural, and other forms of diversity, can enhance creativity and productivity, which is the very life blood of science.

A great case in point is that of Dr. Nettie Stevens whose research published in 1905 entitled "*Studies in Spermatogenesis*" affirmed that chromosomes play a role in determining sex during development, an idea that was against the more popular belief of that time that sex was determined by external factors (Brush, 1978). Due to her exclusion at scientific conferences because she was a woman, her findings were ignored and overshadowed by other more established male researchers, like Edmund Wilson who published a similar discovery using a different model of heredity and received all credit for Stevens' original findings and conclusions.

Similarly, renowned embryologist Ernest Everett Just (1883–1941) emphasized the role that non-nuclear factors play in development and heredity. Specifically, he supported the view that embryonic differentiation was driven by all the parts of the

cell, but especially the cytoplasm. This view was in sharp contrast to the emerging gene theory and nucleo-centric developmental processes put forth by Thomas Hunt Morgan and his followers (Manning, 1983; Sapp, 1998, Sapp, 2009). Although not all details of his view were correct, E.E. Just was correct about the importance of interactions between cytoplasmic factors and the nucleus (Manning, 1983; Sapp, 1998, Sapp, 2009). His work and views are worth revisiting within the context of his time and current knowledge that overwhelmingly questions genes and chromosomes as the sole basis of development.

E.E. Just's insights and unique life experiences as an African American in the Academe were unlike those of Morgan's whose patriarchal lineage included slave owners and Confederate General John Hunt Morgan (Sturtevant, 1959). E.E. Just's drive to challenge Morgan was likely due to his ability to see things very differently than his peers (Manning, 1983; Byrnes and Eckberg, 2006; Byrnes and Just, 2015). Reflection on the important findings and interpretations of their work in developmental biology—both Nettie Stevens and E.E. Just were scientists whose careful observations and insightful interpretations were ignored and marginalized by the White male majority because of who they were—female or Black. As practicing research scientists, we recognize that exclusion practices of all scientific voices severely impair the scientific endeavor. We have helped spark a movement within the SDB to incorporate and establish inclusive practices in its education, training, networking and knowledge-sharing activities as detailed in this report. The momentum to recruit, attract and retain widely diverse scientific minds will lead to continued improvements in the quality of the scientific work we do. This is why diversity in science is important; critical scrutiny of all research done by scientists from different backgrounds leads to better collective knowledge. Understanding the evolution of our natural world is best done by the collective input of diverse developmental biologists

CONCLUSIONS

To increase the diversity of experiences and backgrounds of individuals doing research in developmental biology and related fields, we have described ongoing efforts to improve the recruitment, retention, and inclusivity of individuals at all academic stages—from undergraduate to full professorship—in all activities sponsored by the SDB. Sparked by the *Choose Development!* Program first funded in 2013 by the NSF, the SDB has gradually expanded the multi-pronged approach by increasing the diversification of its Board of Directors membership, the speakers and institutions participating in the society's regional and national meetings, widening the topics covered in professional development workshops to address broader needs, and galvanizing all members to fully engage in a scientific society that endorses its unofficial motto, "*Developmental Biology for All and by All.*"

It is not unrealistic nor impossible to make swift notable changes in how "we do science" within our niches to impact the number and diversity of individuals invited to be part of the scientific endeavor, peer review, decision making process and activities of a scientific society. The multi-pronged approach exemplified by the *Choose Development!* Program is one model by which a scientific community has encouraged and invited all its members to participate in helping make their community become more open, safe and inclusive environment for everyone. We have used *Choose Development!* to actively recruit underrepresented scientists for talks at meeting symposia, nominate these individuals for awards, and encourage them to run for elected office within the Board of Directors. Collectively working towards a more diverse and inclusive community of scientists where these young *Choose Development!* Fellows see themselves not just as a resource but rather the lifeblood that constitutes science itself is crucial for their success and for the scientific endeavor. All scientific communities can achieve effective inclusion and diversity. Creating an inclusive culture is not a one-off initiative. It is about a clear narrative that building diversity and maintaining it necessitates ongoing support, mentorship and governance. The pay-off of this *Choose Development!* program, is the creation of a more colorful and inclusive space that is pushing the frontiers of developmental biology in exciting directions.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

KB: Co-founder and first coordinator of the *Choose Development!* Program and Professor Emerita from the University of Missouri School of Medicine, who fostered many minority undergrads. Previously served as an NSF program officer in the Developmental Mechanisms program, Midwest representative on SDB Board of Directors, and member/chair of the Professional Development and Education Committee; IC, Co-founder of the *Choose Development!* Program and Co-PI in both NSF and NICHD grants; administrator of the grant and programmatic logistics; SDB Executive Director; CD, Master Mentor, Academic Mentor of 3 CD! Fellows, past West Coast representative on SDB Board of Directors, and member of the SDB Inclusion and Outreach Committee; GU, Co-founder of the *Choose Development!* Program, Program Director Principle Investigator of NSF (2013–2017) and NIH R25 (2021–2026) grants funding this program, and Chair of Inclusion and Outreach Committee.

FUNDING

This work is supported in part by the following funding sources: NSF GRANT IOS-1239422 (2013–2017): "*Broadening participation of underrepresented groups in developmental biology.*" Partnership for the Advancement of Cancer Research NCI Grants no. U54 CA132383 (New Mexico State University; G.A.U.). Society for

Developmental Biology and private donations from SDB members and other private donors for sustaining bridge funding. NICHD R25 HD105600 (2021–2026): *Choose Development! to broaden participation of underrepresented undergraduates in developmental biology research.*

ACKNOWLEDGMENTS

We thank: Marsha Lucas, SDB Publications and Communication Director, who supported the online activities as well promotion of the Program at various meetings. Christine Weston, John Hopkins Bloomberg School of Public Health, the external Program Evaluator during the NSF award period., David Burgess, Boston College, the first Lead Mentor of the Program. Richard Behringer, MD Anderson Cancer Center, the current Coordinator of the Program. SDB Board members for their continued support of the *Choose Development!* Program. Former *Choose Development!* Fellows and Mentors for their dedicated participation and teaching moments to the SDB community.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Sociology

PERSPECTIVE
published: 18 February 2022
doi: 10.3389/fsoc.2021.784399

The Inclusive Professional Framework for Societies: Changing Mental Models to Promote Diverse, Equitable, and Inclusive STEM Systems Change

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Science, technology, engineering, and mathematics (STEM) professional societies (ProSs) are uniquely positioned to foster national-level diversity, equity, and inclusion (DEI) reform. ProSs serve broad memberships, define disciplinary norms and culture, and inform accrediting bodies and thus provide critical levers for systems change. STEM ProSs could be instrumental in achieving the DEI system reform necessary to optimize engagement of all STEM talent, leveraging disciplinary excellence resulting from diverse teams. Inclusive STEM system reform requires that underlying "mental models" be examined. The Inclusive Professional Framework for Societies (*IPF: Societies*) is an interrelated set of strategies that can help ProSs change leaders (i.e., "boundary spanners") and organizations identify and address mental models hindering DEI reform. The *IPF: Societies* uses four "I's"—Identity awareness and Intercultural mindfulness (i.e., equity mindset) upon which inclusive relationships and Influential DEI actions are scaffolded. We discuss how the *IPF: Societies* complements existing DEI tools (e.g., *Women in Engineering ProActive Network's* Framework for Promoting Gender Equity within Organization; *Amplifying the Alliance to Catalyze Change for Equity in STEM Success'* Equity Environmental Scan Tool). We explain how the *IPF: Societies* can be applied to existing ProS policy and practice associated with common ProS functions (e.g., leadership, membership, conferences, awards, and professional development). The next steps are to pilot the *IPF: Societies* with a cohort of STEM ProSs. Ultimately, the *IPF: Societies* has potential to promote more efficient, effective, and lasting DEI organizational transformation and contribute to inclusive STEM disciplinary excellence.

Keywords: inclusive professional framework for societies, mental models, intercultural mindfulness, equity mindset, inclusive relationships, identity awareness, influential actions, DEI (or Diversity Equity and Inclusion)

OPEN ACCESS

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Specialty section:
This article was submitted to Gender, Sex and Sexualities, a section of the journal Frontiers in Sociology

Received: *27 September 2021*
Accepted: *14 December 2021*
Published: *18 February 2022*

Citation:
Leibnitz GM, Gillian-Daniel DL, Greenler RMcC, Campbell-Montalvo R, Metcalf H, Segarra VA, Peters JW, Patton S, Lucy-Putwen A and Sims EL (2022) The Inclusive Professional Framework for Societies: Changing Mental Models to Promote Diverse, Equitable, and Inclusive STEM Systems Change. Front. Sociol. 6:784399. doi: 10.3389/fsoc.2021.784399

INCLUSIVE STEM DISCIPLINARY EXCELLENCE REQUIRES SYSTEMS REFORM

Addressing complex global challenges, such as climate change and health disparities, requires optimal engagement of people trained in science, technology, engineering, and mathematics (STEM). Because diverse teams embody enhanced capacity for problem solving, innovation, and resilience, they advance disciplinary excellence in a way that homogenous groups cannot (e.g., Page, 2007; Borman et al., 2010; Page, 2017; McGee, 2020). Consequently, not only are more STEM-trained people needed, but specifically more diverse STEM-trained people are needed.

Unfortunately, STEM cultures often discourage diversity by reproducing exclusionary norms and values (Tonso, 1996, 1999, 2007; Seymour and Hewitt, 1997; Pawley and Tonso, 2011; BaillieKabo and Reader, 2012; Riley et al., 2014; Cech and Rothwell, 2018; Hughes, 2018; McGee, 2020). Current US STEM systems privilege white, and/or men in STEM, and are typically perceived as unwelcoming by marginalized groups, especially women from various backgrounds (Metcalf et al., 2018; McGee, 2020; Campbell-Montalvo et al., 2021a). Expression of majority priority is manifest in complex ways, such as equating masculinity with technical ability, embracing and centering whiteness (Hacker, 1981, 1989; Eisenhart and Finkel, 1998; Lohan and Faulkner, 2004; Faulkner, 2007; Foor et al., 2007; Tonso, 2007; Pawley and Tonso, 2011; BaillieKabo and Reader, 2012), and fostering the false idea that STEM is an apolitical, value-free, empirical meritocracy (McGee, 2020; Metcalf, 2017). Systems of power, privilege, and oppression intersect with those shaped by gender, race, ethnicity, sexuality, disability, nationality, class, and more (Crenshaw, 1989; Crenshaw 1991; Griffin and Museus, 2011; Collins, 2015; Metcalf, 2016; Warner et al., 2016; Metcalf et al., 2018). Collectively, these intersecting systems influence opportunities, create barriers, and can in turn promote exclusionary experiences for a variety of individuals, including women and other groups underrepresented in STEM. These experiences of exclusionary STEM systems are often replicated in, and sustained, not just in established STEM work environments but also by a STEM education system that socializes the next generation of the STEM workforce to abide by and reproduce these norms and values (Trouillot, 1995; Foucault, 2007; Tonso, 2007; Tonso, 2014).

While STEM systems reform is clearly needed to attract, retain, and support a thriving diverse STEM talent pool, there is widespread expectation that minoritized and marginalized people will, and should be, the ones tasked with changing a system by which they are oppressed and largely excluded (Forrester, 2020). Majoritized people receive disproportionate power within the current system, so it is incumbent on them to be leaders in STEM system change to promote inclusive disciplinary excellence. This change must be supported through both "intentional introspection and subsequent action" (Chaudhary and Berhe, 2020, pg. 3).

UNCOVERING PROFESSIONAL SOCIETY MENTAL MODELS

Mental models are "deeply held beliefs and assumptions, and taken-for-granted ways of operating that influence how we think, what we do, and how we talk" (Kania et al., 2018, p. 4). We argue that intentional introspection of mental models can foster systems change. Systems change is "shifting the conditions that are holding the problem in place" (Kania et al., 2018). Kania et al. (2018) identified six conditions of systems change that are explicit (i.e., *policies*, *practices*, *resource flows*), semi-explicit (i.e., *relationships and connections*, *power dynamics*), and implicit (i.e., mental models). *Mental models* hold the other conditions in place. Unless we learn to work at the mental models level, other structural changes "...will, at best, be temporary or incomplete" (Kania et al., 2018, p.8). While work addressing mental models has been increasing in academic institutions (e.g., NSF ADVANCE-funded initiatives) and industry settings, few projects have undertaken these efforts within professional societies (ProSs).

Given the multiple, varied disciplinary functions performed by STEM ProSs, and that STEM ProSs often engage other STEM system gatekeepers (e.g., corporate, laboratory, and academic organizations), STEM ProSs are uniquely positioned as critical levers for STEM systems change (e.g., National Academy of Sciences et al., 2005). Peters and others (in press) identify 11 functions performed by STEM ProSs (i.e., governance and leadership; membership; programming; professionalization; student chapters; prizes, awards, and funding; outreach and engagement; employment; advocacy; and publishing). Through functions such as these, the ProS reinforces mental models regarding how the discipline "looks, feels, and acts." Leaders are identified, innovations celebrated, and the next generation is nurtured. For example, students enter STEM degree programs with varying levels of social capital (Skvoretz et al., 2020), and ProSs keep them in their programs (Smith et al., 2021; Campbell-Montalvo et al., in press). Some STEM ProSs are actively engaged in STEM systems change to promote diversity, equity, and inclusion (DEI) through STEM ProS functions (e.g., Segarra et al., 2020a; Segarra et al., 2020b; Campbell-Montalvo et al., in press, Campbell-Montalvo et al., 2020; Etson et al., 2021). However, we believe that to foster greater engagement by STEM ProSs, more STEM ProS-specific tools are needed, especially those that can help make explicit and reframe mental models underpinning STEM ProS functions.

THE IPF: SOCIETIES AS A TOOL FOR MENTAL MODEL CHANGES

We offer the *Inclusive Professional Framework for Disciplinary and Professional Societies* (*IPF*: *Societies*) as an approach to help elucidate and adjust mental models that underlie STEM ProS functions (INCLUDES Aspire Alliance National Change, n.d.). The *IPF: Societies* is a framework that can be used to explore how internal conditions support and hinder current ProS DEI aspirations and help set a foundation for lasting organizational change. Specifically, the *IPF: Societies* is a research-informed approach that focuses on awareness and skill development to build an equity mindset—an orientation in which actions are grounded in understanding of how social positionings affect access to resources. This mindset creates greater capacity for

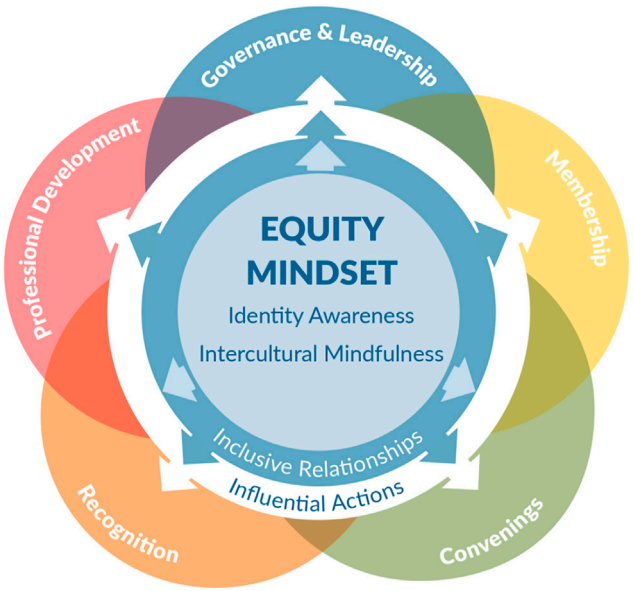

FIGURE 1 | The IPF: Societies graphic with five example professional society functions (INCLUDES Aspire Alliance National Change, n.d.).

inclusive relationships and supporting actions that are focused on DEI change. The *IPF: Societies* includes the four "I's":

1. Identity awareness,
2. Intercultural mindfulness,
3. Inclusive relationships, and
4. Influential DEI actions.

The *IPF: Societies* derives from the *Inclusive Professional Framework for Faculty* (*IPF: Faculty*). The *IPF: Faculty* was developed by the Aspire Alliance's National Change Initiative, which is part of the National Science Foundation's Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES). The IPF: Societies was developed with input from leaders from the NSF ADVANCE-funded Amplifying the Alliance to Catalyze Change for Equity in STEM Success (ACCESS+), (n.d) Initiative, whose mission is to "accelerate the awareness, adoption, and adaptation of NSF ADVANCE evidence based, gender-related, DEI policies, practices, and programs within and across STEM ProSs, by providing support to STEM ProS boundary spanners." Through partnership with ACCESS+ the *IPF: Societies* graphic was created, along with example functions (see **Figure 1**); and the model was tailored to a ProS audience, refined, and piloted. Ongoing work through ACCESS+ will support engagement and continued refinement through use with future cohorts of ACCESS+ ProSs and the development of complementary resources.

Given the parallel role that mental models play in university and ProS systems, we propose that it is valuable to adapt the *IPF* for use in ProSs. Like the *IPF: Faculty*, the *IPF: Societies* at its core focuses on building an equity mindset through identity awareness and intercultural mindfulness and then puts that mindset into practice through reinforcing skills that support inclusive relationships. Where the frameworks (i.e., *IPF: Faculty and IPF: Societies*) differ is in the contexts and roles of those applying the framework. The *IPF: Faculty* was developed to promote inclusive skill development for faculty across their roles within academic institutions (e.g., teaching, advising, research mentoring, collegiality, and leadership) (Gillian-Daniel et al., 2021b; Dukes et al., in press). For the *IPF: Societies*, application occurs, initially by society DEI change leaders (i.e., "boundary spanners"), in the various functions that the society performs for its members and discipline, as discussed in greater detail below (see **Figure 1**: *IPF: Societies* with example ProS functions).

The *IPF: Societies* has dual target audience foci: 1) DEI change leaders (individual focus) and 2) the ProSs as a system (organizational focus). Key individuals within the organizational system are ProS DEI change leaders, known as "boundary spanners," who are people within an organization who work to connect ideas, resources, and stakeholders (Hill, 2020). These individuals engage in five key behaviors: 1) finding—identifying knowledge and resources outside one's organization to advance innovation, research, and development (Ancana and Caldwell, 1992; Tushman and Scanlan, 1981); 2) translating—making sense of what is found for modification and application within one's own organization (Katz and Tushman, 1981); 3) diffusing—sharing what is gained from extra-institutional connections with fellow organizational members (Rogers, 2003); 4) gaining support—laying the political foundation and support within an organization to implement innovation (Brion et al., 2012; Faraj and Yan, 2009); and 5) social "weaving" behaviors by being the bridge wherewith to connect diverse stakeholders from multiple organizations under a common purpose (Burt, 1992; Kania and Kramer, 2011). Boundary spanners are an ideal lever for enacting and promoting DEI change given that they are often in positions to reach other boundary spanners in their ProSs and beyond (Aldrich and Herker, 1977; Katz and Tushman, 1981; Ancona and Caldwell, 1992; Hill, 2020). We propose that uptake of the *IPF: Societies* by boundary spanners to develop and refine DEI awareness, knowledge, and skills can better position these change leaders to make systemic changes within their ProS. This in turn has potential ripple effects extending to the wider STEM system (Leibnitz et al., 2021). Similarly, by STEM ProSs using the *IPF: Societies* to explore the ProS organizational system, both internal-focus (i.e., the STEM ProS business infrastructure) and external-focus (i.e., member and disciplinary serving STEM ProS infrastructure) DEI awareness and organizational capacity are enhanced, better positioning ProSs to enact DEI systems change.

Figure 1 depicts the progression of the *IPF: Societies'* processes, showing how the equity mindset is developed and expands into relationships and actions that guide ProS core functioning, catalyzing STEM DEI systems change. We propose that the *IPF: Societies* can be usefully applied at both

TABLE 1 | How the IPF: Societies informs practices within five example professional society functions.

Example ProS function name and definition (Peters et al., 2021)	Example ProS policies/practices	Example ProS questions generated with an *IPF: Societies* lens	Example ideas for implementing more equitable practices
Governance and leadership—How the ProS is run and major decisions are made (internal focus)	Governing board members are selected based on seniority within the discipline	• How is seniority a result of structural inequality within the ProS and U.S. broader society? • How does using seniority as a measure of qualification shape the pool of possible governing board members?	• Develop a mission/vision statement or other commitment to equality and diversity that includes a non-discrimination clause regarding leadership and members (e.g., Potvit et al., 2018) • Identify clear goals and adequate resources to support change • Gather inclusive organizational data; analyze the data intersectionally; share results publicly; and use the data to inform action planning • Ensure that DEI commitment is reflected consistently in charges to all committees • Build a case for more diverse senior leadership as essential to the long-term success of the organization • Build understanding, buy-in, and support from grassroots organizational members as well as from leadership • Engage male and/or majority member allies and advocates at all levels of the organization in the culture-change effort (e.g., Bilimoria et al., 2008)
Membership—ProS members and the structures that shape membership makeup (external focus)	In order to reduce survey burden and avoid being too intrusive, the ProS collects limited demographic data through its membership application	• What data are collected, and for what purpose(s) • How are the data collected currently used to further an inclusive mission of the society? • Do members feel that the measures accurately capture their social and cultural identities? • How is the rationale for collecting demographic data articulated to members as being both valuable and aligned with ProS DEI priorities and efforts?	• Maintain accountability by collecting data on society membership and leadership and present these numbers publicly • Develop a mission/vision statement or other commitment to equality and diversity that includes a non-discrimination clause regarding leadership and members (e.g., Potvit et al., 2018) • Frame diversity as a positive and enact anti-discriminatory policies (e.g., societal codes of conduct) • Work to address systemic bias to create a culture of belonging and an environment that recognizes and supports the experiences of members with marginalized identities (e.g., Abernethy et al., 2020)
Convenings—Who, where, and how people participate in ProS events (external focus)	Conference committees are composed of volunteers who determine the speakers, program, content, and social activities	• How do social and cultural identities of the committee members affect decisions about speakers, program content, or social activities? • How does the ProS create buy-in from membership around DEI-focused programming? • How does the selection of the event's location reflect dominant views about what feels comfortable, safe, or enjoyable (e.g., restaurants, entertainment, amenities)?	• Switch to fully virtual conferences with multi-location in-person "local" conferences (e.g., Sarabipour et al., 2021) • Select meeting locations that will be safe for all members • Choose environmentally responsible accommodation near public transportation • Choose sustainable food catering • Provide free and on-site nursing and childcare facilities at regional meetings; include this information in registration materials • Generate meeting codes of conduct and ethics (e.g., Sarabipour et al., 2020)

(Continued on following page)

TABLE 1 | (*Continued*) How the IPF: Societies informs practices within five example professional society functions.

Example ProS function name and definition (Peters et al., 2021)	Example ProS policies/practices	Example ProS questions generated with an *IPF: Societies* lens	Example ideas for implementing more equitable practices
Recognition—The established procedures in which people apply or are nominated for recognition or support (internal and external foci)	Institutional affiliation is required on membership applications, award nominations, and presentation proposals	• How is institutional affiliation tied to structural inequality? • Is using institutional affiliation necessary? • Does institutional affiliation serve as a proxy for exclusionary notions of legitimacy, excellence, and thus bias selection? • How are scholars in career transition and without institutional affiliation provided access to ProS resources?	• Broaden what applicant qualifications are considered when awards and recognition are determined. For example, for travel awards, consider both evidence of a candidate's scientific achievement as well as their expressed interest in attending/benefiting from the event • Vette top nominees by cross-checking code of conduct reports with other societies and contacting Title IX offices at current and previous institutions or employers (e.g., Fernandes et al., 2020) • Evaluate the extent to which award program goals and outcomes are being met (e.g., Segarra et al., 2020a)
Professional development—Job boards, mentoring, practitioner continuing education, and similar efforts aimed at cultivating members' successful careers (external focus)	Professional development offerings provide suggestions to members about how to be successful job candidates	• What are the biases or assumptions in career training that reinforce and normalize whiteness and masculinity? • What systems can be introduced to improve these society offerings?	• Provide professional development programming to build core equity, diversity, and inclusion competencies, including and not limited to building awareness around implicit bias (e.g., Coe et al., 2019) • Include diversity-related programming during annual meetings (e.g., offer workshops on effective mentoring) (e.g., Abernethy et al., 2020)

individual and organizational levels. Below we describe specific aspects of the *IPF: Societies* as well as its application.

Identity awareness is an awareness of aspects of one's own social and cultural identities and how those identities are situated within larger intersecting systems of power. Intercultural mindfulness is the "ability to understand cultural differences in ways that enable one to interact effectively with others from different racial, ethnic, or social identity groups in both domestic and international contexts" (Gillian-Daniel et al., 2021a). Collectively, "these domains encompass many features of intercultural humility, including: 1) awareness of one's own cultural backgrounds, including intersecting social identities; 2) recognizing one's biases and privileges in relation to self and others; 3) committing to learning about others' cultural backgrounds; and 4) addressing disparities in relational power by, in part, learning to recognize power differentials" (Gillian-Daniel et al., 2021a). The more aware one is of aspects of one's own social and cultural identities, the identities of others, and how those identities are situated within larger, intersecting systems of power, the more equitably mindful one can be of impacts, decisions, and programming driven by those identities.

Equity mindedness underpins building inclusive relationships. At both personal and organizational levels, willingness, capacity, and the communication skills to effectively engage those whose lived experiences may not match one's own is vital for examining mental models and advancing inclusive ProS DEI reform. At the boundary spanner level, inclusive relationships mean reflecting on whose voices are, and are not, centered and carry decision-making power when discussing important ProS policies, processes, and activities. From the STEM ProS perspective, building inclusive relationships could be reflected in collaborations with a range of organizations with intention to build mutual capacity. Inclusive relationships at the society level help shift social narratives and can inform sense making around information collected about the ProS, two examples of how mental models have critical impact on organizational systems (Kania et al., 2018).

Influential actions are how boundary spanners and ProSs drive STEM system change. We propose that informed and diversely networked people serving as DEI boundary spanners will be motivated and held accountable for positive DEI change. Boundary spanners' actions can be focused on core ProS functions. Peters and others (2021) identified 11 functions of STEM ProSs for action focus. For explanatory purposes, we focus on a subset of five ProS functions identified by Peter et al. (2021) as depicted in the outer circles of **Figure 1** and highlighted in **Table 1**. Ultimately, we propose that *IPF: Societies*-informed boundary spanners will engage in the influential actions associated with establishing new mental models and create accountability for nurturing the new diverse, equitable, and inclusive ProS look, feel, and actions.

TABLE 2 | Example IPF: Societies implementation strategies within professional societies.

Level of ProS DEI engagement (Peters, et al., 2021)	Description of DEI engagement level within a society (Peters et al., 2021)	Example IPF: Society-based implementation strategies
No activity	No case for DEI has been developed yet	Society boundary spanners use the IPF: Societies to help identify a network of others interested in DEI change and make the case for DEI engagement to ProS leaders and members.
Idling	The DEI case is developing; however, DEI has not been prioritized; no substantial planning or activity	Society boundary spanners engage in IPF: Societies-based programming to build their equity mindset and interpersonal communication skills.
Emerging	There is a DEI case for action; initial DEI conversations, planning, and action are underway, and activity is minimal/ad hoc	Society boundary spanners use the framework together with a DEI tool to work with leadership and staff to identify areas of opportunity for growth in the society. Their equity mindset supports them asking equity-based questions about society functions. Society policies and procedures are considered through this lens.
Progressing	The DEI case is well established; DEI actions have been carried out from planning phases, and activity may not be routine yet	Society boundary spanners work with staff and key members to design and implement DEI-based programming. Collaborations with other organizations and initiatives allow the society to leverage existing programming and resources as they infuse DEI throughout the society. There is a "tipping point" of engagement by leadership, staff, and now membership in these programs that support the "institutionalization" of said efforts.
Achieving	The DEI case is being realized; planning and action have been underway for several iterations, and impacts are clear	Society leadership and staff routinely collect and review data, for example, on membership, about who engages in society leadership, on who speaks at society functions, and who receives recognition from the society for their scholarship. Policies and procedures are regularly reviewed and revised to be more equitable and inclusive. The society uses a DEI tool to benchmark their progress relative to peer societies and collaborates with these societies to share best practices.

DISCUSSION

The *IPF: Societies* complements the use of other DEI organizational tools and increases both individual and organizational capacity to more efficiently and effectively identify and engage with DEI actions resulting from use of these tools. For example, we offer the Women in Engineering ProActive Network's (WEPAN's) *Four Frames for Promoting Gender Equity Within Organizations* (WEPAN, 2013). Originally adopted from Simmons University's Center for Gender in Organizations (1998), the four frames include: 1) equipping the individual, 2) creating equal opportunity, 3) valuing difference, and 4) revisioning culture. A STEM ProS DEI boundary spanner employing the *IPF: Societies* can evaluate and introduce more inclusive professional development programs (Frame 1); examine and recommend DEI changes to organizational structures, policies, and practices (Frame 2); call attention to ways in which ProS leaders and the organization are not "walking the DEI walk" (Frame 3); and identify and remedy incongruences between ProS existing practices and goals outlined in the ProS strategic plan (Frame 4). Similarly, from an organizational perspective, WEPAN's frames could be used to evaluate the equity of professional development programs and educational pathways (Frame 1); examine and revise organizational structures, policies, and practices to support greater DEI integration across all society functions (Frame 2); ensure that all leaders are, and continue to be, trained and coached on how to enact DEI-focused changes (Frame 3); and create opportunities to re-vision ProS culture and reflect that updated vision in the ProS mission and strategic plans (Frame 4).

As with WEPAN's four frames, the *IPF: Societies* complements the *Equity Environmental Scanning Tool (EEST)* (Peters et al., 2021). The *EEST* is a DEI self-assessment tool for ProSs adapted by ACCESS+ from The Royal Academy of Engineering and Science Council Diversity and Inclusion Progression Framework (2021). We propose that boundary spanners skilled in using the *IPF: Societies* will be more efficiently and effectively able to enact changes in areas identified by the *EEST*. **Table 1** illustrates how the *IPF: Societies* can inform ProS DEI practices in relation to a subset (i.e., 5 of the original 11) of Peters et al. (2021) ProS's core functions, each of which have an internal focus (i.e., the STEM ProS business infrastructure) and/or an external focus (i.e., member and disciplinary serving STEM ProS infrastructure). We propose that taking an *IPF: Societies* lens to the policies and practices associated with each of these functions will help uncover and offer an opportunity to change previously implicit ProS mental models. We use questions to illustrate application of the *IPF: Societies*. In each core ProS function (column 1), existing policies or practices are presented that might appear reasonable to some (column 2), but when the *IPF: Societies* lens is applied (column 3), systemic and structural inequities affecting how the ProS engages with staff and members become more visible. We offer example ideas of equitable practices that could emerge from application of the *IPF: Societies* (column 4). This table shows how the ProS may not be making programming decisions with an understanding of structural issues (i.e., equity mindset), therefore missing out on the

opportunity to address them and counter obstacles to DEI through inclusive relationships and influential actions.

When and where the *IPF: Societies* is brought into the ProS DEI change cycle will likely be dictated by the culture of the ProS and/or ProS leaders. Examples for how the IPF: Societies can be used and inform engagement is depicted in **Table 2** below.

CONCLUSION

In sum, Identity awareness and Intercultural mindfulness create an equity mindset that supports inclusive relationships and influential actions. The four "I's" core to the *IPF: Societies* provide a framework for reflecting and acting on ProS culture at individual (e.g., STEM ProS DEI boundary spanner) and organizational levels. The *IPF: Societies* offers a way to guide change of mental models. ProS DEI boundary spanners employing the *IPF: Societies* can leverage their positionality and ability to straddle groups to affect cultural change across STEM ProSs, in combination with the efforts of other boundary spanners and in the disciplines in which they engage.

Of critical importance when working with mental models in ProSs is the expectation that there may be resistance to DEI initiatives, especially among members with majoritized identities who may be invested, even subconsciously, in maintaining existing power structures (Lipsitz, 2006). Because people occupy a constellation of identities of various positionings, awareness of common discourses rejecting DEI could help in ProSs navigating them (Bonilla-Silva, 2006). The *IPF: Societies* offers a framework to begin difficult discussions and offers a structured approach for working toward change. Of course, to be effective, the *IPF: Societies* requires sustained mobilization of its pieces, *vis-à-vis* making DEI concerns part of the fabric of ProSs.

Potential outcomes of wide-scale implementation of the *IPF: Societies* could be ProS actions in service of a more diverse, inclusive, and equitable STEM culture writ large. Resultant increased individual capacity to engage in the articulation and reframing of legacy mental models in turn guides organizational transformation and culture reform through broader systems change. As organizations engage in systemic change, greater ProS and STEM culture DEI changes can be made. Eventually, DEI change becomes less about individual efforts for specific DEI actions and more about broad, structurally patterned ProS organizational transformation and, ultimately, STEM culture reform.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

GML, DG-D, and RMcCG contributed to conception, design, and finalization of the paper. RC-M and HM contributed to drafts of the manuscript with special emphasis on social-science sections of the manuscript. SP had special focus on the IPF: Societies figure development. JWP and RC-M contributed to drafts of the manuscript with special emphasis on the sections associated with the ACCESS+ Equity Environmental Scanning Tool (EEST). VAS, AL-P, and ELS provided IPF model and figure refinement. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This material is based upon work supported by the National Science Foundation under Grant Nos (2017953, 1834518, 1834522, 1834510, 1834513, 1834526, and 1834521). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Conflict of Interest: GML is the director of ProActualize Consulting, LLC, a consulting business specializing in applying evidence-based strategies to promote inclusive organizational and disciplinary excellence.

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frontiers in Education

MINI REVIEW
published: 29 March 2022
doi: 10.3389/feduc.2022.757816

Scientific Societies Fostering Inclusivity in the Life Sciences Through Engagement of Undergraduate Scientists

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Scientific societies serve as communities of practice in which scientists develop many of the skills and connections required for the progression of their careers. For example, scientific societies offer their members opportunities to attend career development programs, gain experience in communicating science, and receive recognition for achievements within their discipline. Programming for undergraduate student members has recently been increasing, both in prevalence and in its range of offerings. The Alliance to Catalyze Change for Equity in STEM Success, ACCESS, a meta-organization seeking equity and inclusivity in life sciences fields, has examined programs and opportunities focused on undergraduates across its member scientific societies to identify common themes, promising practices and challenges. In this article, we share and discuss our findings.

Keywords: undergraduate students, diversity, equity, inclusion, scientific societies, student chapters, STEMM workforce, early-career scientists

OPEN ACCESS

Edited by:
Adriana Bankston, University of California Office of the President, United States

Reviewed by:
Gary McDowell, Lightoller LLC, United States
Susan Walsh, Soka University of America, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *12 August 2021*
Accepted: *24 January 2022*
Published: *29 March 2022*

Citation:
Primus C, Zimmerman AN, Terovolas AK, Block KF, Brown CG, Burton MD, Edwards A, Etson CM, Flores SC, Fry C, Guillory AN, Ingram SL, McGee R, Neely-Fisher DL, Paxson S, Phelan L, Suggs K, Vega LR, Vuong E, Lujan JL, Ramirez-Alvarado M and Segarra VA (2022) Scientific Societies Fostering Inclusivity in the Life Sciences Through Engagement of Undergraduate Scientists. Front. Educ. 7:757816. doi: 10.3389/feduc.2022.757816

INTRODUCTION

Scientific societies serve as unifying hubs that advance the disciplinary Science, Technology, Engineering, Mathematics, and Medicine (STEMM) communities they represent. They provide long-term, cross-institutional communities for individuals within a scientific discipline which renders them ideal organizations to facilitate networking, collaboration, and mentoring among members (Hulede, 2018; Segarra et al., 2020a; Womack et al., 2020). Scientific societies can also serve as agents of change to promote diversity, equity, and inclusion in their fields of interest. To this point, in 2017, five different professional societies in the life sciences established the Alliance to Catalyze Change for Equity in STEM Success (ACCESS) a meta-organization that brings together the diversity committees of the American Society for Biochemistry and Molecular Biology (ASBMB), the American Society for Cell Biology (ASCB), the American Society for Pharmacology and Experimental Therapeutics (ASPET), the Biophysical Society (BPS), and the Endocrine Society (ES). The purpose of ACCESS is to provide a unified voice through which scientific societies can foster inclusivity in their disciplines by identifying challenges and solutions through shared experiences.

In this review article, ACCESS societies in collaboration with the Association for Southeastern Biologists (ASB), synthesize and discuss their efforts to foster inclusivity in the life sciences through engagement of undergraduate scientists. We also specifically highlight society offerings aiming to engage undergraduates from underrepresented backgrounds (UR) in STEMM. UR backgrounds in STEMM are those whose representation in STEMM disciplines is smaller than their representation in the United States population. For example, women, members of minority racial and ethnic groups (Black/African-American, Hispanic/Latino, Native American or Alaska Native, Native Hawaiian, and other Pacific Islanders), persons with disabilities, and low-income persons are all considered UR in STEMM fields (National Science Foundation, 2019; National Institutes of Health, n.d.). Of the early undergraduate students who intend to earn a degree in STEMM, less than 40% will obtain it; this percentage is even smaller for those from UR backgrounds (Mourad et al., 2018; Ahern-Dodson et al., 2020). Therefore, a big portion of the early talent pool is lost before students earn their baccalaureate degrees (Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). Scientific societies are in a position to help retain this undergraduate talent through early access to their disciplinary learning communities.

Professional and scientific societies foster the advancement of their disciplines and can play an integral role in connecting practitioners with one another, fueling collaborations, and mentoring relationships. Society events and programs are accessible opportunities for undergraduates to network, stay up to date on the newest research discoveries, and gain skills necessary for their future careers inside or outside of academia. While undergraduate institutions may be able to provide some of these resources, many are not able to do so in a discipline-specific way that transcends geographical boundaries. Also, resources may be limited at many undergraduate institutions. This might leave undergraduates searching for opportunities to get involved within their larger scientific community, placing scientific societies in an ideal position to fill this need. Moreover, undergraduates from UR backgrounds may attend institutions where they do not see themselves represented in their department's faculty or in their peers. The importance of seeing successful practitioners that share one's background has been examined in numerous studies, many concluding that access to these role models can help combat feelings of imposter syndrome and self-stereotypes (Asgari et al., 2010; Chemers et al., 2011; Casad et al., 2016). Given that undergraduates are practitioners in-training and may not have developed a secure identity as scientists, they might be more susceptible to feelings of isolation within the scientific community. Becoming part of a larger STEMM community and organization, such as a scientific society, can connect young trainees with role models and near-peers of similar backgrounds in their STEMM disciplines of interest and lessen feelings of isolation, especially for UR STEMM undergraduates (Smith et al., 2021). However, it is also important to note that, while scientific societies can be beneficial, society climate can still expose members to social forces such as marginalization and racism, further highlighting our responsibility to intentionally create inclusive society environments (Solebello et al., 2016; Hays et al., 2021; Huyck et al., 2021; Leibnitz et al., 2021; Segura-Totten et al., 2021).

Scientific self-efficacy, sense of community, and fit are also factors that drive undergraduate student persistence in STEMM (Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021; Campbell-Montalvo et al., 2021; Smith et al., 2021). However, these factors may be especially difficult to cultivate and develop in UR undergraduates due to discrepancies in common values, cultural isolation, and lack of support (Seymour and Hewitt, 1997; Good et al., 2000). These discrepancies can lead to those from UR backgrounds feeling marginalized; therefore, discouraging them from their aspirations in STEMM (Morales et al., 2020). Multiple lines of research have demonstrated that early research experiences and membership in STEMM learning communities can deepen fellowship and increase persistence in STEMM paths amongst undergraduate students, particularly those of UR backgrounds (Chemers et al., 2011; Graham et al., 2013; Sharp et al., 2014; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Mourad et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). Building an identity as a scientist by interacting with a community that includes motivating faculty, staff, and peers leads to an increased number of students who will seek to further their STEMM education by seeking additional training experiences such as graduate school (Eagan et al., 2013). This can particularly be impactful for undergraduates that attend community colleges where STEMM communities and undergraduate research opportunities may be more sparse (Hewlett, 2018).

Taken together, these observations indicate that undergraduates can benefit from the resources available to society members such as networking opportunities, conferencing,

research fellowships, professional development workshops, and achievement award. For this reason, active participation in a professional society can benefit early-career undergraduates by plugging these students into a built-in community of scientists, facilitating their navigating the complex landscape of their chosen scientific discipline (Graham et al., 2013; Matyas et al., 2017; Hulede, 2018; Abernethy et al., 2020; Bruthers and Matyas, 2020; Segarra et al., 2020c; Womack et al., 2020; Bruthers et al., 2021). Using the current literature on the topic to anchor our review, we discuss the undergraduate programming within ACCESS member societies and identify common themes, challenges, and promising practices. Our goal is that this analysis will help us pinpoint gaps in scientific society programming geared toward undergraduates.

SCIENTIFIC SOCIETY ENGAGEMENT OF UNDERGRADUATE SCIENTISTS

While a fair amount of programming for undergraduate members is offered at annual society meetings, with most societies offering discounted membership fees, there are additional opportunities outside of these meetings such as student chapters, and undergraduate research experiences (**Table 1**). Below we describe and discuss the undergraduate programs offered by ACCESS societies and their benefits.

Society Membership Accessibility for Undergraduate Students

By regularly offering affordable membership fees for students, scientific societies hope to foster recruitment and retention of undergraduate members. In 2021, the undergraduate student membership fees in ACCESS societies range from $10–$30 a year. ASBMB and ASPET both charge the least, with an annual fee of $10 for undergraduate students. At the top of the range, ASCB and BPS charge $26 and $25/year, respectively, while the ASB undergraduate membership fee falls in the middle at $20. Some, but not all ACCESS societies offer student members the opportunity to establish a student chapter at their home institution. **Table 2** lists the undergraduate membership fee for each ACCESS society, along with the number of institutions with student chapters, the number of undergraduate members, and the percentage of undergraduate members within the society. Societies with the most undergraduate programming offerings and the most affordable membership fees do not necessarily display the highest levels of undergraduate membership, meaning other factors must be at play. Additional offerings can influence an individual's decision to become a member of a professional society (Markova et al., 2013). These offerings include employment opportunities, professional development workshops, access to recent updates in the field, and spaces for networking (Markova et al., 2013).

Free membership for undergraduates would remove the financial barrier to these students belonging to a scientific society. In the past, at least one ACCESS scientific society has made undergraduate memberships free. However, removing this financial barrier completely did not translate into more undergraduate students becoming regular members. The practice of providing free memberships can also bring on additional costs to societies that can be difficult to sustain, for example, costs related to membership data maintenance and follow up. For societies with a high percentage of undergraduate participants, such as ASB, free undergraduate membership/participation would translate into loss of a large portion of the funds needed for society operations. For these reasons, a model in which undergraduates are charged a nominal fee for membership (**Table 2**) is likely more sustainable. While the nominal undergraduate membership fees collected by societies likely do not fully cover the benefits offered to students, they help offset some of the costs. For ACCESS societies with student chapters, registration can be linked to chapter registration and renewal, a cost that can easily be absorbed by the home academic institution of the chapter. ACCESS societies like ASBMB find that most chapters pay the registration fees either through their institutional department or student life office rather than collecting fees from students.

Undergraduate Student Engagement at Annual Society Meetings

Travel Award

Travel award are funds given to members of a scientific society to either partially or fully cover expenses related to attending annual society meetings. To obtain a travel award, an award application must be completed, usually requiring the applicant's curriculum vitae (CV) or resume, reason for wanting to attend the conference, career aspirations, statement of financial need, and, if an undergraduate student, a letter of support from a faculty member. Additionally, a poster abstract is commonly required, as it is often the case that travel awardees are required to present their research in the form of a poster to be eligible for a travel award. While this is the case, non-presenting students have been shown to benefit from scientific meeting attendance as well (Gopalan et al., 2018). In fact, we identify broadening travel award eligibility to non-presenting students as an opportunity societies have to further foster inclusivity of talent in their discipline.

Travel award allow for undergraduates to attend the annual meeting who may not have been able to do so otherwise. Particularly, those who may come from UR backgrounds may largely benefit from connecting with other practitioners of similar backgrounds and building a network of contacts (Asgari et al., 2010). Receiving a travel award not only benefits the recipient by allowing them to experience a scientific conference, but it also benefits the society by increasing the diversity of meeting attendees.

Attending scientific conferences as a practitioner-in-training can aid undergraduates developing a scientific identity by giving them the opportunity to interact with successful scientists in their discipline. Undergraduate travel award recipients can also put the award on their CV as an achievement, earning the undergraduate awardees an early accomplishment to heighten feelings of belonging and self-efficacy within their scientific community. A recent publication describes ACCESS member societies travel award offerings in detail and also notes travel

TABLE 1 | Summary of programming offered by ACCESS member societies to their undergraduate members as of summer 2021.

ACCESS member society	Travel award	Networking opportunities	Achievement award	Poster sessions	Student chapters	Discounted membership fee	Professional development sessions at conferences	Research fellowships
ASB	X	X	X	X		X	In progress	In progress
ASBMB	X	X	X	X	X	X		
ASCB	X	X		X		X	X	
ASPET	X	X	X	X		X	X	X
BPS	X	X	X	X	X	X		X
ES	X	X				X		

TABLE 2 | Summary of undergraduate membership, dues and student chapters in ACCESS member societies as of summer 2021.

ACCESS member society (no. members)	Professional membership fee	Undergraduate membership fee	Number of institutions with student chapters	Number of undergraduate members	Percentage of undergraduate members
ASB (938)	$50	$20	N/A	264**	51%**
ASBMB (9800)	$160	$10	153	2210	22.6%
ASCB (5363)	$185	$26	N/A	210	3.9%
ASPET (3505)	$180	$10	N/A	115	3.3%
BPS (5358)	$200	$25	38	173	3.2%

***ASB collects academic stage information at the time of annual meeting abstract submission (not during membership registration). For this reason, the estimate provided for "Number of Undergraduate Members" is based on number of undergraduate presenters at the last pre-COVID (in-person) meeting (2019). Likewise, the percentage provided for "Percentage of Undergraduate Members" is based on the percentage of undergraduate presenters at the last pre-COVID (in-person) meeting (2019).*

award for undergraduate scientists with amounts ranging from $400 to $1700 (Segarra et al., 2020c). All ACCESS societies offer undergraduate travel award. Most societies also offer specific programming for award recipients, and we describe this programming below.

Professional Development Sessions and Networking Opportunities at Annual Conferences

Professional development can catalyze an undergraduate's self-efficacy and growth in STEMM disciplines (Helm and Bailey, 2013; Cuker et al., 2016; Doerschuk et al., 2016; Abernethy et al., 2020). Annual society meetings provide an opportunity for undergraduate students to enhance their professional development. ASCB and ASPET both have professional development sessions during their annual meetings that are geared toward undergraduates (**Table 1**). ES also holds an Early Career Forum, which undergraduate students at the conference can attend and obtain orientation in a range of professional development topics. These sessions during annual meetings can facilitate undergraduates networking with others, such as peers and faculty members. Additional opportunities for networking include dedicated spaces for undergraduate students at annual conferences. For example, BPS provides students a lounge at their annual meeting as a dedicated space for them to catch up on missed coursework and connect with peers while attending the BPS annual meeting which is held every spring. BPS also holds a "Pizza Breakfast" event with a guest speaker at their annual meeting, bringing about additional networking opportunities for students. Networking with peers and faculty members increases undergraduates' sense of community, and, in turn, increases the likelihood of them persisting in STEMM (Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021).

Presentation Opportunities at Annual Conferences

Undergraduate research is an important part of undergraduate education for students in STEMM, and communicating scientific findings is a key skill that scientists must develop. ACCESS societies like ASCB, ASPET, and BPS offer trainees dedicated poster sessions, in addition to poster presentations held on the main exhibit floor, at their annual conferences. These trainee-focused poster sessions are often judged, and poster award are offered to the top performing scientists at different academic levels–including undergraduates (ASCB, n.d.). Undergraduate specific poster sessions could be viewed in a negative light due to the intentional separation of undergraduates from more experienced practitioners. However, literature shows that most undergraduate presenters feel an increase in scientific self-efficacy after presenting at a professional conference, including these trainee-focused sessions (Helm and Bailey, 2013; Walkington et al., 2017; Little, 2020; Segarra et al., 2020a). Programming like poster sessions and award allow students to highlight their work in research and continue to develop their scientific communication skills (Poster Competitions, n.d.).

Student Chapters

Undergraduate membership in a scientific society can provide opportunities beyond attending annual meetings. For example, two ACCESS societies (ASBMB, BPS) enable their student members to establish disciplinary chapters at their home academic institutions that can serve as a place of community for scientists-in-training. Undergraduates can use these chapters as a scaffold for membership and participation in the headquarter

organization. For example, over 80% of ASBMB's current undergraduate members participate in the society through their student chapters. Student chapters can contribute to a society establishing a welcoming environment to its discipline's scientists-in-training. This type of environment has been shown to be vital to undergraduate persistence in STEMM fields (Chemers et al., 2011; Graham et al., 2013; Cuker et al., 2016; Gopalan et al., 2018; Bruthers and Matyas, 2020). Student chapter membership can also allow entry into prestigious academic fraternities such as ASBMB's Chi Omega Lambda which recognizes undergraduate upperclassmen seeking degrees in molecular life sciences. ASBMB also offers numerous achievement award and scholarship opportunities to members of student chapters, which can also be listed as evidence on an undergraduate's CV as a disciplinary honor. Furthermore, BPS offers opportunities for student chapter establishment outside of the United States, providing an international community for early-career scientists. To enhance leadership skills, student chapter members are encouraged to serve on the chapter board at their institutions, where they learn to schedule chapter events, budget funds, lead meetings, and plan attendance to national conferences. Student chapters help provide undergraduates with the resources to build at a scientific community at their home institutions while also gaining leadership and technical skills (Barnes et al., 2021).

Research Programs

Undergraduate research experiences (UREs) have proven themselves to be one of the most valuable approaches to increasing the number of UR students earning degrees in STEMM fields (Doerschuk et al., 2016). These experiences foster students' ability to network and communicate, allow them to gain more research skills, and further their STEMM career aspirations. These opportunities often leave positive, lasting impacts on students and provide them with a number of different life skills (Bruthers and Matyas, 2020). For example, UREs can help develop undergraduate students' self-efficacy and sense of belonging through professional development and positive reinforcement (Mourad et al., 2018). Moreover, UREs can also guide students along their STEMM career paths with support, necessary information, news of novel scientific findings, and the opportunity to receive recognition as a scientist (Eagan et al., 2013). It is pertinent to mention that a majority of URE programming has been delayed or adapted due to the COVID-19 pandemic. For example, in 2020, ASPET had more than an 84% decrease in undergraduate summer research programs held; however, this pushed them to successfully hold their first fully virtual research program (ASPET, 2020).

Alliance to catalyze change for equity in STEM success societies support UREs in a variety of ways. For example, ASBMB furthers the research aspirations of their undergraduate student members by offering $1,000 award to support their research. Furthermore, BPS's Summer Research Program (SRP) was a collaborative effort with the University of North Carolina at Chapel Hill and presented UR undergraduate students with the opportunity to receive a research assistantship. SRP provided participants with graduate-level class work on disciplinary concepts and methods, opportunity to do lab work and research, and programming to facilitate networking and community building. At the end of the program, program alumni transitioned to become "biophysics ambassadors" within BPS and at their universities, enabling them to collectively become a support system for each other as well as others at their home communities. From 2008 to 2017, approximately 100 students were served by this program, many of them successfully transitioned into Kirschstein-NRSA predoctoral fellowships from the National Institutes of Health (NIH) or Graduate Research Fellowship from the National Science Foundation (NSF). SRP ended in 2017 due to lack of funding.

Additionally, ASPET sponsors institutions, as well as individual students, through their Summer Undergraduate Research Fellowship (SURF). This 10-week summer laboratory experience provides mentored research for pharmacology undergraduates and has been strengthening young scientist's professional skills since 1992. Over 90% of its participants remain involved in biomedical sciences after program completion. Through a variety of collaborative activities such as field trips and picnics amongst faculty and peers, SURF drives the development of a strong network of alumni. This expanding network further serves the program as some past participants become mentors for newcomers. Importantly, participation in this program has paved paths for undergraduates to pursue doctoral programs in their SURF laboratory departments (SURF Summer Undergraduate, n.d.; ASPET, 2020).

Other UREs organized by scientific societies for UR undergraduates include the Ecological Society of America's Strategies for Ecology Education, Diversity and Sustainability (SEEDS) Research Fellowship and the American Physiological Society's Short-Term Research Education Program to Increase Diversity in Health-Related Research (STRIDE) (Mourad et al., 2018; Ahern-Dodson et al., 2020; Bruthers and Matyas, 2020). These programs have had positive outcomes in developing strong research skills in their participants (Bruthers and Matyas, 2020). For example, many of the students who participated in STRIDE commented on gaining knowledge in experimental design, data analysis, management, organization, applying statistics and math to experiments, and made note of a number of realities such as the patience and determination that is required when conducting research (Bruthers and Matyas, 2020). Furthermore, STRIDE program participants have adjusted their career aspirations to incorporate clinical research.

Scientific Society Representation in Conferences Attended Predominantly by Undergraduates

Science, technology, engineering, mathematics, and medicine conferences that are directed at undergraduate participation create an opportunity for students to enhance their professional skills in their field while simultaneously strengthening their sense of community. The important skills students obtain from attending these scientific conferences make these events a good place for experiential learning (Gopalan et al., 2018). Most, if not all, conferences allow students to network, to present their

research as talks or in the form of a poster, and to obtain award. Additionally, there are typically panels, professional and scientific workshops, and keynote or plenary speakers geared toward undergraduate scientists (McLaughlin et al., 2009; Hurd et al., 2011; Casad et al., 2016; Gopalan et al., 2018; ABRCMS, n.d.; SACNAS, n.d.; Zarate and Gonzalez, n.d.). Across the United States, the Society for Neuroscience has created many regional, undergraduate specific conferences including SYNAPSE for the southeast, NEURON for the northeast, and MidBrains and mGLuRs for the midwest regions (Frye and Edinger, 2004; Goyette et al., 2007; McLaughlin et al., 2009; Hurd et al., 2011; Wiertelak et al., 2012; Ramos et al., 2020). They provide an intimate setting for students to receive feedback from professionals (Hurd et al., 2011). Furthermore, at ASB's annual meeting, more than 50% of presenters at the 2021 virtual annual meeting were undergraduates. Altogether, the demand for these undergraduate-focused conferences shows that undergraduates want to be connected to disciplinary communities.

At the Annual Biomedical Research Conference for Minority Students (ABRCMS) and the National Diversity in STEM Conference organized by the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), students can network on a larger scale than they do at regional conferences (Casad et al., 2016; Zarate and Gonzalez, n.d.). These conferences have exhibit halls where societies can use exhibit booths as a tool to encourage membership and allow students to network with those in their disciplines. For example, ASCB, ASPET, and BPS have had exhibit booths at ABRCMS and SACNAS in the past. ASCB has also held symposium sessions at both conferences and BPS has held sessions at SACNAS. These sessions facilitate networking and encourage interest from undergraduates in specific STEMM disciplines.

SACNAS also holds a separate "mini-conference" called Community College Day. While it is virtual, the conference provides similar programs to their in-person conference. There are panels, workshops, talks, and presentations, allowing students to learn more about careers in STEMM. Students that attend Community College Day also have the options to present their research and attend a networking lunch with their peers (SACNAS, n.d.). Similarly, ABRCMS has a specific program track for community college students in which they can present research, network, and learn specifics about transitioning to a 4-year university (ABRCMS, n.d.). These specific programs for community college students offer exposure to STEMM careers (ABRCMS, n.d.; SACNAS, n.d.). Inclusion of community college students in ABRCMS ultimately provides societies with exhibit hall representation there like ASCB, ASPET, and BPS, the opportunity of an early introduction to these trainees.

CHALLENGES AND OPPORTUNITIES

Scientific Societies as a Tool to Retain Undergraduate Scientist Talent

While programming from scientific societies allows for undergraduate students to gain confidence, professional skills, and the ability to network, recent studies have uncovered that membership in scientific societies may be more beneficial to some students than others (Morales et al., 2020). Scientific societies can help navigate the barriers to success in STEMM but, oftentimes, UR students who are members of societies still experience marginalization, isolation, and identity stereotypes within the society (Morales et al., 2020). Specific inclusivity and diversity programs within scientific societies can counteract the marginalization and isolation UR members may experience (Maton et al., 2000; Casad et al., 2016; Cuker et al., 2016; Ahern-Dodson et al., 2020; Bruthers and Matyas, 2020; Segarra et al., 2020b; Womack et al., 2020; Starck et al., 2021). The heightened sense of community and self-efficacy undergraduates can feel from involvement in societies can lead to higher retention rates for UR undergraduates (Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). This, in turn, highlights the potential of this type of programming to help decrease the attrition of the UR undergraduate talent pool in the early stages of their education.

Many societies offer opportunities and programs for UR members, such as travel award, to help participants feel integrated into the scientific community, but undergraduate society programs that engage students beyond a society's annual meeting can be limited (Segarra et al., 2020c). When a society creates an inclusive environment, scientists from all backgrounds and career stages feel acknowledged and welcomed in their professional STEMM community. Not only do diverse groups produce innovative solutions and bring fresh perspectives to the discipline (Freeman and Huang, 2014), but having members of diverse career stages can act as an asset to the society and help create a mutualistic relationship between both the society members and the organization itself.

Engaging Community Colleges

Over half of all undergraduates have received some form of education from a community college at one time in their careers (American Association of Community Colleges [AACC], 2017; Schinske et al., 2017). Apart from SACNAS' Community College Day and ABRCMS' specific track for community college attendees, there is a noticeable lack of involvement of community college students in scientific societies. This means societies could easily increase the possibilities for engagement of community college undergraduates. It is important to mention that about 37% of students that enroll in a community college come from families that are financially below the poverty line [Community College Research Center (CCRC), 2021]. This heightens the potential value of society engagement with community college students since economic inequities may have limited the engagement of these students with STEMM.

Early engagement in disciplinary learning communities increases persistence in STEMM (Good et al., 2000; Chemers et al., 2011; Cuker et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). Professional scientific societies are well positioned to act as this early-career learning community and impact a large number of undergraduates. This connection might lead to increased opportunities for networking and connections with faculty between 4-year institutions and

community colleges. This connection could then potentially ease the transition from a 2-year institution to 4-year university for the students. The COVID-19 pandemic has presented additional challenges to those with financial disadvantages along with those living in rural areas. Due to the pandemic, there has been a sizable increase in the amount of online conferencing offered by scientific societies, which has posed challenges for undergraduate members in rural areas, who may not have reliable access to the internet. Increases in virtual meetings means access to internet connection is more important than ever [Community College Research Center (CCRC), 2021]. While online meetings make conferences more accessible for many people (due to the lack of travel and decreased cost), scientific societies still must be cognizant of this issue when interacting with community college undergraduates.

As time goes on, more predominantly undergraduate institutions are recognizing and accepting undergraduate research experiences as one of the most direct ways of reinforcing undergraduate students to view themselves as "real scientists." Despite the fact that they are in the beginning stages of their careers, studies show that when undergraduate students have deeper and broader learning experiences in science it increases their chances of persisting in their major and aspiring to complete a post baccalaureate degree (Eagan et al., 2013; Casad et al., 2016; Gopalan et al., 2018; Bruthers et al., 2021). Involvement and support for undergraduate research taking place in community colleges is an approach societies could undertake to aid institutions and students. Currently, the Council on Undergraduate Research (CUR) has made strides toward making UREs more accessible for community college students. Since 2005, CUR has used NSF funding to identify challenges preventing community colleges from offering UREs, while also identifying models for community colleges to implement research experiences into their undergraduate biology curriculum. At over 110 community colleges, CUR has been able to successfully hold workshops that teach community college faculty the most sustainable ways to implement UREs into their curriculum (Council on Undergraduate Research, n.d.).

Students at community colleges play a vital role in the local workforce as they move on to transfer into a 4-year university or begin working. Oftentimes, courses teach students the basics of a research project, but students do not always have the chance to apply their knowledge (Cejda and Hensel, 2009). These students are highly motivated and need undergraduate research experience to put them on the same competitive level as other students when they transfer to a 4-year institution (Coggins, 2011; Hensel, 2011). This experience would also help them transition to a 4-year institution by increasing their scientific identity and self-efficacy, but to support the undergraduates in the community college system, societies must first support the faculty. Faculty need support in writing and finding grants to support the development of UREs (Cejda and Hensel, 2009). This is a place where scientific societies could assist community college faculty members, by creating relevant programming in areas like grant writing.

Creating Additional Opportunities to Recognize Undergraduate Excellence

Scholarships and society award can both provide undergraduates with recognition and/or support, oftentimes paving paths for further professional development in STEMM fields (Matyas et al., 2017). Examples of society scholarships include ASBMB's Marion B. Sewer Distinguished Scholarship which is awarded to an undergraduate student who is of a UR background. This scholarship provides up to $2,000 for a student's tuition at an undergraduate institution [ASBMB's Marion B. Sewer Distinguished Scholarship, (n.d.)]. Similarly, ASPET offers the Dolores C. Shockley Poster Award, which recognizes UR scientists and includes an undergraduate category.

Robust Assessment of Undergraduate Program Outcomes

While many life sciences professional societies have increased the range of undergraduate programming they offer, the majority continue to lack measurable outcomes for this programming (Matyas et al., 2017). Without a way to measure the effectiveness of their undergraduate programs, societies lack data that could be used to iteratively optimize program implementation in ways that ensure the desired goals are being met. The American Physiological Society (APS) demonstrates ways in which scientific societies can articulate programming objectives and assess their achievement. For example, through the use of entry and exit surveys for undergraduate research fellowships since 2016, APS has been able to consistently track the most beneficial elements and make informed adjustments to the program when needed (Bruthers et al., 2021).

Expanding Undergraduate Mentorship Programs

Mentorship is another important component of creating community and increasing retention in STEMM for undergraduates (Good et al., 2000; Chemers et al., 2011; Cuker et al., 2016; Doerschuk et al., 2016; Russell, 2017; Ahern-Dodson et al., 2020). The lack of undergraduate mentorship programs in the life sciences has created a gap that scientific societies are perfectly positioned to fill in ways that transcend geographical barriers. More robust mentoring programs could be designed to highlight STEMM professions outside of academia, exposing students to a wider range of possible careers in their fields of interest. Within smaller academic institutions, it may be harder to discover all possible career paths within STEMM, including those in industry. Scientific societies have the ability to offer mentors of diverse career backgrounds as a resource to interested undergraduates.

Societies can look to the Society for Freshwater Science (SFS)'s Instars Mentoring Program (IMP), where undergraduates are mentored by graduate students during their annual meeting. While this program is not long term, it does connect undergraduates with an individual at a more advanced career stage within their discipline. The students are also guided through the annual meeting which lessens confusion and

overwhelming feelings that come with attending a large conference. Undergraduate student participants in the IMP report that this program reinforced their career and education aspirations in their discipline (Abernethy et al., 2020). Comparable programs are organized by ASCB and ASPET at their annual meetings, called "Multiplying Participants Accomplishing Career Transitions (M-PACT)" and "Partnering for Success," respectively.

Creating Opportunities for Non-presenting Students at Annual Conferences

While undergraduate attendance at annual society meetings has been shown to be beneficial to non-presenting students (Gopalan et al., 2018), most societies require that students applying for travel award present their research at these conferences. This might present a barrier for non-presenting undergraduates who are early on in their STEMM careers and desiring to experience their disciplines of interest and connect with practitioners in these fields at a deeper level. For this reason, societies should consider adjusting the eligibility criteria for undergraduates applying for their resources and programming, to ensure they are not excluding those early-on in their STEMM careers. Societies may also consider hosting hybrid sessions at their conferences, so that undergraduates who are not in attendance can connect remotely and benefit from relevant content, increasing awareness for the resources provided by the society to undergraduates.

Meeting the Needs of Recent Graduates Experiencing Career Transitions

Similarly, most societies require that students applying for travel award or other programs identify a specific career stage (e.g., undergraduate, graduate student, and postdoctoral trainee) and an academic affiliation (Segarra et al., 2020c). This might present a barrier for recent graduates who desire to stay connected with their disciplines but might be transitioning between jobs or positions. By reassessing applicant requirements for their program offerings, societies can help make these opportunities more inclusive of those who might need them most.

CONCLUSION

Evidence shows that the implementation of specific STEMM-focused undergraduate programming can have positive outcomes such as increases in students' sense of community and scientific identity. This, in turn, can increase retention rates among undergraduate scientists at their home institutions (Asgari et al., 2010; Chemers et al., 2011; Graham et al., 2013; Casad et al., 2016; Doerschuk et al., 2016; Russell, 2017; Gopalan et al., 2018; Ahern-Dodson et al., 2020; Bruthers et al., 2021). This highlights an opportunity scientific societies have to leverage their resources and networks in the service of the next generation of scientists at the undergraduate level. ACCESS societies are striving to find ways to expand professional development options for undergraduate scientists, making sure to be inclusive of and nurture their future workforce.

AUTHOR CONTRIBUTIONS

All authors contributed to the generation of this manuscript and participated in its revision and refinement and approved the final manuscript in its current form.

FUNDING

ACCESS work is supported by the National Science Foundation, grant number 1744098 to MR-A and VS.

ACKNOWLEDGMENTS

We thank the past and current members of ACCESS.

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ORIGINAL RESEARCH
published: 25 April 2022
doi: 10.3389/feduc.2022.780331

"Now I'm Not Afraid": The Influence of Identity-Focused STEM Professional Organizations on the Persistence of Sexual and Gender Minority Undergraduates in STEM

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OPEN ACCESS

Edited by:
Candice M. Etson, Wesleyan University, United States

Reviewed by:
Andrea Haverkamp, Oregon State University, United States
Alexa Martin, Université de Sherbrooke, Canada

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *20 September 2021*
Accepted: *10 March 2022*
Published: *25 April 2022*

Citation:
Campbell-Montalvo R, Cooke H, Smith CAS, Hughes Miller M, Wao H, Puccia E, Mayberry M and Skvoretz J (2022) "Now I'm Not Afraid": The Influence of Identity-Focused STEM Professional Organizations on the Persistence of Sexual and Gender Minority Undergraduates in STEM. Front. Educ. 7:780331. doi: 10.3389/feduc.2022.780331

In comparison to work on women and historically excluded racial/ethnic minority students in science, technology, engineering, and math (STEM), research on sexual and gender minority (SGM) students in STEM is somewhat incipient. There is little scholarship available on SGM-focused STEM organizations (e.g., oSTEM). Building on the previous literature, we examine how SGM-focused STEM organizations provide social capital, both expressive (e.g., emotional support) and instrumental (e.g., academic resources), that helps students feel they fit in STEM and ultimately persist. We report findings from a large online survey with 477 SGM STEM undergraduates, 463 of whom participate in STEM organizations, which offers one of if not the largest study on the topic to date. We compare three types of identity-focused organizations, SGM-focused, women-focused, and race/ethnicity-focused, finding that they each provide expressive capital to SGM students. The organizations helped students cultivate supportive networks of peers like themselves who then help them feel they fit in STEM through similar but not identical mechanisms. For SGM-focused organizations, their assistance in helping students reconcile their SGM identities with their STEM identity was an important nuance tailored to SGM students' needs. However, students described how SGM-focused organizations provided instrumental capital far less, which we posit may take a back seat to SGM STEM students' expressive needs. Unfortunately, women-focused organizations were not always welcoming to SGM students, an issue not documented in race/ethnicity-focused societies. However, some identity-focused organizations established partnerships with other identity-focused organizations, highlighting the possible role of such collaboration in better serving SGM students, particularly those with minoritized ethnic/racial identities. Implications for research and practice are included.

Keywords: fit or belonging, inclusion, social capital, social networks, LGBTQIA+, oSTEM, societies, STEM (science, technology, engineering, and math)

INTRODUCTION

The STEM Climate Faced by People With Marginalized Sexual and Gender Identities

People with sexual minority (e.g., lesbian, gay, bisexual, asexual, pansexual) and gender minority (e.g., transgender, agender, non-binary) identities often face an unwelcoming environment in science, technology, engineering, and math (STEM). This often hostile environment is rooted in STEM's competitive and heteronormative "dude" culture, which is particularly harrowing for STEM gender minority students and faculty (Fisher and Waldrip, 1999; Seymour and Hewitt, 1999; Toynton, 2007; Antecol et al., 2008; Grunert and Bodner, 2011; Stout and Wright, 2016; Mattheis et al., 2019; Miller et al., 2020; Voigt and Reinholz, 2020; Cech and Waidzunas, 2021; Haverkamp, 2021; Palmer et al., 2021; Campbell-Montalvo et al., 2022b). This environment can lead to a lack of fit for sexual and gender minority (SGM)[1] students and faculty (Toynton, 2007; Bilimoria and Stewart, 2009; Cech and Waidzunas, 2011; Patridge et al., 2014; Cooper and Brownell, 2016; Cech and Pham, 2017; Mattheis et al., 2019; Cooper et al., 2020; Voigt, 2020; Friedensen et al., 2021; Lezotte et al., 2021; Campbell-Montalvo et al., 2022b). For SGM students, and women along with historically excluded racial/ethnic minority students, feelings of not being welcomed or belonging in STEM along with limited access to social capital comprise barriers to SGM students' STEM persistence (Schneider and Dimito, 2010; Smith et al., 2015; Cooper and Brownell, 2016; Stout and Wright, 2016; Hughes, 2018; Blosser, 2020; Voigt, 2020; Campbell-Montalvo et al., 2021, 2022b; Haverkamp, 2021).

Recent studies have shown that SGM students are more likely to not persist in STEM than non-SGM students (Cech et al., 2015; Hughes, 2018; Sansone and Carpenter, 2020; Maloy et al., 2022), and the exclusion of SGM faculty is particularly pronounced in later career stage STEM professionals (Rushworth et al., 2021). Unfortunately, SGM student persistence in STEM remains understudied. The lack of research on the topic is exacerbated by the paucity of demographic data on SGM identities among the U.S. STEM workforce (Freeman, 2020). Likewise, there is an indisputable scarcity of research examining the impact of STEM professional organizations on SGM STEM students and their persistence, and few mentoring programs are known to be available to explicitly serve SGM students in STEM (Beck et al., 2021). The present study, in which we report findings from a large online survey with 477 SGM STEM undergraduates, extends the literature on the topic by more closely examining a variety of social capital (i.e., expressive, instrumental) across identity-focused STEM organizations, such as those focused on SGM, racial/ethnic minority, or women students, to inform on how SGM STEM students are served by a range of organizations.

[1]The authors use the term SGM (sexual and gender minority), widely used in psychology and public health literature, as we perceive it to be a more inclusive term than terms such as LGBTQ+, which only list certain sexualities or gender identities and represent the rest with the + sign (see e.g., Scholl et al., 2021). We acknowledge critiques of the term 'minority,' and in our use of SGM we use the term 'minority' to represent a marginalized relationship to dominant culture.

Research on Professional Organizations and Student Persistence

STEM professional organizations, by virtue of both their location of chapters on university campuses and their overarching purpose, comprise a powerful potential agent for broadening participation in STEM. In terms of identity-focused STEM organizations, findings are mixed about the role of those which are not SGM-focused. Specifically, Haverkamp (2021) reported that the race/ethnicity-focused Society of Hispanic Professional Engineers (SHPE) provided support to SGM STEM students, but that the women-focused Society of Women Engineers (SWE) was not always welcoming.

Recent research on SGM-focused STEM organizations (e.g., Out in Science, Technology, Engineering, and Mathematics [oSTEM]) highlights their impact on SGM STEM college students. For instance, Haverkamp (2021) interviewed 20 transgender and gender non-confirming (TGNC) engineering undergraduates. Findings showed that TGNC engineering students drew support from SGM-focused STEM organizations on campus, including oSTEM and the National Organization of Gay and Lesbian Scientists and Technical Professionals (NoGLSTP), with affirmation and acceptance being central themes in what attracts students to go to these sources for support (Haverkamp, 2021). In addition, Voigt (2020) conducted four sets of focus group interviews with a total of 17 queer-spectrum students having a range of SGM identities and from various STEM majors across four universities. Voigt underscored the role of oSTEM in impacting SGM students' experiences because it creates a "smaller, removed, and voluntary space for student participation, but it also seeks to foster the political mobilization that challenges the dominant assumption that STEM is intended for Straight white men" (p. 262). Similar to Voigt (2020), Haverkamp (2021) found that some of the main benefits of oSTEM included its relational resources about Queer issues, its provision of ingroup social networks and connections to outside allies, and how it empowered members by providing role models.

In terms of general STEM organizations, SGM students have reported feeling unwelcome in engineering campus clubs and activities, with standards of dress and pronoun usage being areas of particular concern (Haverkamp, 2021; Campbell-Montalvo et al., 2022b). In fact, STEM clubs and organizations that are not identity-focused (i.e., industry and discipline organizations) were places where students often reported that they did not fit and were unsafe to be out, and participation in them actually caused some students to question their persistence in STEM (Voigt, 2020).

Regarding organizations that are SGM-focused but outside of STEM (e.g., Out for Undergrad [O4U]), SGM students have reported feeling more supported by these campus clubs, activities, and people than they did in non-identity-focused engineering organizations (Haverkamp, 2021). On one hand, Fisher (2013) draws on the idea that a leading identity, such as Queer identity, can support other subordinate identities, such as mathematical identity. Thus, non-STEM SGM-focused organizations would be essential in SGM STEM student persistence by providing feelings of confidence with one's SGM identities that could serve as a strong foundation for STEM identity development.

Fischer writes, a "strong Queer identity creates a personal environment that is conducive to understanding and absorbing other information and knowledge" (Fisher, 2013, p. 113). On the other hand, Voigt (2020) argued that SGM-focused groups that are not STEM-related may pressure students to shed their STEM identity and prioritize their SGM identity, rather than holding both a STEM identity and queer identity at the same time.

We also draw on the body of scholarship on identity-focused STEM organizations that has examined the role of women-focused and race/ethnicity-focused STEM professional organizations. Research on women-focused and general engineering organizations has tied participation to increased persistence in women and students from ethnic/racial groups that are excluded in STEM (Hartman and Hartman, 2005; Smith et al., 2021). For example, drawing on 2,186 engineering undergraduates who participated in five rounds of an annual survey, Smith et al. (2021) demonstrated through inferential analyses that engineering undergraduates from historically excluded groups (i.e., African American/Black students, Latinx students, and American Indian students) who participate in engineering organizations were more likely to persist. The authors found that NSBE (National Society of Black Engineers) and SHPE (Society of Hispanic Professional Engineers) helped historically excluded students build their social capital in three areas:

> (1) academic and social integration through academic support, such as developing time management skills and tutoring, as well as social networking, such as meeting other students and engineers of color some of whom become friends and mentors; (2) connecting with industry internships and employment opportunities through attendance at national conferences; and (3) professional resources for career development such as improving leadership skills, resume writing, and interview skills (Smith et al., 2021, p. 8).

Additional analyses of a portion of the participants in Smith et al. (2021) work was conducted by Campbell-Montalvo et al. (2021) in which the authors interviewed a subsample of 55 women and historically excluded students. Here, Black students recounted dealing with anti-blackness in STEM, a group of disciplines known to be especially fraught with biases and discrimination (Bullock, 2017; Cedillo, 2018; Martin et al., 2019; Vakil and Ayers, 2019; Lee et al., 2020; McGee, 2020; Nxumalo and Gitari, 2021). An important manifestation of these biases is "stereotype threat," which refers to "the immediate situational threat that derives from the broad dissemination of negative stereotypes about one's group; the threat of possibly being judged and treated stereotypically, or of possibly self-fulfilling such a stereotype" (Steele and Aronson, 1995, p. 798). Stereotype threat has been a widely documented issue for women and ethnoracial minority students in STEM (Massey and Fischer, 2005; McGee and Martin, 2011; Beasley and Fischer, 2012; Gregory, 2015, 2016). Here, Campbell-Montalvo et al. (2021) found that a main mechanism through which people in the social networks of historically excluded students helped their persistence in STEM was through the provision of warnings to expect bias from others—the provision of warnings helped students engage in stereotype management (McGee and Martin, 2011) to cope and continue on when the discrimination occurred.

At the same time, in another article on the 55 women and historically excluded interviewees, Campbell-Montalvo et al. (2022a) provided additional nuance to Smith et al.'s (2021) previous findings on the importance of NSBE. Specifically, NSBE provided Black students a range of social capital that was especially effective because it came from other Black engineers or mentors. Being around numerous other Black engineers served as an example that success in engineering could be done. In addition, academic resources like tutoring or career advice were particularly effective because they were provided by homophilous alters, or individuals who were similar to students (i.e., same race). Importantly, the specific types of advice and resources offered by Black people in a student's network depended on their social proximity—the closer, more intimate relationships found in Campbell-Montalvo et al. (2021) provided students warnings of discrimination, the more distant, professional relationships provided through NSBE provided academic and career resources that were particularly effective because of who they were provided by (Campbell-Montalvo et al., 2022a). It is unknown as to how well this mapping of homophilous relationship types to support types might apply to SGM students.

We do know that similar mechanisms may be at play when it comes to women in STEM. Stout et al. (2011) tested of a model similar to our emphasis on homophilous alters that they call the "stereotype inoculation model." The authors proposed that "contact with same-sex experts (advanced peers, professionals, professors) in academic environments" in STEM enhanced "women's self-concept in STEM, attitudes toward STEM, and motivation to pursue STEM careers" (Stout et al., 2011, p. 255).

In interviews with 29 SGM students, Campbell-Montalvo et al. (2022b) found that SGM students often turned to other SGM students—or women and people of color when they did not have access to SGM STEM peers—for personal and academic advice. Yet having other SGM people with whom they could discuss their identity and STEM path was so important that students built their own homophilous social networks outside of their field when they did not have access to SGM STEM mentors. Given the demonstrated evidence of the function of homophilous alters in STEM persistence for historically excluded students and women, our research contributes by examining the role of homophilous alters in professional organizations and the types of support they provide on SGM STEM student persistence.

In sum, incipient research shows that oSTEM has supported SGM students in negotiating their identity and making relationships with other SGM STEM students with whom they can exchange and develop academic and career resources (Voigt, 2020; Haverkamp, 2021). Previous research suggests that there are parallels in the type of identity management that identity-focused STEM organizations, including oSTEM and NSBE, are able to confer upon members, particularly when the social capital is delivered by homophilous alters. These parallels, along with the dearth of research on SGM-focused STEM organizations, warrant further investigation using larger samples into how

various organization types may provide certain types of advice and resources, how they can encourage SGM student persistence, and what can be done to increase their reach.

Theoretical Orientation of the Present Study

To investigate the social mechanisms at play in how identity-focused STEM organizations, particularly those that are SGM-focused, influence the experiences and persistence of SGM STEM students, we mobilize theory on social capital, the advice and resources gained from others. We pay special attention to three forms of social capital: participatory, instrumental, and expressive. Participatory social capital includes the networks and resources gained through participation in organizations that have as part of their mission a goal to help members accrue a variety of capital to help them succeed (Skvoretz et al., 2020). Expressive social capital includes emotional support and encouragement to help people fit in or feel welcome, while instrumental social capital includes more direct resources, such as academic knowledge or advice on career opportunities, to help with success (Puccia et al., 2021). In previous research with women and historically excluded students, both forms of social capital provided by STEM organizations were shown to be crucial to students' declaration and persistence in STEM majors and their path into the workforce (Skvoretz et al., 2020; Campbell-Montalvo et al., 2021, 2022a,b; Puccia et al., 2021; Smith et al., 2021).

We extend this body of previous work to our examination of the role of identity-focused STEM professional organizations on SGM student persistence, adopting Smith et al.'s (2021) classifications as an analytical lens of STEM organization grouping by type. This classification model includes their framing of organizations as women-focused and race/ethnicity-focused. In the present study, we add the framing of SGM-focused organizations under our articulated umbrella term of identity-focused organizations.

We contribute to the recent focus on the role of SGM-focused STEM organizations by analyzing data from a large survey of SGM STEM undergraduates. Given the STEM climate for SGM students and their exclusion in the field, along with the role of social capital from professional organizations in student persistence, our goal is to better understand how identity-focused organizations (i.e., SGM-focused, women-focused, race/ethnicity-focused) may nurture SGM student capital and encourage persistence. We surveyed 477 SGM students, of whom 463 participate in professional STEM organizations–one of or possibly the largest sample of SGM STEM students who participate in a STEM professional organization to date. We address the following research questions, with an emphasis on organizations that are STEM-related:

(1) What *expressive* social capital do SGM students obtain from identity-focused organizations that help them persist in STEM?
(2) What *instrumental* social capital do SGM students obtain from identity-focused organizations that help them persist in STEM?
(3) What barriers to participation in identity-focused organizations did SGM students encounter?

Our aim is that outcomes of this research add to the discussion of how STEM professional organizations can broaden participation in STEM, especially for diverse SGM students.

METHODS AND PARTICIPANTS

Recruitment

We first recruited survey respondents who were currently enrolled STEM undergraduates from six partnering national professional organizations. These six partners were either:

- non-STEM SGM-focused organizations,
- STEM SGM-focused organizations,
- STEM women-focused organizations, or
- STEM non-identity-focused organizations with an active subdivision of or previously demonstrated interest in SGM students.

To increase the ethnic/racial diversity of our sample, we then recruited respondents from two additional STEM national professional organizations with a substantial number of Black and Latinx students.

Each of the eight total organizations was asked to send our IRB-approved recruitment statement to their membership. Organizations did so by distributing the recruitment statement using their listserv and/or social media accounts and/or including it in their e-newsletter. The recruitment statement explained the purpose of the study and the eligibility criteria (i.e., students who identified as LGBTQPIA+ and were enrolled in a STEM major). Students were given the option to enter their university email address to win one of twenty $100 gift cards. The survey was closed after 2.5 months.

Survey Demographic Measure

Student demographic characteristics were identified via items asking about students' sexual and gender identities as well as their racial/ethnic identities. The sexual and gender identity items were developed with guidance from the literature (particularly, Strunk and Hoover, 2019) and were based on analysis of 29 interviews the research team conducted with STEM SGM students during which the identity items were piloted and participant feedback was sought to inform the development of the survey. To measure sexual identities on our survey, we included an item that read, "Your sexual orientation is... (select all that apply)" and participants were able to check one or more boxes on the following list, with a final choice in which they were able to write in any additional identities:

☐ Asexual
☐ Bisexual
☐ Gay

☐ Heterosexual
☐ Lesbian
☐ Queer
☐ Questioning
☐ Pansexual
☐ If there are other/additional identities, please specify_____

Respondents identified 55 different configurations of sexuality, in addition to 10 write-ins under 'Other' (e.g., 'aromantic,' 'biromanti,' etc.). Twenty-four of the 55 (44%) configurations had a single person with that specific combination. This speaks to the fluidity and diversity of the sexual identities of participants in the sample. These 55 distinct combinations were re-classified into seven categories: bisexual; multiple sexual identities (MSIs); lesbian; queer/pansexual; asexual; gay; and other. We retained four of the original sexuality categories because respondents reported those identities alone in sufficient quantities to warrant retention: bisexual (31%), lesbian (14%), asexual (6%), and gay (4%). All respondents who reported more than one sexual identity were coded as Multiple Sexual Identities (MSI) to reflect their multi-dimensional sexuality (28%). Respondents who solely identified either Queer or Pansexual were combined into a single variable (11%). This combination was to reflect that both terms, in terms of sexuality, refer to fluid, inclusive understandings of sexual identity and attractions to more than one gender. The remaining respondent configurations were coded as Other and included those who marked Other originally, or who reported Questioning or Heterosexual.

Similarly, to measure gender identities on our survey, we included an item that read, "Your gender identity is... (select all that apply)" and participants were able to check one or more boxes on the following list, with a final choice in which they were able to write in any additional identities:

☐ Agender
☐ Gender Non-binary/Genderqueer/Gender Non-conforming
☐ Intersex
☐ Man
☐ Woman
☐ Cisgender
☐ Transgender/Trans
☐ Bigender/Pangender/Multigender/Gender fluid
☐ If there are other/additional identities, please specify_____

Respondents identified 25 distinct configurations of gender identity (plus three 'Other' write-ins: 'queer,' 'I'm mostly a girl but I'm also just chilling,' and 'questioning'). Eleven of the configurations (44%) were unique to one individual. The 25 configurations were re-classified into five categories: woman; non-binary/transgender; man; multiple gender identities (MGIs); and other. Those who identified themselves as woman or woman and cisgender were coded as Woman (77% of sample[2]). The same combination was used to denote Men (5%). We interpret both the Woman and Man categories as representative of individuals who identify with those gender categories and do not presume they are cisgender. Respondents who reported singular or combinations of non-binary, transgender, or bigender identities were coded as non-binary/transgender (8%). Individuals who reported multiple gender categories (with the exception of woman + cisgender or man + cisgender) were coded as MGI (4%). The Other category included individuals who identified as Agender, Cisgender (with no other designation), or Other (5%).

Here, declaration of the cisgender qualifier did not categorize a student as MGI unless they had two gender identities. Participants who identified as trans or trans + woman or trans + man were categorized as trans. Participants who only identified as woman were categorized as women. This likely means that some trans women participants did select solely the identity of woman. We chose to retain those selections given that that is how participants thought of themselves. For example, 43% of participants marked woman and 34% marked cisgender and woman. We put those participants all in the woman category without calling it cisgender, because they identify as women.

Categorization of Identity Variables

Our survey allowed participants to select all identities they held[3], and any reporting of data using such an item would necessarily need to regroup in order to facilitate quantitative description. For the descriptive analysis, we acknowledge that collapsing larger groupings of identities into smaller grouping does erase identity, so we balanced that drawback with the power that comes from using smaller groups to describe participation in the STEM organizations. The re-classification is also necessary for future quantitative analyses, which require a certain population size; positioning the current study to articulate with our forthcoming work using the same categories to support robust interpretation across datasets. For the qualitative examples provided in this study, students' full chosen identity markers are included with their quotes.

Allowing the selection of more than one identity and giving space to write additional identities promoted the exercise of participant agency in the survey. For both sexual and gender identities the team engaged in several rounds of back-and-forth discussion and coding about how to group the multitude of responses. The discussion was based on the team's previous first review of the demographic data, their previous research on the topic, and the existing literature, culminating in a codebook using the criteria mentioned earlier. The subsequent creation of the categorization schemes, particularly the MSI and MGI groupings, supports us in honoring the complexity of our respondents' sexual and gender identities. Our use of the MSI and MGI categories might be a novel categorization that seeks to retain identities selected by participants, to combat the erasure inherent in data recategorization. In this way, this can be seen as a strength of the design of the present study.

[2]Figures do not add to 100% due to rounding.

[3]Raw data are available upon request if readers would like to see the range of identities in light of the recategorization.

Rich scholarly debates are ongoing regarding how SGM identities are defined and measured (Vogler, 2021; Guyan, 2022), though consistent measures and data regarding SGM identities, particularly in STEM education research, have not been established (Freeman, 2020). One contribution of our work lies in the sharing of our SGM identity survey items here to help advance measurement in the field.

Survey Items on STEM Organization Participation

The data analyzed for this study include student responses to two survey items. The first was a close-ended survey item in which participants were asked about the organizations in which they participated, "Which of the following STEM organizations have you participated in? (Select all that apply) You do not have to be a member, you could have attended or participated in events/activities." Participants were able to check one or more boxes on the following list, with the final choice permitting them to write in any additional organizations.

- ☐ Out for Undergrad (O4U)
- ☐ Out in Science, Technology, Engineering, and Mathematics, Inc. (oSTEM)
- ☐ National Organization of Gay and Lesbian Scientists and Technical Professionals (NOGLSTP)
- ☐ National Society of Black Engineers (NSBE)
- ☐ Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS)
- ☐ Society of Hispanic Professional Engineers (SHPE)
- ☐ Society of Women Engineers (SWE)
- ☐ Engineering industry or discipline specific organizations (e.g., SAE International, Institute of Electrical and Electronics Engineers [IEEE]), please specify_____
- ☐ National science student chapters/organizations/clubs (e.g., the American Chemical Society [ACS]), please specify_____
- ☐ Other, please specify_____
- ☐ None

The second survey item we analyzed was an open-ended item which read, "Please describe how your participation in _____ has contributed to your progress as you pursue your STEM degree." Using Qualtrics' piped text feature, the blank was automatically filled in with the name of the organization in which participants had reported participating in the earlier item. If students had participated in more than one organization, they received the prompt asking how their participation contributed to their progress for each organization, displayed one at a time.

Analysis

We calculated descriptive statistics on the first survey item that asked in which organizations respondents participated. On the second open-ended item asking about how students' participation in organizations contributed to their progress in STEM, we analyzed data related to responses in the identity-focused organization choices provided on the survey using thematic analysis (Braun and Clarke, 2006). Six members of the research team met regularly to review the data, discuss approaches to data analysis, and discuss ideas for codes and themes that might generally apply to the full dataset. In focusing on the data presented here, two team members created a codebook based on an initial review of the dataset and the team's previous discussions, research, and the literature, which has previously highlighted the role of (1) expressive and (2) instrumental social capital in a range of areas, including in engineering students' major declaration (Puccia et al., 2021), in their academic resources (Smith et al., 2021), and in their fit (Campbell-Montalvo et al., 2021, 2022a,b). We were also interested in understanding (3) the barriers to participation in organizations that students reported, since such information could potentially be used to increase the reach of the organizations.

Once the codebook was established, the two members of the research team reviewed the data of focus to articulate an operationalization of and examples of each code that would be used, and to confirm the codes would be suitable for use with the data. Then, one member of the research team organized the data by applying one or more of the three codes to student responses. The two members of the research team met several more times to review and discuss the coding process, clarify code meanings, and confirm codes used on the data. The final codebook is shown below (**Table 1**). The two team members continued to meet to discuss how the coded data were interrelated, associating the organized data into themes. The themes were then parsed out by organization type (i.e., SGM-focused, women-focused, or race/ethnicity-focused) and presented in this manuscript using illustrative examples.

In the end, the researchers reached consensus about the ability of the codebook to allow for the organization of data in relation to the research questions, demonstrating the reliability of our analysis. Our interview questions were based on previous research, as articulated earlier, supporting the

TABLE 1 | Codebook used for analyzing qualitative data.

Code	Definition/examples
Expressive social capital	Sense of belonging, community, likeminded, support, identity, safe space, "not alone," encouragement, motivation, inspiration, outreach, giving back
Instrumental social capital	Mentoring, academic support (tutoring, advice about classes), professional networking, professional development/career-specific skills, internships/jobs, scholarships
Barriers to participation	Time, scheduling conflicts, lack of fit, lack of interest

TABLE 2 | Organization participation by race/ethnicity, sexual identity, gender identity (*N* = 477).

Identity	*n* (%)	O4U (*n* = 11)	oSTEM (*n* = 88)	NoGLSTP (*n* = 4)	NSBE (*n* = 69)	SHPE (*n* = 51)	SWE (*n* = 415)
Race/Ethnicity							
White	285 (60%)	6	55	1	11	17	263
Asian/Pac. Islander	55 (12%)	1	11	1	5	2	52
Multiracial	53 (11%)	0	10	0	9	9	46
Black	41 (9%)	1	5	0	39	8	15
Latinx	23 (5%)	1	2	1	3	11	21
American Indian	11 (2%)	1	3	0	2	1	10
Other	9 (2%)	0	1	1	0	1	7
Sexual Identity							
Bisexual	148 (31%)	1	15	1	22	20	129
Multiple (MSI)	134 (28%)	3	34	1	14	11	119
Lesbian	68 (14%)	2	16	0	7	4	62
Queer/Pansexual	51 (11%)	3	12	1	9	3	42
Other	31 (7%)	0	6	0	5	4	30
Asexual	28 (6%)	0	2	1	3	3	25
Gay	17 (4%)	2	3	0	9	6	8
Gender Identity							
Woman	368 (77%)	6	61	2	40	34	341
Non-binary, Trans	38 (8%)	2	9	1	7	3	28
Man	26 (6%)	2	6	0	16	8	8
Other	24 (5%)	0	6	1	2	2	22
Multiple (MGI)	21 (4%)	1	6	0	4	4	16

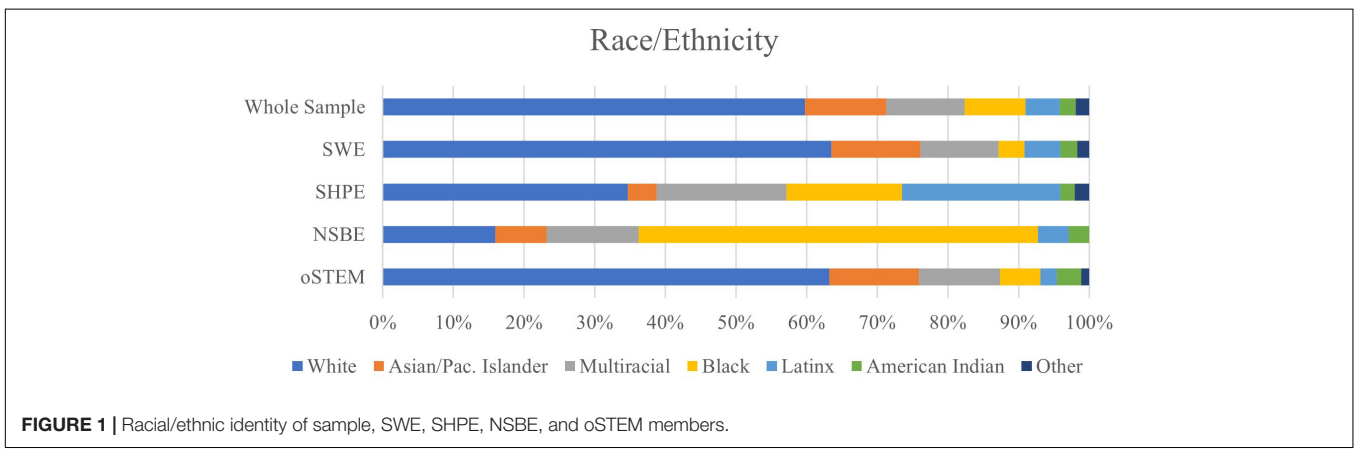

FIGURE 1 | Racial/ethnic identity of sample, SWE, SHPE, NSBE, and oSTEM members.

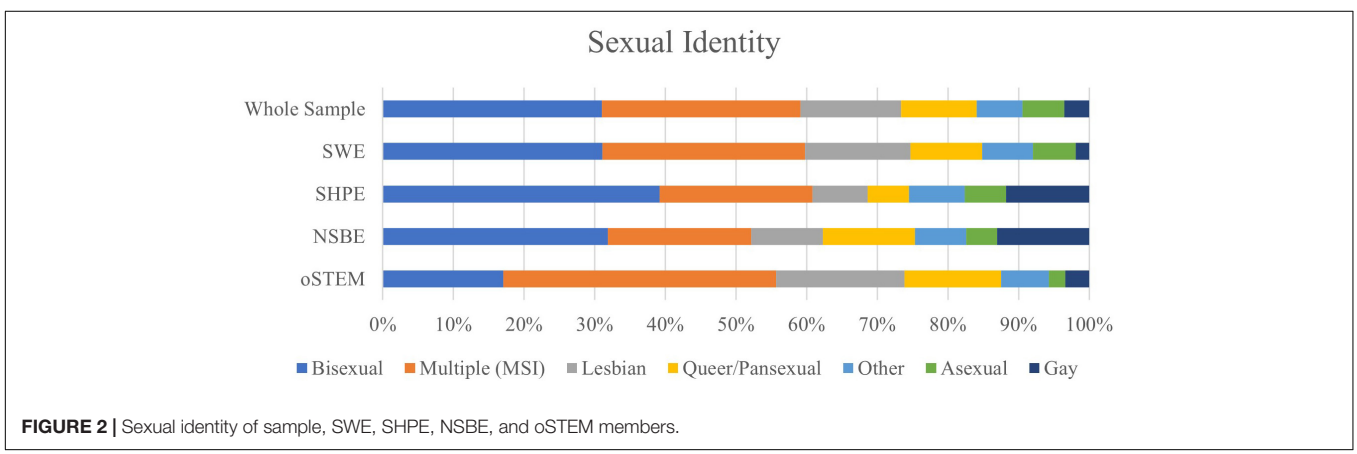

FIGURE 2 | Sexual identity of sample, SWE, SHPE, NSBE, and oSTEM members.

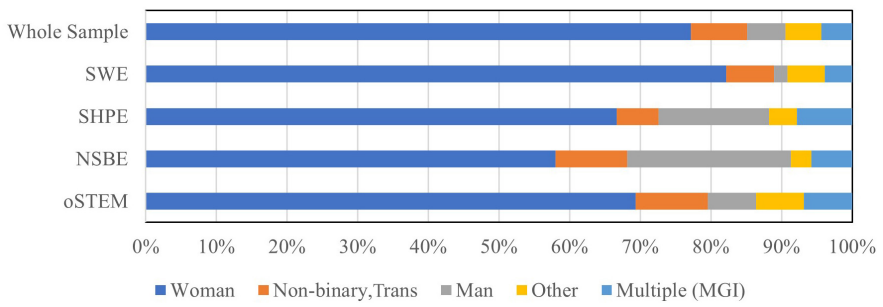

FIGURE 3 | Gender identity of sample, SWE, SHPE, NSBE, and oSTEM members.

credibility of our work. By using robust probing techniques in interviews and implementing the recruitment procedures we did to engage a diverse sample, we bolstered the transferability of our findings to additional contexts exploring how identity constellations intersect with social capital to impact outcomes. Our results are confirmable since they emerge from our multi-step analysis process and are presented in participants' own words. Additionally, our results are also dependable given that we expect other scholars researching SGM students in STEM will obtain similar data on student experiences in these organizations (Nowell et al., 2017).

Participants

In terms of race/ethnicity, the sample was 60% white students (n = 285), 12% Asian/Pacific Islander students, 11% multiracial students (n = 53), 9% Black students (n = 41), 5% Latinx students (n = 2), 2% American Indian students (n = 11), and 2% other students (n = 9). With respect to sexual identity, the sample was 31% bisexual students (n = 148), 28% MSI students (n = 134), 14% lesbian students (n = 68), 11% queer/pansexual students (n = 51), 7% other students (n = 31), 6% asexual students (n = 28), and 4% gay students (n = 17). With respect to gender identity, the sample was 77% women students (n = 368), 8% non-binary/trans students (n = 38), 6% men students (n = 26), 5% other students (n = 24), and 4% MGI students (n = 21). Of the seven provided as a choice, students participated in the following six identity-focused organizations: SWE (n = 415, 87%), oSTEM (n = 88, 18%), NSBE n = 69; 14%), SHPE (n = 51; 11%), O4U (n = 11; 2%), and NoGLSTP (n = 4; 1%). **Table 2** shows the number of students who participated in the organizations listed as a choice on the survey, by student demographics. The three stacked bar graphs that follow show the racial/ethnic, gender, and sexual identity breakdown of participants in the four largest organizations (**Figures 1**–**3**).

FINDINGS

Overview

In this section, we detail findings related to our three research questions on how SGM STEM students receive expressive and instrumental social capital from identity-focused organizations and may encounter barriers to participation. **Table 3** presents a concise representation of the findings related to these research questions.

To help the reader get an idea of the level of endorsement of themes among the sample, **Table 4** depicts the amount of responses about student participation in societies that were coded as expressive or instrumental social capital or barriers to participating in the societies of focus. Responses could have been coded using none, one, two, or three of the codes.

Expressive Social Capital: Sexual and Gender Minority-, Women- and Race/Ethnicity-Focused Organizations Help Sexual and Gender Minority Students Negotiate Identity to Fit in STEM

Expressive social capital helps students feel welcome in STEM and encouraged to continue toward their STEM goals. SGM-, women-, and race/ethnicity-focused organizations each provided expressive capital to SGM students from a range of SGM and ethnoracial groups, albeit in varying ways. In the case of each identity-focused organization (i.e., SGM-focused, women-focused, race/ethnicity-focused), the base of the capital stemmed from the organization's development of a safe community network where students with particular identity sets were welcome and had the opportunity to negotiate how they fit into STEM given their identities (i.e., as SGM students, as women, as ethnoracial minority students [particularly Black students]).

Sexual and Gender Minority-Focused Organizations Contribute Most in SGM Identity Negotiation

Sexual and gender minority-focused chapter organizations, namely oSTEM, helped SGM students stay in STEM in two main ways:

- They provided an infrastructure for students to network with other SGM students, creating a safe and supportive community.

TABLE 3 | Main research findings.

Research question	SGM-focused	Women-focused	Race/Ethnicity-focused	Overall identity-focused
(1) What *expressive* social capital do SGM students obtain?	Provided infrastructure for networking with other SGM students, creating a supportive community. Helped students understand themselves in terms of their SGM identities and feel belonging in STEM at the same time.	Provided a supportive network in a comfortable space where students could express identity. Students felt motivated from being part of an organization with women in a safe space, with role models who show it can be done, and with a history of women's excellence.	Provided a network of support of Black engineers, who also provide an example that success in engineering can be done. Provided a sense of belonging and increased confidence.	Each helped expand social networking with homophilous others who provided capital for identity negotiation in STEM. Each helped motivate students as they became part of something greater than themselves and helped others in STEM.
(2) What *instrumental* social capital do SGM students obtain?	Students less often reported receiving instrumental social capital, and what was received centered on careers.	Provided extensive academic and career support. This support was often tailored toward women and ground in the development of networks and networking.	Provided robust academic and career resources ground in the development of networking, often with same-race engineers.	Students wrote far less about how SGM-focused organizations helped with academics and/or career.
(3) What were barriers to participation?	SGM students did not report exclusion.	Did reproduce cultures of exclusion toward SGM students.	Issues of fit were rare, and relation to SGM identities not substantiated.	Some organizations collaborated with other organizations to better serve SGM students.

TABLE 4 | Count of codes applied to data across the three society-types.

Society type	Expressive social capital code	Instrumental social capital code	Barriers code
SGM-focused	71	9	2
Women-focused	276	142	20
Race/ethnicity-focused	69	42	5

- They were especially valuable in helping students understand themselves in terms of their gender and sexual identities and feel belonging in STEM at the same time.

For example, regarding how oSTEM helped her connect to other SGM students which contributed to her persistence in STEM, a white bisexual queer woman wrote:

> My participation in oSTEM connected me to the only other out student I have met in my major. We are friends now and have been able to support each other in ways straight/cis students and faculty cannot. This solidarity makes me more willing to stay in engineering.

Likewise, an Asian queer pansexual non-binary student described their participation as the Conference Chair of oSTEM, highlighting the value of empathy across members and how it helped them stay in STEM:

> Our weekly meetings gave me a safe space where I was certain that a majority of the members could empathize with the struggles of queer students (especially non-binary students) in the STEM field. Without this mental and emotional support provided by members of this organization, I may not have been able to continue in STEM.

In addition, in discussing specifically how the community of oSTEM helps negotiate STEM fit with SGM identities, a Black cisgender lesbian woman shared:

> It has given me confidence to be my full self at all times while pursuing this degree. Going to the conference has given me the encouragement to truly believe in myself and my abilities. My identities make me who I am, but they are not all that I am. I can do all things despite the harsh past that I come from. Being comfortable with oneself enables students to persist.

Also connecting a sense of community with the dual identity acceptance of SGM and STEM to progress in STEM, a Muscogee and white bisexual woman stated, "oSTEM has showed me that I am not alone and has given me a community in which I can be honest about two major parts of myself." At the same time, an Asian lesbian queer woman wrote that oSTEM has "given the best type of education related to the intersectionality of being LGBT+ and not hiding your sexuality even in a professional setting while at the same time not outing yourself and ruining professional work." Likewise, a white queer lesbian woman wrote of oSTEM, "It is a pretty solid reminder that my experiences and identity aren't necessarily isolating, and that there is a support network for me." Similarly, a Latinx pansexual woman described her experience with O4U in helping her negotiate her own identities personally and in STEM:

> I went to two O4U Engineering Conferences and they helped me a lot. After the first conference I was able to come out and be more happy with myself, which helped me to be better in my classes and general life. To be a

> successful professional you have to be authentic and to be sure of who you are. I was afraid of how being part of the LGBTQ+ community could negatively affect my life (academical and professional). Now I'm not afraid and I try to inspire other people.

A white bisexual queer gay man comparably described his experience in O4U, "I attended the O4U Engineering conference, and it really opened my eyes to the importance of my two identities, STEM and LGBTQ+. After the conference I felt more comfortable with who I am." An Asian queer pansexual non-binary student also talked about how an SGM-focused organization helped them understand their identities:

> I attended the NOGLSTP conference in the spring of 2019 and attended educational sessions about the science of gender, which helped me figure out different aspects of my gender identity and validate some of my feelings about my own biological sex.

These comments show that SGM-focused organizations offered expressive social capital especially attuned to community, which was particularly useful in SGM students integrating their SGM and STEM identities.

Women-Focused Organizations

Women-focused organizations helped students persist in STEM via two key mechanisms:

- They provided a supportive network in a comfortable space wherein students could express their identity outside of the hetero-cisgender-male STEM environment.
- Students received feelings of motivation from being part of an organization with women in a safe space, with strong role models who show it can be done, and with a history of women's excellence in STEM.

Writing about the influence of SWE in making space for women in engineering, a white pansexual cisgender woman described the importance of this community in light of the engineering environment: "SWE has served as a place for female engineering majors to gather and exist without worrying about our male peers infringing on our existence or worrying about spinning our mannerisms to appease them." Likewise, a white woman who self-describes her sexual identity as fluid and unlabeled wrote how SWE helped her to feel like she belonged in engineering, "I struggle in engineering as both a queer person and a woman. My close friends are mostly all other women in my major, and we attend occasional SWE events together, which always makes us feel like we belong in the engineering community." Similarly, a white pansexual cisgender woman wrote, "While it was not explicitly focused on sexual orientation, having a community of women who were able to relate to my struggles and share their own experience helped me feel like I was not alone." A white bisexual woman shared that SWE provided "validation as a gender minority." For some students, SWE extended feelings of community to identities outside of gender, as an Asian and white demisexual cisgender woman wrote, "SWE has taught me that there is value in my identity as a woman in engineering. The values I've learned in this club also translate to how I express my sexuality identity and identity as a person of color." A Middle Eastern gay man also emphasized sense of community and safety: "SWE helped build a family for me at school that I can feel safe in and connect with. Helped ground me and be myself."

Students in SWE wrote about how they gained motivation and inspiration to persist in STEM from being around women in a safe environment, meeting and becoming role models for others, and taking part in the history of women in STEM promoted by SWE. A white bisexual cisgender woman said of SWE, "Having a safe space with other women who experience the same issues helps motivate me." A Black non-binary bisexual queer pansexual student described the motivation they got from the organization, "SWE has given me motivation to work harder and engage more with fellow engineers in my field." Also describing SWE's impact on her motivation, an Asian and white bisexual cisgender person wrote, "I've felt much more empowered and motivated to do my best in school. They also make me feel reassured that I can do this, and everything will work out." Again connecting the safe space to motivation, as well as highlighting role models, a white bisexual woman wrote, "Being in SWE provides me with a safe place where I can discuss both academic and personal issues with a set of strong, passionate STEM role models who truly want to help me succeed." An Asian and Latinx lesbian cisgender woman's response echoed the importance of role models in SWE, "They are a strong network of role models that show me that my dreams really are within reach." A white queer and questioning cisgender woman located SWE's history as a source of her motivation in its legacy, "I love knowing that there are women who came before me and did the same things that I am doing now." Similarly, a white bisexual queer woman wrote, "SWE is the main reason I continued to pursue engineering. Being part of a cause greater than myself or even my education inspires and encourages me to get my degree." These examples show how SWE particularly aided women in fitting into STEM by providing a safe space and buttressing feelings of motivation from being around women, role models, and the historical legacy of SWE.

Race/Ethnicity-Focused Organizations

Race/ethnicity-focused organizations, particularly the most often cited NSBE, helped students cultivate expressive social capital. These organizations helped students persist in engineering by:

- Providing a network of support of Black engineers, who also provide an example that success in engineering can be done even though there are few Black engineers.
- Providing a sense of belonging and increased confidence in engineering.

For example, in writing about how NSBE increases fit in light of the lower numbers of Black students in engineering, a Black asexual pansexual man wrote, "NSBE provides a sense of belonging being a person of color in a field that there are few in." Likewise, a Black bisexual woman stated, "NSBE has been one of my biggest support systems as there are not many

Black students on campus." A Black and white bisexual cisgender woman highlighted her confidence increase because of this, "My participation in NSBE has helped increase my confidence in myself as one of the few, and sometimes only black person in my STEM classes." In addition to the scarcity of Black engineering students, the lack of women engineers was also a concern NSBE helped some students face; another Black bisexual woman wrote of how it built her confidence as a Black woman in STEM, "NSBE has helped me find my place in a field dominated by men, I have found friends and a safe place. This group has helped me build my confidence being a Black woman in STEM."

National Society of Black Engineers sustained fit by providing students the opportunity to see and be around other Black students in STEM. For instance, a Black gay transitioning woman wrote of NSBE, "Seeing other people who look the same as me and have similar cultures as me succeeding in what I want to do has pushed me to love my major even more." Similarly, a Black lesbian cisgender woman in NSBE said, "It's nice to see people of my racial background pursuing engineering because I rarely ever see that in my classes." At the same time, a Black bisexual non-binary student recounted how NSBE empowered them, "It was uplifting and empowering to see Black people like me. . .I felt less like an outsider attending club meetings." A Black gay man also wrote of the motivation he drew from NSBE and being around Black engineers, "NSBE has kept me motivated and inspired to see other people of color succeed in the STEM field." A Black and Latinx bisexual queer woman who identifies as multigender[4] described how NSBE increased her confidence by enabling her to develop a network of colleagues who provide resources that help her persist in engineering:

> I have been a part of NSBE since my freshman year, and it really has brought me closer with the Black community, improved my confidence, and helped me network with numerous engineers across the country. Now, with a strong network of people, I am able to get through classes with classmates that I have met through the organization.

Similarly, on NSBE's impact on his confidence, a Black asexual queer cisgender man wrote of NSBE's long-term effect on his engineering fit:

> They have helped mold my confidence to pursue my education. They inspired as far back as high school and were the living example I needed of students who at a glance I knew could graduate. I needed these examples to help me see those qualities in myself.

One participant wrote about the benefits to feelings of belonging from SHPE. A Black bisexual woman stated, "SHPE has supported me because it has shown me that all minorities care and support one another." Together, these excerpts show how race/ethnicity-focused organizations, particularly NSBE, helped engineering students of color, particularly Black students, develop a network of students like themselves and see engineering as a place for them.

[4]Participant selected Bigender/Pangender/Multigender/Gender fluid on the survey; for readability on the quoted examples, we use multigender.

Expressive Social Capital: Amplifying Others' Voices in Organizations Raises One's Own

In addition to helping students persist in STEM by helping them negotiate their identities and develop networks, students experienced emotional benefits from these organizations at the same time they put in the work to run them. Specifically,

- Students received feelings of contributing to a greater purpose through organizations as they advocated and encouraged other students in STEM.

For instance, when asked how the organization influenced their STEM progress, a white bisexual non-binary woman mentioned the advocacy role of SGM-focused organizations, responding, "oSTEM has been essential in advocating for the LGBTQ student body, since we are the only LGBTQ organization on campus." Likewise, a white bisexual lesbian queer woman wrote, "I founded the oSTEM chapter at my institution and was able to help others in the LGBTQIA+ community find a voice and advocate for them." A white bisexual gay queer man described how he got involved in helping SGM students:

> I was inspired in part by attending the O4U conference, so I joined the e-board of my school's oSTEM chapter. I have attended a couple of conferences, and I am passionate about providing opportunities/serving as a guide for those just entering STEM and the LGBTQ+ community, or allies who wish to know how they can help.

A white bisexual gay queer man similarly described his experience in O4U, "I had more drive to make a difference for the STEM and LGBTQ+ community."

On the role of women-focused organizations, a Black bisexual queer pansexual non-binary student described their experience in SWE advocacy, "As the vice president of the Society of Women Engineers, I have a partial responsibility in planning meetings, and engaging students on campus to advocate for women in engineering." A white queer questioning cisgender woman additionally described helping incoming students in SWE, "I love knowing that I can be a role model for the younger students, and that they will look up to me and know that I have made their path just a little bit easier." Similarly, a white lesbian non-binary student wrote that becoming a role model in SWE was motivating, "SWE allows me to encourage others and see that I am a role model to some so therefore I should keep going." Likewise, a white bisexual queer woman wrote of the inspiration she felt by participating in SWE to "serve as an example to other female identifying students that they can do it too!" A Latinx pansexual woman shared her experience in SWE and how her involvement inspired others:

> I've met amazing people and mentors, I've inspired people and I've been inspired too. . .This year I got to be part of a panel as a Latinx/Latino/Pansexual person, representing the LGBTQ+ community in the "Diversity and Inclusion in the Latinx Community." SWE gave me tools that I couldn't find in any classroom and I'm grateful for it.

Of race/ethnicity-focused organizations, a Black asexual cisgender woman wrote about giving back to the university, "NSBE . . . allows me to take a role of leadership and give back to the campus." A Black lesbian cisgender woman similarly wrote about her joy in giving others someone to look up to in NSBE, "Interacting with younger students in the organization motivates me to continue being great so that they have someone to look up to. I'm currently the president at my university and I love it." Similarly, an Asian and Latinx lesbian cisgender woman identified outreach opportunities through volunteering in SHPE as influential on her STEM progress, "The volunteer opportunities remind me why I chose to be in STEM." Thus, these comments show how participating in these organizations motivates students to persist in STEM as they advocate for and welcome new students like themselves into the field.

Instrumental Social Capital: Providing Career Opportunities Is a Strength of Women and Race/Ethnicity-Focused Organizations

Instrumental social capital gives students "insider knowledge" about how to succeed in STEM. Organizations provided SGM students resources focused on aiding them in their academics and in their careers. Academic support came in the form of tutoring, organized study groups, and upper class students offering advice. Respondents mentioned that their organizations assisted with developing professional skills related to their future careers as well. Overall, students highlighted instrumental capital somewhat less robustly than expressive capital, particularly in SGM-focused organizations. Findings primarily showed:

- In comparison to race/ethnicity-focused organizations and women-focused organizations, students wrote far less about how SGM-focused organizations helped with academics and/or career.

In terms of SGM organizations, students less often reported that they offered instrumental social capital, what they did offer centered on career advancement. For instance, a white lesbian cisgender woman shared how oSTEM provided connections to career opportunities that would be safe for her given her SGM identity, "oSTEM has provided career opportunities with LGBTQIA friendly organizations and has provided me with LGBTQIA professional connections." In addition, an Asian queer trans student identifying also as transmale described, "My oSTEM connects me with different STEM students of different ages and backgrounds. I am able to ask LGBT upperclassmen for advice regarding career options and academics." More generally, a white lesbian woman indicated, "O4U helped me get a full-time job after graduation." While sparse, these comments show the potential of SGM-focused organizations in impacting their members' academic and career paths.

Members of SWE wrote more than those of oSTEM about receiving academic and career support. This support was often tailored toward women and ground in the development of networks and networking. In terms of academic support, a white bisexual non-binary[5] and multigender student wrote that SWE "helped me find people to study with and hold me accountable." A white lesbian cisgender woman described:

> Society of Women Engineers provided me with a network of women to support me in my classes. I was given study tips, tutoring, support for difficult assignments, resources to help me succeed, and de-stressing activities during exam weeks. SWE is the main reason I decided to remain an engineering student.

Regarding career support, a white bisexual woman wrote that "SWE has provided helpful lectures and guest speakers to talk about how women can move forward in their STEM career." A Middle Eastern bisexual woman wrote of the skills she developed, "SWE helps a lot with getting jobs and preparing for the application process." A white bisexual questioning cisgender woman also described the professional skills SWE afforded her as a woman and said, "I attend SWE professional meetings where I learn about companies that could hire me, how to behave in the industry." Similarly, an Asian bisexual woman wrote, "At SWE general meetings we discuss how to have success in the classroom and also how to learn the soft skills needed to network." A Latinx bisexual cisgender woman wrote about the additional experiences SWE offered that helped in her career path, "SWE has helped me step into leadership positions which enabled me to find internships/co-ops." A Latinx pansexual woman also discussed the leadership skills and job opportunities she has received through her involvement in SWE:

> I'm pretty much sure that I'm the leader I am today because of all the roles and opportunities I got as a SWE member. . .I've been recognized with awards two times because [of] my commitment and work with SWE in and outside my school/community. I've had interviews and offers thanks to them.

More directly connecting SWE events to obtaining jobs or internships, a white lesbian woman wrote, "Attending the SWE conference was the steppingstone to landing my first job." At the same time, a white asexual queer aromantic biromantic cisgender woman said, "I have received numerous job/internship offers from the national SWE conference, which I would not have gotten otherwise." An Asian bisexual cisgender woman "even got a job offer at the SWE conference." A white queer woman also described acquiring an internship and job at an SWE event, "I have attended the national SWE conference the past 2 years and have gotten my internship last year and full-time job this year at the career fair there." Connecting SWE as a women-focused networking organization to job opportunities, an American Indian and Asian bisexual and lesbian cisgender woman shared her experiences where women-positive firms provided opportunities at SWE events:

> I have attended two SWE conferences that had job fairs with companies who value diversity, promoting

[5]Non-binary is used for participants selecting Gender Non-Binary/Genderqueer/Gender Non-conforming for readability.

> the work and lives of women in engineering. I learned an immense amount.

These excerpts highlight the various processes through which SWE promotes its members' academics and careers. These include providing access to networks that are often the linchpin in students obtaining study groups, providing professional development, and providing connections to internships and jobs.

Race/ethnicity-focused organizations also provided academic and, more often, career resources ground in the development of networking opportunities, often with same-race engineers. Pointing out that she may not have had access to such resources without NSBE, a Black queer cisgender woman wrote, "NSBE provided guidance for my academic and professional journey and provided resources I wouldn't otherwise have access to." A Black, Latinx, and Chickasaw bisexual pansexual cisgender woman also wrote about academic resources, indicating that SHPE promoted her academic achievement by providing "a safe place to study." Similarly, a Black gay queer man highlighted the value of having a place to study: "NSBE has allowed me to meet more Black engineers and have a place to study." Emphasizing the specific professional development opportunities offered through NSBE, a Black and white bisexual cisgender woman wrote, "NSBE helped me with improving my resume, networking, and other professional stuff." A Black gay man underscored professional development, grounding its applicability in the support of a network of Black engineers, "NSBE has exposed me to career development opportunities and has helped me develop a professional network with other Black engineers which is important to me." Similarly, a Black gay man commented on the resources attuned to Black students, "NSBE has provided professional development resources specific to ethnic minorities." A Black gay man wrote that examples of Black engineers provided a role model into careers, "NSBE provided panels on other NSBE members and how those members found their current careers." Likewise, a Black lesbian cisgender woman wrote of its impact on her job prospects, "NSBE is the main reason I have continued engineering. They have given me multiple career opportunities." Of SHPE, a Latinx bisexual woman similarly noted, "SHPE is a great source of career advice and a place for job searching." A Black gay man wrote that SHPE also provided networking opportunities, "SHPE encouraged me to go to my first conference called Great Minds in STEM. Although I didn't find any job offers I did have the ability to network with different people." These comments show how race/ethnicity-focused organizations advance SGM students in STEM through academic and especially career resources and connections to engineers like themselves.

Barriers (and Bridges) to Organization Participation

While students described how identity-focused organizations cultivated their expressive and instrumental capital, they also mentioned that identity-focused organizations could include or exclude members with multiple minoritized statuses not within the stated purview of the organization. Specifically:

- Women-focused organizations could reproduce cultures of exclusion toward SGM students.
- Some organizations collaborated with other organizations to better serve diverse students.

Of women-focused organizations, a Muscogee and white bisexual woman wrote of the poor initial impression she had of SWE that made her never go to another meeting, "SWE felt hostile during the first meeting and I never went back." When asked about the influence of SWE on her progress, a white bisexual pansexual cisgender woman's response indicated that while she had a good chapter, some women-focused organization chapters were known to be problematic, "I do appreciate how inclusive the SWE local student chapter is. I am extremely disappointed how openly exclusionary other SWE chapters can be." A white genderqueer student concurred, rooting displeasure in an inability to feel comfortable in SWE due to identity conflict:

> SWE has helped a lot and was a lot of the reason I received my internship. However, I struggled to feel comfortable there, because I am not out as genderqueer to any of my SWE peers and I am not a woman, and even though it is an inclusive environment, I feel dysphoric every time I attend any events.

Similarly, responding to the question of how SWE impacted their progress, an Asian queer and pansexual non-binary student wrote that they were unable to take advantage of SWE's resources because of the feeling of unwelcomeness SWE could cultivate among diverse students:

> They have not. I have never felt welcome within that space as a non-binary, femme-presenting person. In the general meetings that I have attended, there was a lack of recognition of gender non-conforming and non-binary people, and a complete lack of sensitivity to the possibility of intersectional identities of their membership.

A white gay lesbian queer non-binary woman that self-describes as "mostly a girl but I'm also just chilling" also wrote about not fitting in at SWE, "I was briefly involved in SWE at the beginning of my first year, and it only solidified that I don't ever want to be a corporate sellout. I also don't associate with SWE anymore." A Black and white queer pansexual cisgender woman described SWE's lack of impact on her progress similarly and succinctly, locating the issue within the white women who comprise a numerical majority of the participants, as she said, "White women are problematic." An American Indian and white "but white-passing" lesbian queer non-binary trans woman indicated that while things began poorly, they seemed to be looking up in her SWE chapter:

> Society of Women Engineers has been bittersweet; when I started many people were not educated on LGBTQ+ issues, but as I reach my last few semesters, I can see the change I initiated and encourage younger members to be out in order to increase visibility.

In contrast, an Asian and white demisexual cisgender woman's experience differed with many others' in that she found her SWE

chapter to be accepting and helpful in preparing her to negotiate her identities in the STEM workplace:

> Society of Women Engineers has really made me feel like I can be out and open within my education and career further down the line. They help identify opportunities and put together things like workshops on how to discuss your identities with potential employers in professional settings.

These comments show how women-focused organizations can be unwelcoming to SGM students, particularly in their rendering invisible diversity.

Regarding race/ethnicity-focused organizations, issues of poor fit were infrequent. A Latinx asexual heterosexual agender woman wrote, "I was very committed to SHPE and held multiple officer positions. Now, I am no longer a member since I realized that I don't really fit in in that group." Likewise, a Black queer non-binary student described their experience saying:

> I've met some people through NSBE, but ultimately, the chapter at my school is so cliquey that I struggled to find support through it. It has made me look to other people in my other organizations, such as my sorority, to help me as I pursue my degree.

These comments suggest that race/ethnicity-focused organizations' fit issues, when they do occur, may be less related to students' SGM identities.

Collaboration between organizations helped organizations serve students with multiple minoritized statuses. For instance, students mentioned that different organizations worked together for certain events to advance inclusion across women, racial/ethnic groups, and SGM groups. Collaborations spanned women-focused (SWE), race/ethnicity-focused (SHPE, NSBE), and SGM-focused (oSTEM) organizations. For example, a white bisexual multigender student wrote, "NSBE and SWE have done many collaborative activities," and "SHPE and SWE have done a few collaborative activities." Likewise, a white bisexual cisgender person noted the expressive social capital outcomes of such partnerships, "My SWE committee holds events with SHPE to further connections between minority student groups, it gives me a more diversified, inclusive perspective of STEM." Comparably, a white lesbian woman shared, "SWE works closely with NSBE on several events to encourage equality in engineering." In addition, an Asian queer pansexual non-binary student observed a partnership between SHPE and oSTEM in service of academic resources, writing, "SHPE and oSTEM have collaborated on a few Study Nights." These excerpts speak to how some feelings of exclusion cultivated in some organizations might be mitigated through collaborative efforts.

DISCUSSION

In sum, there were similarities and differences in the expressive social capital provided by identity-focused organizations (i.e., women-, SGM-, and race/ethnicity-focused organizations). In general, identity-focused STEM organizations provided students expressive social capital in the form of social networks and feelings of acceptance by being around others like themselves—they could be confident in their identity and ability to persist in their major at the same time (Voigt, 2020). These organizations provided role models, mentors, and more experienced students whose advice, encouragement, and example influenced students' motivation to persist in STEM. This built a supportive homophilous community on campus for SGM students. This network of similar and/or accepting peers and others meant that students did not have to experience challenges alone, especially challenges they faced related to others' perceptions of their identities, and their network offered sources of encouragement to keep going during difficult times. This also meant that students did not necessarily need to expend extra effort to cultivate relationships with other SGM students outside of STEM, who might be less able to provide advice germane to STEM (Campbell-Montalvo et al., 2022b).

Sexual and gender minority-focused organizations particularly helped students negotiate and better understand their own identities and, within the unwelcoming STEM climate, how their SGM identities could co-exist with a STEM identity (Voigt, 2020). The students were also able to facilitate and participate in conversations regarding LGBTQIA+ issues that they might otherwise not have had to chance to participate in elsewhere, especially in STEM settings. The value of this aligns with work by Friedensen et al. (2021) which identified a tension in SGM STEM students' persistence in which they had to separate their SGM and science identities to persevere and looked toward a STEM career with eyes on how they would survive it. Our findings underscoring the value of oSTEM in cultivating a connection between SGM and STEM identities replicate previous work that found "[in comparison to other Queer clubs,] oSTEM, which seeks to foster this connection between STEM and Queer identity, was more well received and helpful in supporting a sense of belonging in STEM" (Voigt, 2020, p. 262).

Women- and race/ethnicity-focused organizations provided students safe spaces and exposure to other people like themselves who were excelling in STEM. For participants of SWE, it allowed them to escape the "dudebro" culture of engineering (Fisher and Waldrip, 1999; Seymour and Hewitt, 1999; Toynton, 2007; Antecol et al., 2008; Grunert and Bodner, 2011; Mattheis et al., 2019; Miller et al., 2020; Voigt and Reinholz, 2020; Palmer et al., 2021), and its legacy was also a motivating factor in continuing in STEM. For NSBE, seeing other Black engineers motivated students by increasing their confidence. Our findings here are consistent with the research conducted by McGee and Martin (2011), Campbell-Montalvo et al. (2021, 2022a,b), and Smith et al. (2021) which emphasized the particularly negative climate Black students face in STEM and how advice from others, including those in NSBE, helped students deal with stereotype threat and gain confidence by being around other Black engineers. The present study extends this previous work by showing that Black SGM students are able to access the same expressive capital open to the general population of Black engineering students. This is particularly important as Skvoretz et al. (2020) showed that Black students may enter their engineering program with less social capital than other groups, and SGM students face added burdens in accessing social capital in STEM spaces (Voigt, 2020;

Haverkamp, 2021; Campbell-Montalvo et al., 2022b). In addition, students in all identity-focused organizations talked about the feelings of motivation and satisfaction they got from welcoming students like themselves into the discipline; helping others helped them to persist.

The various social positioning of the groups of focus in these organizations as well as the larger social and historical context informs the ways participants reconciled their identities and arrived at particular identity outcomes from the expressive social capital provided by organizations. For instance, SGM identity needs, particularly for gender minority students, may comprise a more pressing need than their STEM needs (Kersey and Voigt, 2020; Campbell-Montalvo et al., 2022b). Accordingly, SWE's earlier inception date (1950) and white women being a main beneficiary of affirmative action policies (Crenshaw, 2006), both likely play into the proud history of SWE that motivates its members to persist, at the same time likely feeding into some of its members being close-minded about inclusive identities among would-be SWE members. This replicates previous research by Haverkamp (2021) in which SWE was not always welcoming to TGNC students (see also Kersey and Voigt, 2020).

The crucial source of identity confirmation from NSBE (established in 1975) to Black students may be influenced by the reality that Black students remain more excluded in STEM in comparison to their makeup of the U.S. population, in comparison to women's representation in STEM. For example, in 2018 nearly 4% of engineering undergraduate degrees were awarded to Black/African American students (∼13% of the U.S. population), while nearly 22% were awarded to women (∼51% of the population) (Roy, 2018). Thus, these social realities provide the setting in which a gathering of Black engineers profoundly motivates Black students through the provision of role models and excellence (Smith et al., 2021; Campbell-Montalvo et al., 2022a). Thus, NSBE, as a source of Black engineers to surround oneself with, is an oasis in the desert of U.S. and STEM disciplinary culture where the intelligence, personhood, and respectability of Black students in STEM (and Black people more broadly) is suspect (Steele and Aronson, 1995; Massey and Fischer, 2005; McGee and Martin, 2011; Beasley and Fischer, 2012; Gregory, 2015, 2016).

Participation in identity-focused organizations also provided SGM students access to instrumental social capital, particularly that related to academic and career support. Students were able to form study groups and gained access to career fairs, professional networking, and jobs and internships. Students were also exposed to settings or scenarios related to their anticipated career path or introduced to more specialized aspects of their anticipated career, offering anticipatory socialization in the area of employment.

However, within identity-focused organizations, SGM-focused organizations were less written about by students in terms of the instrumental social capital they provided. The details and various mechanisms that participants provided regarding how SWE and NSBE helped them in their academic and career suggests that these organizations have established robust mechanisms to increase students' instrumental social capital as part of the fabric of how the organizations operate. The comparable lack of instrumental social capital provided by oSTEM could potentially be explained in part by it being a relatively new organization, having been founded in 2005. Still, this does raise questions about how well SGM students' instrumental social capital needs are being met.

However, in comparison to instrumental social capital needs, perhaps SGM-students' more imminent needs relate to negotiating their SGM identities with their STEM goals and identity, specifically increasing students' seeking of expressive social capital. Indeed, STEM students' SGM identities are "central to their higher education experiences" (Linley et al., 2018, p. 1). Yet, supporting the development of such identity-related expressive social capital could be an ideal point of departure for later instrumental social capital acquisition, in line with Fisher (2013). Importantly, the validity of taking this point of departure likely differs within SGM groups; for example, in Kersey and Voigt's (2020) research, and in the present study finding gender minority students fit in less, students "who were more gender-non-conforming felt a greater need for community with other queer people" (p. 1). In the end, the need to increase oSTEM's capacity to support instrumental social capital identified in the present study is supported by previous research that found that "Queer-spectrum students conveyed the greatest sense of belonging in STEM when engaged with resources that supported academic and social integration" (Voigt, 2020, p. 262).

Unfortunately, women-focused organizations were unwelcoming to many SGM students, particularly due to ideologies members exercised against those who were non-binary. Leaders and members in some organizations may feel that SGM students and their needs "don't speak to" the interests of the organizations' goals, reproducing the false notion that STEM is apolitical and that all that matters are one's skills as a scientist (McGee, 2020; Friedensen et al., 2021). This matches the broader STEM culture in which "heteronormative assumptions frequently silence conversations about gender and sexuality in STEM" which result "in complicated negotiations of self for Queer professionals" (Mattheis et al., 2019, p. 22).

CONCLUSION

Identity-focused professional STEM organizations are an important source of participatory social capital for SGM students, social capital that SGM students may not receive from other STEM sources, including family or faculty (Campbell-Montalvo et al., 2022b). Identity-focused organizations help SGM students persist in STEM by promoting their accumulation of expressive and instrumental social capital that specifically aids SGM students in managing their fit in STEM. Given the less robust identification of instrumental social capital provided by SGM-focused societies, SGM-focused organizations may want to evaluate the instrumental social capital offerings they have and consider expanding them if appropriate. Given the identification of barriers faced by SGM students in participating in women-focused organizations, these organizations have work to do when it comes to maximizing the capital received by their

participants and ensuring that members with multiple identities are included in order to promote STEM persistence.

Students described instances when organizations engaged in collaborations to promote instrumental and expressive social capital gains across a range of students, providing a glimpse into a more inclusive STEM future that might be achieved by wielding the power of partnerships among organizations. Such an approach could be particularly helpful in serving students with multiple minoritized identities whom this and other research shows are often excluded from accessing resources in women-focused organizations. Collaboration across organizations to support structural change, coupled with efforts to educate non-SGM and other majority people in STEM to be accepting, could be a promising strategy for enacting change to improve how SGM and other minority students are treated and thus experience STEM. Specifically, adjustments in the mental models of advisors and members of organizations, particularly those of advisors and members with majority identities, along with changes advancing practices and policies conducive to SGM student success through a range of expressive and instrumental capital and mechanisms could be promising (Campbell-Montalvo et al., 2020, 2022c; Kang, 2021; Leibnitz et al., 2021; Peters et al., 2021). These additional efforts are notable, especially given that most interventions only focus on helping students survive rather than on improving the STEM climate they experience. Changes in how organizations operate could have ramifications for diversity in STEM professions writ large. Future work should seek to further uncover how SGM students are served by a range of organizations including those not identity-focused, and how interventions in how organizations operate, such as those mentioned here, affect how students experience and are served by the organizations and persist in STEM.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because this data contains sensitive participant information. Requests to access the datasets should be directed to RC-M, rebecca.campbell@uconn.edu.

ETHICS STATEMENT

This study involving human subjects was reviewed and approved by University of Connecticut Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CS, MH, and MM were the PI team for the grant that funded this research. CS, MH, MM, and RC-M conducted interviews informing survey creation. CS, MH, MM, RC-M, JS, HW, and EP designed the survey together. HW calculated descriptive statistics from the results. HC with the guidance of RC-M, led the analysis of the qualitative data, including coding and thematic grouping, and drafted the findings section. RC-M drafted the other sections of the manuscript. All authors participated in meetings to discuss project approach, including data analysis and wrote up, review and editing of the final piece.

FUNDING

This material was based upon work supported by the National Science Foundation under grant nos. 1747583 and 1747580.

ACKNOWLEDGMENTS

The authors acknowledge Finn Lefevre, University of Massachusetts-Amherst, for their consultation work conceptualizing the gender and sexual identity variables.

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Conflict of Interest: EP was employed by the company Beta Research Associates Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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ORIGINAL RESEARCH
published: 30 May 2022
doi: 10.3389/feduc.2022.842618

What Can Professional Scientific Societies Do to Improve Diversity, Equity, and Inclusion: A Case Study of the American Elasmobranch Society

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OPEN ACCESS

Edited by:
Veronica A. Segarra, High Point University, United States

Reviewed by:
Quintana Clark, University of Wisconsin–Madison, United States
Fadie Coleman, Boston University, United States

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *23 December 2021*
Accepted: *25 April 2022*
Published: *30 May 2022*

Citation:
Shiffman DS, Arguedas Álvarez T, Bangley CW, Boyt R, Côté IM, Daly-Engel TS, Davis ACD, Gaskins LC, Graham J, Graham RT, Johri S, Macdonald CC, Paig-Tran EWM, Roca AI, Schwieterman GD, Whitenack LB, Wiley TR and Ferry LA (2022) What Can Professional Scientific Societies Do to Improve Diversity, Equity, and Inclusion: A Case Study of the American Elasmobranch Society. Front. Educ. 7:842618. doi: 10.3389/feduc.2022.842618

Scientific professional societies are reviewing diversity, equity, and inclusion (DEI) practices and policies in response to recent calls for much-needed change. Organizations like scientific professional societies contribute to establishing disciplinary norms, and can influence the diversity of disciplinary workforces in multiple ways through both action and inaction. This paper examines these issues using the American Elasmobranch Society (AES), a medium-sized professional scientific society, as a case study. It consists of three parts: (1) an analysis of the demographics of AES members, leaders, and award winners; (2) an evaluation of a diversity initiative created by the society which includes a survey of program alumni focusing on potential improvements to the program; and (3) a synthesis of recommendations of steps that AES and similarly sized societies can take to better support DEI goals. AES's membership in recent years is more than half women, but 71.5% of all leadership positions in the Society's history (including all but two Presidents) have been held by men since the society was founded in 1983. AES's membership has significantly fewer Black/African-American members than the United States scientific workforce overall, with just 1 member out of over 400 identifying as Black in 2019, and 86.6% of Society leadership positions have been

held by white-presenting members. The Society's diversity initiative has led to some limited professional benefits for awardees, but could benefit from additional resources and support to enact suggested expansions and improvements. We provide a series of actionable recommendations that will make the annual meetings of societies like AES, and the field of chondrichthyan science, safer and more inclusive.

Keywords: diversity and inclusion, marine science, shark, marine biology, professional societies and associations

INTRODUCTION

Disciplines within the world of science, technology, engineering, and mathematics (STEM) are facing a long-overdue examination of the treatment of professionals from historically marginalized and excluded groups, including but not limited to individuals who identify as Black, Indigenous, and People of Color (BIPOC; e.g., Subbaraman, 2020), women (e.g., Llorens et al., 2021), members of the LGBTQIA+ community (e.g., Mallapaty, 2020; Cech and Waidzunas, 2021), and disabled people (e.g., Powell, 2021). When people are marginalized due to their identities, they are subject to exhausting experiences such as outright discrimination possibly preventing employment or promotion, or emotionally taxing and draining "death by a thousand cuts" microaggressions and associated physiological stress (see Dzirasa, 2020). Additionally, the emotional labor of mentoring and supporting students and trainees who face these issues disproportionately falls upon those from historically marginalized backgrounds, even when the student or trainee is not officially their mentee (Jimenez et al., 2019). Individuals who hold multiple marginalized identities (e.g., LGBTQIA+ and Black) can experience additional disenfranchisement or trauma and compounded stressors as a result of their intersecting identities (Crenshaw, 1990; Purdie-Vaughns and Eibach, 2008).

In academia as a whole, 58% of women report experiencing sexual harassment in the workplace (Johnson et al., 2018), but rates within the marine sciences are considerably higher (78%, Women in Ocean Science, 2021). Harassment is most likely to occur early in a scientist's career or during their time as a graduate student, and academic scientists across many disciplines who do fieldwork report male-dominated cultures permissive of sexual harassment and assault (Clancy et al., 2014). These incidents may also occur during scientific conferences, with 17% of respondents reported unwanted touching and/or remarks, and many saying that they did not report these incidents because there are no formal channels for reporting, they felt that decision-makers were friends with their harasser, or they believed their harasser had power over their career and could retaliate (Women in Ocean Science, 2021). A recent survey of 48 marine scientists from historically underrepresented backgrounds (Graham et al., under review) found that scientific professional societies and their conferences were often associated with negative feelings and a sense of not belonging in the field.

Growing recognition of these issues has brought a renewed focus on creating and implementing actionable, equitable solutions (this volume). While some solutions must be enacted at the level of an institutional employer (e.g., a university, governmental agency, or private company), scientific professional societies can also play a role in creating, enacting, and enforcing solutions. Professional societies often set disciplinary norms across institutions, and can contribute directly to the success of young scientists by offering speaking opportunities (e.g., at annual conferences, see Oester et al., 2017), leadership and service opportunities, networking that leads to collaborations or job offers, and grants and other awards. The role of professional scientific societies in contributing to or solving disciplinary diversity, equity, and inclusion (DEI) issues has been discussed in general (Consortium of Social Science Associations [COSSA], 2012) and for many specific disciplines including astronomy (Kewley, 2019), and geology (King et al., 2018). Specifically, professional societies have been recommended to recruit and retain underrepresented minorities as well as to enhance the mentoring of underrepresented minorities (Consortium of Social Science Associations [COSSA], 2012), though we note that merely bringing more people from historically underrepresented backgrounds into an unsafe and unwelcoming environment does not solve these problems.

In recent years, discussions surrounding DEI issues in different disciplines within the marine sciences have occurred for fisheries science (Penaluna et al., 2017; Miles, 2021), coral reef biology (Ahmadia et al., 2021), marine geology (Behl et al., 2021), and marine conservation biology (Smith et al., 2017; Johri et al., 2021). To date, no formal discussion of these issues has occurred for the specific subdiscipline of chondrichthyan biology (the study and management of sharks and their relatives). This field has faced long-term problems with racism, sexism, homophobia, and many other related problems (see Graham, 2017; Whitenack, 2017; Macdonald, 2020).

The potential benefits of professional societies involving themselves in DEI issues may occur as part of addressing structural problems along both sociocultural and organizational pathways. Sociocultural pathways include the need for changing cultures and norms so they are less permissive of racism, homophobia, sexual harassment and assault, and other problematic norms, including altering "perceptions of the appropriate use of power" (Cleveland and Kerst, 1993). This may be especially important in settings like academia, where power differentials can be significant but not explicitly delineated, and senior scientists possess substantial power to influence the career prospects of early career researchers (Benya, 2019). Organizational pathways include changes to power structures, culture and climate, and existing levels of diversity (Bishu and Kennedy, 2020).

Underrepresentation of women and minorities in leadership roles can erode or prevent the formation of "safety conscious" organizational structures (e.g., Alvinius and Holmberg, 2019; Bishu and Headley, 2020).

This and other evidence suggests that, however, well-intentioned, DEI initiatives within academic institutions and professional societies are not always well thought out or effectively implemented, and substantial room for improvement remains (Madzima and MacIntosh, 2021). Key steps in this process would include reflective work within organizations to identify marginalized groups within organizations and the institutional structures, practices, and cultures contributing to that marginalization, and efforts to thoughtfully, intentionally, and specifically intervene around these identified barriers to create more inclusive, safe, and welcoming environments (Madzima and MacIntosh, 2021). Where effective, these interventions will most likely cluster along three key axes: efforts to promote greater diversity, representation, and inclusion, to establish responsive and trusted reporting systems, and to build meaningful accountability measures (Bishu and Kennedy, 2020).

Here we endeavor to provide essential background for conducting such reflective work within our own professional community, and to connect that reflective work to potential interventions across all three axes. We also incorporate an assessment of the complexity and feasibility of proposed interventions based on the current bylaws and regulations of the society and the current role of the society within the broader discipline.

Case Study Background: The American Elasmobranch Society

The American Elasmobranch Society (AES[1]) is the world's oldest and largest professional society focusing on the scientific study and management of sharks and their relatives. Founded in 1983 (see Castro, 2016), AES now has approximately 500 members with some annual fluctuation. AES typically holds an annual conference at rotating North American locations as part of the Joint Meeting of Ichthyologists and Herpetologists, a gathering with three other similarly sized professional societies: the American Society of Ichthyologists and Herpetologists, http://asih.org; the Society for the Study of Amphibians and Reptiles, http://SSARherps.org; and the Herpetologists' League, http://HerpetologistsLeague.org. AES is a taxon-focused society rather than a methodologically focused society, with members who research chondrichthyan fishes and fisheries using a variety of tools and techniques (Ferry and Shiffman, 2014; Shiffman et al., 2020).

The AES Equity and Diversity (E&D) Committee was initially established as an *ad hoc* committee, with members appointed by the sitting president in 2014. The committee's initial role was to develop the conference Code of Conduct (see Favaro et al., 2016), the first version of which was approved by the Board of Directors in December 2017. The Code of Conduct has been intermittently updated since its inception in an attempt to address new or persistent issues, and to offer sufficient protection to all members, and the latest version is available online at http://elasmo.org/pub/AES_CoC_Updated_May31_2018.pdf. The Code of Conduct prohibits discrimination, sexual harassment, retaliation, bullying, and unreasonable behavior, and notes that it also applies to off-venue events that occur under the auspices of the conference. It includes general procedures for reporting an incident that occurs at a conference governed by AES and general procedures for resolution, and was developed based on published examples from other professional societies. It is important to note that the Code of Conduct does not govern or attempt to govern the behavior of members outside of the annual conference aside from during sanctioned AES-related activities, like when interacting on AES social media pages or official AES-related emails, etc. Additionally, though the Code of Conduct process was initiated with majority support from AES membership and leadership, there were (and continue to be) objections to the process and content of the code of conduct from some members from many different perspectives (e.g., some feel that it does not do enough, others feel that it attempts to do too much). Though promoting equity and diversity in the field has champions across all career stages in the society, we have observed significant frustration particularly from early career members at the perceived slow pace of implementation of even basic changes, and a common perception among younger members that some powerful senior members do not consider DEI a problem that is worth addressing. While these discussions are nuanced and complex, there is an easy-to-detect ripple running through the society with many members suggesting that more could and should be done.

In 2018 the membership voted to make the E&D Committee a standing committee.[2] The roles of the E&D Committee are, as of this writing, to review and update the Code of Conduct, educate the Society membership about DEI issues, serving as points of contact for reporting code of conduct violations, and selecting the Young Professional Recruitment Fund (YPRF) awardees.

American Elasmobranch Society leadership is elected by members, following selection of the slate of candidates by an elected nominating committee (see bylaws in Supplementary Material or linked online here: http://elasmo.org/bylaws). Any member can nominate another member in good standing for any position, and members may also self-nominate. Nominees who agree to run for a position may (or may not) be placed on the ballot by the nominating committee, whose deliberations and procedures are confidential with a process that varies from year to year.

American Elasmobranch Society also has a professional code of ethics that applies to members of the field in general, not just at the annual meeting. This code of ethics focuses on scientific integrity when performing and publishing research, but includes an anti-discrimination clause. The code of ethics notes that members have an affirmative duty to publicly criticize misrepresentations of the state of knowledge related to the scientific study or management of chondrichthyan fishes. The code does not currently include a procedure to report or investigate violations, or a description

[1] http://elasmo.org

[2] http://elasmo.org/bylaws

of any possible consequences. The text can be found in Supplementary Material or online at http://elasmo.org/pub/AES-Code-of-Ethics-v1.pdf.

Like many professional scientific societies and the scientific community as a whole, AES and its members are not immune from DEI challenges, with incidents including but not limited to unwanted touching and inappropriate and discriminatory remarks, including in the laboratory, in the field, and at the annual meeting (Graham, 2017; Whitenack, 2017; Macdonald, 2020). Some examples include actions that rise to the criminal level (e.g., several incidents reported in Macdonald, 2020), and as in much of academia, "whisper networks" (*sensu* Tuerkheimer, 2019) in which new members may be warned about potentially predatory senior members. Considering the personal experiences of several authors on this contribution (largely but not exclusively female authors), one could argue that it is common knowledge that particular members within the larger society repeatedly display inappropriate and problematic behavior. Individuals such as these, while few in number, have a hugely disproportionate effect on culture and community within the society, with similar patterns reported in other societies like AES. The society has had limited means for or success at taking concrete actions to address these problems. This challenge is compounded by the lack of formal training of AES officers on best practices for objectively evaluating and acting upon reports of Code of Conduct violations, and a lack of resources necessary for hiring external professionals to provide these. As of this writing, only one AES member has received AES-sponsored external training for the purpose of serving as a Society safety officer.

Case Study Background: The Young Professional Recruitment Fund

In an effort to improve the AES's membership diversity, the YPRF award was established in 2014 in partnership with the diversity in STEM non-profit organization DiverseScholar, publisher of the career portal, MinorityPostdoc.org. Though independently conceived, the YPRF award is broadly similar to other professional society's mentoring fellowships (reviewed recently among biology organizations, see Segarra et al., 2020a,b). The goal of the YPRF award program is to seek out early career researchers, managers, and environmental advocates from historically underrepresented backgrounds and bring them into AES with a complementary membership, enhancing the diversity of the society while providing professional development and networking opportunities for awardees.

The YPRF is currently funded by AES, with a program administrator who is responsible for planning professional development trainings, identifying and putting awardees in contact with specific mentors, and communicating with awardees. This is a competitive program that draws many applicants, with awardees chosen by AES's E&D Committee (since 2019). Potential applicants to the program are recruited *via* social media (including professional Facebook groups and twitter accounts with a focus on hashtags used by diversity in STEM conversations), professional listservs, and word of mouth.

While AES membership offers a significant discount for annual meeting registration costs (the 2021 JMIH meeting costs $200 for members and $250 for non-members), and members in their second year of membership are eligible to apply for student travel support, the YPRF program itself does not include travel support for the meeting. This differentiates the YPRF from programs in other similarly sized societies (e.g., the Cashner program at the American Society of Ichthyologists and Herpetologists, and Segarra et al., 2020a,b recommends such travel support to improve the diversity of a professional society).

A major benefit to YPRF awardees are the monthly professional development discussions, which are targeted at YPRF but open to the entire membership, and hosted in the AES Facebook group, which counts over 1,500 chondrichthyan scientists, conservation advocates, and natural resource managers in its membership. For awardees interested in specific technical topics, the opportunity to speak directly with senior AES members can be arranged. With the assistance of the YPRF program coordinator, awardees are encouraged to develop their professional network of relationships to extend beyond their YPRF award year, and are encouraged to renew their membership after their complementary year of membership ends.

Eligibility requirements are as follows. The YPRF program is designed to bring new members into the Society, and therefore people who have been members in the past are ineligible. Applicants must have a genuine professional interest in chondrichthyan research or management as a career, as opposed to non-professional "shark enthusiasts." Applicants must be early-career chondrichthyan research professionals, defined as a current or prospective graduate student or someone within 5 years of their terminal degree, such as postdoctoral researchers, junior faculty, or early-career resource manager or non-profit advocacy organization employee. Applicants must also self-identify as belonging to a community that is historically underrepresented within AES, which includes underrepresented minority groups in the United States as well as early career scientists, advocates, and managers from the Global South.

The goal of this paper is to reflect on the current status of DEI issues within our society, identify published best practices that contribute to resolving these challenges, and to recommend tangible, actionable ways in which professional societies can improve and work toward solving these challenges. To do this, we use the AES as a representative case study, as AES is a medium-sized United States-based professional scientific society that is in many ways typical and representative in terms of the resources and governance structures available to solve DEI challenges. The manuscript consists of three parts: (1) an analysis of the demographics of AES members, leaders, and award winners as compared with National Science Foundation (NSF) statistics for United States-based scientists and engineers; (2) an evaluation of AES's diversity initiative and a survey of what alumni believe worked and could be improved about the program; and (3) a synthesis of recommendations about what scientific conferences and societies can do to improve their DEI practices.

Research Questions

This project was undertaken to assess six research questions: (1) What are the demographics of the membership of the American Elasmobranch Society? (2) How do those demographics differ from those of AES leadership, the scientific workforce in the United States overall, and the United States population overall? (3) Have there been notable changes in the demographics of AES over time? (4) What do alumni of AES's diversity initiative think the YPRF program does well? (5) What do alumni of AES's diversity initiative think the YPRF program needs to improve upon? and (6) What suggested improvements to improve a professional society's DEI issues could AES implement?

Our goal is for this manuscript to be useful to AES and to other professional scientific societies with similar DEI challenges and similar goals to improve their institutional culture.

MATERIALS AND METHODS

Demographics of American Elasmobranch Society Members, Leaders, and Conference Award Winners

Following Arizona State University Institutional Review Board permit #00013030 and with the written support of the 2019–2020 AES Executive Committee, we obtained all available membership data for the AES. Only the lead author DS had access to all raw data through this project, though co-author TW independently had access to these data through her role as AES's Secretary. Other coauthors were given anonymized subsets of these data to assist with analysis. AES record keeping has been inconsistent over the years, which *means* that complete comparative data across the lifetime of the Society was not available. This dataset allowed us to assess several axes of diversity within AES, including career stage (students vs. professional members), gender, and racial/ethnic identity. For the years 2001–2019, AES offered a variety of membership levels, which have recently been simplified and combined. To allow for easy comparison, we sorted membership type into "student" (typically but not always graduate students) and "professional" (anything other than a current or recent-enough-to-still-qualify-for-student-membership student).

Since 2019, AES has distributed a voluntary demographic survey of membership, which we obtained and compared with publicly available NSF statistics about the diversity of the United States STEM workforce and associated statistics about the United States' population. We note that while these NSF statistics are the best available comprehensive data source, they only focus on the United States, and do not include certain categories of interest here (e.g., there is a "do not wish to disclose" option for gender, but not a non-binary option). AES's voluntary demographic survey asks about gender, age, professional career stage, employer type, ethnicity, and country of residence.

American Elasmobranch Society is led by an elected volunteer Board of Directors who serve 5-year terms, and an elected volunteer Executive Committee whose structure has changed over the years but currently consists of a President, Treasurer, Secretary, Immediate-Past-President, President-Elect, and Meeting Management Committee Representative. The list of past AES leaders and award winners were all publicly available, and accessed through, Elasmo.org/history and publicly available business meeting minutes) and therefore did not require IRB or Society Leadership approval to access. For each senior leader (Board of Directors member and Executive Committee member) or major award winner (Best Student Poster, Best Student Talk, Research Grant Awards), a list of names was extracted.

Following Whitenack et al. (2021), one author (RB) searched for formal online biographies and photographs of each leader or student award winner. Biographies were scanned for the use of pronouns, noting that people can be misgendered in an official biography and that pronouns and gender identities can change. Photographs were examined to assess if the member would likely be considered white-presenting by a United States audience (i.e., would most white people consider them white, modified from Ginsberg(ed.), 1996). Uncertainty (n = 8, 11.8%) resulted in authors DS and LW discussing the issue and coming to a decision. Only people for whom photos could be found were included in race analysis, and only people for whom biographies were found were included in the gender analysis. We note that someone presenting as white may hold other minoritized identities.

A Case Study of the American Elasmobranch Society's Young Professional Recruitment Fund Diversity Initiative

As of 2021, the program has awarded memberships to 104 early career scientists, of which 91 (87.5%) are alumni who have completed their YPRF scholarship year. The 81 alumni for whom we could find current contact information (not including the three YPRF alumni who are coauthors on this study) were sent a voluntary anonymous online survey by then program administrator (author DS) asking for their thoughts about the program, with a focus on identifying what worked, what did not, and suggestions for improvement. Most questions were free response, and some were multiple choice. Thirty alumni (response rate = 37%) completed all required questions on the survey and had their responses counted here, though several questions were not required and not every alumnus answered every question. This survey was covered by Arizona State University Institutional Review Board permit #00013030.

Progress: What Can Professional Societies Like American Elasmobranch Society Do to Help?

The coauthors on this study represent thought leaders in improving STEM fields' issues with DEI along multiple axes of diversity, with several having co-founded organizations dedicated to these causes. Coauthors were asked to synthesize recommendations from their organizations and to provide key

references from their personal libraries. Additionally, coauthors on this study have been working on improving DEI issues within AES (or their other societies) for years, including speaking with many concerned members, and were encouraged to submit their own specific suggestions for improvement. This was supplemented by a Web of science search for keywords related to diversity equity and inclusion in STEM and an in professional societies.

Suggestions were compiled, and then organized both by which aspect of institutional culture and climate would be affected and by difficult of implementation. Following Bishu and Kennedy (2020) these recommendations are structured into three axes: efforts to create greater diversity representation and inclusion, attempts at establishing responsive and trusted reporting systems, and work to create meaningful accountability. We note that most suggestions here fall into the "create greater diversity representation and inclusion," but that all three are extremely and profoundly important. Some proposed solutions straddle multiple aspects of institutional culture and climate.

Difficulty of implementation is based on the current structure and powers of the AES leadership as determined by our society's bylaws. The available options range from very easy (e.g., could be implemented by a Presidential directive, Board of Directors vote, or request to the annual conference meeting manager with no significant costs or rule changes) to more complex (e.g., would require moderate to significant costs and bylaw changes, or a reimagining of the role of the professional society within the broader discipline). Some proposed solutions straddle multiple degrees of difficulty to implement.

RESULTS: DEMOGRAPHICS OF AMERICAN ELASMOBRANCH SOCIETY MEMBERS, LEADERS, AND CONFERENCE AWARD WINNERS

From 2001 to 2019, an average of 43% of AES members were students (**Figure 1**). Student members, who notably have less financial security and professional power than senior members, are a major part of AES's current structure and contribute meaningfully to meeting operating expenses. Additionally, we note that while the structure of the society's membership has changed with the percentage of student members increasing, the structure of the society's leadership has not, potentially contributing to stated concerns that leadership is insufficiently responsive to student priorities like equity and diversity issues.

Demographics of American Elasmobranch Society Membership

Results show that AES (53.9% of members in 2019) has a higher percentage of women members than the United States resident population (50.8% of the United States population in 2017) or the United States scientific workforce (47.6% in 2017 as noted in the NSF statistics, **Figure 2**) or NSF survey of employed scientist or engineers, with one member who identified as non-binary in 2019 and two who selected "I prefer not to answer this question" out of approximately 400 members that year.

In terms of race and ethnicity, AES has a substantially higher percentage of white/Caucasian members (79.3% of members in 2019) than the United States population (63.9%) or the United States scientific workforce (71%), and significantly fewer Black/African American members than either group; only one AES member identified as Black/African American in 2019 despite 12.3% of the United States population being Black. AES membership also is underrepresented in terms of Native American and Alaska Native members and Hispanic/Latino members, but membership from these groups is more comparable to the United States scientific workforce. We note that neither the NSF data nor the AES data disaggregate United States Citizens or Green Card holders with Hispanic/Latino backgrounds from those living and working in Latin America. The percentage of Asian AES members is comparable to that of the United States population, but lower than the United States scientific workforce (**Figure 3**).

Demographics of American Elasmobranch Society Leaders and Conference Award Winners

A total of 82 different people served in analyzed AES leadership positions since 1983, with many serving in multiple roles in different years. Fifty-four of these 82 used he/him pronouns, 21 used she/her pronouns, and official biographies containing pronouns could not be found for 7. Of leaders elected to more than one term on the Board of Directors, 21 used he/him pronouns and 1 used she/her pronouns. Seventy-one (93%) were white-presenting, 5 (7%) were not white-presenting, and photographs could not be found for 6. Twenty of 21 (95%) female leaders were white-presenting, and 49 of the 54 (91%) male leaders were white-presenting. As of this writing, AES has had just one female president who served a full term (i.e., author LF) and another who did not serve a full term, though

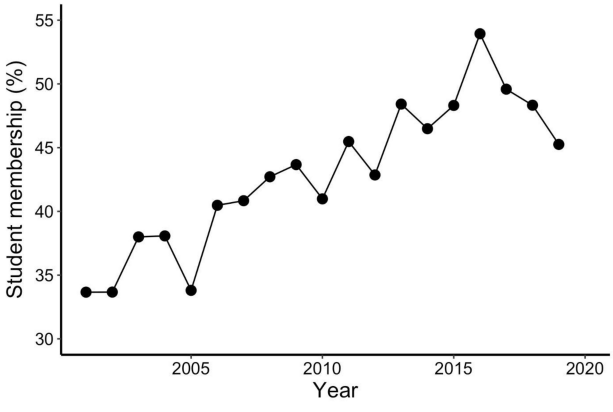

FIGURE 1 | Percent of AES members who had a student membership.

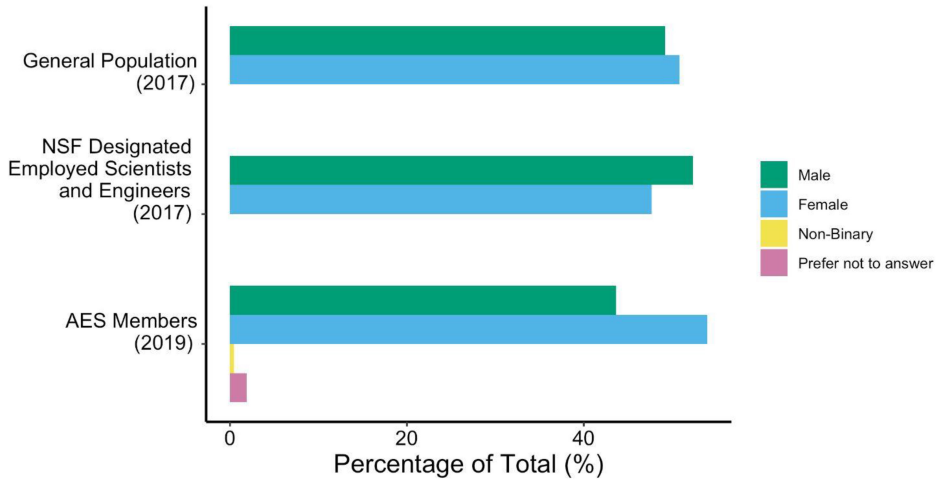

FIGURE 2 | Gender of AES members compared with National Science Foundation statistics.

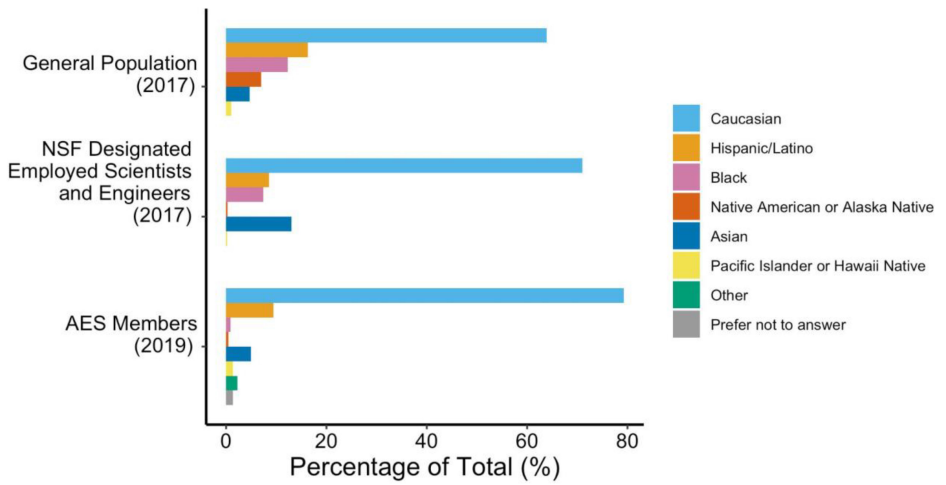

FIGURE 3 | The race/ethnicity of AES members compared with National Science Foundation statistics.

another woman was recently elected to begin her presidency in January 2022.

The structure and size of AES's Board of Directors and Executive Committee has changed over the years, and roles last between 2 and 5 years. To simplify calculations, one leader in place for 1 year was counted as a "leadership position," and as of 2021 there have been 902 "leadership positions" in the history of AES. Six hundred and forty-five (71.5%) have been held by men, and 181 have been held by women. Seven hundred and eighty-two (86.6%) have been held by white-presenting members, and just one President has not been white-presenting. For much of the society's history, these leadership positions have been held entirely by white-presenting men apart from one member (**Figure 4**), and while the percentage of women leaders has increased in recent years, the percentage of non-white leaders has not. We note again that terms last a variable length of time, and some people may serve multiple terms or serve in multiple leadership roles non-concurrently, which means that the observed pattern is explained by a combination of more leadership positions going to men and/or white-presenting members in any given year, more men and/or white-presenting members getting multiple different leadership positions, and the leadership positions with a longer term more often going to men and/or white presenting members. Some of this phenomenon of this is likely due to some members being more willing or able to volunteer repeatedly, though part of the reason why white males are more willing to serve in leadership positions (and why women or people of color may be less willing) may be related to institutional culture and climate (see Hewlett et al., 2008). We recommend that future AES nominating committees prioritize diversity in the slate of available leadership candidates.

We are also aware of cases where non-white candidates have been nominated for leadership positions and have agreed to run for the position, but their names were not on the final ballot sent

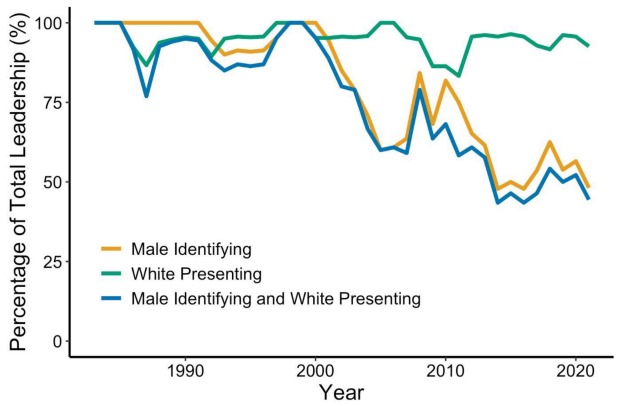

FIGURE 4 | The percentage of AES leaders in any given year that identified as male, are white presenting, or both.

for members to vote on. As nominating committee deliberations (including who was nominated, who among the nominees was selected for the slate of candidates and who wasn't, and why some nominees were not selected) are confidential and no records are kept, we do not have the data to evaluate the extent to which this has occurred or why. We recommend some possible solutions to this problem, centered around simple transparency.

The Society offers a variety of student research and travel grants, as well as conference-related awards for the best student poster and best student talk, which can professionally benefit early career researchers who receive them. These are currently not available to postdoctoral scholars who fall between the ranks of student and faculty. A total of 90 different people have won major student awards (i.e., best student talk, best student poster, student research award), with some winning multiple awards in different years. Thirty-nine (43%) were given to students who use he/him pronouns, 42 (47%) were awarded to students who use she/her pronouns, and pronouns could not be found for the remaining 9%, a pattern generally consistent with student member demographics. Seventy-nine (87.7%) of awards were given to white-presenting students.

RESULTS: A CASE STUDY OF THE AMERICAN ELASMOBRANCH SOCIETY'S YOUNG PROFESSIONAL RECRUITMENT FUND DIVERSITY INITIATIVE

Fifty-seven percent of respondents had heard of AES prior to applying for the YPRF program. Those who had not noted that they did not have mentors in chondrichthyan science or management at the time they applied, or that the society is less well known in some parts of the world. The two most common reasons cited for not joining AES prior to applying for the YPRF program were (1) the cost of membership (with several noting that the $25 student membership fee is a significant expense for early career researchers in the Global South), and (2) uncertainty whether the society is open to non-Americans. Two respondents reported that they had long been considering joining the society, and the YPRF program made that decision easier for them.

Fifteen respondents (50%) reported that their professional goals are to be academic scientists, while 11 (37%) reported that their goals are to work for an environmental non-profit organization. Two respondents wished to work for a government management agency, and two had "other" goals, with no detail provided. A plurality of respondents reported that the YPRF program was "somewhat helpful" or "only a tiny bit helpful" in achieving their goals (9 respondents or 30% each), 7 (23%) respondents reported that the program was "not really helpful," and 4 (13%) reported that it was "extremely helpful."

The most common professional benefit reported by YPRF alumni was "meeting international colleagues" (N = 15, 50%), with eight of these respondents reporting that those international colleagues have since become collaborators, mentors, or thesis committee members. Twelve respondents (40%) reported that being able to ask technical or professional questions to the community was professionally beneficial to them, with four reporting that this led directly to helping them solve a methodological question. Nine respondents reported that they found the professional development chats in the AES Facebook group to be useful, and seven reported that they found the mentorship component useful.

Nine respondents (30%) reported that they attended an annual meeting, with four of those noting that they renewed their AES membership after their YPRF year and then got AES travel support as student members. A further 11 (37%) said that they would attend an AES annual meeting if travel support was available. More respondents who attended an AES annual meeting found the YPRF program professionally useful than those who did not attend an AES annual meeting, though two respondents who found the program "not useful at all" did report attending a meeting. Thirty-five YPRF alumni renewed their membership at the conclusion of their YPRF scholarship year (38.4% of YPRF awardees, AES Secretary Tonya Wiley, personal communication). Of the respondents who did not renew their membership, none revealed why they did not do so in this survey.

Several specific suggestions for improving the YPRF program were made by alumni, mostly focusing on expanding the benefits offered to awardees, which would require increased resources from the Society. The most common suggestion, which seven members requested, was YPRF-specific travel funding to attend the annual meeting, and three respondents noted that the Cashner Award (the analogous program at the American Society for Ichthyology and Herpetology) attempt to do this. Four alumni suggested that an expanded or more formalized and structured mentorship program would be helpful, especially one in which existing members with specific skill sets would serve as mentors to students with similar research interests and professional goals. Currently the mentorship program is relatively informal; it generally consists of an awardee telling the YPRF coordinator that they would like to learn a particular skill, and the program coordinator

reaching out to a specialist in their professional network for assistance.

Four YPRF alumni suggested the creation of virtual check-ins and hangouts, which can have a specific theme or topic, such as "feeding ecology chat," in which we invite AES members knowledgeable about this topic, or just to get to know one another and YPRF alumni. One specific example provided by a respondent suggested an organized program for YPRF scholars who attend the annual meeting to receive guidance, similar to the ESA SEEDS program at the Ecological Society of America meeting (a specific example provided by the respondent which is an organized program where first-time conference attendees are paired with an experienced attendee)—this member noted that they felt lost and overwhelmed when attending AES in person. One respondent noted that the AES member directory was difficult to use for searching for someone with a specific skill set rather than someone in a specific region. One noted that the program could benefit from translation services, as discussions are only available in English.

Four (13%) noted that they had personally experienced racism or sexism from AES members, including inappropriate and offensive comments from senior members. These respondents suggested that inviting more members from historically underrepresented backgrounds to join the Society, or any society, without also working to create a more welcoming environment, will not create meaningful solutions to membership under-representation.

RESULTS: WHAT CAN PROFESSIONAL SOCIETIES LIKE AMERICAN ELASMOBRANCH SOCIETY DO TO HELP?

These data, along with numerous anecdotal reports from within the field of chondrichthyan science (Graham, 2017; Whitenack, 2017; Macdonald, 2020) and from science more broadly (Clancy et al., 2014; Women in Ocean Science, 2021), illustrate the extent to which both reflection on current challenges and tangible steps toward improving them is necessary for AES. DEI goals including an inclusive culture, diverse membership, and representative leadership are not currently being achieved.

To contribute to addressing these complex and challenging issues, here we present a partial synthesis of recommendations from a variety of sources related to DEI issues in academia and STEM culture in general, as well as for professional societies and marine science in particular (**Table 1**).

Though developed with grounding in the rules and realities of AES, it is our hope that these recommendations are broadly applicable to professional societies that are similar in size and scope and face similar current challenges and have similar resources and governance structures available to solve these problems. This is not intended as a checklist (i.e., do these things and all problems are fixed), but as a starting point in a long and constantly evolving conversation that requires dynamic solutions as societies change and grow.

Solutions That Will Contribute Toward Greater Diversity, Inclusion, and Representation

Easy to Implement Solutions

Publicly Amplify Voices of Those Who Have Been Minoritized Using Existing Communications Channels, and Create New Channels If Necessary

An effective strategy that carries almost no financial cost is to use Society communication channels to amplify the voices of scientists from underrepresented backgrounds who are already present within the Society or field (see Miriti et al., 2020; Remmel, 2021). Being a featured scientist in a professional society's newsletter, journal, or social media can serve as a professional boost, especially for early career researchers, and can be especially professionally beneficial for members from historically underrepresented backgrounds. Societies in general, including AES, have a mixed record of publicizing the achievements of members from historically underrepresented backgrounds, which was one of the reasons for the founding of the independent-from-AES Minorities in Shark Sciences[3] in 2020. AES has a Twitter account (managed by the AES editor, who as of this writing is co-author CB), which shares research written by or relevant to the membership; this channel could be used to highlight the work of members from underrepresented backgrounds.

However, this is not enough. In contrast, we highlight one example from a larger society, the Society for Integrative and Comparative Biology[4] (which many AES members are also members of), which has a "Public Affairs Committee" responsible for choosing which member research to feature in press releases and on the Society website. AES and similar medium-sized societies could institute the same strategy. AES, for example, recently created an *ad hoc* "Outreach and Education Committee," which could fill some of this need if charged with the mission to do so. We suggest that official society blogs also could include interviews with featured members. Additionally, at the annual meeting, such members could be invited to give opening plenaries. Societies like AES have presidents who serve for more than 1 year, and thus often give a plenary their first year and appoint another member to give a plenary the following year. This represents another high-profile platform for members from historically underrepresented backgrounds to present their work, and their journeys, though we note that asking BIPOC scientists to speak only about DEI issues and not their own research is a common problem in STEM.

The lockdown associated with the COVID-19 pandemic led to the emergence of virtual seminar series run through Zoom and other platforms, providing more speaking opportunities for members and a further source of value for members who watch these talks. A society-branded virtual seminar series could be established to air throughout the rest of the year when the annual meeting is not occurring to provide another career-boosting platform for early career members, including members from

[3]MISSelasmo.org

[4]SICB.org

TABLE 1 | A summary of suggestions to improve the DEI issues surrounding AES.

Recommendation	References for further reading
CONTRIBUTING TO GREATER DIVERSITY, INCLUSION, AND REPRESENTATION	
Easy to implement solutions	
Publicly amplify voices of those who have been minoritized using existing communications channels (social media, websites, plenary talks), and create new channels (virtual seminar series) if necessary	Miriti et al., 2020; Remmel, 2021
Make meeting spaces more accessible and inclusive, including wheelchair accessibility, an accessibility coordinator, trans and non-binary friendly restrooms, dietary restriction and allergy friendly food, no longer centering alcohol, and having quiet/meditation/prayer rooms and nursing rooms	Boyt, 2021
Nametag options to improve inclusivity, such as pronouns and associated member education, thoughtful use of "ally" badges following training, and indicating comfort levels with physical proximity to others and touch	Miles, 2021
Make conference talks and Q&A more inclusive and safe, including color and font suggestions, closed-captioning and microphone use when possible, and carefully moderates Q&A sessions	Hinsley et al., 2017; Irish, 2020; Boyt, 2021
Consider diversity equity and inclusion in awards and grants (and if applicable, publications), possibly through involving the equity and diversity committee in award nominations to ensure that members with troubling histories are not honored	Johri et al., 2021
Improve the searchability and usability of the membership directory to allow full participation from members who don't know everyone	Survey (this study)
Solutions that are moderately complex to implement	
Provide educational opportunities for members and leaders focusing on equity and diversity issues, including book or journal clubs and offering trainings to members who want it	
Establish formal mentor networks, possibly by expanding the YPRF program	Smith et al., 2017; Giakoumi et al., 2021; Johri et al., 2021
Lower the barriers to joining or continuing to participate in the society	Survey (this study)
Make meetings more accessible to parents through childcare options and nursing rooms	Gould, 2018; Giakoumi et al., 2021
Ensure diversity of speakers especially for high-profile symposia	Ford et al., 2019
Create an award honoring contributions to DEI, or other aspects of improving the culture of the field	
Solutions with significant costs or difficulty	
Expand the Young Professional Recruitment Fund program following alumnus suggestions including expanded mentorship and dedicated travel support	Survey (this study)
Meeting location and physical meeting spaces	Boyt, 2021
Continuation or expansion of hybrid attendance options	Niner et al., 2020; Sarabipour, 2020
Ending unpaid internships	Fournier and Bond, 2015; Chaudhury and Colla, 2021; Osiecka et al., 2021
Ending parachute science	De Vos, 2020; Belhabib, 2021; Trisos et al., 2021
RESPONSIVENESS, TRUSTED REPORTING SYSTEMS, AND TRANSPARENCY	
Solutions that are simple to implement	
Make DEI initiatives and information publicly available and transparent	
Solutions with moderate difficulty	
If we can't restrict attendance, publicize who is attending and allow people to cancel their own attendance	
Solutions with significant difficulty	
Information sharing about problematic members between conferences	
SOLUTIONS THAT WILL IMPROVE ACCOUNTABILITY	
Solutions that are simple to implement	
Prioritize diversity and transparency in nomination and election processes	Penaluna et al., 2017
Solutions with moderate difficulty	
Expand the professional code of ethics to change the culture of the field	
Solutions with significant difficulty	
Create a process by which someone can be excluded from future meeting participation for egregious violations	
Hire an independent safety officer	

historically underrepresented backgrounds. Care must be taken when choosing which members and which research to feature to ensure that not only are we featuring members across multiple axes of diversity, but also that we are asking members from underrepresented groups to speak about their research and not exclusively about DEI topics (unless DEI topics are the focus of their work).

Make Meeting Spaces More Accessible and Inclusive

The physical spaces where annual conferences take place and their various amenities need to be considered when making meetings more accessible and inclusive to make sure that disabled members can physically attend professionally beneficial events. At all meetings, there should be clearly designated spaces within all meeting rooms for members in wheelchairs or other designated places for disabled attendees to sit, and there should be a clear pathway (wide enough for wheelchairs and without wires or other attendees' bags on the floor) to get to those spaces from the hallway of the meeting center (Boyt, 2021). Coffee breaks and other networking and social activities should include stools or chairs, as not everyone can stand for long periods of time, and there should be assistance available at conference meals featuring buffets for those who cannot reach the food easily (Boyt, 2021). To facilitate understanding the needs of members and attendees, meeting registration forms should contain an optional place to request specific accommodations they will need, or an anonymous portal for sharing such information (Boyt, 2021).

If professional societies required that event venues provide certain dedicated spaces, it would contribute to inclusive meetings. For example, requiring gender neutral bathrooms at conference venues, and placing signage indicating that people can and should use the restroom of their choice, can make meetings safer and more welcoming for trans and non-binary members, though we note that this must be complemented by member education and actions to prevent trans and non-binary members from harassment. Similarly, having a private space for nursing parents attending the meeting would increase participation by parents at a particularly vulnerable time in their career, when they may already be taking time off for childbirth or child care. Many meeting venues already offer such spaces as required by law, and others could easily do so if a request was issued by the annual conference's meeting manager or committee. Many sites or locations seeking to host meetings will readily provide such accommodations, and simply need to be made aware of the need. These easy-to-implement changes will make it easier for trans, non-binary, and/or nursing members to attend the meeting.

At coffee breaks or conference-sponsored meals, options should be available to meet a range of dietary needs including but not limited to gluten-free, dairy-free, nut-free, kosher, halal, vegan, and vegetarian. This would help ensure networking times are inclusive of people with religious, medical, or personal dietary requirements, and most event space caterers can provide these options if they are aware of the need. Making sure that there are at least some food options that all members can eat helps ensure that all members can participate in these professionally important networking evenings.

In a similar vein, many conference-associated networking events center around alcohol (we note here that there is an important distinction between events where alcohol is available and events where alcohol is centered). This may lead to individuals with a personal or family history of addiction, or with certain religious beliefs, feeling excluded from these career-building social events—and without blaming victims or excusing perpetrators, we note that the presence of alcohol may lead to additional instances of inappropriate behavior. Shifting the emphasis of networking, and the times of day when these events occur, away from alcoholic beverages reduces the likelihood that such individuals will feel excluded and may contribute to creating safer conferences.

To facilitate inclusivity for attendees who need quiet places for prayer or meditation, meetings should have a designated quiet room. This would also help provide a place of sanctuary for individuals with sensory overload or sensory processing disorders.

Nametag Options to Improve Inclusivity

Allowing members to put their pronouns on conference attendee nametags (Miles, 2021) could help normalize the inclusion of trans and non-binary members while reducing the chance of unintentional misgendering during conversations. However, the authors have observed members express confusion at the presence of pronouns on name tags, and have observed outright mockery of the concept, so we suggest doing this in concert with member education initiatives and other actions to protect trans and non-binary members from harassment. Miles (2021) also recommends using gender-neutral language in conference announcements and communications.

Some conferences provide attendees with the option to indicate on their attendee name tag (*via* a sticker, pin, or different colored name tag lanyard) that they are an ally. While this may help alert a meeting attendee from a historically underrepresented background who they can go to for help if needed, we caution that some people may consider themselves allies without necessarily knowing how to assist in common problematic situations, and additionally note that best practices state that "ally" should be a title bestowed on someone and not one that should be self-identified. We recommend that ally skills workshops and professional development training be offered to members, as the Society for Integrative and Comparative Biology does, and that this kind of training be strongly recommended or required before self-identifying as an ally with a voluntary pin.

Some conferences also allow attendees the option to indicate their comfort level with things like hugs or other physical touching *via* a sticker or different colored nametag lanyard. We have observed this primarily in the context of conferences in the era of COVID-19 when some people may be comfortable attending a meeting but still choose to engage in social distancing, but the same principle can be more broadly applicable. There are many valid reasons why members might prefer that strangers not touch them, and we are aware of cases where students have decided not to attend future AES meetings because of unwanted hugs and other touching.

Make Conference Talks and Q&A More Inclusive and Safe

An important goal of attending conferences is to catch up on research, which takes the form of watching and listening to talks

by colleagues. It is therefore important that, to the extent possible, these talks be accessible. There are typically no requirements for font sizes or color schemes in presentations (see Irish, 2020), leading to presentations that are all but impossible for some members to read, resulting in missing key information. While some conference talk slide deck designs are a matter of personal style, suggesting or requiring some minimum standards for accessibility could make the slides easier to read without infringing on individual stylistic choices.

Conference centers often have a microphone for speakers to use, for example, but many speakers choose not to use these because they incorrectly assume that anyone can hear them if they just speak loudly. Using a microphone and speaking instead of shouting tends to improve clarity and therefore understanding. Further, recorded talks, such as for recent online or hybrid meetings, are usually not required to offer closed captioning, though many chose to use this free feature during the COVID-19 pandemic. We recommend that microphone use be required for all in-person talks, and automatic closed captioning is turned on for all hybrid and online talks (see Boyt, 2021). Whenever possible, conferences should strive to make a sign language interpreter available if needed, but we recognize that this comes with a significant monetary cost. These changes would make it easier for people to read conference talk slides and hear conference talk presentations, maximizing the benefits of attending a meeting.

While the Q&A section of a conference presentation is important for the integrity of the field and professionally beneficial for the presenters, some questions are inappropriate in content or tone, and there are clear patterns in who asks more (and more hostile, and less professionally relevant) questions (Hinsley et al., 2017). Session moderators could, but rarely do, step in when inappropriately hostile questions are asked, possibly because moderators are usually less advanced in their career stage and the hostile questioner may have power over them. Clear guidelines and training for session moderators could help, as could Society leaders requesting that repeat offenders confine their questions to the boundaries of professional decorum, and possibly restricting certain repeat offenders from asking questions at all. This could potentially be tied to the Code of Conduct and/or Code of Professional Ethics. These changes would make early career presenters more willing to present their research without fear of inappropriate hostility by senior scientists who behave inappropriately, and could do so while still allowing the professionally important Q&A session.

Consider Diversity Equity and Inclusion in Awards and Grants (and If Applicable, Publications)

American Elasmobranch Society offers several competitive grants for student research, as well as honoring the best talk and poster. AES does not currently operate a society journal, but many comparable societies do. Ensuring that opportunities for these awards, grants, and publications are equitably distributed should be a priority (Johri et al., 2021).

Additionally, professional society awards are sometimes given to people who hold views or perform actions that are not compatible with the spirit of various codes of ethics or inclusivity statements, more often than not to the detriment of underrepresented groups. These views and actions are sometimes well known but dismissed as a concern since society awards are often meant to celebrate "research excellence." We suggest that recognition of research excellence should be conditional upon collegial and supportive behavior. One way to do this is to require a brief personal statement about contributions to DEI, mentoring, and similar, from each person nominated for an award. In addition, individuals writing letters of recommendation should be required to state that their nominee has, to their knowledge, consistently upheld the relevant Society code of conduct and code of professional ethics. The E&D Committee should also be consulted about whether awardees are appropriate. We wish to flag this issue within AES especially with respect to lifetime achievement awards for senior members, such as the Distinguished Fellow of the Society award.

Other Easy to Implement Solutions That Would Contribute to Diversity Inclusion and Representation

One of the benefits of belonging to a scientific professional society is professional networking. Currently, the AES maintains a member-access-only directory of current and former members as a service for those who wish to contact each other. However, a YPRF alumnus suggested that this member directory could be improved to add value to members and to make it easier for new members less familiar with the field to use. For example, if someone wanted to find contact information for leading chondrichthyan endocrinologist John Doe, they could search for his name in the directory, but the directory does not allow people to search for people in the society whose research includes endocrinology if one doesn't already know their names. This poses a barrier to full participation in the society for people new to the field, though we note that some members may have concerns about this leading to an increase in e-mails from prospective students.

Solutions That Are Moderately Complex to Implement

Provide Educational Opportunities for Members and Leaders

Some AES members do not consider DEI issues to be a priority, while others do not know the most effective ways that they can help or know the full extent of the problems. To contribute to solving these problems, the AES E&D Committee is tasked with providing member education opportunities on DEI issues including both problems and solutions (see bylaws in Supplementary Material, available online here: http://elasmo.org/bylaws). This could take the form of no-cost book or journal clubs centered on DEI readings, brief regular email updates or posts in the AES Facebook group, and more. Professional development training and webinars have significant costs associated with them, but we urge Society leadership to budget for these, because they meet a stated member need and are considered best practice.

Given the impact that professional society leadership has on the climate of the organization, some society leaders could receive specific training on building and managing diverse, inclusive, and safe communities. A variety of options exist for these types of trainings, including virtual training any time or an in-person workshop immediately before, during, or after the annual

meeting. While these workshops can be a significant expense, budgeting for diversity training is an important part of making a conference inclusive and safe (Barrows et al., 2021), and such training can even be extended to the membership at large, making the expense a better value overall for the society.

Establish a Mentor Network

An organized and supported mentor network for early career members of underrepresented backgrounds (e.g., Smith et al., 2017 for racial minorities, or Giakoumi et al., 2021 for women and gender minorities), which could take the form of an expanded YPRF program, could help members to navigate professional hurdles while building professional networks. This can include an organized meetup at the annual meeting (including mentorship for first-time conference attendees as with ESA's SEEDS program), as well as conversations during the rest of the year (as with the Association for the Sciences of Limnology and Oceanography's Multicultural Program[5]). This program could be modeled off of the successful mentorship network created and used by the organization Minorities in Shark Science (see text footnote 3) or could even operate in partnership with them and their mentors, who are either MISS members or "friends of MISS," a program for allies that includes a vetting process. We note that mentorship of underrepresented minorities often falls disproportionately on the shoulders of underrepresented minority faculty (Jimenez et al., 2019; Johri et al., 2021), and suggest that strategic society support can alleviate some of this.

Lower the Barriers to Joining or Continuing to Participate in the Society

Some professional societies allow prospective members to simply fill out a form, pay a fee, and join, while others have additional standards which can serve as barriers to entry. Until 2019, AES required all new members to have a current member as a sponsor. While the goal of this requirement was to screen out non-professional "shark enthusiasts" whose past involvement in scientific discussions at AES have been disruptive, the effect was excluding early career scientists who might not yet know any current members who could sponsor them. The decision to eliminate this requirement has helped new members to join who otherwise could not have, and we encourage other societies operating under this model to consider a similar change.

Additionally, membership fees, while vital for the operation of the society and usually designed to be affordable (AES's student member annual fee is, as of this writing, $25 USD) and/or paid by a member's institution and not out of pocket, can pose a barrier to entry and participation. The YPRF program covers the membership fees of a few early career members each year, which has contributed to growing the diversity of AES. However, other solutions can further lower barriers to participation. For example, the registration page of the 2020 virtual International Marine Conservation Congress offered people the chance to pay not only for their own registration, but to pay more to help cover the cost of prospective attendees from the Global South. Professional (non-student) AES members could be offered the opportunity at the time of membership renewal to pay more to help cover the cost of a student membership, or potentially to donate toward travel funds for YPRF awardees, which would help lower barriers to participation by reducing or removing costs for members for whom cost is a challenge.

There are also potential barriers to continued participation in the society. While AES offers a variety of types of financial support to student members (reduced cost memberships, reduced cost meeting registration, dedicated travel support, and competitive research grants), once someone completes graduate school, they no longer have access to this support. While Postdocs, early career faculty, and entry-level government or environmental non-profit employees are certainly more financially secure than graduate students, they are less financially secure than more senior members despite being treated the same by the existing AES benefits structure. Some form of sliding scale, which could even take the form of counting people as students for a few years after they graduate, would help make sure that members can still participate in the field after they complete graduate school but before they have a financially secure mid-career position.

Make Meetings More Accessible to Parents

Members who are also parents face a heavy burden as they try to remain in a competitive field, share their research, and raise children. Providing childcare at professional meetings can ensure that parents, especially of younger children, are able to fully participate. Nurturing support networks for new parent scientists along with childcare can further reduce the incidences of "leaky pipeline" that sees primarily a loss of women scientists. Offering childcare opportunities at the annual meeting can allow parents to more easily attend and benefit from the professional connections made at conferences (Gould, 2018; Giakoumi et al., 2021). We are aware of many members, but particularly women, who have not been able to attend annual meetings because of the lack of available childcare. As of this writing, we recognize that that the JMIH childcare issue has been resolved after a surprisingly lengthy set of negotiations. However, we urge careful monitoring of the situation, data collection about use of the service, and encourage other conferences to offer this option using the "best practices" that can be gathered by JMIH societies including AES.

Ensure Diversity of Speakers

While some other professional societies report significant issues with the gender or racial balance of speakers who are selected or invited to present their work at the society's conference (e.g., Ford et al., 2019), JMIH operates under a different model. Anyone can submit an abstract, and almost all abstracts are accepted. Abstracts are currently screened for professional relevance only and not for perceived major impact or importance of the work. AES as well as the other societies participating in JMIH also have an annual symposium, a set of themed invited and featured talks whose presenters have access to supplemental travel funds offered by AES. While some symposium organizers have done an excellent job of ensuring speaker diversity, rules or guidelines to ensure such diversity do not currently exist, so the extent to which diversity is successfully achieved varies from symposium to

[5]https://www.aslo.org/opportunities-in-aslo/aslo-multicultural-program/

symposium (e.g., Byrne, 2021). Since the symposium consists of some of the highest-profile research at the AES meeting, and the only talks whose speakers receive official society travel support, it is important that diversity of speakers be prioritized.

Create an Award Honoring Contributions to Diversity, Equity, and Inclusion, or Other Aspects of Improving the Culture of the Field

Awards reflect a professional society's values and contribute to setting culture and other norms. Therefore, while it is extremely important to avoid giving awards to bad actors despite their other contributions, there should also be tangible professional benefits with prestige (or even associated funding) to members making important contributions in this arena.

Other Solutions That Are Moderately Complex to Implement

As previously discussed, it is important for professional societies to highlight the work of their members from historically underrepresented backgrounds. Societies such as the Canadian Society for Ecology and Evolution currently offer grants to BIPOC scientists to make outreach-focused videos about their research. This could take the form of contracting a skilled digital video editor, and a video about a scientist's work could also be offered as a prize for student research awards.

Solutions With Significant Costs or Difficulty

Expand the Young Professional Recruitment Fund Program Following Alumnus Suggestions

Results from this study show that the YPRF has been moderately successful at achieving its goals, but could be improved. These improvements would require significant society funds and other resources including time. AES, like many societies, offers competitive travel scholarships to student members after their first year. As travel costs are the main reason that YPRF scholars surveyed in this manuscript report not attending the meeting, funding in this area could make a large difference to inclusion. We suggest an expansion of AES' YPRF program, to include dedicated travel support to awardees (see Tulloch, 2020), which could help improve the diversity of attendees by allowing YPRF awardees to more easily and fully participate, and also suggest a formal mentorship program for first-time AES conference attendees (targeted at the YPRF awardees but open to anyone) as suggested by YPRF alumni.

The YPRF program could also be meaningfully and usefully expanded in other ways, possibly through partnerships with comparable programs in other societies. We also suggest the creation of a "YPRF member of the year" award which could come with a small grant for research or education purposes. This award could be based off of engagement with the program or other accomplishments while a part of the program.

Additionally, following recommendations from YPRF alumni in this survey, we recommend more fully involving awardees and alumni in goal-setting for the program. We also recommend regular check-ins and updates to the program.

Meeting Location and Physical Meeting Spaces

Like many scientific conferences, AES and JMIH are hosted in rotating locations. While regional parity is important from the perspective of travel costs, other considerations about the meeting location must also be taken into consideration. LGBTQIA+ members face a difficult choice professionally if conferences are booked in states or countries where they are not welcome due to discriminatory laws, and other members face difficult choices about attending meetings in cities that see frequent racial violence. We suggest that conference organizers take current events into account, and follow the guidelines of the State of California and not hold conferences in states where California employees cannot be reimbursed for state-funded travel without special requests. Since this list is updated regularly in response to discriminatory laws against the LGBTQIA+ community, the leadership of AES or JMIH can simply monitor the existing list without having to make their own, though we note this requires scientists who live in states with discriminatory laws to always have to travel to meetings.

It is also important that the meeting venue including lodging and offsite event spaces be ADA accessible (including parking, braille on signage ramps and elevators, accessible bathrooms, instructing conference center staff to take care not to leave AV cables on the floor of the meeting rooms, and ensuring that all venues have doors wide enough to accommodate wheelchairs) (Boyt, 2021). Additionally, any meeting-associated activities should either be held in that same location, or accessible transportation options should be provided to those who need it (Boyt, 2021). Boyt (2021) also recommends adding an accessibility officer to the meeting leadership team, who could be the point person for coordinating all accessibility issues.

Continuation or Expansion of Hybrid Attendance Options

Virtual conferences or conferences with "hybrid" remote attendance options, which have become the norm due to the COVID-19 pandemic, have made scientific meetings affordable and accessible to more people all over the world (Niner et al., 2020; Sarabipour, 2020). Though many regular attendees of annual conferences are eager to return to in-person meetings, we urge leaders to keep accessible hybrid options, which can take a variety of forms. We recognize that adding a second modality to a conference is not free, and implementing this comes with its own set of challenges. However, the accessibility benefits to a well-run hybrid meeting, including having recordings of all or many talks available after the meeting and allowing members who medically or financially cannot travel to participate in meetings, make the challenges worth undertaking. We encourage a continued discussion about how to most effectively accomplish these goals, possibly in the form of a dedicated high-level society task force.

Ending Unpaid Internships

Unpaid or pay-to-participate internships (Osiecka et al., 2021) within the field of chondrichthyan science are common. Some high-profile internships require volunteers to pay upwards of $1,000 a month to participate, with few or no known internal options for those who cannot afford to pay this amount. However, we note that MISS currently fundraises to pay for some of their members to participate in some high-level internships that would otherwise be unaffordable for them.

This means that the ability to pay for such an experience becomes a professional barrier for non-affluent students, and because of well-documented correlations between racial group and socioeconomic status in the United States (Chaudhury and Colla, 2021), diversity and inclusivity suffers (Fournier and Bond, 2015). Most societies, including AES, have no authority to govern internship payment practices in programs run by their members, but could issue a set of general recommendations for equitable technician and intern labor that members would be urged to follow, which could be part of the code of professional ethics. Or, more simply, societies could rule that society-owned communication tools, like a Facebook group, twitter account, blog and podcast, cannot be used to advertise such positions. We encourage a high-level, cross-society discussion about the issue of unpaid and pay-to-participate internships, which must consider solutions in order to increase equity and accessibility.

Ending Parachute Science

Parachute science is defined as situations in which scientists from wealthy (western) nations perform field work in a developing nation with little effort to include or train local scientific experts or share data and findings (De Vos, 2020). It is rampant in both marine science and in the broader field of ecology (Belhabib, 2021; Trisos et al., 2021). The code of professional ethics of most societies, to our knowledge, currently does not govern this harmful and common practice, but could be expanded to do so. We know of no instance where conference abstracts and research award applications are screened for this (or other issues surrounding the code of professional ethics), but such processes could be easily modified to accommodate consideration of these practices. Moreover, guidelines could be provided whereby authors and applicants would need to confirm the absence of such practices in their research, much like scientific researchers using animals must acknowledge that proper protocols were established and followed. We note that, to our current knowledge, the ethical use of animals in research is not commonly screened in abstracts, but more commonly considered by journals at the publication stage. Thus, it may be appropriate for societies that manage journals to make this change. As such, similar society guidelines could be drafted to guide journal editors in this process.

Responsiveness, Trusted Reporting Systems, and Transparency

Solutions That Are Simple to Implement

Make Diversity, Equity, and Inclusion Initiatives and Information Publicly Available and Transparent

All relevant information about DEI issues could be placed front and center in a dedicated website, as another larger society, the Ecological Society of America, has done with its dedicated page on their official website for "diversity in ecology,"[6] or in the American Geophysical Union's annual report on DEI.[7] This page includes the Society's policy statements on diversity, links to reports and task force recommendations, external resources, and ways to report issues, all in one place. AES, like many medium-sized societies, currently does not have this, but could create this relatively easily, and could also include ways for allies to help and expert-curated resources to learn more about these important issues. This could be a task for the aforementioned Outreach and Education Committee within AES, along with keeping these up to date year after year. Making this information more easily available and accessible can help members to make informed choices about their attendance and participation, and can make improvements easier to facilitate.

Many small-to-medium sized societies like AES have issued public statements about broader societal issues surrounding diversity and inclusion, but do not currently have an official society-specific diversity and inclusion statement, in contrast to larger organizations, like the Ecological Society of America. Such a statement should be created, and updates to the code of conduct and code of ethics should be tied to it, and provided in the dedicated website mentioned above.

Finally, to the extent possible without revealing confidential information, members should be kept updated about the status of DEI issues, including investigations regarding code of conduct violations, such as number and type of incidents, resolutions, and so forth. This discussion should also include more detail about reporting processes and consequences in general, as many members are unaware of these processes, and in some cases the rules aren't available anywhere. As such, careful discussions can serve as both educational opportunities and opportunities to reset culture and expectation.

Solutions With Moderate Difficulty

If We Can't Restrict Attendance, at Least Publicize Who Is Attending and Allow People to Cancel Their Own Attendance

Sexual assault is common in isolated field stations in many disciplines (see Clancy et al., 2014; Demery and Pipkin, 2021), as is sexual harassment (Women in Ocean Science report), and both occur in the field of chondrichthyan research (Graham, 2017; Whitenack, 2017; Macdonald, 2020). If this doesn't occur at a society meeting, most societies, including AES, would have no official way of responding to it, or preventing a perpetrator from attending future meetings. This means that a victim of sexual harassment or assault that occurred outside of the conference would have to decide whether to attend and risk encountering the person who harassed and/or assaulted them, or to not attend and to miss out on professional opportunities. Most often, it appears it is the latter choice. While restricting the attendance of bad actors is strongly preferred here as it punishes the perpetrator rather than the victim, this may not be possible under current society rules and bylaws. At the very least, making registered attendee lists public in advance, and offering people the opportunity to cancel their registration with no financial penalty if they learn that certain people are attending, would help members to avoid stressful or traumatic encounters.

Solutions With Significant Difficulty

Information Sharing About Problematic Members

We are aware of cases where someone has been restricted from attending one professional conference due to bad behavior,

[6]https://www.esa.org/about/diversity-in-ecology/#gsc.tab=0

[7]https://www.agu.org/-/media/Files/Learn-About-AGU/AGU_Annual_Ethics_Report_2020.pdf

and simply attends a different conference where organizers are unaware of (or more tolerant toward) that bad behavior. If someone has been restricted from attending one scientific conference because of reprehensible behavior, this information should be shared with other related professional conferences to avoid simply passing the buck between events. Similarly, information sharing between professional societies and the institutions that employ their members is important to ensure that appropriate consequences occur. This requires an accepted and somewhat uniform (or at least comparable) code of conduct and similar documents between professional societies be put in place, so that members are not banned from multiple societies without proper investigation and options for recourse. However, this should be possible once DEI-friendly society culture and norms are established.

Solutions That Will Improve Accountability

Solutions That Are Simple to Implement

Prioritize Diversity and Transparency in Nomination and Election Processes

Currently, ensuring diverse representation among possible candidates for elected society leadership positions (e.g., Penaluna et al., 2017) is not a stated priority for AES's nominating committee, so outputs vary from year to year. While there is language in the AES constitutional bylaws encouraging the E&D Committee to include members from historically underrepresented backgrounds, the burdens of service often fall disproportionately on scientists from underrepresented backgrounds (Jimenez et al., 2019), so we suggest a balance between including diverse perspectives and sharing service burdens. Making a good faith effort to ensure that there are options for candidates from diverse backgrounds would help to reverse the trend documented in this paper, showing that while AES is increasingly diverse, leadership is overwhelmingly not. Additionally, there is no process to ensure that eligible members who are nominated for positions appear on the ballot, leading to concerns that eligible and interested members from historically underrepresented backgrounds are nominated and willing to serve in leadership roles but not offered the opportunity to run in the election. Nomination methods that allow societies to provide transparency about who was nominated, and who was or was not selected to be on the ballot (and, to the extent possible, why that was), could be a useful solution to this, and could also help to prevent candidates who run for office specifically to obstruct diversity measures from being enacted.

Additionally, requiring those members that are nominated, and/or do appear on the ballot, to provide a statement explaining their interest and qualifications for such positions can eliminate elections that are essentially popularity contests, based solely upon name recognition with no information about what the candidate would actually do in the role. This last action can help to ensure that diverse candidates, who have had fewer opportunities to achieve name recognition, for all of the aforementioned reasons, can still be elected to office.

Finally, societies should also create an annual review and revised goal-setting process relating specifically to DEI issues. This should result in a detailed report available to members as well as prospective members.

Solutions With Moderate Difficulty

Expand the Professional Code of Ethics to Change the Culture of the Field

Often a professional society's rules only govern member behavior at official society events. This is generally the case with AES, for example, with the exception of the general code of professional ethics, which governs member behavior at all times (not just during the conference). However, many common issues in the field occur during the 51 weeks a year outside of the annual meeting, and expanding the role of the code of ethics could. Since most societies, including AES, have already initiated a professional code of ethics governing behavior of members outside of the annual meeting, and since members, especially, but not exclusively, elected leaders, represent the society not just during meetings, there is value in considering the role of society standards of behavior and ethics, and how they can influence behavior within the broader discipline beyond the annual conference. This could take the form of an expanded and reimagined AES professional code of ethics. This expanded professional code of ethics should include a process for investigation of violations and consequences for those violations, similar to the conference code of conduct. It should include equitable treatment of mentees, employees, and colleagues. It should include an affirmative duty for a member who witnesses violations of any sort to call them out or report them—currently the only affirmative duty is to call out misrepresentations of chondrichthyan science. A combination of member education from the E&D Committee and consequences for violating professional ethics is likely required to significantly change the culture of the field.

Solutions With Significant Difficulty

Create a Process by Which Someone Can Be Excluded From Future Meeting Participation for Egregious Violations

Despite some egregiously bad behavior by some members, there is currently no clear process by which someone can be excluded from future meeting participation. Most professional societies do not have the capacity or jurisdiction to investigate incidents that occur outside of the conference, but in cases where an external investigation occurred and due diligence was followed, a society could restrict the attendance of people who have committed unacceptable behavior, making the meeting safer for all attendees. This could take the form of expanding the professional code of ethics to include safe and respectful treatment of students in the field, including restrictions from attending the annual meeting as a consequence of severe violations of the code of professional ethics, or other possible procedures. We note here that making it easier for people from historically underrepresented minority groups to participate in meetings may be of limited value of those meetings are not made more safe and welcoming, and restricting the attendance of bad actors is key to making meetings safe and welcoming. In the past, discussions of this topic have been

dismissed with concerns about how complicated it would be to implement such a rule change, but it is vitally important.

Hire an Independent Safety Officer

The task of investigating issues that are reported can be complex. Hiring an independent, professionally trained safety officer to investigate and adjudicate violations of the code of conduct that occur at meetings is an important step, as it eliminates concerns about a "good ol' boys club" that protects some members from consequences. However, this can be a significant expense. Training a member to serve in this role can reduce this expense, though it is crucial that such a person be seen as impartial and is protected from any possible backlash or retaliation.

CONCLUSION

Professional scientific societies, and the decisions their leaders make, could play a more significant role in improving the culture and practices of science, particularly as they related to DEI issues. Although past initiatives have made progress, major issues remain.

Demographics of American Elasmobranch Society Members, Leaders, and Conference Award Winners

A key component of improving the culture and practices of an organization is analysis of and reflection upon current norms. This analysis of the demographics of AES members and leaders reveals some cause for concern. While a slight majority of AES members are women, a large majority of AES leaders are men, though the rate of (white-presenting) women in leadership positions is increasing in recent years. The AES membership is severely underrepresented in terms of racial and ethnic minorities, and the AES leadership is nearly entirely white-presenting. Though to some extent this is a consequence of who is willing to serve in a time-consuming and unpaid position, we note that despite hundreds of members, many leadership positions are held by the same individuals over and over. This level of data analysis cannot determine to what extent this is a problem with recruitment of people of color into the society and to what extent it is a problem with retaining those members, but the success of organizations like Minorities in Shark Sciences (see text footnote 3) have shown that there are hundreds of women of color who are interested in this field.

A Case Study of the American Elasmobranch Society's Young Professional Recruitment Fund Diversity Initiative

The YPRF program's goals are to contribute to a more diverse and inclusive AES. Survey responses from alumni of the Young Professional Recruitment Fund program suggest that the program is professionally useful to some (but not all) awardees, and can be made more useful with some additions and improvements to the program. Specific suggestions include dedicated travel funding for YPRF awardees that would allow for full participation in the annual AES meeting, as well as a more organized and formal mentorship program. Successfully accomplishing these goals would require additional support from AES in the form of both funding and time from leaders. This will also require dedicated leadership inside and outside of the society's formal leadership structure in the form of people willing to advocate for improved inclusivity in the society, and creating additional or improved pathways for members to speak up about their negative experiences from problematic AES members, noting that doing this can carry professional risks to the reporters if complementary actions aren't taken. Additionally, this program may benefit from organized collaboration with similar programs in other societies. We recommend additional and ongoing collection of feedback from YPRF alumni to further improve the program, including involving awardees and alumni in goal-setting and restructuring of the program.

What Can Professional Societies Like American Elasmobranch Society Do to Help?

Small to medium-sized societies like the AES have an opportunity and responsibility to improve their practices despite their resource constraints, and may even have an advantage over some larger societies to more-flexibly make the necessary changes. Here we have issued a series of recommendations, based upon established effective strategies and best practices, that AES and other societies can take to make science safer and more welcoming for all.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Arizona State Institutional Review Board permit #00013030. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Following the terms of the IRB permit, participation in the survey was considered to be informed consent.

AUTHOR CONTRIBUTIONS

DS and LF designed the study and coordinated the planning. GS designed the figures. RB performed the demographic analysis of society leaders and award winners. All authors contributed to data analysis and synthesis of recommendations.

FUNDING

LG was supported by NSF Graduate Research Fellowship (GRFP DGE-1644868).

ACKNOWLEDGMENTS

We would like to thank Veronica Segarra for curating this special issue. Sheila Colla, Solomon David, and Jennifer Wyffels assisted in early drafts of this project and contributed significantly to our thinking surrounding DEI issues in the sciences. We would like to thank the YPRF alumni who completed the survey reported here for their time, and would like to thank the AES Equity and Diversity Committee for their efforts coordinating selection for the YPRF program and for their other ongoing efforts to improve AES's institutional culture. Finally, we would also like to thank the many people in our field who have confidentially shared their stories, and their hopes that the field can do better, with us.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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PERSPECTIVE
published: 14 June 2022
doi: 10.3389/fsoc.2022.755372

Refining a DEI Assessment Tool for Use in Optimizing Professional STEM Societies for Gender Equity

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OPEN ACCESS

Edited by:
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Reviewed by:
Carol Muller,
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Specialty section:
This article was submitted to Gender, Sex and Sexualities, a section of the journal Frontiers in Sociology

Received: *08 August 2021*
Accepted: *17 May 2022*
Published: *14 June 2022*

Citation:
Leibnitz GM, Peters JW, Campbell-Montalvo R, Metcalf H, Lucy Putwen A, Gillian-Daniel DL, Sims EL and Segarra VA (2022) Refining a DEI Assessment Tool for Use in Optimizing Professional STEM Societies for Gender Equity. Front. Sociol. 7:755372. doi: 10.3389/fsoc.2022.755372

Historic science, technology, engineering and mathematics (STEM) disciplinary cultures were founded in a system that was predominately male, white, heterosexual, and able-bodied (i.e., "majority"). Some societal norms have changed, and so has demand for inclusive STEM engagement. However, legacy mental models, or deeply held beliefs and assumptions, linger and are embedded in the STEM system and disciplinary cultures. STEM reform is needed to maximize talent and create inclusive professions, but cannot be achieved without recognizing and addressing norms and practices that disproportionately serve majority vs. minoritized groups. As leading voices in disciplinary work and application, disciplinary and professional societies (Societies) are instrumental in shaping and sustaining STEM norms. We, leaders of the Amplifying the Alliance to Catalyze Change for Equity in STEM Success (ACCESS+) project, recognize the need to provide Society diversity, equity, and inclusion (DEI) change leaders with tools necessary to foster systemic change. In this Perspectives article, we present the Equity Environmental Scanning Tool (EEST) as an aid to help Society DEI change leaders elucidate legacy mental models, discern areas of strength, identify foci for advancement, and benchmark organizational change efforts. We share our rationale and work done to identify, and, ultimately, adapt a Society DEI self-assessment tool from the United Kingdom. We share background information on the UK tool, content and structural changes made to create the EEST, and an overview of the resulting EEST. Ultimately, we seek to increase awareness of a Society-specific DEI self-assessment tool designed to help Society DEI change leaders advance inclusive reform.

Keywords: science technology engineering mathematics (STEM), equity, professional societies and associations, assessment, survey design, diversity, equity, and inclusion (DEI) tool, professional society self-assessment tool, Equity Environmental Scanning Tool (EEST)

INTRODUCTION

Success in science, technology, engineering and mathematics (STEM) is commonly believed to be the result of objectively determined talent, training, and hard work. In discussing scientific meritocracy, Taylor (2022) explained, "If we have the correct training and skillset for the role combined with enough ambition, if we work hard and do well at our job, then we will be appropriately rewarded via promotion and other recognitions of our career" (p. 729). However, this belief conflicts with the experiences of marginalized individuals, for whom structural biases, discrimination, and inequities exist which blocks them from achieving levels of funding, recognition, and/or reward that are conferred upon peers from majority backgrounds without such barriers, discrimination, and inequities (e.g., McGee, 2020; Bird and Rhoton, 2021). National concern and acknowledgment of barriers faced by women, especially those with additional intersecting identities, and other marginalized groups is longstanding and well-documented (e.g., Valian, 1998; Faulkner, 2007). Still, STEM culture reform to maximize engagement of STEM talent is needed.

STEM disciplinary and professional societies (Societies) are uniquely positioned as agents for DEI reform (National Academy of Sciences, 2005). They play an important role in shaping and maintaining disciplinary culture, fostering STEM awareness and education, and informing standards (Borman et al., 2010; Chanderbhan-Forde et al., 2012). Society members and supporters are drawn from diverse STEM influencers, including academia, industry, and national laboratories. Because Societies shape disciplinary culture and serve diverse stakeholders, they provide multiple levers for STEM diversity, equity, and inclusion (DEI) reform; however, it has not been until the last decade that studies have explored Society members' experiences, and strategies to guide Society DEI change.

One study by Cech et al. (2018) provided evidence of differential experiences of Society majority and minoritized members. Over 16,000 STEM professionals across 14 Societies were studied. Results documented the cumulative disadvantages faced by women, people of Latino, Asian, and African American origin, LGBTQ+ members, and people with disabilities. In comparison to white participants, marginalized respondents reported working harder, being harassed verbally or in writing, and having their work devalued and disrespected. Recent work (e.g., Burnett et al., 2022), pushes for inclusive data collection to enable Societies to better serve underrepresented group members.

Societies aware of experiences of marginalized members can address barriers and promote DEI. Smith et al. (2021) and Campbell-Montalvo et al. (2022a) demonstrated that by providing critical support (e.g., mentoring, networking), Societies increased engineering degree persistence for women and underrepresented engineering undergraduates. Further, the Campbell-Montalvo et al. (2022c) study on LGBTQIA+ undergraduates found that Societies attuned to participants' identities positively impacted retention in STEM. These findings are consistent with the National Academies of Sciences Engineering Medicine (2018) conclusions that many Societies desire to understand the experiences of underrepresented professionals and incorporate strategies to address inequities, but lack critical information, "We can't solve the problems in a vacuum.… We want to identify what kinds of challenges our members are facing and what [we] can do to be a partner and an educator in helping to create actionable steps toward solutions" (p. 5).

In 2017, the Alliance to Catalyze Change for Equity in STEM Success (ACCESS) brought together Minority Affairs Committee (MAC) leaders from five biological Societies to create collective impact around Societies' DEI efforts. These leaders documented and disseminated information on challenges faced as they worked to create systematic inclusive change (Segarra et al., 2020a,b; Primus et al., 2022). ACCESS work demonstrates the value of bringing together Society DEI change leaders to support systematic change.

Building on the work of ACCESS, the recently funded National Science Foundation ADVANCE funded Amplifying ACCESS (ACCESS+) partnership project proposed strategies and tools to help cohorts of STEM Society DEI experts, and "first generation equity practitioners" (Bensimon and Gray, 2020), affect desired DEI change. While ACCESS+ uses multiple tools and strategies [e.g., The Inclusive Professional Framework for Professional Societies (Leibnitz et al., 2022), a monthly Community of Practice, and an annual convening], this paper specifically explores the development of the *Equity Environmental Scanning Tool* (EEST) to help Society DEI change leaders gain a clearer picture of the ways in which the Society may differentially serve majority and minoritized members.

THE EEST: FOUNDATION, ADAPTATION, AND OVERVIEW

When exploring Societies' diversity programs and goals, Solebello et al. (2016) found that Society leaders experience tension between the espoused inclusion values, and the drive to protect the exclusivity of the profession and the Societies' history and culture. Addressing this tension requires self-reflection on "deeply held beliefs and assumptions, and taken-for-granted ways of operating that influence how we think, what we do, and how we talk," (Kania et al., 2018, p. 4), called mental models. Society mental models are manifest in the operations, or functions of the society. They can be reflected, for example, in ideas about what research topics deserve funding, who is qualified to hold Society leadership positions, or whose research or scholarship deserves to be highlighted in convenings or society publications. Because Society mental models represent "how things are done" they can obfuscate the need for, and potentially create counter-pressure to, change.

Self-assessment is a means of uncovering mental models, and is central to ACCESS+'s approach to helping Societies take informed systematic action to advance DEI. Consistent with others (e.g., Ritchie and Dale, 2000), we argue that internally conducted Society self-assessment stimulates critical conversations; affords opportunity to record Society-identified DEI performance benchmarks; provides opportunity for

collective recognition of strengths and weaknesses; centralizes data to inform reports and communications; and encourages ownership, broad engagement, and accountability for actionable changes. Society culture reform begins with self-assessment.

After reviewing a number of DEI self-assessment tools, we selected the *Diversity and Inclusion Progression Framework for Professional Bodies* (Framework), created by the Royal Academy of Engineering and Science Council (2021) based in the United Kingdom. The Framework provided UK Societies with means for intra/inter Society DEI conversations; collective benchmarks; rationale for focused action; and for recognizing strengths and identifying blind spots—efforts that have arguably made DEI progress more systematic and robust. We selected the Framework because it was developed by STEM Societies, had a history of meaningful use and application within and between Societies, and had been refined over time (i.e., from an 8-frame model in 2017, with the latest iteration into a 10-frame model in 2021). The Framework not only provided an existing tool specific to the ACCESS+ target STEM Society audience, it provided evidentiary support for the beneficial use and application of such a tool.

Adaptation

In assessing the Framework's applicability for use with US. Societies, we determined that two main types of changes were needed: first, content changes related to differences in the Society functions between the United Kingdom and the United States; and second, structural changes permitting the assessment to be used as both a discussion tool and a means of measurement. Content changes related to differences in: (a) how professional licenses work and are awarded; (b) distinctions in how study programs in universities are accredited; (c) the important role of US. regional and student chapters; and (d) the role of US. Society disciplinary advocacy in providing comment and contribution on issues of national importance. We also took the opportunity to incorporate recent learning on DEI and academic publishing (Day et al., 2020; Institute of Physics, 2021), and explore the influential role in STEM culture reform Societies have through their choices of partnerships, vendors, and sponsors.

Structural changes dealt with item wording and assessment changes that included the addition of a Likert scale. Additionally, based on preliminary work with the original ACCESS societies, we found that asking Societies to report actual demographic data of their membership created a barrier to completing the tool; consequently, we revised the requirement to reduce demand, yet still provide important demographic information, by clarifying compositional categories (e.g., race/ethnicity, gender) that informed data collection by Societies. Overall, throughout the adaptation and revision process, we consulted subject matter experts and Society DEI leaders to ensure changes.

The EEST is currently undergoing ongoing piloting and refinement with a first ACCESS+ cohort of the original 5 ACCESS biological societies, and a second cohort of 14 predominately engineering societies. Tool refinement efforts are informed by semi-structured interviews, informal interviews, and focus groups with Society cohort change leaders, as well as discussion and outcomes from Community of Practice meetings.

Overview

The EEST tool is embedded in a process designed to provide integrated support for Society DEI leaders as they guide DEI change. Consistent with prior work on organizational transformation (e.g., Bilimoria and Liang, 2012), formal authorization and support of the Society chief executive officer (CEO) is required as a necessary part of the ACCESS+ cohort application submitted by Society DEI change leaders. Society DEI change leaders, or "Boundary Spanners," as identified in prior work (e.g., Leibnitz et al., 2021), then receive and orchestrate completion of an electronic version of the EEST over a span of 8 weeks. Upon receiving the completed Society EEST, ACCESS+ provides Society reports and recommendations. DEI Action Plans informed by EEST results are created at an annual ACCESS+ convening (Campbell-Montalvo et al., 2022b). Ongoing support for identified DEI actions (e.g., helping Societies develop their data monitoring and reporting strategies), as well as deeper exploration of EEST results and other cohort driven topics, is provided *via* monthly Society DEI change leaders' Community of Practice meetings.

Specifically, the EEST consists of three parts. Part 1 identifies twelve Functions representing typical operations that Societies may undertake. Societies complete only the Functions relevant to their operations. Part 2 explores Society data collection approaches on diversity representation; and Part 3 offers the opportunity to document DEI progress, challenges, and priorities. Together these three Parts provide functional measurements, identify data collection that needs to be addressed, and promote distillation of organizational narratives so that DEI progress becomes part of the Society's benchmark records. In doing so, the EEST provides a framework for Societies to undertake a rigorous review and reflection of what it is doing, and what it could do, to benefit members (and potential members), stakeholders, the profession, and the discipline.

Part 1

Part 1 of the EEST comprises twelve common functions typical of Society operations (see **Table 1**: EEST Function Titles and Descriptions). Together, the functions collectively represent the core structures of a Society that are central to its performance. These include the people, staff and members in the Society (i.e., Governance & Leadership, Membership), how the Society engages with its members (i.e., Meetings, Conferences & Events, Chapters & Affiliates, Marketing & Communication, Community Outreach & Engagement), how it socializes and recognizes members within the field (i.e., Professional Development, Awards & Recognition, Publishing, Public Policy & Advocacy), and how it operationalizes staff and business relationships (i.e., Employment and Partners, Sponsors, & Vendors). Please note, the numbering of the Functions is not intended to convey DEI priority or importance (e.g., #11 Publications is no less a priority for DEI focus than #4 Professional Development). Additional explanation of the functions can be found in Peters et al. (2021).

Within each of these 12 Society functions are three sections: (1) Management and Administration, (2) Policies, Procedures and Practices, and (3) Insights and Evaluation. Sections contain between 5 and 15 statements for consideration. We use these

TABLE 1 | The EEST Part 1 twelve society functions and descriptions.

EEST part	Society function	Description
1.1	Governance & Leadership	Explores how DEI is integrated into the ethos of the Society's leadership, how the Society is governed, and how major decisions are made about its goals and activities.
1.2	Membership	Examines the design and delivery of the Society's membership activities, as well as the experience of its members.
1.3	Meetings, Conferences & Events	Identifies who participates, how they participate, and what they experience during Society meetings, conferences, and events.
1.4	Professional Development	Focuses on professional development opportunities, including skills in leadership and management, networking, and technical certifications/licensure.
1.5	Chapters & Affiliates	Examines the support, development, and activities available for members in chapters, including those active in secondary, postsecondary, and other educational and non-academic settings.
1.6	Awards & Recognition	Identifies the established application and selection policies and procedures by which people apply to, or are nominated for, awards and recognition.
1.7	Marketing & Communication	Considers how the Society communicates with its members and stakeholders and the content that is communicated/marketed.
1.8	Community Outreach & Engagement	Explores how the Society promotes and engages the wider community, public, and other stakeholders in the Society's sphere of influence.
1.9	Employment	Examines how employees are recruited, managed, and promoted in the Society.
1.10	Public Policy & Advocacy	Focuses on how the Society promotes and protects the interests of the discipline and its members.
1.11	Publishing	Explores how the Society manages its publishing processes and produces official publications and journals.
1.12	Partners, Sponsors & Vendors	Considers how the Society selects and works with partners, sponsors, and vendors.

three sections to help understand how Societies are embedding DEI into strategies, actions, and impacts. Statements within each section are evaluated on a 5-point Likert Scale (0 = Never; 1 = Rarely; 2 = Sometimes; 3 = Often; and 4 = Always) to assess if, and how often, the case of DEI change is enacted in the operations of the society. A "Not Applicable" option is available for statements that do not apply to both individual statements and whole Functions. An overview of sections and example statements are provided below.

The first section on *Management and Administration* incorporates statements about the composition of leadership groups, DEI professional development in which leaders are engaged, and governance strategies employed by leaders as related to DEI. Previous research shows that *leadership* is key to cultural change within an organization (Bilimoria et al., 2008; Bilimoria and Liang, 2012, 2014; Martins, 2020). Specifically, organizational change is facilitated by leaders' attitudes and approaches, assistance in developing new ways of thinking, and responsiveness to stakeholders (Eckel et al., 2001). An example statement in Section 1 for the "Governance and Leadership" Function is, "The society has a strategic plan that specifically addresses DEI." Another example is, "The society's process for selection and/or election of Organizational Leadership is transparent, equitable, and inclusive."

The second section on *Policies, Procedures and Practices* incorporates statements that explore the day-to-day operations and enforcements of policies in which norms and expectations are constructed, and programming is aligned (or not) with espoused leadership goals as related to DEI. An example statement in this section, for the "Awards and Recognition" Function, is "The Awards Team has developed and regularly reviews equitable criteria for selecting awardees." Another example statement is, "The Awards Team engages with other STEM Professional Societies to develop society DEI good practices."

The third section, *Insights and Evaluation*, asks respondents to consider statements "tracking key indicators of representation and equity; evaluating programmatic interventions and strengthening the institutional research infrastructure to improve data collection, analysis and use" (Bilimoria et al., 2008) as related to DEI. An example statement in this section, for the "Publishing" Function, is "The Publishing Team has articulated what data it will collect from and about authors and how they will be used to inform inclusive publishing practices." Another example statement is, "The Publishing Team agrees on what constitutes clear evidence of sustained behavioral and cultural change with regard to its DEI work."

Once completed, Part 1 statements are averaged for each of the 12 Functions, and three Sections, to help ascertain Society DEI activity. Averages for Functions and Sections are computed and interpreted based on the following five-point scale, going from no activity to transformative:

- *No Activity (Scores = 0–0.99)*: a case for DEI change has not been made
- *Idling (Scores = 1–1.99)*: a case for change is emerging, data and insights are starting to be gathered, actions tend to be informal, isolated bottom-up or one-off
- *Developing (Scores = 2–2.99)*: the case for DEI change is clear, some data are being gathered, responsibility and accountability being formalized, guidelines being developed, activity being launched, connections being made
- *Engaging (Scores = 3–3.99)*: the case for DEI change is well-established, data are being gathered and shared, sustained

senior level support is in place, skills and capabilities being built, activity catching on, high levels of collaboration, clear signs of change
- *Transforming (Scores = 4)*: the case of DEI change is focused on transforming the culture and systems of the organization. Complex qualitative and quantitative data are being routinely, intentionally, and systematically gathered and shared, high levels of dialogue, collaboration and learning, clear evidence of change in individual behavior and organizational culture

Part 2

In Part 2, Society respondents are asked to provide information on how DEI efforts are measured by the Society for each of the 12 Functions covered in Part 1. Actual data are not requested, instead Societies are asked to indicate demographic data collected based on "compositional" categories (e.g., gender, race, ethnicity, disability, sexual orientation, sociometric background).

Part 3

Part 3 asks the Society team completing the EEST to answer open-ended questions designed to gather information about areas of Society DEI successes and challenges; intersectional strategies employed in Society Functions, and DEI priorities for the future. Specifically, the open-ended questions include: (1) "In what area of DEI has the society made the most progress?" (2) "Of what organizational DEI efforts are you most proud?" (3) "How are you employing an intersectional approach?" (4) "What are the society's main challenges in making progress on DEI?" (5) "What are the Society's DEI priorities for the next 12–24 months?" and (6) "Is there anything else you feel is important to document about the society to benchmark for future consideration?"

CONCLUSION

In our experience, many Society leaders recognize that STEM is better able to address global concerns when diverse talent is welcomed, supported, and retained in the field (Borman et al., 2010). They also recognize that disciplinary excellence is being undermined by (1) loss of talent, (2) lack of equitable advancement, and (3) compromised STEM research, products and services due to lack of inclusivity in approach, design and/or application. STEM Professional Societies are uniquely positioned to address these limitations and act in support of DEI, but can encounter pockets of resistance, and lack resources and/or tools to elucidate and address the existing mental models that protect the history and culture of the Society, resulting in restricting the change desired. The ACCESS+ leaders have identified, adapted and are refining a needed Society DEI self-assessment tool to support Society DEI change leaders. The EEST, paired with the *Inclusive Professional Framework for Societies* (Leibnitz et al., 2022), and supported by a Society cohort-based Community of Practice provide valuable scaffolding for Society transformation. Evaluation results from preliminary work with the first ACCESS+ cohort of five biological Societies indicate that DEI change leaders value the EEST for structured conversations, as well as for raising awareness of the breadth, and depth, of what can be done. Cohort one also valued the professional support from the ACCESS+ team during office hours, and at the Annual Convening (Campbell-Montalvo et al., 2022b). To date, pilot efforts support the EEST's potential efficacy, along with ACCESS+'s programming, to provide systemic support for Society leaders to create consequential DEI change.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

JWP and RC-M completed an initial draft of the manuscript. GML and JWP completed the final revision of the manuscript. All authors contributed to review, edit, revision, and/or addition of new material.

FUNDING

This material is based upon work supported by the National Science Foundation under Grant No. 2017953.

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Conflict of Interest: GML is the Director of ProActualize Consulting, LLC, a consulting business specializing in applying evidence-based strategies to promote inclusive organizational and disciplinary excellence. JWP is the Director of Katalytik, a consulting business based in the United Kingdom focused on promotion and creation of evidence-based equity and inclusion across STEM education and employment.

The remaining authors declare that the work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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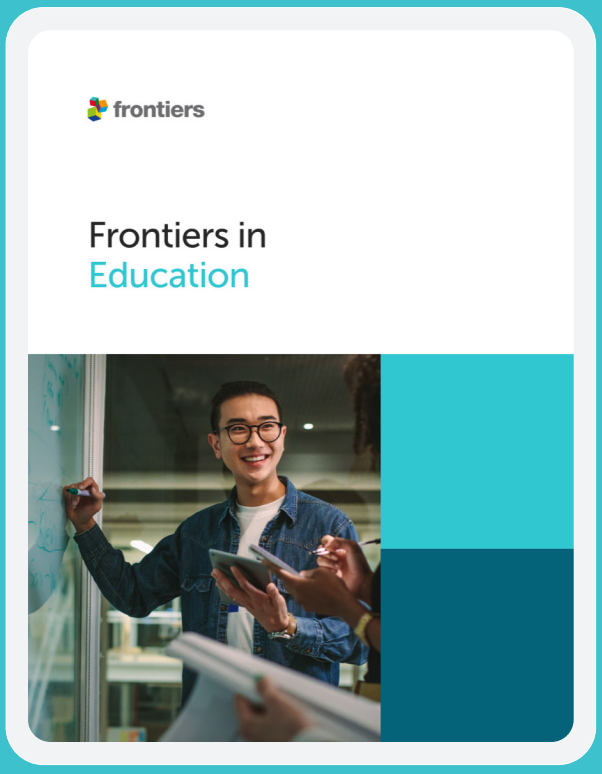

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