Chemistry Education Research and Practice

Chemistry Outreach as a Community of Practice: Investigating the Relationship Between Student-Facilitators' Experiences and Boundary Processes in a Student-Run Organization

Journal:	*Chemistry Education Research and Practice*
Manuscript ID	RP-ART-04-2020-000106.R2
Article Type:	Paper
Date Submitted by the Author:	26-May-2020
Complete List of Authors:	Santos-Diaz, Stephanie; Purdue University, Chemistry Towns, Marcy; Purdue University, Chemistry

Journal Name

ARTICLE

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Received 00th January 20xx,
Accepted 00th January 20xx

DOI: 10.1039/x0xx00000x

www.rsc.org/

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Previous work on chemistry outreach has mainly focused on designing and implementing demonstrations for outreach. Recent studies indicate student organizations are at the forefront of chemistry outreach and described their outreach practices and conceptual understanding of demonstrations. However, more research is needed regarding the experiences of facilitators leading outreach events to understand their motivation, what they are gaining from participating, how they are contributing to the community, etc. By providing this information, we can give more structure to outreach initiatives as an informal learning environment. This work is part of a larger study that explores the relationship between leadership in student organizations and chemistry outreach events. Here, we present how diversity plays a role in chemistry outreach, as informed by interviews involving nine graduate students who actively participated in outreach. Communities of practice (CoP) has been used as a framework to describe learning environments and student organizations participating in outreach can be thought of as a CoP. The findings suggest diversity and inclusion influence boundary processes of the student organization as a CoP. Specifically, students' prior experiences related to gender, race/ethnicity, education and other outreach events play a role in their purpose for doing chemistry outreach, how they contribute to planning of events and how they interact with the audience of outreach events.

Introduction

Informal science learning occurs via activities or events that happen outside a school setting or that are not part of an ongoing school curriculum (Stocklmayer *et al.*, 2010; Ryu *et al.*, 2019). These informal settings include, but are not limited to: museums (M. K. Brown *et al.*, 2017), after-school programs, summer camps (Levine *et al.*, 2015; Schwarz, Frenzel, *et al.*, 2016), workshops and one-day outreach events (Houck *et al.*, 2014; Schwarz, Burger, *et al.*, 2016). In recent years, national entities have released reports (Hein, 2009; Committee on Communicating Chemistry in Informal Settings *et al.*, 2016; National Science & Technology Council, 2018) that show an increase of support for the informal science education community. Recently, a report titled *Effective Chemistry Communication in Informal Environments*, specifically targeted the chemistry education community (Committee on Communicating Chemistry in Informal Settings *et al.*, 2016). The report offers advice and serves as a guide in the design and implementation of "chemistry communication activities", a term that encompasses the majority of the outreach events carried out by the community of scientists.

Some science outreach programs are part of ongoing initiatives to increase the engagement and presence of underrepresented communities in science, technology, engineering and mathematics (STEM) disciplines. Such programs have been designed to enhance interest in the sciences to address gender gaps (Levine *et al.*, 2015; Levine and DiScenza, 2018; Roy *et al.*, 2020) and to hopefully increase the presence of minority groups in STEM fields (Wilson *et al.*, 2014; Gagnon and Komor, 2017; Casasanto *et al.*, 2018). Issues around recruitment and retention of females, individuals who identify as Hispanic/Latinx and those who identify as African-American in STEM has been widely acknowledged and documented in different forms by researchers and other entities (Peters, 2005; Villafañe *et al.*, 2014; Wilson *et al.*, 2014; Stewart *et al.*, 2017; National Science & Technology Council, 2018; Boateng and Gaulee, 2019; Rocabado *et al.*, 2019). Gender gaps have been studied across different fields of STEM. A study in an introductory physics class indicated that women feel a lower sense of belonging than men, arising from the negative cultural stereotype about women's inferior abilities in physics (Stout *et al.*, 2013). The importance of inclusivity and belonging was also discussed by female astronomy hobbyists as factors to encourage participation and persistence in STEM (Hite *et al.*, 2019). It has been documented that facilitators benefit from outreach by having a feeling of belonging and engagement (Gagnon and Komor, 2017), having an increase in self-confidence in communicating science (Gagnon and Komor, 2017; Zack *et al.*, 2017) and having the possibility of more autonomous and creative learning (McCauley *et al.*, 2018).

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See DOI: 10.1039/x0xx00000x

The importance of acquiring communication skills, and general professional development, is highlighted in the report titled *Graduate STEM Education for the 21st Century* (Committee on Revitalizing Graduate STEM Education for the 21st Century *et al.*, 2018). In this report, the authors outline a list of core educational elements that should characterize all Ph.D. education. These core elements include for the students to "develop the ability to work in collaborative and team settings involving colleagues with expertise in other disciplines and from diverse cultural and disciplinary backgrounds" and to "acquire the capacity to communicate the significance and impact of a study or a body of work to all STEM professionals, other sectors that may utilize the results, and the public at large" (Committee on Revitalizing Graduate STEM Education for the 21st Century *et al.*, 2018). Kuk and Banning (2010) argue that student organizations are important for student involvement, contributing to student learning and development, and can serve as significant agents to advance multicultural and diversity goals of college campuses. Thus, student organizations can be spaces in which graduate students acquire the skills outlined in *Graduate STEM Education for the 21st Century.*

Most notably, a previous study with college student organizations involved in chemistry outreach highlights the purpose for students to engage in outreach events focuses on the audience: to learn, to see that chemistry is fun, and to enjoy themselves (Pratt and Yezierski, 2018a). Faculty and staff shared similar notions of what the purpose is, with the addition of faculty having the college students learn chemistry and develop into scientists. A follow-up study addressed the college students' conceptual understanding of the demonstrations they presented (Pratt and Yezierski, 2018b). The study presented evidence that college students in chemistry outreach have misconceptions related to two common outreach experiments, despite of having prior experiences in outreach.

Although there is an extensive collection of demonstrations and activities for chemistry outreach events (Turner *et al.*, 2014; Morais, 2015; Gaquere-Parker *et al.*, 2016; Schwarz, Burger, *et al.*, 2016; C. L. Brown *et al.*, 2017; Flynn *et al.*, 2017; Ting *et al.*, 2017; Dietrich, 2019; Kuntzleman, 2019), there is a lack of research that focuses on understanding other aspects of chemistry outreach such as: who are the facilitators of outreach events and what groups do they belong to, what is the role and preparation of the facilitators, resources used by organizations participating in outreach, what is the impact of outreach events on different groups, etc. As an example, there is no specific research on the experiences of underrepresented communities in chemistry outreach beyond these individuals being the target audience for outreach events. In order to expand our knowledge about chemistry outreach, here we conceptualize student organizations participating in outreach as a *community of practice*.

Guiding Framework: Communities of Practice

Communities of Practice (CoP) has been used as a theoretical framework for studying learning environments, and how knowledge develops and evolves in groups (Bodner and Orgill, 2007). We adopted the following definition of a CoP for this study: "… a group of people who share a common passion or concern and deepen their understanding of the topic by interacting in an ongoing basis." (Wenger, McDermott, *et al.*, 2002). The *Effective Chemistry Communication in Informal Environments* presents the idea of collaborations across different groups –chemists and experts in science communication, for example– to build a CoP that shares common goals and effective practices for communicating chemistry (Committee on Communicating Chemistry in Informal Settings *et al.*, 2016). To that end, the study presented in this manuscript is grounded in the notion that student organizations planning and implementing outreach events are a community of practice. The remainder of this section provides a general description of constructs associated with a community of practice in order to explicate and provide support for this choice.

The term CoP was conceptualized to describe a social learning system and is characterized by a domain, the community and the practice. The domain refers to the "shared common passion or concern". The members of a CoP are committed to learn about a specific domain and have a shared competence pertaining to that passion. The members value the collective competence and learn from each other by engaging in events, joint activities and discussions. The community characteristic refers to "interacting in an ongoing basis". The process of understanding and learning more about the domain from interacting with other individuals is what constitutes the community. Thus, individuals are not necessarily a CoP just by expressing interest in a topic (i.e. domain). There needs to be an exchange of knowledge or collective learning in order for the CoP to exist. Additionally, there needs to be a practice (third characteristic) through the development of a shared repertoire of resources. The resources are tools or processes that facilitate the learning of specific knowledge pertaining the domain (i.e. members "deepen their understanding" of the topic or passion).

The combination of domain, community and practice is what constitutes a CoP. Taking into account these characteristics is what brings a CoP into existence, it is safe to assume a CoP exists in a variety of forms and that one is (or can be) member of numerous CoPs (Wenger and McDermott RA, 2002). In the healthcare sector, for example, doctors can be established as a CoP and nurses could be a different community; however, doctors and nurses are considered members of the same clinical practice CoP when compared to members of the healthcare management CoP (Kislov *et al.*, 2011). In higher education, multiple communities of practice have been identified: undergraduate mathematics lecturers, student-staff across universities, graduate students, and others (McDonald and Cater-Steel, 2017).

Different communities of practice are similar in structure (i.e. domain, community and practice as characteristics). Individuals' participation, sense of belonging, competence and experience also play a role in delineating and cultivating a CoP but may differ to various degrees across communities of

practice. There are tiers of participation in a CoP (Wenger and McDermott RA, 2002). The first tier is the *core* group, who are those members who actively participate in discussions in the public community, identify projects for the CoP to be involved in, etc. The next tier are *active* members or those that occasionally participate in activities but not with the same intensity or regularity of the core group. Another tier is members who are *peripheral*, they rarely participate in activities for different reasons. These members are still part of the CoP because they are still learning and engaging in the practice to their best extent and sometimes in ways the core or active members are not. Lastly, the outsiders are individuals who are not members of the CoP but have an interest in the community.

The degree of participation of a member in a CoP is influenced, and can be influenced by, competence and experience. For members of a CoP, knowing is the interplay between competence and experience (Wenger, 2000). Competence is established over time by the community and experience includes that within the context of a given CoP and beyond. According to Wenger (2000), competence and experience converge in a CoP allowing for a deep expertise on the domain. Wenger argues that not much learning takes place between individuals or within a CoP when competence and experience are too similar. This introduces the construct of *boundaries.* At the boundaries of a CoP, a different learning opportunity presents itself because competence and experience diverge. For example, members of a CoP could be exposed to a new competence by interacting with members outside of the CoP. The processes taking place at the boundary, shown in the outer circle of **Figure 1**, are members acting as brokers (brokering), boundary objects, and interactions among people from different CoPs (Wenger, 2000). Brokering, boundary objects, and interactions are collectively considered *boundary processes*. This study specifically examines these boundary processes, which we continue to operationalize.

[INSERT FIGURE 1]

Brokers can introduce elements of one practice into another (Smith *et al.*, 2017). They create connections across communities of practice and move knowledge. *Brokering* can happen by establishing intentional connections in "exploring new territories" (Wenger, 2000) or it can happen by a personal connection between two members of different CoPs. *Boundary objects* refer to tools, documents, the common language used to communicate across communities and shared processes to coordinate actions. *Boundary interactions* (herein, *Interactions*) take different forms depending on the purpose. All are described in **Table 1;** but, particularly relevant to this study is *Peripheries* as a boundary process. This is when communities serve people who need service, are curious or intend to become members of the CoP.

[INSERT TABLE 1]

Furthermore, Wenger (2000) points out six elements or "doable" actions that characterize a CoP when designing itself: leadership, events, connectivity, membership, projects, and artifacts (inner circle of **Figure 1**). A CoP needs multiple forms of leadership to help it develop, such as members who document the practice, networkers, etc. The community decides what leaders they need, and the forms of leadership may change over time. In terms of Events, the CoP decides the type of activities and its frequency to organize events that bring members together. Connectivity involves brokering relationships between people who need help and those who can offer help. Membership in a CoP includes devising processes by which newcomers can become full members without diluting the community's focus or practice. Learning projects serve to explore the community's knowledge domain and revisit the practice. Last, artifacts such as symbols, documents, tools and websites are produced and maintained by the CoP.

To contextualize CoP in this study, collegiate science student organizations meet the characteristic 'requirements' to be considered a CoP. As summarized and stated in Table 1, the ways in which a collegiate student organization can be a CoP is not necessarily generalizable to all individual student organizations. The domain of a particular student organization CoP could be chemistry, brought together by their members' practice as a chemist, a scientist, a student or a researcher or a science communicator. The members of the organization may interact with each other by participating in meetings, social events or private conversations. These modes of participation facilitate the sharing or exchange of knowledge about research methods, techniques, new concepts, etc. In this manner, competence and experience start to develop, cultivating the organization as a CoP. Considering the concept of multimembership (i.e. being part of more than one CoP), the members of the student organization CoP are acting as brokers by bringing experiences, routines and procedures from one CoP to another. This might happen intentionally or unintentionally; it may be recognizable, or it is unnoticed because it is all part of who the member is and what they do (i.e. identity). As an example, a student who is member of another CoP that participates in a different type of outreach (science or non-science) might have a different perspective on what recruiting volunteers for outreach events entails.

It is important to note communities of practice as a framework is considered highly abstract (Storberg-Walker, 2008) and does not describe how the elements of a CoP interact with each other or with boundary processes. In addition, the framework does not consider how constructs like gender or race, for example, can influence the design elements of a CoP and its boundary processes. This provides the opportunity to build on and extend the framework by exploring and describing experiences of facilitators, who are the leaders of student organizations, in chemistry outreach events, and how these experiences influence boundary processes of the CoP.

Research Question

The research question addressed in this manuscript emerged from the data analysis of a larger study that aimed to characterize leadership styles (*Leadership* in the context of a CoP) in student organizations participating in chemistry outreach. Here, we aim to address the research question: What factors, related to diversity and inclusion, contribute to the facilitators' experiences in outreach events in terms of

Boundary Processes of the student organization as a community of practice?

Methods

A case study methodology was adopted for the larger study. This methodology is recommended when researchers want to understand a real-world case and assumes understanding will likely involve important contextual conditions pertinent to the case (Yin, 2014). Following the guidelines provided by Baxter and Jack (2008), the study presented in this manuscript was designed as an exploratory, single case study with embedded units (Yin, 2014). The case, or unit of analysis, is defined as experiences of student-facilitators participating in chemistry outreach events through a student organization. The embedded units are student-facilitators participating in *Girl Scout Chemistry Discovery Day* and student-facilitators participating in *National Chemistry Week*. These cases are bounded by chemistry outreach events as the context. **Figure 2** depicts this representation, adapted from Yin (2014). It is important to note the unit of analysis, or the case, focuses on specific experiences of individuals rather than the individuals as a whole. Additionally, it should not be assumed that the embedded units were compared; the analysis at a subunit level (i.e. leaders participating in specific events) served to inform and better illuminate the case set out to understand (i.e. experiences of student-facilitators) (Baxter and Jack, 2008). Thus, the findings will be discussed holistically and not specific to outreach events or participants.

[INSERT FIGURE 2]

Participants

Purposeful sampling is used to select participants the researcher can learn from the most (Merriam and Tisdell, 2016). Therefore, the recruitment of participants for this study took place at institutions that met one of the following criteria:

- The institution has an active American Chemical Society (ACS) Student Chapter that participates in outreach efforts
- The institution has an organization, not affiliated with ACS and with the majority of membership being students, that participates in chemistry outreach efforts

The pool of participants included two student organizations, one for each criterion. These criterions were established in the initial stages of designing the study to serve as a basis of comparison, because organizations affiliated to ACS may have different membership and access to resources that non-affiliated to ACS organizations may not have access to. Out of the two different student organizations at a research intensive (R1) institution invited to participate of the study, one agreed to participate in the study. This student organization is an all-female organization, not affiliated to ACS. The specific criterion for recruiting participants was mainly informed by the larger study focused on understanding the relationship between leadership and chemistry outreach. Consequently, the participants recruited for the study were students leading outreach efforts and students volunteering to carry out the outreach effort.

The researcher first contacted the Outreach Committee within the board of the student organization to have these members consider participating in the study. If the sample was too small (i.e. only one leader accepted the invitation to participate of the study), the invitation would be extended to other leaders within the board of the student organization. Snowball sampling (Merriam and Tisdell, 2016) was used to recruit volunteers of the outreach events, meaning that individuals with whom contact was already made refer the researcher to people who could potentially contribute to the study.

Nine graduate students, who volunteered as facilitators for outreach events sponsored by the all-female graduate student chemistry organization, agreed to participate in this study. Four of the participants were part of the "Outreach Committee" within the organization and two occupied other leadership positions. Three participants did not occupy leadership positions; as a result, they had no role in the planning of the event and solely volunteered as facilitators of the outreach event. One participant is male, and eight participants are females. A higher female representation in participants for the study was expected due to the nature of the student organization (i.e. all-female). Out of the nine participants, seven self-identified as underrepresented minorities (URM) in terms of race and two of these identified English as their second language.

Context of Outreach Events

The student organization, for which the participants were part of, plans one or two chemistry outreach events throughout the Fall and Spring semester, but do not participate in outreach events during the summer. During the Spring semester, the organization plans *Girl Scout Chemistry Discovery Day*, an outreach event expected to serve around 100 participants: 40-75 girl scouts ranging from 4th to 8th grade and 20-25 volunteers. However, during the time the study took place, 13 girls attended Girl Scout Day and 16 graduate students volunteered as facilitators during the event. Due to the small number of attendees, the leaders changed the Girl Scout Day event from being a large group of girls led by a graduate student to have a one-on-one structure, in which one girl scout was paired with a "graduate student buddy". The event was hosted at the student organization's campus; specifically, in laboratory rooms traditionally used to teach undergraduate general chemistry laboratory courses. During the Fall semester, the organization plans *National Chemistry Week.* The organization adopted the theme suggested by the ACS to select demonstrations and experiments for the outreach event (National Chemistry Week (NCW)). To prepare the facilitators, the student organization planned four training sessions and facilitators attended a session of their choosing. While mandatory, there were no consequences for not attending a session. These sessions were carried out in laboratory spaces

usually used to teach undergraduate laboratory courses. In total, the student organization visited 26 local schools and 78 classes/classrooms for 50-minute sessions. The facilitators visited the schools in partners or groups of three and were responsible for choosing an order in which to present the activities/demonstrations.

Data Collection and Analysis

The larger study involved four phases: a survey on outreach practices, observations during an outreach event, a semi-structured interview and completing a questionnaire to identify leadership styles. In addition, email communications and experiment guides were collected and analyzed. All of these phases and data collection methods were approved by the academic institution's Institutional Review Board (IRB). The primary sources of data for this manuscript are the first part of the interviews, which were informed in part by the survey on outreach practices and observations.

The Characterizing Collegiate Organizations' Chemistry Outreach Practices Survey (Pratt and Yezierski, 2018a) was administered to leader-participants, as they were deemed to have more accurate information on the organization's practices. The survey was set up using Qualtrics, an online survey platform, and sent to the leader-participants months before their outreach event. The participants completed the survey within two weeks of being sent out. On the day of the outreach event, all participants were video-recorded and audio-recorded to capture their interactions with leaders of the organization and with the audience.

Then, all participants were interviewed within six weeks after the outreach event. The semi-structured interview consisted of three parts: (a) general questions about experiences in outreach, as leaders and as volunteers, (b) questions involving reflection on clips portraying interactions with others (DeKorver, 2016; Johnson, 2017) and (c) questions related to participants' understanding of the chemistry present in experiments done throughout the outreach event. The interview protocol used for this study was informed by studies on mentor-mentee interactions (Johnson, 2017) and on conceptual understanding of outreach demonstrations (Pratt and Yezierski, 2018b). The interviews lasted between 1-2 hours; and, participants had the option of being interviewed in their first language. As discussed later in this section, having this option available to participants was advantageous in the study.

As stated earlier, the primary sources of data for this manuscript are the interviews informed by the survey and observations. As an example, during the interview, participants were asked "How do you think diversity influences how outreach is being carried out?". The relevant portion of the interview protocol is included in the Appendix sections. Two participants preferred to be interviewed in their first language, therefore the interview protocol is included in English (Appendix A) and Spanish (Appendix B). Being interviewed in their first language established a common ground between the participant and the researcher (i.e. rapport), it allowed the participant to be more at ease during the interview as they were having a conversation in the language they are fluent in, and it potentially decreased the likelihood of the researcher missing nuances or misinterpreting responses (Merriam and Tisdell, 2016; Taber, 2018).

The interview transcriptions were analyzed through open-coding (Merriam and Tisdell, 2016) where similar statements or responses were coded then grouped into different themes pertaining the facilitators' experiences. The initial coding scheme resulted in five categories or themes. The analysis process was discussed with another researcher which allowed for reflection on the coding and grouping process, which led to five categories. Ultimately, it led to the consolidation of two categories into a broader category that better encompassed the participants' experiences. To address inter-rater reliability, a subset of interview excerpts was randomly selected and assigned to two other chemical education researchers to code with the four categories designed by the main researcher. One of the secondary researchers coded responses in English and the other secondary researcher coded responses in Spanish. The main researcher then discussed any discrepancies that emerged with the secondary researchers. This allowed the category descriptions to be refined. The final coding scheme and examples of codes per category are shown in **Table 2.** An additional layer of coding was applied to the excerpts coded with the four themes. The excerpts were deductively coded using the three boundary processes described in the *Guiding Framework* section: brokering, boundary objects and interactions. In doing so, the analysis led to insights on how factors related to diversity are present at the boundary of the student organization as a CoP.

[INSERT TABLE 2]

During the interview, some participants shared concerns about their information being identifiable. For this reason, experiences shared and discussed by URM participants will be presented under the pseudonym Angel and experiences shared by non-URM participants will be presented under the pseudonym Skyler. Creating composite characters based on shared experiences is a common practice in qualitative studies when it is necessary to conceal the identity of participants (Taber, 2013; Eisenbach, 2015; Dwyer *et al.*, 2016; Allen, 2018). Being labeled, or identified, as an URM is a shared experience in itself. However, this is not to imply, or for the reader to assume, all URMs go through the same experiences. As a technique, creating composite characters is especially relevant when concealing the identities of easily identifiable populations, such as URM students, given that the likelihood of identification of these students is higher based on institutional demographics (Zeller, 1995; Patton and Catching, 2009). In this study, the composite character technique is used solely as a mean to present identifiable information and not as a tool to analyze information provided by participants.

Both trustworthiness and authenticity were addressed by adopting the strategies suggested by Merriam & Tisdell (2016). Credibility refers to how the findings of the study match the participant's reality (Merriam & Tisdell, 2016). Even though reliability in qualitative work is problematic, as results regarding human behavior might not lend themselves to replication,

consistency was addressed (Merriam & Tisdell, 2016). Consistency refers to whether the results are consistent with the data collected. Here, both credibility and consistency were addressed by peer review, triangulation and member check (Merriam & Tisdell, 2016). The first, peer review, was discussed earlier with interrater reliability. The use of multiple sources of data collection aimed to corroborate findings facilitates triangulation (Yin, 2014). The process for member checks involved sharing preliminary findings with the participants in order for them to give feedback on the researcher's interpretation. The participant's feedback included suggestions to better capture their perspectives with their statements, which allows authenticity of the data in terms of consistency. An additional strategy to address consistency is an audit trail (Merriam & Tisdell, 2016), which was addressed by the researcher recording memos throughout the process in order to provide a detailed account of how the study was conducted and how data was analyzed.

Findings and Discussion

Amongst the factors contributing to facilitators' experiences in chemistry outreach addressed by the participants throughout the interviews are: general different experiences with outreach initiatives, educational backgrounds, gender and race/ethnicity. As a reminder, the case under study is experiences of student-facilitators whereby non-URM participants are labeled as Skyler and URM participants are labeled as Angel.

Experiences with Outreach Initiatives

All the participants had a varied range of experiences, which informed their expectations of the outreach event, how outreach is structured and how things should be done in order for the event to be considered a success. These prior experiences involved efforts through their ACS Undergraduate Student Chapters and sometimes through other science outreach programs, all events serving a spectrum of audiences. Angel, an URM, used events in their CoP to engage in *Brokering* and *Interactions*. Angel reminisced about previous outreach events they participated in and shared: *"[…] back in (my home country) we were all excited about the same thing and wanted to* ***bring science to the general community because science is not something highly promoted in a country where there's not a lot of scientific development****. […] I differed or disagreed with other leaders here because for me it's important to* ***have the audience learn****. Not only tell them the answer, but rather explain or ask questions so they (audience) can generate their own understanding of the concepts […]"* These outreach events might have been one of the few times students at their hometown were exposed to science, meaning the event served as an opportunity to hone the audience's critical thinking skills.

Based on their previous experiences, specifically with an award-winning outreach initiative, they also believed having fun with an outreach demonstration and learning from it were not mutually exclusive. This was in contrast to Skyler's simple views on outreach, where the primary goal is for the audience to have fun: *"I think my goals for volunteering are mostly for* ***the kids to have fun*** *[…]"* These findings align with previous reports stating that the purpose for chemistry outreach is mainly centred around audience's feelings towards science (Pratt and Yezierski, 2018a). The contrasting views on the goals for chemistry outreach, informed by prior experiences in chemistry outreach, influences the intentions and nature of *Interactions* between facilitators and the audience, future potential members of the science CoP. Facilitators either highlight which concepts explain outcomes of experiments/demonstrations providing a deeper immersion in the science CoP or they limit the exchange to peaking the audience's interest in the CoP by creating an enjoyable experience.

As for the experiments presented during Girl Scout Day, Angel and Skyler both stated *"[…] past experiences in outreach is what allows me to feel more* ***confident*** *in participating of these types of events and understand my role in these events."* To Angel, the confidence was linked to having done the experiments several times for other outreach events. However, Angel heavily relied on Skyler throughout Girl Scout Day to understand the structure of the event because of Skyler's prior experiences with similar outreach events. This is an example of how previous experiences with outreach events positively impact *Interactions* as a boundary process. When discussing National Chemistry Week, Angel stated *"[…] this was* ***their second workshop****. So, they knew how things would go.* ***I specifically wanted them to talk*** *because they had experience."* The lack of experience impacts how Angel engages in *Interactions* as a boundary process because they relied on their partner facilitator to do so.

Angel and Skyler have participated in various capacities of outreach events sponsored by the student organization and other organizations at their current institution. Throughout the years, Skyler has planned and led outreach events and also only fulfilled the role of a volunteer. When comparing their experiences as a leader versus experiences as a volunteer, Skyler said: *"I like being in the leadership position […] I kind of want to step in and help, but at the same time,* ***it's very stressful to plan these events****. It's kind of nice to not have to do all the work, but then at the same time,* ***as a leader, you know every single thing that's supposed to happen, whereas as a volunteer, you're kind of in the background.*** *And so, there's only so much you can do to help since you don't know fully what the plan is supposed to be." Skyler added: "[…] being on the other side of it,* ***outreach, in general, is a very time-consuming thing****. So after National Chemistry Week, where you plan all the experiments, and you get funding, and you practice the experiments, and you get volunteers, and it's a week straight,* ***you're just so burnt out by the time the next outreach event comes around****."*

Throughout their interview about *National Chemistry Week*, Angel alluded to a similar leader-volunteer comparison by stating that they had no desire to pursue a leadership position with an organization planning outreach events because it was a 'triggering' experience. Instead of being related to the workload associated to a leadership position in outreach events, these feelings rose from friction between leaders, which leader-

participants attributed to cultural differences (further discussed in *Race/Ethnicity* section).

Educational Background

Both Angel and Skyler mentioned having leaders and volunteers with different educational backgrounds influences how the organization prepares for the outreach event. Reflecting back on past outreach events, Angel believed it was easier to guide undergraduate volunteers to use the organization's version on how to explain the chemistry of a demonstration, stating *"[…] at the graduate school level it's more difficult to try to guide student/facilitators in terms of what you want them to teach the audience because* ***each student comes with their own understanding*** *(of the experiments) […]"* Angel's perspective aligns with findings of prior research in formal learning environments that show new knowledge is constructed when prior knowledge is elicited and cognitive dissonance happens (Linenberger and Bretz, 2012). According to Angel, graduate students are to more difficult to train on how to explain the demonstrations because they all have their own set of experiences that inform ideas on how something works.

Skyler used a similar reasoning as their argument as to why it is difficult for the student organization to achieve the dual goal of the audience to have fun and to learn chemistry during the outreach event. According to Skyler: *"Some people say 'You can do both' which is very* ***hard when you have grad students teaching children*** *[…]. I was like '****This is difficult. I don't know how smart 10-year-olds are. I don't know what they know****.' […] We have an education college who teach teachers how to teach,* ***we should ask people to help us.****"* Skyler mentioned they would have preferred to take advantage of on-campus resources, which is a form of *Brokering* and *Boundary Objects*, to help graduate students understand "how to teach" in an outreach context. By engaging with other CoPs, the student organization could adopt new practices, routines or establish connections with resources that could better prepare facilitators of chemistry outreach events.

The quality of education and what is covered in each grade level varies across nations. Having been exposed to a different type of education, Angel relied on other leaders and volunteers more familiarized with the American educational system to come up with explanations of the demonstrations. However, they also thought that by designing an event with the sole intention of girls to have fun, the facilitators were underestimating the audience. They believed the event could have served as a learning experience in addition to a fun time.

Skyler briefly mentioned: *"[…] So when I did outreach, we always practice the experiments because there's a lot of times that those experiments don't work, and so you don't want the experiment with the audience to be the first time you're trying something in case it doesn't work. But I also know outreach is very challenging and it's very time consuming,* ***so if you don't have the ability to kind of push research off to do those things****, then it's very understandable for things to fall through the cracks."* The workload of a graduate student hinders the amount of time and effort that can be put into designing and implementing outreach programs. It is easier and less effort for current leaders of the organization to rely on the prior cohort and mimic what they did in order to implement outreach activities. Even though participants did not mention the organization having explicit procedures to carry out outreach events, Skyler acknowledged student organizations need these *Boundary Objects* to help structure outreach by stating the necessity of adopting practices from education-oriented CoPs.

In an attempt to address the challenge posed by Skyler, Angel mentioned the goal of the organization was to start planning for *National Chemistry Week* three to four months in advance: *"[…] the purpose of the summer was to prepare for National Chemistry Week, to talk about our experiments, to trial these experiments. To definitely get things off the ground in the summer. This way,* ***when the semester comes, then we don't have to be so flooded with work and school****. […] so, everyone decides to meet the first two weeks of school which is the most hectic time to meet. […]* ***It was late on my approach of doing things, but it was early for what their (the organization) usual is****."* Here, Angel attempted to act as a broker (i.e. *Brokering*) by bringing in their own practices to coordinate actions of the student organization CoP while taking into consideration educational responsibilities, or those associated to being a graduate student.

Gender

Angel and Skyler were part of events planned and coordinated by an all-female organization. For this reason, the discussion of the role of gender in leadership and outreach was expected when asked about diversity during the interview. Angel mentioned *"I come from a place that the population is 80% male. So****, I am used to working with men****; even my closest friends in my group are men. I was sort of disappointed, so* ***I joined the organization to interact with more people****."* Since their prior experiences in outreach were within a population that the vast majority were men, Angel saw joining the all-female organization as an opportunity to interact more with women and people from other cultures. However, issues pertaining to language and ethnicity, discussed later on in this manuscript, made them feel they were part of a not inclusive environment. This discouraged them from applying their extensive experience in chemistry outreach to this new context, presenting a missed opportunity for the CoP to further cultivate and define their practice and boundary processes. They felt they could not portray themselves as the leader they are.

Skyler thinks of Girl Scout Day as an opportunity to highlight female representation in STEM: *"[…]* ***since it's women teaching other women****, and when you have women of different ethnicities who are in the front taking charge and leading the experience, and then you have the girls that are participating,* ***I feel like that's a lot more inspiring than if you just go to a science camp run all by men****. Because I feel like women […], if they don't see themselves* ***represented in the sciences,*** *they don't think that that's something that they can do."* Angel alluded to the same idea by stating: *"I think in the role models growing up and I just didn't see* ***a whole lot of people that***

***looked like me doing things that I wanted to do**. […] So that was kind of my goal and for the girls to have fun."* In fact, they thought the one-on-one setup for this specific event (i.e., the girl scouts paired with a graduate student) was beneficial in achieving that goal. In the student organization as a CoP, it is through leadership and events that outreach facilitators engage in *Interactions*, to serve those who are curious about science and perhaps intend to become scientists.

Additionally, Angel shared *"[…] being in the organization is **empowering and it's nice that there's an all-female organization** […] because I am in a research group that **most of the members are men and you can tell they treat you differently because you're a female versus if you were a male**. Similar to as they could treat you for being a minority versus if you were white."* For this participant, being part of the organization and participating of outreach events was their way of contributing to society's efforts to inspire younger girls to get excited about science, a form of *Interactions*. This goal is not uncommon for females and other underrepresented minorities in science, given that there is a persistent underrepresentation of these communities in STEM as pointed out by Angel and reported in the literature (Aschbacher *et al.*, 2010; Smith *et al.*, 2013).

Race/Ethnicity

Different races and ethnic groups have different languages. Participants described experiences with language that negatively and positively impact boundary processes. Angel shared *"[…] For me it has been difficult to adapt here **or be 100% myself like I was in (my home country**). […] I'm still **scared to speak English in public** […] I joined the organization to force myself to work on it. […] I feel like language is a barrier to insert myself in conversations. **I felt excluded from conversations** (during meetings). I didn't feel comfortable."* The language barrier negatively affected their interactions with the audience and with other facilitators at the outreach event. Angel's experience with language as a barrier is consistent with literature that discusses how language and other factors experienced in underrepresented communities impact the overall persistence and motivation along the student's academic journey (Dias, 2017). In addition, as discussed in the *Experiences with Outreach Initiatives* section, Angel had led award-winning outreach initiatives as part of other CoPs. Angel's negative experience with language did not allow for an appropriate exchange of ideas or routines to coordinate actions, hindering *Brokering* and the opportunity for the current CoP to further develop *Boundary Objects.*

Angel also mentioned language is a persistent concern of theirs: *"I had to think on how to make this accessible to children […] trying to use simple language. Of course, **language in my case is also an extra effort because English is my second language, so it was an extra thing I have to think about**. […] Pronunciation is the first thing that always worries and concerns me when I'm teaching, **I don't want my pronunciation to cause misunderstanding of concepts**. […] I **figure language is more of an issue in my mind** that is actually in the class."* While this concern with language did not present an obstacle for Angel to engage in boundary processes, it is still an intrinsic concern that could have surfaced and negatively influenced how boundary processes take place in the CoP.

Angel acknowledged that language could hinder the type of connection you make with the audience, which can influence *Interactions* as a boundary process; however, their own experiences with language in outreach events were positive. They discussed two examples during the interviews, one pertaining a past outreach event, with the same student organization: *"[…] my partner started explaining the demonstrations and a girl raised her hand to ask if he spoke Spanish. He said: 'Yes.' And she said 'You speak just like my teacher! You have her accent!' […] "* and the other in relation to National Chemistry Week *"[…] The children know when English is not your first language, they asked us 'You speak Spanish, right?' and they will say 'Oh, I know how to talk in Spanish too.' […]"*. In these two instances, language helped facilitators engage the audience and establish a common ground to engage in *Interactions*. For this participant, differences in cultural background presented more of a challenge than language during Girl Scout Day. *"It can be complicated in terms of English being my second language, **so I don't know if I'm being understood**. […] I don't know much about USA, the culture, etc. so asking about which school you went to means nothing to me. So**, it (culture) can influence conversations I had with the audience** […], it's important for the audience to feel comfortable with me and ask questions."* Angel engages in *Interactions* and *Brokering* by using culture to establish a common ground and trust between themselves and the audience. Not being familiarized with American culture limited their conversation to getting through the experiments of the outreach event. By not knowing how to engage with students, they had difficulties gauging how comfortable the students felt asking questions, which was part of the participant's goal for doing outreach.

Angel self-identified as URM based on their race and ethnicity. Similar to when gender was discussed, Angel mentioned a goal for doing outreach and being involved in *Leadership* is to present themselves as role model because that's what they wished they had when they were younger. For them, outreach events can be used to showcase how underrepresented minorities are scientists and do science.

When discussing experiences related to National Chemistry Week, a common theme addressed by participants was communication across leaders. Angel mentioned *"[…] my biggest thing is **communication and how people talk**. […] I realize it's not even they're (other leaders) trying to be disrespectful, **that's just their norm. Where I come from, you approach people in a certain manner or things go left.** […] nobody has a problem with helping anyone, **but you can't dish it out as a dictator.** […] I would be more careful when deciding which organization I decide to fulfill the leadership position in. […] I don't have a problem with cultural diversity, but I think I'll need it to be a little bit more than it is now. […] I would just like to be a volunteer and I actually do it with 100% because I think that **behind the scenes is where actually triggered me, more so than a volunteer**."* Angel used their leadership position to *"[…]*

give the little kids some type of science experience […]", a form of *Interactions*. Wise (2019) has reported that even when a student has genuine intentions for being involved in a student organization, the stress of intercultural communication still persists in individuals. In this study, the inability of other leaders to appropriately communicate across cultures discouraged Angel to pursue any other leadership positions in the future, which negatively contributes to developing and cultivating the CoP. Due to this experience, their first time as a leader at their institution, Angel now prefers to act as a volunteer-facilitator rather than be involved in the planning process of chemistry outreach events.

Limitations

As stated earlier, the work presented here is part of a larger study. The interview protocol was not framed or designed to fully explore diversity in outreach. However, when analyzing the data, noteworthy information came about providing a different insight on what we know about chemistry outreach. In addition, the participants for this study have specific characteristics (i.e., from an all-female student organization not affiliated to ACS, or from a research-intensive institution) that limit the transferability of these findings. Investigating how other students from other populations, organizations, institutions, or geographical locations experience diversity in chemistry outreach could potentially reveal more about the issue at hand.

For this study, we used communities of practice as a guiding framework. We acknowledged and addressed part of its limitations by describing the boundary processes of a student organization as a CoP. However, our findings show diversity heavily influences boundary processes within a CoP. As more research is carried out with facilitators in chemistry outreach, exploring diversity aspects should be carried out with frameworks that explicitly offer perspectives on these topics. These frameworks may include, but should not be limited to, gender analysis frameworks, equity literacy framework or frameworks founded on critical race theory (March *et al.*, 1999; Denzin and Lincoln, 2018; Gorski and Pothini, 2018).

Conclusions

Overall, racial/ethnical, gender and educational background factors influence boundary processes of the community of practice described in this study. Based on our findings, *Brokering* across different CoPs and *Boundary Objects* are underdeveloped boundary processes in the student organization CoP. *Brokering* and *Boundary Objects* were mainly identified when participants discussed planning and preparing for the outreach event, while *Interactions* was mainly identified throughout the implementation. One factor that hinders these *Brokering* and *Boundary Objects* is differences in languages. Additionally, when leaders or other facilitators are unable to properly communicate across cultures, they are fostering an environment that does not allow for the boundary processes to be developed and the CoP to grow. Being unfamiliar with the current educational system might create a barrier for facilitators of outreach events to engage in *Interactions*. Language, culture and gender guide how facilitators of outreach events interact with the audience and serve people outside of the student organization or community of practice (i.e. *Interactions*).

Leadership takes place in different forms, and diversity is an integral component of leadership. The participant's experiences with ideas related to diversity show these factors play a role in the facilitator's purpose for chemistry outreach, the reasons why they volunteer as facilitators of outreach events and how they interact with the audiences. The discussions of, and experiences with, role models can be described with the mediation model presented by Chemers et al. (Chemers *et al.*, 2011). In the case of role models through chemistry outreach, 'community involvement' is a support component that influences the psychological process 'identity as a scientist' which affects commitment to a science career.

It is important to note that while diversity is usually thought of as "racial/ethnic or gender diversity", it can also encompass diversity in ages, professional expertise, educational trajectories and overall experiences. In fact, the National Science Foundation (NSF) defines diversity as:

> "[…] a collection of individual attributes that together help agencies pursue organizational objectives efficiently and effectively. These include, but are not limited to, characteristics such as national origin, language, race, color, disability, ethnicity, gender, age, religion, sexual orientation, gender identity, socioeconomic status, veteran status, educational background, and family structures. The concept also encompasses differences among people concerning where they are from and where they have lives and their differences of thought and life experiences."

In this study, diversity in terms of gender identity or members of the LGBTQIA+ group was not discussed as the participants never addressed such issues. Other authors have published work on LGBTQIA+ issues in STEM and chemistry (Mattheis *et al.*, 2019), and public entities have carried out science outreach events for the LGBTQIA+ community (Adler Planetarium, 2019), but this is a topic yet to be formally explored in the context of chemistry outreach.

Implications

The insights provided by the participants of this study can be used by leaders of student organizations and leaders at academic institutions to inform how to design and plan chemistry outreach activities. A suggestion is to take advantage of outreach training available online (American Chemical Society, 2019) and access publicly available resources on informal science education (Science Communication, Public Engagement, and Outreach, 2019). While informative and addressing aspects like managing volunteers, these resources lack in-depth training about diversity challenges present in planning and implementing chemistry outreach events. Therefore, this type of training should be complemented with other actions. For example, coordinators of chemistry outreach

events should plan meetings prior to the events to get to know the volunteers. While this might be more time consuming than most outreach practices, it is an effort than can benefit both the volunteer and the organization, especially if coordinators plan or meet with a specific purpose. Being aware and understanding the differences amongst members of an organization or facilitators of an outreach event can influence the organization's performance (Robbins and Judge, 2016). By being more mindful about the facilitators' needs, like language being a barrier or having difficulties engaging the audience at events, can be better addressed. By being more mindful about the facilitators' strengths, like the ability to speak more than one language, the leaders of an organization can cultivate the CoP and its boundary processes by serving a different population and adding to the repertoire of resources available to carry out outreach; Patel and Wilson (Patel and Wilson, 2019)showcase an example what this looks like in the field of Material Science and Engineering. The student organization can adopt new practices coming from the facilitator's prior experiences in outreach and their educational background. Furthermore, institutions or faculty people in charge of student organizations should design and enforce new mandatory training to help leaders develop *intercultural communication competence*. In doing so, leaders can learn how to effectively adapt verbal and nonverbal messages to the appropriate cultural context (Neuliep, 2017) and avoid discouraging participation of individuals from other cultures in the CoP.

For science and chemistry education researchers, this study sets up a starting point for in-depth studies on the role of diversity and inclusivity in informal learning environments. The use of appropriate frameworks to study abstract constructs of the community of practice framework (e.g. belongingness, identity) will expand the CER community's knowledge of student organizations participating in outreach events. If we set out to understand these student-facilitators' experiences in chemistry outreach, researchers can design well-structured training and outreach initiatives taking these into account. Ultimately, the implementation of well put-together outreach events might contribute to the efforts to recruit and retain URM in STEM fields and higher education. However, to quote Hernandez (2020), *"Student diversity must be supported by inclusion throughout the institution through systems of integration and accountability. It is not merely enough to think of diversity as metrics of educational milestones such as enrollment and education."* For faculty and professionals in higher education, findings of the study suggest that minority groups occupying leadership positions currently are not supported in the student organization. Faculty advisors of student organizations should act as champions of implementing new systems, rules, training and policies that work towards fostering an inclusive environment in science student organizations; contributing to the larger goal of increasing diversity in STEM. Additionally, our findings present evidence that being members of student organizations, planning and participating of outreach initiatives is part of the professional development of graduate students. These findings should drive forward a change of culture in academia, one in which advisors and professors treat their students' professional development through informal learning environments equally important as their students' academic development.

Conflicts of interest

There are no conflicts to declare.

Appendix A: Interview Protocol in English

Introduction

Thank you for agreeing to participate in this study on describing leadership in outreach initiatives. I have two purposes for this interview. First, we will talk about your experience working with volunteers in outreach initiatives. Second, I want to play some video clips of you and volunteers working together and have you reflect on them.

1. Please tell me about your volunteering experience.
1a. What were your goals for volunteering?
1b. Did your participation in [event name] meet your goals or expectations?
1c. What aspects did not meet your expectations?
2. How did you begin working with the volunteers for [event name]?
2a. Did you know the volunteers before the outreach event?
3. Approximately how many volunteers have you worked with before the volunteers at [event name]?
4. How do you see your role working with these volunteers?
5. Please tell me about your experiences carrying out outreach initiatives as a member of:
5a. Other student organizations you have been part of.
5b. Your current student organization.
6. Please tell me about your experiences carrying out outreach initiatives as a leader in your current student organization.
7. What other experiences inform how you lead the outreach event or your volunteer?
8. In what ways did you interact with the volunteers for [event name]?
9. What can you tell me about leadership?
9a. What is leadership to you?
9b. How do you "approach" being a leader?
10. How do you think diversity (or lack of diversity) influences:
10a. Your leadership or how you portray yourself as a leader in the organization?
10b. How outreach is being carried out?

Appendix B: Interview Protocol in Spanish

Introducción

Gracias por acceder a participar de este estudio, el cual se enfoca en describir el liderazgo en iniciativas de outreach. Tengo dos propósitos para esta entrevista. Primeramente, hablaremos de tu experiencia trabajando con voluntarios en iniciativas de outreach. Segundo, te mostraré algunos videos que te incluyen a ti y voluntarios trabajando juntos, para que reflexiones sobre los videos.

1. Por favor, háblame sobre tu experiencia como voluntario.
1a. ¿Cuáles eran tus metas para participar en el evento?
1b. ¿Tu participación [nombre del evento] cumplió con tus metas o expectativas?
1c. ¿Qué aspectos no cumplieron tus expectativas?
2. ¿Cómo comenzaste a trabajar con los voluntarios de [nombre del evento]?
2a. ¿Conocías a los voluntarios antes del evento?
2b. ¿Cómo fue el proceso de reclutar voluntarios?
3. ¿Con cuántos voluntarios, aproximadamente, habias trabajado antes de los voluntarios de [nombre del evento]?
4. ¿Cómo visualizabas tu rol trabajando con los voluntarios?
5. Por favor, háblame de tus experiencias participando en iniciativas de outreach como miembro de:
a. Otras organizaciones estudiantiles de las cuales has sido parte.
b. Tu organización estudiantil actual.
6. Por favor, háblame de tus experiencias participando en iniciativas de outreach siendo líder de tu organización estudiantil actual.
7. ¿Cuáles otras experiencias informan cómo tú lideras un evento de outreach o a los voluntarios?
8. ¿En qué maneras interactuaste con los voluntarios de [nombre del evento]?
9. ¿Qué me puedes decir de liderazgo?
9a. ¿Qué es liderazgo para ti?
9b. ¿Cómo tú exhibes tu liderazgo? ¿Cómo eres líder?
10. ¿Cómo crees que diversidad (o la falta de diversidad) influye:
10a. Tu liderazgo o como te presentas como líder en tu organización?
10b. En como outreach se lleva a cabo?

Acknowledgements

We thank the graduate students for accepting the invitation to participate in this study and for opening up about their experiences. Special thanks to Jocelyn E. Nardo for her help with data collection and valuable input on this manuscript.

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1333468. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors(s) and do not necessarily reflect the views of the National Science Foundation.

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Table 1 Contextualizing the framework Communities of Practice (CoP) in a student organization

CoP Constructs [a]	Definition informed by different literature sources [b]	Assumptions on how the construct could be present in a student organization
Domain	Shared passion or concern	A student organization with a general passion for chemistry; an organization brought together because of their status as students in chemistry
Community	The process to understand and learn more about the domain that happens by interacting with those who share the passion (i.e. domain)	When the student organization establishes frequent meetings, events or activities to have members interact and discuss "chemistry"
Practice	Tools, resources or processes that facilitate the learning of specific knowledge about the passion or concern (i.e. domain); "a way of acting in the world"	The organization attending a conference to share knowledge on specific research methods/techniques in chemistry; the organization participating of outreach events to better understand chemistry in informal environments
Participation	Core – small group who move the community along its learning agenda; as the community matures, this core group take on much of the community's leadership	Individuals who have extensive experience in the student organization or are passionate in having the organization be involved with a specific topic; maybe a leadership position that has been occupied by the same person for a long period of time
	Active – members that attend meetings regularly and participate occasionally in activities, without the regularity or intensity of the core group	Leaders who limit their participation to fulfilling responsibilities
	Peripheral – members that rarely participate; they might believe their contributions are not appropriate for the whole or carry no authority; they might not have the time to contribute more actively; should not be assumed that it is a passive involvement	Members of the student organization who attend only events of personal interest
	Outsiders – individuals that are not members but express interest in the CoP	Audience members of outreach events, hosted by the student organization, who want to become a scientist (i.e. interest in the science CoP)
Boundary Processes	Brokering – happens between CoPs to introduce components of one practice into another; consists of creating connections or establishing personal relationships between members of different CoPs;	A student organization collaboration with education practitioners or researchers to adopt practices that improve outreach
	Boundary Objects – tools, documents, models, language and shared processes that facilitate and support communication or connections between different practices	When different student organizations share processes on how to plan an outreach event
	Interactions – can happen to different degrees and take different forms: (1) to provide direct exposure to a practice and be fully immersed in it; (2) to serve people who need some service, are curious or intend to become members (i.e. Outsiders)	An expert on science communication providing training on how to communicate chemistry; planning event with the intentions of encouraging people to join STEM fields
Leadership	A community need multiple forms of leadership to play their role and help the CoP develop. Examples: thought leaders, networkers, people who document the practice, etc.	Executive board or officers of a student organization; faculty advisors of the student organization

[a] The constructs presented on this table are those particularly relevant to understanding the methodology and findings of this study.

[b] Sources include (Wenger, 2000; Wenger and McDermott RA, 2002; Smith *et al.*, 2017)

Table 1 Descriptions and examples of categories emerged from data

Category or Theme	Description	Example in data	Translation
Outreach initiatives	Participant talks about past experiences with outreach events	"So national chemistry week was absolutely a lot but also incredibly rewarding and I got to see a very different aspect of planning and organizing and whatever. With girl scout day, it's a lot more relax. And I would say it was a lot less pressure."	-----
Educational Background	Participant talked about their own different educational background, differences between education systems across cultures or nations, experiences as instructors, etc.	"…specifically, for that, it reminded me when I teach lab with my students when they freak out because something didn't go right. […] If something weird happened or didn't work, a lot of the time, I'll be like, "That's okay. Think through how you guys did your procedure. Tell me where you think something went from to get the results you got instead. […]"	-----
Gender	Participant addresses situations concerning women in science, women in STEM fields and/or other gender issues in STEM	"Si tú estás en una asociación que son todas mujeres – especialmente porque las mujeres siempre la ciencia las han echado a un lado, todavia no crea que tenemos misma paga en todo sitio – que es una asociación de empoderamiento.""	"If you are in a society where everyone is a woman – especially because women have always been marginalized in science, I don't think we have the same pay everywhere – I think it's a society of empowerment."
Race/Ethnicity (combined language and culture)	Participant alluded to ideas pertaining race, cultural background, experiences as minorities, ethnicity, language, etc.	"Puede ser complicado en cuestión de 'el inglés es mi segundo idioma', si me estoy haciendo entender. No por el acento sino si me estoy hacienda entender con ella. También puede influir en el tipo de conexión porque yo no sé mucho de Estados Unidos, de la cultura, etc. Preguntarle a ella [girl scout] en qué escuela estudió, o en qué ambiente, no significa nada para mi."	"It can be complicated in terms of 'English is my second language', if I'm making myself understood. Not so much the accent but if I'm being understood by her. It can also influence the type of connection because I don't know much about the United States, the culture, etc. Asking her [girl scout] which school did she go to, or which environment, means nothing to me."

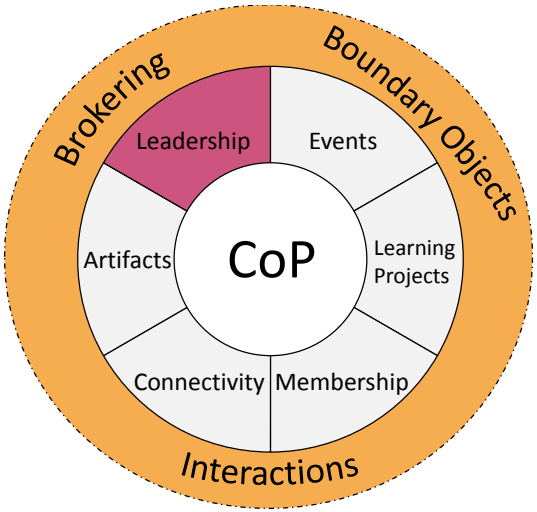

Fig. 1 Elements and boundary processes that characterize a community of practice

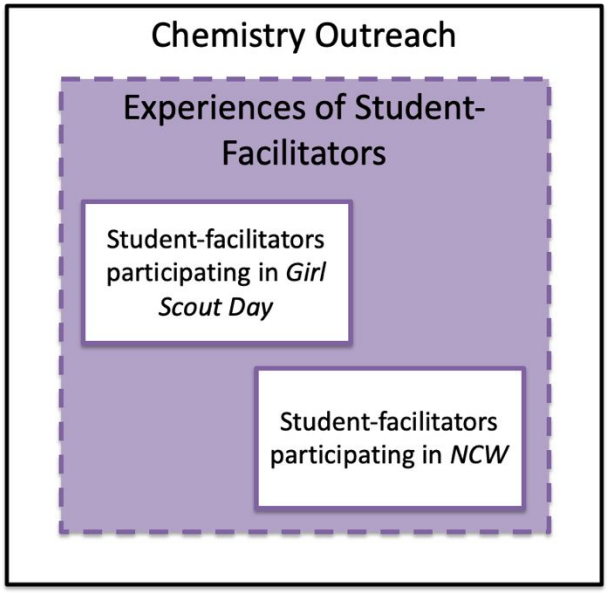

Fig. 2 Single case study with embedded units, adapted from Yin (2014)