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**An All-Female Graduate Student Organization Participating
in Chemistry Outreach: A Case Study Characterizing
Leadership in the Community of Practice**

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An All-Female Graduate Student Organization Participating in Chemistry Outreach: A Case Study Characterizing Leadership in the Community of Practice

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Outreach initiatives are typically framed as informal learning environments that provide an opportunity to increase the participants' interest in science. Research on chemistry outreach has primarily focused on designing and implementing demonstrations for outreach. Recent studies indicate student organizations are at the forefront of chemistry outreach, describing their outreach practices and facilitators' conceptual understanding of demonstrations. Although leadership has been linked to the success of groups and organizations, the leadership structure of student organizations is an understudied aspect of chemistry outreach. Here, we conceptualize student organizations participating in chemistry outreach as a community of practice (CoP) with the goal of expanding the chemistry education community's knowledge of this CoP. Specifically, we aim to characterize leadership styles within the student organization in the context of an outreach event. Using a case study approach, we collected multiple sources of data, including the organization's outreach practices, an assessment of leadership style, observations, and semi-structured interviews. Results indicate leaders of the student organization, particularly those in charge of planning outreach events, displayed behaviors associated with the transactional and laissez-faire leadership styles more frequently than behaviors associated with the transformational leadership style. As a long-term outcome for this study, the results can be used by national organizations to inform the development of new workshops for leadership training, with the purpose of teaching practices to leaders that can bring success to their chapter or local group.

Introduction

The report titled *Effective Chemistry Communication in Informal Environments* (Committee on Communicating Chemistry in Informal Settings *et al.*, 2016) offers the informal science education community a *Framework for Communicating Chemistry*. This framework is a five-element guide to design and implement "chemistry communication activities", a term encompassing the majority of the outreach events carried out by the scientific community. The five-elements are:

Element 1: Set communication goals and outcomes appropriate to the target participants

Element 2: Identify and familiarize yourself with your resources

Element 3: Design the communication activity and how it will be evaluated

Element 4: Communicate!

Element 5: Assess, reflect and follow up

Most chemistry outreach activities focus on designing the activity with content-related goals and implementing the outreach activity, focusing on Elements 1, 3 and 4. However, there is a lack of information on resources (i.e. Element 2), specifically of facilitators of outreach events as resources.

Facilitators as an aspect of outreach has been the least frequently discussed element of outreach activities in the chemistry outreach literature. There is little mention regarding who designed the activities, who carried out the demonstrations, expertise, prior experiences, role in outreach events, etc. Typically, facilitators were described in general terms as scientists (Brown *et al.*, 2017), tutors (Flynn *et al.*, 2017), graduate and postdoctoral researchers (Ting *et al.*, 2017), or female role models, referring to female professors, postdocs, and graduate and undergraduate students (Levine *et al.*, 2015). While other authors were also vague in describing the facilitators, some were clearer about the role of the facilitators (Schwarz *et al.*, 2016; Ting *et al.*, 2017) by stating how the facilitators were involved in the planning or the facilitator's background, for example.

There are some exceptions to the details provided about the facilitators. A previous study with college student organizations involved in chemistry outreach shared the purpose for students, faculty and staff to engage in chemistry outreach activities: to learn chemistry, for the audience to see that chemistry is fun, and for students to develop into scientists (Pratt and Yezierski,

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2018). Houck et al. (2014) explicitly stated all aspects concerning the organization of their one-day camp were managed by unpaid, graduate and undergraduate student volunteers who carried out the experiments, attended meetings with safety coordinators, and developed the lesson plans and worksheets. As for the course by Sewry and Paphitis (2018), graduate students enrolled in the course carried out the outreach activities at schools, had to participate in debriefing meetings after each school visit, and submitted a reflection.

There are other activities that exemplify how participating in chemistry outreach events can potentially be opportunities for students to “develop leadership, communication and professional competencies”, which is part of the core educational elements outlined in the report titled *Graduate STEM Education for the 21st Century* (Committee on Revitalizing Graduate STEM Education for the 21st Century et al., 2018). Carpenter’s (2015) work in outreach focused on understanding undergraduate students’ perspectives and ideas about science teaching and learning, as facilitators of outreach. These students participated in outreach events throughout multiple years, for a total of over 100 hours. Some outcomes of these students participating in outreach involved developing leadership and communication skills, learning how to teach different populations and increased interest in science. Additionally, Gagnon and Komor (2017) documented that facilitators benefit from outreach by having a feeling of belonging and engagement and having an increase in self-confidence in communicating science.

Pratt and Yeziarski (2018) pointed out that student organizations are leading chemistry outreach efforts, which means these students are the ones acting as facilitators of outreach events and/or recruiting volunteers to act as such. Moreover, Kuk and Banning (2010) argue that student organizations are important components of student involvement and serve as agents to advance goals of college campuses. For these reasons, it is worth studying the leadership structure these student organizations have, how the structure drives the outreach efforts they participate in, the role of diversity and inclusion in practices pertaining outreach events, and current facilitators’ experiences in outreach.

In order to expand our knowledge about chemistry outreach, specifically the relationship between leadership and facilitators of chemistry communication activities, here we conceptualize student organizations participating in outreach as a community of practice (CoP).

Guiding Theoretical Framework: Communities of Practice

The *Effective Chemistry Communication in Informal Environments* states “Collaborations –between chemists and experts in science communication, informal science learning, and chemistry education– not only support communication events but also build a community of practice that shares common goals and effective practices for communicating chemistry.” (Committee on Communicating Chemistry in

Informal Settings et al., 2016). To that end, this study was designed and developed with the assumption that student organizations implementing and participating in chemistry outreach events are a community of practice (CoP). The remainder of this section summarizes constructs that supports this choice; a more detailed explanation has been provided in our earlier publication (Santos-Díaz and Towns, 2020).

For this study, we defined a CoP as “... 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 et al., 2002). This definition brings together three constructs that constitute a CoP: a domain, the community and the practice. The members of a CoP have a shared competence pertaining a specific passion or concern (i.e. domain) and interact in an ongoing basis (i.e. community) through events, joint activities and discussions to develop that competence. The practice refers to tools and processes that help CoP members deepen their understanding about the domain.

While the definition of a CoP has changed throughout the years, Wenger (Wenger et al., 2002) points out “doable” actions or elements that characterize a CoP: leadership, events, connectivity, membership, projects, and artifacts. It is important to highlight that the study presented in this manuscript focuses on the element of leadership. According to Wenger, *leadership* is way to help the CoP develop, with multiple forms for leaders needed (Wenger et al., 2002). This term will be further operationalized in the section *Guiding Analytical Framework*. In addition to these doable actions, a CoP also has boundaries as shown in Fig. 1. *Boundary processes* are where competence and experience tend to diverge. The processes taking place at the boundary are boundary objects, brokering and interactions among people from different CoPs. Boundary processes of the CoP were also explored in this study, as it is at the boundary where individuals of the community attempt to connect to individuals outside of the CoP.

[INSERT Figure 1]

In the context of science education, and this study, we conceive of groups of people participating in outreach are a community of practice. To narrow the scope of the study, the design element explored was *leadership*. While equally important in a CoP, the rest of the elements encompass other aspects of the community participating in outreach that might not directly involve facilitators of outreach events. Table 1 summarizes how student organizations participating in chemistry outreach can be considered a CoP, based on the elements and boundary processes explored in this study.

[INSERT Table 1]

Guiding Analytical Framework: Full-Range Leadership Theory

Communities of Practice as a theoretical framework presents certain limitations and is considered highly abstract, in the

sense that it does not describe how the elements of a CoP or the processes happening at the boundaries interact with each other. Therefore, we selected a second framework, one used in leadership studies, to expand and build on CoP as a theoretical framework.

Leadership is “the process of influencing others to understand and agree about what needs to be done and how to do it, and the process of facilitating individual and collective efforts to accomplish shared objectives.” (Yukl, 2010) Given this definition of leadership, it is a safe assumption that there are numerous leadership styles. Leadership styles are ways in which leadership is enacted or the “...total pattern of explicit and implicit actions performed by the leader...” (Newstrom, 2011). Theories related to leadership styles, as is the *Full-Range Leadership Theory* (FRLT), have been used in other fields to describe management dynamics in businesses, religious non-profit organizations, health authorities, group of librarians, and corporate industries (Sosik and Godshalk, 2000; Tarsik *et al.*, 2014; Chan and Du-Babcock, 2018; Gilbert and Kelloway, 2018). Analysis informed by leadership styles has not yet been applied to student-run organizations, STEM outreach or chemistry education contexts. The FRLT will be used to identify behaviors in leaders and classify them according to the three leadership styles: transformational, transactional, and laissez-faire.

Transformational Leadership Style

Transformational leadership has been found to influence job performance positively (Khan *et al.*, 2014; Pourbarkhordari *et al.*, 2016). Regarding innovation, previous research with Iranian companies shows the elements of transformational leadership style foster organizational innovation (Mokhber *et al.*, 2015). Research in public and private sectors in Dubai also have shown that transformational leadership positively correlates with intra-organizational innovation (Alsalami and Behery, 2014). In general terms, transformational leaders help followers develop their full potential by stimulating them intellectually and enhancing their creativity (Tarsik *et al.*, 2014). Leadership characterized by this style can result in individual and group performance that exceeds expectations. Some behaviors associated with transformational leadership are idealized influence, inspirational motivation, intellectual stimulation and individualized consideration. Antonakis *et al.* (2013) define the behaviors or factors of transformational leadership as follows:

1. idealized influence, attributed (IIA): the socialized charisma, whether the leader is perceived and viewed as confident, powerful, focusing on high-order ideals and ethics;
2. idealized influence, behavior (IIB): the charismatic actions of the leader that are centered on values, beliefs, and a sense of mission;
3. inspirational motivation (IM): the ways leaders energize their followers by viewing the future with optimism, stressing ambiguous goals, projecting an idealized vision, and communicating to followers that the vision is achievable;

4. intellectual stimulation (IS): leader actions that appeal to the followers’ sense of logic and analysis by challenging followers to think creatively and find solutions to difficult problems;
5. individualized consideration (IC): leader behavior that contributes to follower satisfaction by advising, supporting, and paying attention to the individual needs of followers, which allows them to develop and self-actualize.

Transactional Leadership Style

When discussing a transactional leadership style, previous work (Sosik and Godshalk, 2000) showed that a transactional style has no impact on job-related stress and no impact on organizational climate or innovation. As the name implies, a transactional style leader focuses on the follower’s self-interest (Avolio and Bass, 2002) and motivates the follower by describing materialistic rewards upon goal achievement (Tarsik *et al.*, 2014). Here, the leader sets goals, clarifies desired outcomes and provides rewards and recognitions for accomplishments when they are deserved (Sosik and Godshalk, 2000). By clearly communicating performance expectations, a transactional style behavior reduces feelings of uncertainty in followers (Sims and Lorenzi, 1992). To summarize, the three characteristics associated to transactional leadership are contingent reward, management-by-exception active, and management-by-exception passive (Antonakis *et al.*, 2003; Tarsik *et al.*, 2014). Antonakis *et al.* (2013) define these characteristics as:

1. contingent reward (CR): leaders behaviors focused on clarifying role and task requirements and providing followers with material or psychological rewards contingent on the fulfillment of contractual obligations;
2. management-by-exception, active (MBE-A): the active vigilance of a leader whose goal is to ensure that standards are met;
3. management-by-exception, passive (MBE-P): leaders only intervene after noncompliance has occurred or when mistakes have already happened.

Laissez-faire Leadership Style

Lastly, a laissez-faire (LF) leadership style, as defined by Tarsik *et al.* (2014), is one in which the manager provides minimal direction, giving the employees as much freedom as possible. This style is characterized by delays of action, absence, and indifference (Sosik and Godshalk, 2000). Also known as “hands-off” style (Tarsik *et al.*, 2014), the LF leadership style has been reported to intensify job related stress (Sosik and Godshalk, 2000). These findings align with Avolio & Bass (2002) who described the LF style as resulting in less concentration on work, poor quality of work, as well as low levels of productivity, cohesiveness, and satisfaction. In relation to followers, a leader with LF behavior provides no meaning or clarification of events for followers, which is interpreted as lack of communication,

undermining the follower's trust in the leader (Podsakoff *et al.*, 1990). This type of leader delegates decision-making to the followers (Tarsik *et al.*, 2014) or, in other words, the leaders choose to avoid taking action (Antonakis *et al.*, 2003).

Leadership Outcomes

According to the FRLT, the success of a group is determined by outcomes, or results, of leadership behaviour (Avolio and Bass, 2004; Landis *et al.*, 2014). These outcomes are measured in terms of extra effort, effectiveness and satisfaction. Extra effort entails getting others to do more than they expected to do, heightening others' desire to succeed and increasing others' willingness to try harder. Effectiveness refers to adequately meeting organizational requirements and representing their group to higher authorities and essentially leading a group that is effective. Satisfaction is defined in terms of using methods of leadership that are satisfying and working with others in a satisfactory way. Based on FRLT and published studies on leadership styles, more effective and active behaviors lead to favorable leadership outcomes. This idea is portrayed in Fig. 2.

[Insert Figure 2]

Since many outreach initiatives in chemistry are carried out by student organizations, the interactions between leaders of student organizations and volunteers of outreach events should be investigated. This study aims to expand the knowledge on chemistry outreach efforts by studying the leaders in charge of coordinating outreach events. Specifically, by studying how leaders' behaviors and characteristics, as described by FRLT, are present in leader-volunteer interactions and group dynamics in chemistry outreach events.

Research Question

Here, we aim to address the research question: How can leadership styles and leadership outcomes be characterized within student organizations participating in chemistry outreach? As described in the next section, we adopted a case study methodology which calls for data collection from multiple sources, employing both qualitative and quantitative methodologies.

Methods

A case study methodology was deemed appropriate for this study because 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). Given that each student organization and all they encompass is unique (i.e., leadership structure, affiliations, recognitions, membership, leadership styles, etc.), case study is an appropriate approach to address the research questions presented earlier. In addition, Yukl (2010) in *Leadership in Organizations* suggests the use of

case study design for leadership studies because of the extensive descriptive nature of this methodology.

The study presented in this manuscript was designed as an exploratory, multiple case study, per the guidelines provided by Baxter and Jack (2008). The unit of analysis, or case, is defined as the leaders of student organizations participating in chemistry outreach events. The cases are bounded by the specific events in which the leaders participated as the context. It is important to note that, while the multiple case study design lends itself for comparisons across cases, the goal of this study does not call for a comparison across leaders. The research question is addressed by characterizing leadership styles and the intention is not to compare and evaluate the leadership styles.

This study and all protocols (i.e. recruitment of participants, stages of data collection and data analysis) were approved by the academic institution's Institutional Review Board (IRB).

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 had student organizations that participate in chemistry outreach events. The participants for all cases were recruited from chemistry student organizations at a research-intensive (R1) institution in the United States. The institution has four chemistry student organizations, two at the undergraduate level and two at the graduate level. Three of these organizations were contacted to extend the invitation to participate in the study. Out of the three, one student organization agreed to participate in the study: an all-female, graduate student organization. The participants recruited for the study were students leading outreach efforts and students volunteering to carry out the outreach effort. To recruit participants, the researcher first contacted the "Outreach Committee" within the board of the student organization. If the sample was deemed too small (i.e. the members of the outreach committee decided to not participate of the study), the invitation to participate in the study would be extended to other leaders of the student organization. To recruit non-leader, facilitators of the chemistry outreach event, we engaged in snowball sampling (Merriam and Tisdell, 2016). This recruiting technique consists of individuals that had already been contacted to participate in the study referring the researcher to other individuals who could be potential participants in the study.

Those participants who fulfilled both roles as leaders and volunteers were treated as leaders throughout this study. Since there is no standard leadership structure for student organizations, the number of participants per case varied. The students' majors and year in studies may have varied across organizations, and while this information could have been relevant during data interpretation, major and year in studies did not limit the recruitment of participants.

All participation was voluntary as the participants did not receive incentives for participating in the study. To protect the leaders and volunteers' identities, pseudonyms were assigned

to the participants. Specific details for each participant will be discussed in the Findings section, alongside pertinent context for each case.

Data Collection

Common data sources for leadership studies and case studies include interviews, observations, artifacts, and questionnaires (Yukl, 2010; Yin, 2014). The study involved four data collection stages: a survey to characterize outreach practices, observations at different instances before and during the 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.

Survey. The information collected from the survey Characterizing Collegiate Organization's Chemistry Outreach Practices (Pratt and Yeziarski, 2018) informed the context of the study and provided descriptive information (i.e., number of members, affiliations, organizational standing) regarding the participating student organization, their outreach efforts, and general practices. Pratt and Yeziarski (2018) developed the survey used in this study and it was designed for students, faculty, and staff members. The survey items addressed topics such as the purpose of outreach, specific practices and activities, and success and evaluation. While no significant modifications were made to the survey, some vocabulary was edited to tailor the survey to this study. For this study, the survey was set up in an online survey platform (Qualtrics) and sent to the leader-participants months before their outreach event. This survey was administered only to leader-participants as they were deemed to provide more accurate information on the organization's practices.

Video recordings and Interviews. Observations and interviews were used to identify the behaviors of leaders, to compare and examine how these align with results from the Multifactor Leadership Questionnaire, described later in this section. A video-stimulated recall technique (DeKorver, 2016; Johnson, 2017) was the observation and interview approach used for case one. The organization only met with volunteers the day of the outreach event. On this day, the leader-participants and their interactions with other facilitators of the outreach event, including volunteer-participants, were audio-recorded. The leader-participants wore a microphone and audio recorder for 4 hours of the 8-hour long outreach event. The volunteer-participants were audio-recorded at the same time as well. While the volunteer-participants are not the focus of this study, their interactions and experiences with leaders in the outreach event are important in describing the leadership in student organizations. All participants were asked to wear the recorder as soon as they arrived at the event; by doing so, the audio was able to capture pre-event interactions between leaders and volunteers. In order to capture visuals of the leader-participant interactions with others, different cameras were set up in the laboratory space where three of the hands-on experiments took place. The video and audio from the recording were used to take observations of leaders' actions and dialogue with the volunteers. From the recordings, certain clips were

selected to guide the interview and facilitate questions to yield data related to leadership styles, addressing the research question. During the interview for participants in case one, the specific clips were shown to the participant to prompt responses that describe their decision-making and behaviors (Calderhead, 1981). Due to scheduling conflicts and the location of events, video recordings were not collected for case two. To compliment the audio-recordings, extensive and thorough notes about leader-volunteer interactions were taken at the events and specific instances were addressed during the interview.

The semi-structured interview protocols (Appendix A and Appendix B) were similar to the ones used for a published case study on mentor-student interactions (Johnson, 2017). The leaders responded to questions that involved recalling and reflecting about their own actions and interactions, while volunteers provided insight about their interactions with the leaders. All participants were interviewed within six weeks after they attended the outreach event. We acknowledge interviews closer to the 6-week mark may have an impact on the recollection of events, but this timing was based on the availability of each participant.

The interviews lasted around 2 hours; and, if Spanish was the participant's first language, the participant had the option of being interviewed in Spanish (the researcher's native language). Two participants preferred to be interviewed in their first language; therefore, the interview protocol is included in English and Spanish (see Appendix B). Being interviewed in their first language helped the researcher build rapport with the participants. Having the option to be interviewed in Spanish established a common ground between the participant and the researcher (i.e. rapport) and, 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). All interviews were transcribed using a transcription service for English and Spanish text.

Leadership Styles Questionnaire. The Multifactor Leadership Questionnaire (MLQ) was used to identify behaviors associated with different leadership styles in leaders and to determine leadership outcomes. The MLQ was developed by Avolio and Bass (2004) to assess the leadership styles and outcomes presented in the FRLT, through items pertaining to the leaders' interactions with their followers. The Likert-scale format items included in the questionnaire are associated to a specific factor (those described in the *Guiding Analytical Framework* section) or characteristics of leadership styles. Specifically, there are four questions per leadership style behavior and nine questions for leadership outcomes, for a total of 45-items. The respondent's scores for specific items are summed and averaged to determine factors scores. Due to copyright and use license, the MLQ is not included on this manuscript.

The MLQ, also referred to in the literature as MLQ-5X, has been widely adopted by researchers (Sosik and Godshalk, 2000; Antonakis *et al.*, 2003; Eagly *et al.*, 2003; Toor and Ofori, 2009;

Bligh *et al.*, 2018; Gilbert and Kelloway, 2018) because its validity has been well assessed (Antonakis *et al.*, 2003; Sosik & Godshalk, 2000). In addition, the MLQ includes two forms, the leader form and the rater form. The leader form is a self-assessment for leaders, whereas the rater form is completed by volunteers to assess their leaders. In order to make the MLQ accessible to participants, the questionnaire was set up in Qualtrics and administered to the participants after the interviews were finished. The intention in doing this was to use the interview to understand the participants' thoughts on leadership without the influence of the content of the MLQ. Here, the leaders completed the leader self-rate form and the volunteers completed the rater form. The rater form includes the same statements but from a third person perspective.

Artifacts. Understanding what leaders and volunteers are doing at the outreach event can provide descriptive information about their interaction and the context of the case study. Therefore, several artifacts were collected for this study. Specifically, those related to leader-volunteer interactions and the leader's involvement in the event. The artifacts for this study included handouts prepared by student organizations explaining the demonstrations for the event, and written communications sent from leaders to volunteers providing insight regarding how the leaders and organizations operate.

Data Analysis

The setting for each outreach event and instances of leader-volunteer interactions varied per case, requiring methods for data collection to adapt to the situation. However, data analysis was consistent to what is described below.

Analysis of Observational and Interview Data. The observations (*i.e.*, video- and audio-recordings), the written communications from leaders to volunteers and the interviews were deductively coded (Merriam & Tisdell, 2016) using the leadership styles behaviors presented by Avolio and Bass (2004). The descriptions for each code were informed by reports throughout the literature. Throughout the data analysis process, the code "Absent/Missed Opportunity" emerged inductively from the data. This code described instances in which the leader-participants could have addressed a situation differently, could have displayed a more effective behavior associated with leadership styles or the leader's actions were misaligned with volunteer-participants' expectations. The interviews in Spanish were coded in said language and then the coded excerpts were translated to English by the first author.

Inter-rater reliability was carried out with a chemistry education researcher not involved in the design of the study. A set of randomly selected excerpts, from observations and interviews, and the descriptions for each code was sent to the other researcher. After coding the excerpts, these were compared to the main researcher's coding scheme to determine if the codes accurately represent the data. Whenever discrepancies happened, the researchers discussed the coding of excerpts until reaching an agreement.

The pilot study, presented as case one, was used to achieve interrater reliability to then use the same codes to analyze data

for case two. Table 2 shows all codes used for data analysis, its description and examples of how codes are present in the data.

[INSERT TABLE 2]

Analysis of Quantitative Data. The results for the MLQ were analyzed according to the guide published with the questionnaires (Avolio and Bass, 2004). The values obtained from the self-rate forms were compared with the average values obtained by the rater forms using radial plots, with each line in the radial plot representing a point on the MLQ rating scale. There are two radial plots per participant, one for leadership styles and one for leadership outcomes. Starting at the center of the plot and moving to the outside, the scale is as follows:

- 0.0 = Not at all
- 1.0 = Once in a while
- 2.0 = Sometimes
- 3.0 = Fairly often
- 4.0 = Frequently, if not always

As discussed in the section *Guiding Analytical Framework* of this manuscript, leaders with transformational behaviors tend to positively impact the organization and their followers, which is represented through the MLQ by scores close to 4.0 for items corresponding to IIA, IIB, IM, IS, and IC. Behaviors associated to transactional and *laissez-faire* leadership styles tend to have less of a positive impact on organizations. Therefore, MLQ scores close to 4.0 for items corresponding to CR, MBE-A, MBE-P and LF are interpreted as negative because it means the participant frequently or fairly often displays those behaviors. These ideas are better illustrated with the radial plot in Fig. 3. The data line shows an "ideal plot" or trendline, not to be interpreted as data from the study, based on the ideas presented in Fig. 2. The use of radial plots was specifically developed for this study to visualize the MLQ results and elicit trends.

[INSERT FIGURE 3]

Trustworthiness and Authenticity. The strategies of Merriam and Tisdell (2016) were used to address the trustworthiness and authenticity of data. Credibility and consistency were addressed through interrater reliability, triangulation through multiple data sources (Yin 2014), and a member check (Merriam and Tisdell, 2016). Peer review was discussed as interrater reliability in the section *Analysis of Observational & Interview Data*. Triangulation was facilitated by the use of multiple sources of data collection aimed to corroborate findings (Yin, 2014). The process for member checks involved sharing preliminary findings with the participants. Via informal discussions or meetings, the participants gave feedback on the researcher's interpretation on the data associated to them as participants. To further address consistency, the researcher recorded memos throughout the research decision-making process in order to provide a detailed account of how the study was conducted and

how data was analysed (i.e. an audit trail) (Merriam & Tisdell, 2016).

Findings

Case One: Leaders in Girl Scout Chemistry Discovery Day

Participants

Three leader-participants of a graduate student organization agreed to participate in the study and were assigned the pseudonyms: Iris, Caitlin and Cecilia. Felicity and Nora (pseudonyms) were two volunteer-participants working at the outreach event who agreed to participate in the study. Nora was a member of the graduate student organization, while Felicity was not. The volunteer-participants were recruited after the leader-participants and prior to the event, with no intention of collecting leader-volunteer paired data. While this increased the risk of not having interactions between participants, it reduced the risk of volunteer-participants feeling targeted for recruitment because they interacted with specific leader-participants.

Context

Iris, Caitlin and Cecilia were members of an all-female chemistry graduate student organization who were part of the "Outreach Committee" within the board of the organization. The student organization participates in one to two chemistry outreach events throughout the Fall and Spring semesters but does not participate in outreach events during the summer. During the Spring semester, the organization plans *Girl Scout Day*; an outreach event that was expected to serve around 40-75 girl scouts ranging from 4th to 8th grade and 20-25 female volunteers. It is important to note for this year's *Girl Scout Day* 13 girls attended the event and 16 graduate students volunteered as facilitators during the event. Due to the small number of attendees, the leaders decided to change the *Girl Scout Day* event from being a large group of girls led by a graduate student to a "graduate student buddy" system, which is a one-on-one structure that paired one girl scout with a graduate student volunteer. Regarding leader-volunteer interactions, the organization did not plan another instance of potential leader-volunteer interactions besides the day of the outreach event. Communications between leaders and volunteers happened mainly via email.

Leadership Styles and Outcomes Characterized

Iris. Out of the three members of the Outreach Committee, Iris was the only member to volunteer as a "graduate student buddy." This was not planned beforehand, instead it was described as a last-minute decision because more volunteers were needed for the morning session. As part of the Outreach Committee, Iris was involved in the process to select the demonstrations for the event, the process of developing the

experiment guide for *Girl Scout Day*, and the overall structure of the event. Iris defined leadership as: "A leader is someone who can— they lead the group but not from the front. It's kind of like a shepherd. You're getting everyone together to work towards your goals and get everyone on the same page. You're not making all the decisions by yourself. You're not giving out orders. [...] Everything is very democratic. You all get a say and then we split responsibilities." The radial plot comparing self-rate (solid line) and rater (dashed line) results for the MLQ are shown in Fig. 4 and Fig. 5.

[INSERT FIGURE 4 and FIGURE 5]

Iris' plot for self-rating shows a high score for behaviors associated with a transformational leadership style. Self-rating scores for the other behaviors were lower than the transformational behaviors. The raters' scores for Iris are similar to the self-rate score for behaviors *Idealized Influence*, *attribute* and *laissez-faire*, which are at opposite sides of the spectrum. Raters assigned lower scores than Iris' self-rate scores for most behaviors, except *Management-by-Exception, passive* (MBE-P). Altogether, the MLQ results indicate the volunteer-participants do not perceive Iris as the leader she believes she is in the context of doing chemistry outreach with the student organization under study. In contrast to the self-rate MLQ results, the behaviors identified throughout Iris' interview were those associated with *transactional* and *laissez-faire* leadership styles. Iris did not display transformational behaviors frequently; hence, when considering what the FRLT stipulates about leadership behaviors and its associated outcomes, the Iris's MLQ results for outcomes were expected.

When it came to recruiting volunteers for the outreach event, Iris compared the current experience to experiences in undergrad: "... I feel back then it was a lot easier to wrangle volunteers because I knew everyone because they were all in my department. I already knew them because they were either in classes with me or worked in my friends' lab. It was a lot smaller of a community. So, getting people to do things is a lot easier to negotiate because everyone knew each other already. [...] Here, I don't have that leverage anymore to get people to help. [...] you're just asking people to help out of the goodness of your heart."

Iris then added: "... we get a t-shirt for the volunteers and food to get them to volunteer. That's what we leverage." Iris acknowledged that, in a larger community, material incentives are the go-to for recruiting graduate students to help with the outreach event. While her statement supports Iris' low rating of CR behavior, it is also a missed opportunity to display more *transformational*-like behaviors and explains the discrepancies between self-rate and raters' results for behaviors associated to a *transformational* leadership style.

Iris acknowledged that communication between Outreach Committee members was poor. While this represents a *laissez-faire* behavior on behalf of other members and herself, Iris' actions to solve issues arising from lack of communication and clarity aligned with some transformational behaviors. For example, the student organization: "... invites a university

employee to come in the morning of the event and give a safety talk to the kids but they couldn't do it that day. So, the night before I was like 'Did anyone write up a safety talk?' and I was informed 'No, I was going to wing it.' by (another leader) to which I responded 'No, no, no; these are kids in a chemistry lab.' So, we ended up showing them a short video on lab safety I found on YouTube."

With her actions, Iris ensured standards were met which is associated to *Management-by-exception (active)* (MBE-A). Another example is when Iris set up experiment stations, observed by the researcher on the day-of-event. Iris had to find materials in bins prepared by another leader and, in doing so, realized materials were mislabeled or missing. Iris displayed MBE-P behaviors by intervening in issues related to materials when mistakes had already happened.

Caitlin. Throughout the planning of the outreach event, Caitlin was the leader who sent out communications to the volunteers. Per observations during the day of the outreach event, Caitlin fulfilled different roles like welcoming volunteers, giving instructions to the volunteers before the event started, welcoming attendees, and led most of the discussions of experiments performed that day.

Caitlin defines leadership as: "... a leader leads by example, and they shouldn't ask anyone to do something that they're not willing to do themselves. A leader, at the core of it, is an organizer that also has the ability to discern what everyone's specific talents are and put them to best use. [...] It's just someone that steps up to run the show. [...] I try to give everyone an opportunity to step up and improve. But, if things aren't getting done, I will step in and do them."

The radial plot comparing self-rate (solid line) and rater (dashed line) results for the MLQ is shown in Fig. 6 and Fig. 7. Except for IIA, the volunteer-participants rated Caitlin with lower scores than what she perceived herself.

[INSERT FIGURE 6 and FIGURE 7]

Email communications, sent on behalf of Caitlin, were mainly an example of *Contingent Reward* (CR) behavior. Aside information pertaining the location and date of the event, the emails stated: "... Experiment materials and procedures will be provided along with a free T-shirt and either breakfast or lunch. ..." These materials (i.e., food and shirt) were used as "rewards" to encourage graduate students to volunteer as facilitators of the outreach event. During their interview, volunteer-participants expressed they do not need these rewards to be motivated to participate in the organization's events: "[...] I see this event as an opportunity to contribute a little something to a person who might want to study science in the future. For them to realize 'This is cool.', for them to like it and want to pursue it. I don't participate of these events because there's food or free t-shirts or anything of the sort. I wouldn't have woken up at 7:30am to do that. I did it because I want to do something positive for society."

As thoroughly discussed in Santos-Díaz and Towns (2020), the facilitators volunteer for *Girl Scout Day*, and other outreach

events, to be a role model to younger girls, to give back to the community and to contribute to the efforts of learning through outreach. The misalignment of what leaders think about their volunteers' motivation versus the volunteers' true motivation to participate in outreach is a leader's missed opportunity to exhibit *transformational* behaviors. These behaviors could have been *Idealized Influence (behavior)* (IIB) to have actions be centered on a sense of mission or *Inspirational Motivation* (IM) to energize the followers by communicating to them that their vision is achievable.

Caitlin displayed *Individualized Consideration* (IC) behaviors when she encouraged another leader to explain one of the experiments the Girl Scouts were doing: "... I want to give everyone the opportunity to learn and improve. Just because you're not good at something, doesn't mean that you have to stay not good at it forever. We can also work on that. I try to give everyone an opportunity to step up and improve. [...] She was kind of on the side, not fully engaged, so I wanted to give her the chance to do that. I know that the talking and explaining is not the easiest for her, because she is a little bit more soft-spoken. So, I wanted to give her the chance to do that ...". Caitlin understood the other leader thought of the outreach event as a space for professional development to improve public speaking skills. However, interviews and observations explain the differences observed for *Individual Consideration* (IC) in Fig. 6.

According to MLQ results, Caitlin's leadership influenced the volunteer-participants' effort to be more than expected (Fig. 7). Yet, based on interviews with volunteers, Caitlin missed opportunities to display more transformational behaviors throughout her interactions with the volunteers. One of these instances was Caitlin's short speech to the volunteers before the Girl Scouts arrived. In her speech, she stated the purpose of the event was to have fun and, in addition to telling the volunteers to not worry about things going wrong, she mentioned: "... Oh yeah, so we're just rolling with it today. Okay? Just have fun. That's pretty much it." Felicity, a first-time volunteer of *Girl Scout Day*, thought this speech was taking a different direction: "... I was hoping for clear instructions on what we were supposed to do. I was like 'What the heck? I don't understand any of the things that we're supposed to do today'. I think that before starting the event and before the audience arrived, they [the leaders] should have been like 'Okay, we're in charge of the event, this is what we have to do and this each person's role.' Just give specific details about our roles." Felicity had no idea of what to expect from the outreach event or what was her role in it, which comes from *laissez-faire* behaviors from Caitlin and other leaders. Paying attention to the individual needs of the follower (IC), energizing the followers by stressing ambiguous goals (IM) or being confident and focusing on high-order ideals (IIA) are some of the behaviors that could have been more readily implemented into the pre-event speech that could have helped first-time volunteers.

Cecilia. For Cecilia, leadership is: "... understanding the characteristics/traits and weaknesses of the group you are working with for all of you to reach—to be able to guide the group so everyone can reach a common goal." The radial plot

comparing self-rate (solid line) and rater (dashed line) results for the MLQ are shown in Fig. 8 and Fig. 9.

[INSERT FIGURE 8 and FIGURE 9]

Cecilia's rater scores were lower than self-rate scores, except for *Idealized Influence (attribute)* and *Management by exception (passive)*. Contrary to what was found for the other leader participants, for Cecilia the difference between self-rate and rater score for each behavior is less than 1.0. This means Cecilia and the raters have similar perceptions about Cecilia's leadership styles, but the frequency of these behaviors was perceived as less by the volunteers. The MLQ reflects when, as part of the interview, Cecilia acknowledged: "... I wasn't interested in competing for being perceived as the leader of the group. If I felt or noticed someone else wanted to, I would let them do that [...] But also, for me it has been more difficult to adapt here or portray myself 100% as I was in my home country. ..." This could also explain the difference in the outcomes of her behaviors compared to how she was perceived by volunteers.

Cecilia's highest self-rate behavior was *Intellectual Stimulation (IS)*. Throughout the interview, Cecilia shared the following about not having a formal training session for facilitators of Girl Scout Day: "There wasn't a specific week for us to train volunteers. I thought that was wrong, I think we should aim to have a detailed and in-depth discussion of the experiments with the volunteers."

When describing prior science experiences, Cecilia said: "... When I was in science academy group, we had girls between 8-11 years old do hands-on experiments about relatively complex topics and the girls were able to complete the experiments. So, based on that experience I do think we're not asking much of the girls [audience]. [...] with outreach, we teach them [girls] how to think; they do the experiments, we ask questions and the girls come up with crazy ideas or more questions. Those type of questions I had never asked myself, but the girls do ask. That's why I don't underestimate the girls here [USA, Girl Scouts], because they're also capable of asking the same type of questions. Perhaps we just need a different system for that to happen, I don't know." Cecilia's perspectives about outreach events, which are informed by her participation in facilitating outreach events in her home country, explains why she thinks of herself as a leader who challenges followers to think creatively and find solutions to difficult problems.

Cecilia had extensive prior experience planning and leading outreach events. Part of the planning included meeting with volunteers prior to the event to instruct them on how to be a facilitator. According to observations the day of the outreach event, Cecilia took the initiative to hand out materials the volunteers needed and walked around the room checking on volunteers. When asked about these interactions, Cecilia clarified she checked on volunteers and their Girl Scout buddy in case they needed help because she was aware preparation for *Girl Scout Day* did not include training the volunteer facilitators. Taking the time to do this shows a form of *Individualized Consideration (IC)*.

According to other leader-participants, the experiments guide for the day of the event was a group effort with Cecilia being the main lead on this task. The day before the outreach event, the organization shared via email the experiments guide with the volunteer facilitators which included explanations for each activity the Girl Scouts were expected to complete. This delay of action is associated with a *laissez-faire* leadership style and directly impacted how facilitators taught chemistry throughout the outreach event (i.e., *Brokering*) and how the facilitators interacted with the Girl Scouts (i.e., *Interactions*) as CoP boundary processes. Volunteer-participants mentioned the experiment guide was only slightly helpful for various reasons: "Well, really, the board sent the experiment guide the day before. I tried to skim them, but I didn't because I was busy with research. The next day, right before the event, I read it for 10 minutes [...] I was lost because the guide they gave the girl scouts did not include the instructions for the experiments but the one they had sent did have the instructions. So, I didn't think that helped much. [...] Then, whenever the leaders were discussing the instructions it was really fast. I had to go online, find the instructions and then do the experiment with the girl. Sure, I didn't prepare in advance, but I also wasn't counting on the experiment guide not having the instructions. [...] Having the instructions on the handout to be used the day of the event would have helped for when students ask questions or if you're trying to explain things to different age groups ...". These statements on behalf of volunteer-participants highlight the importance of portraying behaviors associated to *Individualized Consideration (IC)* and *Intellectual Stimulation (IS)* but being *Absent/Missed Opportunities* in this scenario.

Case Two: Leaders in National Chemistry Week

Participants

Three leader-participants of the graduate student organization agreed to participate in the study and were assigned the pseudonyms: Thea, Shado and Amanda. Only one of these leader-participants was part of the Outreach Committee within the organization. Harrison (pseudonym), non-member of the student organization, is a volunteer-participant working at the outreach event that agreed to participate in the study. Harrison was recruited after the leader-participants and prior to the outreach event, with no intention of collecting leader-volunteer paired data. While this increased the risk of not having interactions between participants, it reduced the risk of volunteer-participants feeling targeted for recruitment because they interacted with specific leader-participants.

Context

The all-female student organization participating in this study organizes visits to elementary and middle schools to celebrate National Chemistry Week (NCW). At the time of this study, the organization visited a total of 8 schools and more than 70 classrooms over the course of one week. Volunteers/facilitators visited the classrooms in pairs or groups of three and were able to sign up to visit more than one classroom. In order to prepare

the volunteers and facilitators, the board members of the student organization hosted four training sessions. A member of the outreach committee sent a mass volunteer-recruitment email with a sign-up sheet for volunteers to provide information, including which training session they were planning on attending. The low attendance to the first training sessions prompted the organization to plan a fourth training session. There were no repercussions or consequences for not attending training sessions.

Leadership Styles and Outcomes Characterized

Thea. Thea was a member of the Outreach Committee of student organization. She defined leadership as having two-parts: *“Leadership has to be vulnerable and it also has to be assertive. The vulnerability part comes with being able to accept that you are not always right, but able to listen to other points of view. And then the assertive part is making sure that you are able to communicate, as well as help on the various things that need to be done. So, as a leader, I think you need to have both parts, because I believe that you can't think about yourself. It's not about you, it's about other people. I believe you have to think about how-- it's a lot of-- everybody does not have leadership skills because they're not able to communicate, or they're not able to accept criticism. Because leaders have to accept major criticism, because not everybody sees eyes to eye.”* The radial plot comparing self-rate (solid line) and rater (dashed line) results for the MLQ are shown in Fig. 10 and Fig. 11.

[INSERT FIGURE 10 and FIGURE 11]

According to the MLQ results, Thea and followers attributed behaviors associated with transformational leadership style. As part of the Outreach Committee, one of her initial tasks was to send email communications to the academic community to recruit volunteers/facilitators. Initial email communications stated: *“... All materials will be provided along with a free t-shirt and a pizza party ...”* This is a form of *Contingent Reward (CR)*, which explains why followers' rating is higher than the self-rate.

An interesting finding is Thea's self-perception about having *laissez-faire* behaviors was rated as more frequent than what followers perceived. Throughout the interview, Thea expressed there was a plan set in place to start preparations for NCW months in advance: *“NCW goes back to the summer. The purpose of the summer was to talk about our experiments, to trial these experiments and 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. [...] However, no one wants to meet over the summer. So, everyone decides to meet the first two weeks of school which is the most hectic time to meet. Because of that, we were late... we were early but late with getting experiments done. It was late on my approach of doing things, but it was early for what their usual is. ...”* According to Thea, she fulfilled many responsibilities not corresponding to her (or rather, meant to be distributed across four leaders) as a consequence of external factors pertaining other leaders (i.e., rigid research schedule, personal milestones,

preparation for preliminary exams) impacting their commitment to the NCW event: *“... The issue is when you plan the event so close to individuals' milestones, things become even more hectic. Because now you are not able to do your natural functions as part of this group. A lot of us had to go and reach out to a lot of people outside the board to get the help we needed. [...] I was the one in charge of recruiting volunteers, so I was the one sending out emails and talking back and forth to friends, students, staff and teachers to convince them to be volunteers. [...] I was volunteering at other schools because the volunteers didn't show up. If they don't show up, I have to go to the schools... it was sad if those kids missed the experience. [...] For the training workshops, we (leaders) signed up for days but it changed because of the time commitment to their milestones.”*

This idea was also discussed by the other leader-participants. While for Thea the timeline shift in planning the event and not meeting that self-imposed expectation might represent *laissez-faire* behaviors, her actions represent more transformational-like behaviors and less *laissez-faire*.

In addition, Thea voiced other challenges she experienced with the preparation of the outreach event and discussed specific changes she would have implemented or things she would have done differently. When discussing the training provided to facilitators, Thea said: *“... I would make sure that they (the facilitators) understand the purpose of the science. I would make it a real training session where we would go through the science first and then go through the projects.”* Thea's concern for the facilitators explains the high self-rating for *Individualized Consideration (IC)* on the MLQ. However, these actions were just thought of rather than implemented, presenting a *Missed/Absent Opportunity* to display a different behavior and a misalignment with the raters' perceptions on Thea's IC behavior.

Among the group of leaders of the student organization, Thea was one of the leaders that responded when volunteer facilitators were not able to attend their selected classroom visit. During her interview, Thea described one her initial classroom visits: *“When I walked in, I could tell that she was flustered, and she was scared. Another person was supposed to be her partner, but she was expecting that other person to be there to lead it (the event/visit). [...] I could tell she was happy that I took over. I did that only for her, to help her calm down and be more comfortable with it because me and her talked about it outside the school. [...] and she was so thankful because she wanted to volunteer and do it so badly. [...] She was so happy I walked in. But when I saw her I was like, 'You did a great job without me being here. If I wasn't here I know that you would still continue to do a great job'. [...] I just want to give her little things off her back and help her calm down because it's a lot, standing in front of a whole lot of kids. [...] She never interacted with kids before until that day, so it was even more scary for her. She didn't know if she could touch them or anything, so she was happy to see me do that, interact with them and be around them and stuff like that.”* In responding specifically to the need of that facilitator, Thea displayed IC and the way she used charismatic

and positive actions is an example of *Idealized Influence, behavior* (IIB).

When asked about a second visit, particularly about how Thea and another partner facilitator decided on leading the discussion at the school visit, Thea said: "Well, we got there and I asked her 'Which part do you want to do?' She was like 'I don't care.' So, I asked again and when we were putting out materials in the classroom, my partner said 'Okay I'll do this and I'll do this.' To which I said 'Cool, I'll let you lead and then I'll follow' [...] I gave them more leeway because I wanted them to have an experience talking to the kids." This is another example of IC, because Thea's intentions were for her partner to acquire the experience in facilitating an outreach event, complemented by behaviors associated to *Management-by-exception, active* (MBE-A) because the interaction was limited to ensuring the task (i.e., explaining the demonstrations) was completed.

Shado. Shado was part of the board of the student organization but not part of the Outreach Committee. Shado's view on leadership is as follows: "I think leadership is a beautiful thing. It's beautiful for someone to be able to guide others in a positive direction. It's not easy. It comes with a lot of stress... and I think it's also within a person. When you lead someone, you become stressed. Everything doesn't go perfectly, and I think it's all about how you deliver. You're stressed but that's not your followers' problems. It takes a lot of self-control and self-discipline to be able to cope with your stress and to be able to still relay in a positive way to the people who are following you and leading with you." The radial plot comparing self-rate (solid line) and rater (dashed line) results for the MLQ are shown in Fig. 12 and Fig. 13.

[INSERT FIGURE 12 and FIGURE 13]

Both plots show that Shado's self-perceptions about her leadership behaviors and leadership outcomes were overestimated compared to followers' perceptions. Shado had no direct role in planning the outreach event but she was one of the leaders that would fill in for others when necessary. For example, when describing how materials were distributed to volunteers, Shado said: "... the board had to sign up for time slots so that the other volunteers could come pick up their materials. It was just they tell me their name and what school they're going to and I give them the materials. That was the extent of my interaction with them." This represents a *Management-by-exception, active* (MBE-A) behavior.

Shado added: "... I do my job. I do it well. That's all. I will help if I could help when help is needed. But specifically, I do my role. [...] I come in, I fulfill the task, my job is done." This view on her position in the organization can be interpreted as displaying a form of *Management-by-exception, passive* (MBE-P) and MBE-A behaviors.

Shado addressed the topic of communication across leaders. Shado attributed the miscommunication to cultural differences, as discussed in Santos-Díaz and Towns (2020). When sharing her experience with communication within the board of the organization, Shado stated: "... I feel it got to the

point where I don't feel like the outreach committee wanted to do the job themselves anymore, so they needed help. There's four of them, there's one of me, there's one of each other position. Instead of trying to split their job among four... First of all, I feel targeted. Why me? You've got three other people who don't have interactive roles. [...] I thought they were trying to ditch their job to other people. And then, as the conversation escalated, I said in a professional and not disrespectful manner: 'It's all about delivery'. If you want something done, nobody has a problem with helping anyone. But you can't just dish it out as a dictator."

Shado displayed Individualized Consideration (IC) actions as a result of identifying the delivery as part of the issue creating the miscommunication. In pointing out the issue, she allowed for other, individual leaders to develop and work towards improving communication skills. In attributing the miscommunication to cultural differences and acting on it, she (consciously or not, intentionally or not) was supporting other individuals who might have been experiencing the situation from the same perspective. The IC actions could explain the higher effectiveness rating when compared to the other leadership outcomes.

According to observations at the training sessions, the facilitators (mainly other graduate students) were encouraged to explain the chemistry behind experiments as "related to metals" and placed the responsibility on facilitators to research the explanations of each experiment. Instead of these occurrences, Shado shared: "I guess the purpose was to let us know what experiments we were actually doing and explain the experiments to us. I just feel they could've been a bit more thorough, a bit more in-depth. They read the guide to us. What was the point of me going there? [...] I feel like we should've had a hands-on experience with the actual experiment. Because if I work with people on the experiment for the first time with the kids... if something goes wrong with them, yeah, we're all scientists so we should be able to hypothesize how to fix it, but that doesn't always happen." Shado's self-rating for *Intellectual Stimulation* (IS) was higher than rater's score; and, this instance is an example of a *Missed Opportunity* to challenge volunteers to find creative solutions to potential complications arising from the demonstrations. While these ideas are reflective of IS, Shado was acting as a facilitator-in-training during the session so there was no explicit space and time for Shado to display these behaviors or put into action her ideas. Shado understood IS actions would have been of benefit to the volunteer facilitators, her position on the board did not allow for her to put into action her ways or ideas.

The lack of transformational-like behaviors explains Shado's MLQ results for outcomes, which is in alignment with what is presented in the FRLT. According to MLQ results, Shado's self-perception on adopting a *Contingent Rewards* (CR) behavior is frequent, if not always. However, no instances of CR displays were identified for Shado throughout the interview or observations. This was expected based on Shado's views on executing only the tasks associated to her position in the organization.

Amanda. Similar to Shado, Amanda was a leader, part of the board of the student organization but not within the Outreach Committee. Amanda views leadership as: "Being in charge or being the one who is accountable for others under you basically. [...] That they look like they know what they're doing, and they don't expect others to just pick up the slack, whatever nonsense. You can see when somebody is not well organized and are not sure of how they're doing. A lot of leadership is, even if you're not sure of what you're doing, make it a collaborative effort. Talk to everyone, be open as well. It's a lot of how you talk to people as well, I think is important. A lot of my problems with people, especially with people who are in charge is how they say things to me. I don't mind doing, helping out and doing whatever, but if you say it to me the wrong way, I'm not going to do it. [...] Basically, be organized and just good expectations and good communication." The radial plot comparing self-rate (solid line) and rater (dashed line) results for the MLQ are shown in Fig. 14 and Fig. 15.

[INSERT FIGURE 14 and FIGURE 15]

While Amanda was not part of the Outreach Committee within the board of the organization, she was still involved with tasks in preparation for the NCW event. This was Amanda's first year in the student organization and first time occupying a leadership position throughout her graduate program. When asked about expectations, Amanda stated: "... other board members have been here before, they have been part of the board before and they know what to expect of outreach events. So, I had expected them to give the outreach committee more of an idea of what to do or how to go about planning it, which I don't think they did. It was kind of figuring out as you go along. Everybody was expecting you to just drop everything and do what they say. ..." Both the actions of other leaders in not clarifying expectations and Amanda's inactions are characteristic of a *laissez-fair* style. There is a certain lack of communication and a level of indifference towards the situation around expectations.

Furthermore, this situation is an example that supports the argument that *Boundary Objects* and *Brokering* are underdeveloped boundary processes in the student organization CoP. Amanda elaborated on the issue of miscommunication: "... I would have a plan the week before everything started. I know they have had their meetings, and they planned amongst themselves what they're supposed to do... Regardless, when asking the rest of the board to help, they needed to make a plan and give us the schedule, what we need to do, when we need to do it. And a report or something we can all fill out what we're needed for... Because, if you do it so late, we're probably signed up for other responsibilities and it conflicts." While imperfect, not communicating these ideas or acting on them were a *Missed Opportunity* for Amanda to present behaviors associated to a transactional or transformational leadership style.

A different situation shows how Amanda exhibited *Individualized Consideration* (IC) as a response to *laissez-faire* behavior on behalf of other leaders: "... the training session is

the one time with volunteers they meet up. But that was really general. I think it was a demonstration of what they were supposed to do. And you could also see the lack of planning in that as well because it wasn't done well. [...] The demonstration was helpful but what I thought was even more helpful that they didn't really talk about until I specifically asked them, is what are the steps to take when you go to the school for people who've never been there. Because I didn't know when you walk in, you have to sign in, talk with the person. And then, when you go to the classroom-- which is also another thing that I was surprised at my first day was that you're basically in charge. I thought the teachers come, and help you, be part of it. But you were just there by yourself. And I was really worried for the undergrads who volunteered who didn't really have much experience doing this. ..." There was a lack of instructions and guidance on behalf of the leaders to the volunteers-facilitators (i.e., *laissez-faire*) but Amanda's actions align with a *transformational* style. By expressing concerns for undergraduate students for who this was their first-time volunteering for *National Chemistry Week* outreach events, Amanda portrayed *Individualized Consideration* (IC).

Amanda portrayed *Management-by-exception, passive* (MBE-P) behaviors when distributing materials for the outreach events: "... I didn't really have much input until they needed people to do the packing of the bags and stuff. That's when they started asking people to volunteer. [...] I went because they didn't finish the first time. ..." Amanda intervened only when the leaders in charge of said task did not comply or were not able to complete the task in a timely and organized manner. Amanda also mentioned she recruited a colleague to volunteer as her partner by simply asking the colleague to do so; however, she might have employed actions associated to *Idealized Influence, behavior* (IIB) or *Inspirational Motivation* (IM) to do so, as suggested by the rating score difference between self- and rater (Fig. 14).

Similar to Thea and Shado, a frequently visited topic throughout Amanda's interview was communication across leaders: "... everybody was expecting you to just drop everything and do what they say, when they say. We can't do that because we do have other responsibilities. [...] We [other board members] are willing to help, but it's how you go about asking. [...] some people talk in a really demanding way. If she wants somebody to do something, she says 'I need you to do so-and-so' rather than 'could you do this for me?'. Then saying the rest of the board needs to step up and help. She didn't ask us to do anything in the first place to say that we're not doing our jobs. I was really annoyed by it and the way she spoke to us. ..." Amanda attributed these miscommunication challenges to cultural differences. This is discussed in depth in Santos-Díaz and Towns (2020). Amanda identified this as a problem but displayed *laissez-faire* behaviors, given that it was another leader who addressed the communication problem. Amanda's self-perception on the Extra Effort outcome can be thought of as results of the overall instances in which Amanda displayed *laissez-faire* behavior.

Limitations

Leadership studies have been carried out in formal educational settings, such as schools for example. These studies have identified many different leadership styles in education; including transformational, instructional, distributed, ethical, emotional, entrepreneurial, strategic, sustainable, invitational, constructivist, authentic, dictator, coaching, visionary, servant, autocratic, laissez-faire, democratic, pacesetter, transactional and bureaucratic (Lynch, 2012). The use of FRLT by itself to identify leadership styles limits the understanding of student organizations' leadership structures, since it only encompasses three out of many leadership styles. To date there is no framework or instrument to measure all possible leadership styles; therefore, this limitation would be present regardless of which leadership theory guided this study.

The use of a questionnaire in leadership studies does not capture the dynamic process of leadership (Yukl, 2010). This limitation is addressed to some extent with data triangulation, as data from the other sources can better inform the leadership process that is described. Also, as with any other statistical measure, a larger sample is preferred over a small sample. While this presents a limitation for this study, it is important to note the results for the MLQ are not used for statistical purposes but as a complement to the qualitative data. The case study methodology has some inherent limitations to it, including the lack of transferability of findings to other settings and contexts (Baxter and Jack, 2008; Merriam and Tisdell, 2016). However, the results of this study can be used to inform leaders on the potential outcomes (favorable and not favorable) of specific behaviors for their outreach events. This is discussed further in the next section.

By only using some elements of the communities of practice framework as a lens, a limitation is introduced, since studying all the areas of student organizations as a CoP goes beyond the scope of the study. Lastly, it is not feasible to reach a full understanding on leadership dynamics in student organizations doing chemistry outreach because (1) it is impossible to capture every single leader-volunteer interaction between the planning and implementation stages of the outreach event and (2) as CoPs, the members decide what kind of leaders they need and when the community needs them, changing the leadership dynamics of the CoP.

Conclusions

The Multifactor Leadership Questionnaire, an instrument grounded on the Full-Range Leadership Theory, can be used to characterize *Leadership* within the community of practice, that is, student organizations participating in chemistry outreach. A broad range of behaviors were identified across the leaders of an all-female student-run organization facilitating an event for *Girl Scouts* and school visits to celebrate *National Chemistry Week*. Most behaviors were associated with *Transactional* and *Laissez-faire* leadership styles. Behaviors attributed to a *Transformational* leadership style were scarce but many interactions between leader-participants and volunteer-

participants were catalogued as missed opportunities to exhibit a *Transformational* behavior. These behaviors affected *Boundary Processes* that happen in a CoP.

Miscommunication among leaders and not being explicit with volunteers in terms of expectations indicates *Boundary Objects* is an underdeveloped process within the CoP in this study (i.e. graduate student organization). As presented in Santos-Díaz and Towns (2020), some instances of miscommunication are attributed to cultural differences and leaders' lack of understanding of cross-cultural communication. In terms of communication, language was a barrier for facilitators to establish connections with the audience (i.e., *Interactions*) and for leaders to portray behaviors associated to a *transformational* leadership style.

Providing little to no direction to the volunteers/facilitators, associated to a *laissez-faire* style, affected the connections between the facilitator and the attendee (i.e., *Interactions*) because they were not clear on what the facilitators' role was during the outreach event. This is particularly important when taking into consideration those facilitators with no prior outreach experience and those unfamiliar with the local culture and education system. A *laissez-faire* behavior can negatively impact their experiences and hinder the growth of the CoP. For the events presented in this study, facilitators heavily relied on prior experiences with science outreach events to make assumptions on what their role should be throughout the event. Furthermore, delayed actions, lack of communication and not paying attention to the individual needs of the volunteers did not facilitate *Brokering* and *Interactions* as boundary processes.

According to the findings, it seems *Contingent Rewards* (material rewards, such as pizza and t-shirts) is the predominant behavior that leaders adopt to recruit volunteers to act as facilitators of outreach events. However, none of the participants acknowledged these rewards as motivation for them to take part of chemistry outreach events. Participants alluded to ideas pertaining being role models, serving underrepresented communities and bringing fun science to kids as motivations to volunteer as facilitators of the outreach events.

For *Girl Scout Day*, there was no formal interaction to exchange knowledge on how to explain the chemistry concepts associated to the outreach event. Volunteer-participants explained the activities to the girl scouts using their own understanding of the concepts, which was never assessed for correctness by the leaders or anyone else in the organization. Even though the leaders for *National Chemistry Week* did plan a training session for the facilitators, the experience of participants was similar to that of *Girl Scout Day*. The purpose of understanding the science of the experiments and demonstrations was not achieved with the training session; the attendees simply got familiarized with what they were expected to present at the outreach event. Therefore, *laissez-faire* behaviors and a lack of behaviors associated to a *Transformational* leadership style on behalf of the leader-participants resulted in *Brokering* and *Interactions* being hindered.

Implications for Practice

The findings of this study can be used to inform how student organizations plan and carry out chemistry outreach events. The MLQ is a user-friendly tool that can be implemented across student organizations to assess leadership styles of leaders and their influence on followers' extra effort, satisfaction and effectiveness. The MLQ could complement the *Characterizing Collegiate Organizations' Outreach Practices Survey* presented by Pratt and Yeziarski (2018). If properly implemented and used, the organizations could use both instruments to evolve as a CoP. For example, leaders completing such survey at the beginning of their term can have an initial assessment on how current organizational practices introduce challenges associated to chemistry outreach events; then, as leaders, they can take action to address identified challenges. Furthermore, the leaders can complete the survey throughout, or at the end, of their term to compare with the initial assessment and track how the organization is evolving.

Leaders in chemistry outreach, especially those who act as planners of the event, can adopt or keep displaying behaviors associated to a transformational leadership style to positively impact the outreach event and the student organization. For example, adopting *Individualized Consideration* (IC) behaviors can positively impact the *Brokering* process; by understanding how facilitators explain chemistry or what their barriers are, the leaders can decide what is the best way to share knowledge with participants of the outreach event.

Considering participants in the context of this study did not address material rewards as the nature of their motivation to participate of chemistry outreach, leaders should instead adopt *transformational* behaviors to recruit volunteers by appealing to high-order ideals and what the volunteer values. An action that might portray such behaviors is using email communications and other interactions with volunteers to emphasize these ideals, the organization's values and the vision for the events individuals are volunteering for. In doing so, the leaders can focus efforts and resources on developing other aspects of the CoP instead of planning a pizza party for the volunteers, for example. This is not to imply there are no volunteers that are motivated by free food or other material rewards to participate in outreach events, but to encourage leaders to explore what truly motivates their volunteers or organization.

Another practice to adopt is to intentionally plan meetings before the outreach event to understand the volunteers' experiences and how these can be used to plan events. While this might be more time-consuming than most outreach practices, it is an effort that can benefit both the volunteer and the organization as a CoP, especially if coordinators plan or meet with a specific purpose. Being aware and understanding the differences amongst members of an organization can influence the organization's performance (Robbins and Judge, 2016). By being more mindful about the facilitators' needs, issues such as language being a barrier or having difficulties engaging the audience at events, can be more effectively addressed. The organization can adopt new practices coming

from the facilitator's prior experiences in outreach and their educational background.

Implications for Research

The MLQ is a tool that provides information on how leaders are perceived and their self-perception which, in this study, most times aligned with their actions. This lends itself to the opportunity of developing a quantitative study, that can be implemented at a larger scale. As an example, the study could explore leadership styles of ACS Undergraduate Student Chapters using their standing in the organization (i.e., outstanding chapters *versus* non-outstanding chapters) as a basis for comparison to investigate if there is a relationship between leadership styles and organizational standing. Leadership styles of individuals vary with context and is influenced by many factors: the team they are part of, circumstances outside of the student organization, degree of affiliation to national entities, the academic institution at which they are based, etc. Therefore, a longitudinal study with leaders of student organizations could better describe the dynamic process that is leadership. Future research of leadership in student organizations participating in chemistry outreach could incorporate the use of additional questionnaires to assess other leadership styles (Pearce and Sims Jr., 2002); and, it could also incorporate additional perspectives to evaluate how external factors influence the leaders' behaviors as part of a student organization and outreach events (Cook-Sather, 2016; McCollum *et al.*, 2019).

Conflicts of interest

There are no conflicts to declare.

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Appendix A: Sample semi-structured interview protocol in English

1. How did you begin working with the volunteers/leaders for [insert name of event]?
2. How do you see your role working with these volunteers/leaders?
3. Please tell me about your experiences carrying out outreach initiatives as a member of:

- 1
- 2
- 3 a. Other student organizations you have been
- 4 part of.
- 5 b. Your current student organization.
- 6 4. What other experiences inform how you lead the
- 7 outreach event or your volunteer?
- 8 5. What can you tell me about leadership?
- 9 a. What is leadership to you?
- 10 b. How do you “approach” being a leader?
- 11 6. If video recording is available:
- 12 a. How would you describe what you and your
- 13 volunteer/leader are doing in this clip?
- 14 b. What were some challenges you had to face
- 15 that day as a leader/volunteer?
- 16 7. Thinking back on what you think leadership is and how
- 17 you approach being a leader, do you think you
- 18 implemented your ways this day?
- 19
- 20

Appendix B: Sample semi-structured interview protocol in Spanish

- 23 1. ¿Cómo comenzaste a trabajar con los voluntarios de
- 24 [nombre del evento]?
- 25 2. ¿Cómo visualizabas tu rol trabajando con los
- 26 voluntarios/líderes?
- 27 3. Por favor, háblame de tus experiencias participando
- 28 en iniciativas de *outreach* como miembro de:
- 29 a. Otras organizaciones estudiantiles de las
- 30 cuales has sido parte.
- 31 b. Tu organización estudiantil actual.
- 32 4. ¿Cuáles otras experiencias informan la manera en que
- 33 tú lideras un evento de *outreach* o los voluntarios?
- 34 5. ¿Qué me puedes decir de liderazgo?
- 35 a. ¿Qué es liderazgo para ti?
- 36 b. ¿Cómo tú exhibes tu liderazgo? ¿Cómo eres
- 37 líder?
- 38 6. Si el video está disponible:
- 39 a. ¿Cómo describirías lo que tú y tu
- 40 voluntario/líder están haciendo en este
- 41 video?
- 42 b. ¿Cuáles fueron algunos retos que tuviste que
- 43 enfrentar ese día como líder/voluntario?
- 44 7. Teniendo en mente lo que tú piensas es liderazgo y
- 45 como tú exhibes liderazgo, ¿crees que implementaste
- 46 tu forma de ser líder ese día?
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References

- Alsalamy E. and Behery M., (2014), Transformational Leadership and Its Effects on Organizational Learning and Innovation: Evidence from Dubai. *The Journal of Applied Management and Entrepreneurship*, **19**(4), 61–81.
- Antonakis J., Avolio B. J., and Sivasubramaniam N., (2003), Context and leadership: an examination of the nine-factor full-range leadership theory

- using the Multifactor Leadership Questionnaire. *The Leadership Quarterly*, **14**(3), 261–295.
- Avolio B. J. and Bass B. M., (2002), *Developing potential across a full range of leaderships: Cases on transactional and transformational leadership*.
- Avolio B. J. and Bass B. M., (2004), *Multifactor Leadership Questionnaire: Manual and Sample Set*, 3rd ed. Mind Garden, Inc.
- Baxter P. and Jack S., (2008), Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, **13**(4), 544–559.
- Bligh M. C., Kohles J. C., and Yan Q., (2018), Leading and Learning to Change: The Role of Leadership Style and Mindset in Error Learning and Organizational Change. *Journal of Change Management*, **18**(2), 116–141.
- Brown C. L., Barbee M. H., Ko J. H., Maynard H. D., and Craig S. L., (2017), Writing Without Ink: A Mechanically and Photochemically Responsive PDMS Polymer for Science Outreach. *Journal of Chemical Education*, **94**(11), 1752–1755.
- Calderhead J., (1981), Stimulated recall: A method for research on teaching. *British Journal of Educational Psychology*, **51**(2), 211–217.
- Carpenter S. L., (2015), Undergraduates’ Perceived Gains and Ideas About Teaching and Learning Science From Participating in Science Education Outreach Programs. *Journal of Higher Education Outreach and Engagement*, **19**(3), 113–146.
- Chan A. C. K. and Du-Babcock B., (2018), Leadership in action: an analysis of leadership behaviour in intercultural business meetings. *Language and Intercultural Communication*, 1–16.
- Committee on Communicating Chemistry in Informal Settings, Board on Chemical Sciences and Technology, Division on Earth and Life Studies, Board on Science Education, Division of Behavioral and Social Sciences and Education, and National Academies of Sciences, Engineering, and Medicine, (2016), *Effective Chemistry Communication in Informal Environments*, National Academies Press.
- Committee on Revitalizing Graduate STEM Education for the 21st Century, Board on Higher Education and Workforce, Policy and Global Affairs, and National Academies of Sciences, Engineering, and Medicine, (2018), *Graduate STEM Education for the 21st Century*, Leshner A. and Scherer L. (eds.) National Academies Press.

- Cook-Sather A., (2016), Undergraduate students as partners in new faculty orientation and academic development. *International Journal for Academic Development*, **21**(2), 151–162.
- DeKorver B. K., (2016), Undergraduate Students' Goals for Chemistry Laboratory Coursework.
- Eagly A. H., Johannesen-Schmidt M. C., and van Engen M. L., (2003), Transformational, transactional, and laissez-faire leadership styles: A meta-analysis comparing women and men. *Psychological Bulletin*, **129**(4), 569–591.
- Flynn S. P., McKenna M., Monaghan R., Kelleher S. M., Daniels S., and MacCormac A., (2017), Aqua-Art: A Demonstration of Hydrophilic and Hydrophobic Surfaces Fabricated by Plasma Enhanced Chemical Vapor Deposition. *Journal of Chemical Education*, **94**(2), 221–225.
- Gagnon N. L. and Komor A. J., (2017), Addressing an Overlooked Science Outreach Audience: Development of a Science Mentorship Program Focusing on Critical Thinking Skills for Adults Working toward a High School Equivalency Degree. *Journal of Chemical Education*, **94**(10), 1435–1442.
- Gilbert S. and Kelloway E. K., (2018), Self-determined leader motivation and follower perceptions of leadership. *Leadership & Organization Development Journal*, **39**(5), 608–619.
- Houck J. D., Machamer N. K., and Erickson K. A., (2014), Graduate Student Outreach: Model of a One-Day “Chemistry Camp” for Elementary School Students. *Journal of Chemical Education*, **91**(10), 1606–1610.
- Johnson S. L., (2017), Investigating the Conversations that Occur during Undergraduate Research Experiences: A Case Study.
- Khan S., Asghar M., and Zaheer A., (2014), Influence of leadership style on employee job satisfaction and firm financial performance: A Study of banking sector in Islamabad, Pakistan. *ACTUAL PROBLEMS OF ECONOMICS*, **5**(155), 374–384.
- Kuk L. and Banning J., (2010), Student Organizations and Institutional Diversity Efforts: A Typology. *College Student Journal*, **44**(2), 354–361.
- Landis E. A., Hill D., and Harvey M. R., (2014), A Synthesis of Leadership Theories and Styles. *Journal of Management Policy and Practice*, **15**(2), 97–100.
- Levine M., Serio N., Radaram B., Chaudhuri S., and Talbert W., (2015), Addressing the STEM Gender Gap by Designing and Implementing an Educational Outreach Chemistry Camp for Middle School Girls. *Journal of Chemical Education*, **92**(10), 1639–1644.
- Lynch M., (2012), *A Guide to Effective School Leadership Theories*, Taylor & Francis.
- McCullum B., Morsch L., Pinder C., Ripley I., Skagen D., and Wentzel M., (2019), Multi-dimensional trust between partners for international online collaborative learning in the Third Space. *IJSaP*, **3**(1), 50–59.
- Merriam S. B. and Tisdell E. J., (2016), *Qualitative Research : A Guide to Design and Implementation*, 4th ed. Jossey-Bass.
- Mokhber M., Ismail W. K. bin W., and Vakilbashi A., (2015), Effect of Transformational Leadership and its Components on Organizational Innovation. *IJMS*, **8**(2), 221–241.
- Newstrom J., (2011), *Comportamiento humano en el trabajo*, 13th ed. The McGraw-Hill Companies.
- Pearce C. L. and Sims Jr. H. P., (2002), Vertical versus shared leadership as predictors of the effectiveness of change management teams: An examination of aversive, directive, transactional, transformational, and empowering leader behaviors. *Group Dynamics: Theory, Research, and Practice*, **6**(2), 172.
- Podsakoff P. M., MacKenzie S. B., Moorman R. H., and Fetter R., (1990), Transformational Leader Behaviors and Their Effects on Followers' Trust in Leader, Satisfaction, and Organizational Citizenship Behaviors. *Leadership Quarterly*, **1**(2), 107–142.
- Pourbarkhordari A., Zhou E. H. I., and Pourkarimi J., (2016), How Individual-focused Transformational Leadership Enhances Its Influence on Job Performance through Employee Work Engagement. *IJBM*, **11**(2), 249.
- Pratt J. M. and Yezierski E. J., (2018), Characterizing the Landscape: Collegiate Organizations' Chemistry Outreach Practices. *Journal of Chemical Education*, **95**(1), 7–16.
- Robbins S. P. and Judge T. A., (2016), *Organizational Behavior*, 17th ed. Pearson Education.
- Santos-Díaz S. and Towns M. H., (2020), Chemistry outreach as a community of practice: investigating the relationship between student-facilitators' experiences and boundary processes in a student-run organization. *Chem. Educ. Res. Pract.*, 10.1039.D0RP00106F.
- Schwarz G., Burger M., Guex K., Gundlach-Graham A., Käser D., Koch J., et al., (2016), Demonstrating Rapid Qualitative Elemental Analyses of Participant-Supplied Objects at a Public

- 1
2
3 Outreach Event. *Journal of Chemical*
4 *Education*, **93**(10), 1749–1753.
- 5 Sewry J. D. and Paphitis S. A., (2018), Meeting
6 important educational goals for chemistry
7 through service-learning. *Chemistry Education*
8 *Research and Practice*, **19**(3), 973–982.
- 9 Sims H. and Lorenzi P., (1992), *The New Leadership*
10 *Paradigm*, SAGE Publications, Inc.
- 11 Sosik J. J. and Godshalk V. M., (2000), Leadership
12 styles, mentoring functions received, and job-
13 related stress: a conceptual model and
14 preliminary study. *Journal of Organizational*
15 *Behavior*, **21**(4), 365–390.
- 16 Taber K. S., (2018), Lost and found in translation:
17 guidelines for reporting research data in an
18 ‘other’ language. *Chem. Educ. Res. Pract.*,
19 **19**(3), 646–652.
- 20 Tarsik N., Kassim N., and Nasharudin N., (2014),
21 Transformational, Transactional or Laissez-
22 Faire: What Styles do University Librarians
23 Practice? *Journal of Organizational*
24 *Management Studies*, 1–10.
- 25 Ting J. M., Ricarte R. G., Schneiderman D. K., Saba S.
26 A., Jiang Y., Hillmyer M. A., et al., (2017),
27 Polymer Day: Outreach Experiments for High
28 School Students. *Journal of Chemical*
29 *Education*, **94**(11), 1629–1638.
- 30 Toor S.-R. and Ofori G., (2009), Ethical Leadership:
31 Examining the Relationships with Full Range
32 Leadership Model, Employee Outcomes, and
33 Organizational Culture. *Journal of Business*
34 *Ethics*, **90**(4), 533–547.
- 35 Wenger E., McDermott R., and Snyder W. M., (2002),
36 *Cultivating communities of practice: a guide to*
37 *managing knowledge*, Harvard Business Press.
- 38 Yin R. K., (2014), *Case Study Research: Design and*
39 *Methods*, 5th ed. Sage Publications.
- 40 Yukl G. A., (2010), *Leadership in Organizations*, 7th
41 ed. Pearson Education.
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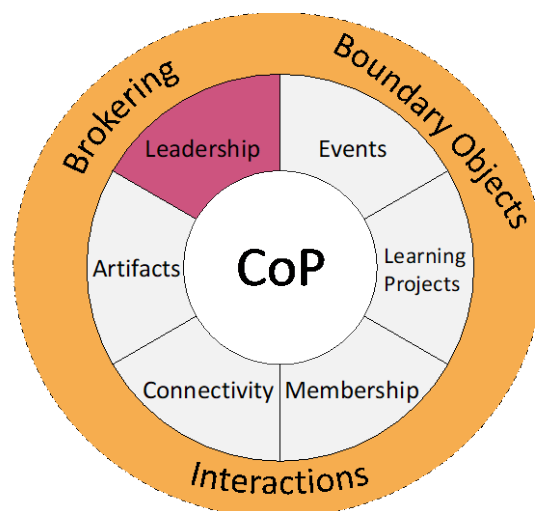


Fig. 1 Boundary processes and elements that characterize of a community of practice

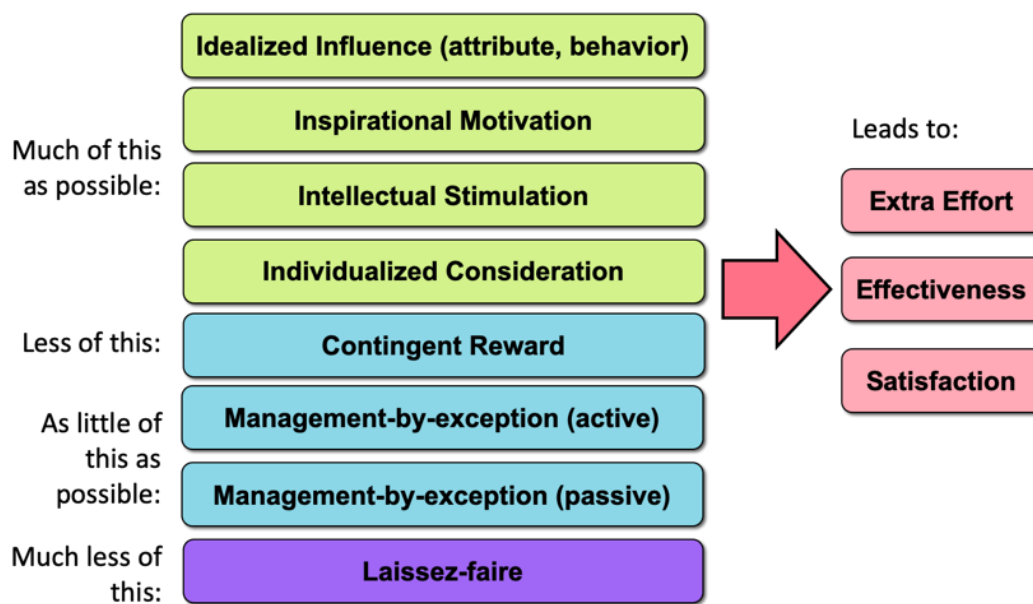


Fig. 2 Relationship between leadership style behaviors and leadership outcomes

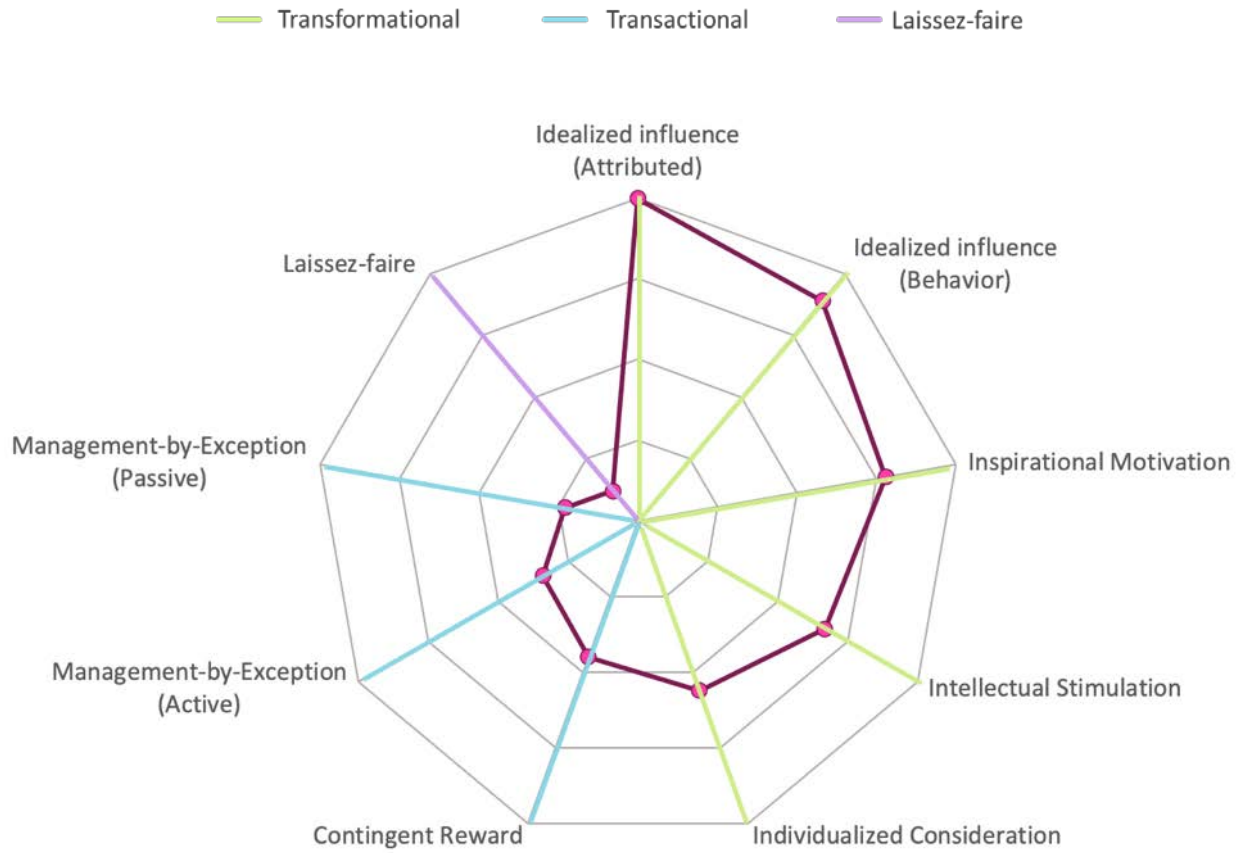


Fig. 3 Example radial plot to show "ideal MLQ results", grounded on the Full-Range Leadership Theory

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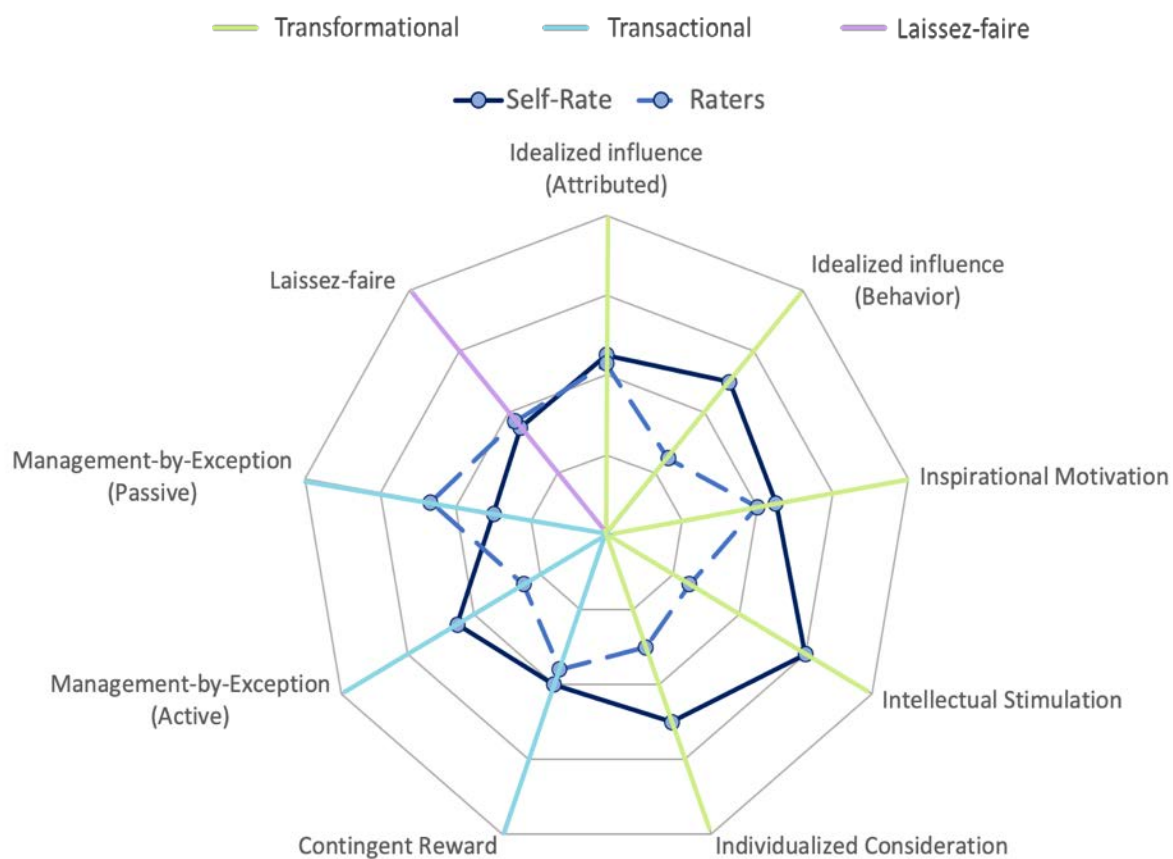


Fig. 4 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Iris



Fig. 5 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Iris

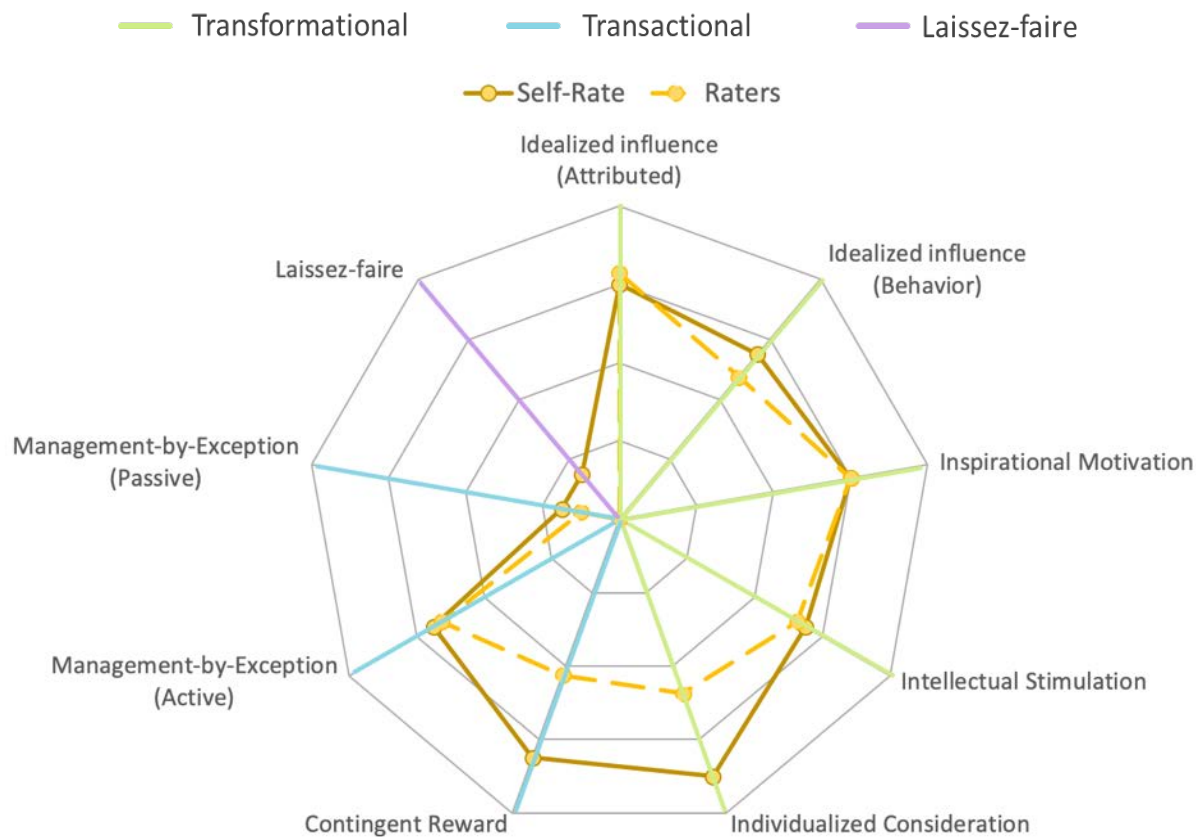


Fig. 6 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Caitlin

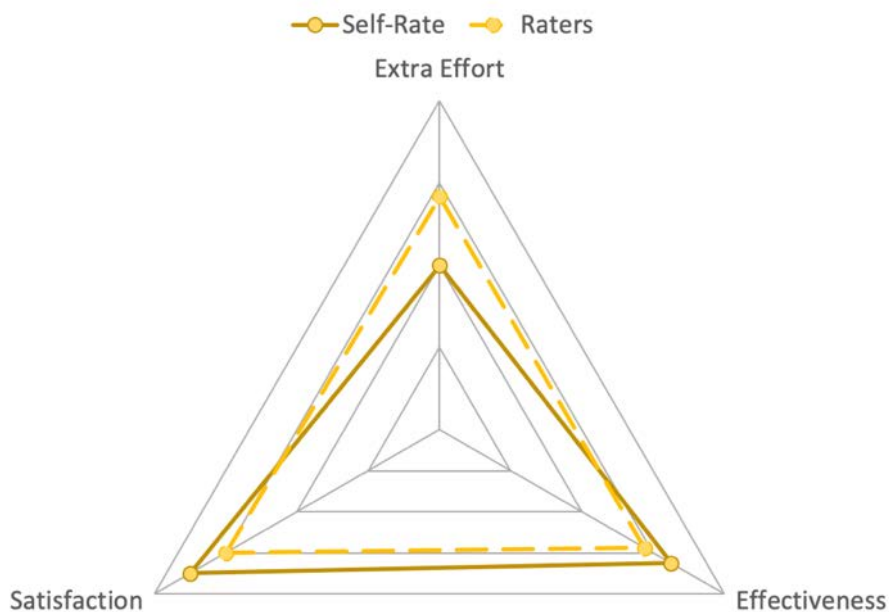


Fig. 7 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Caitlin

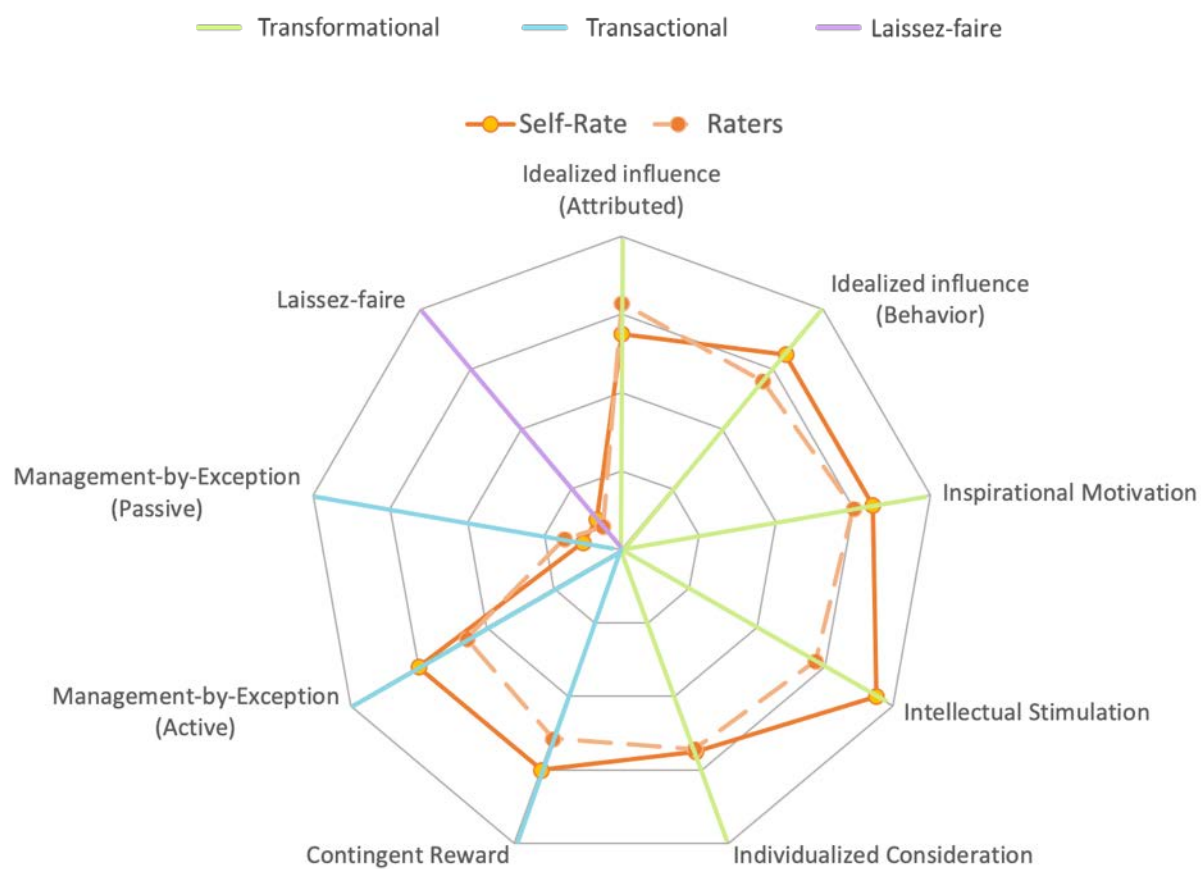


Fig. 8 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Cecilia

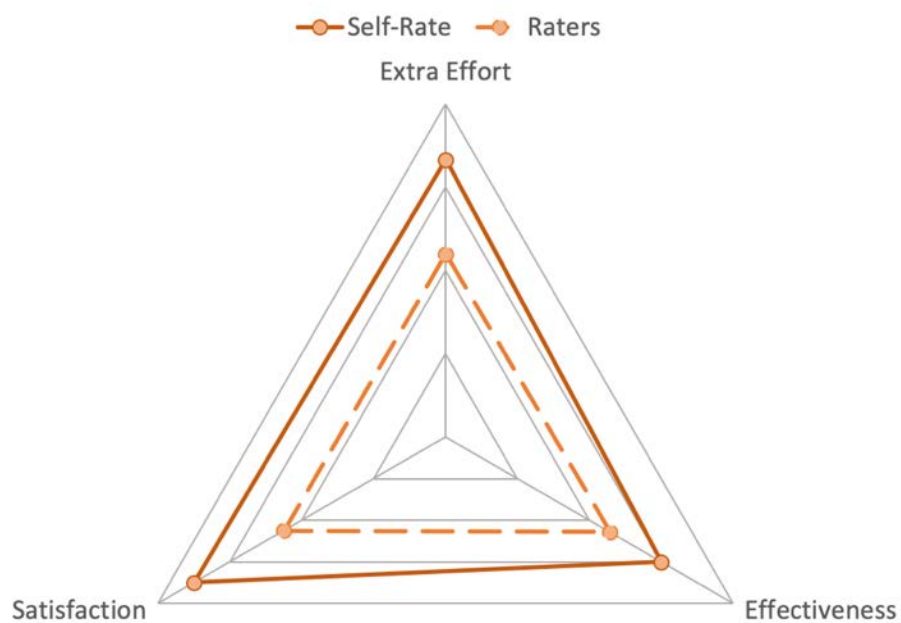


Fig. 9 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Cecilia

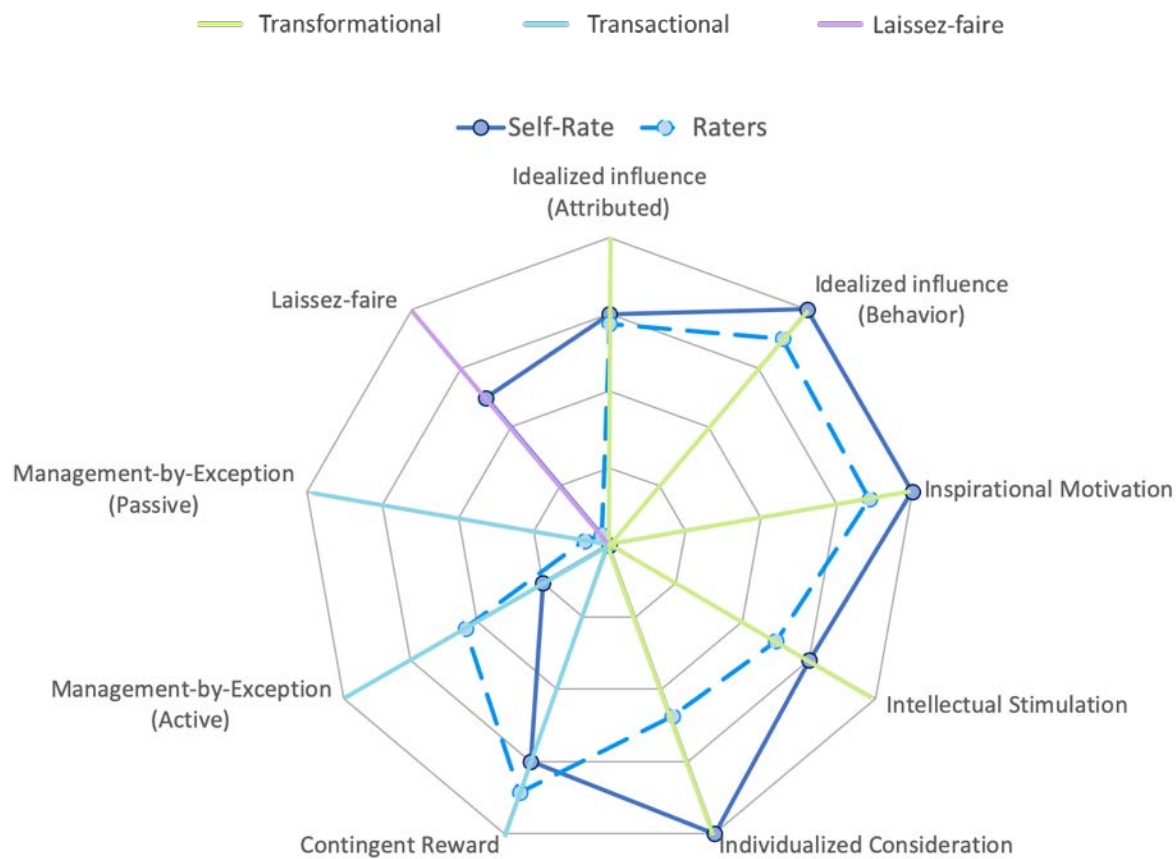


Fig. 10 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Thea

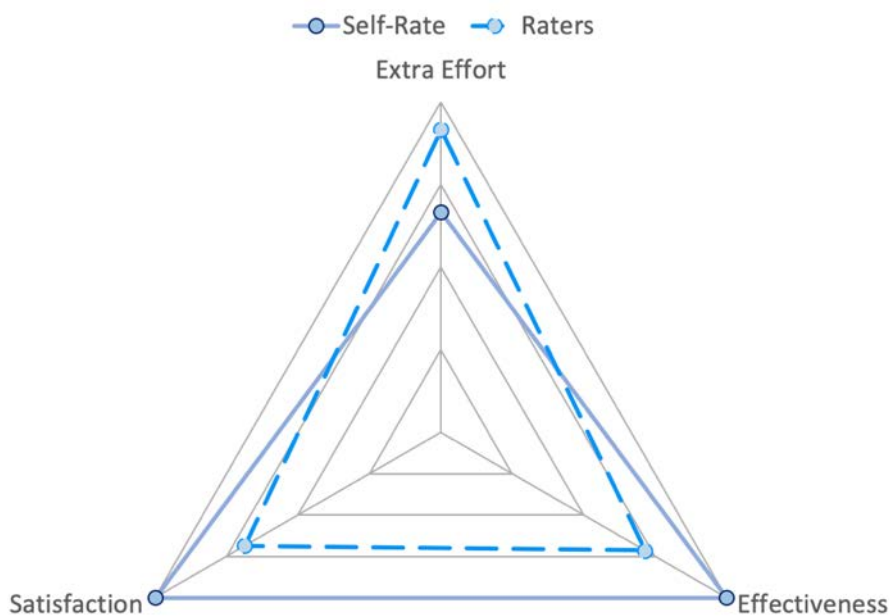


Fig. 11 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Thea

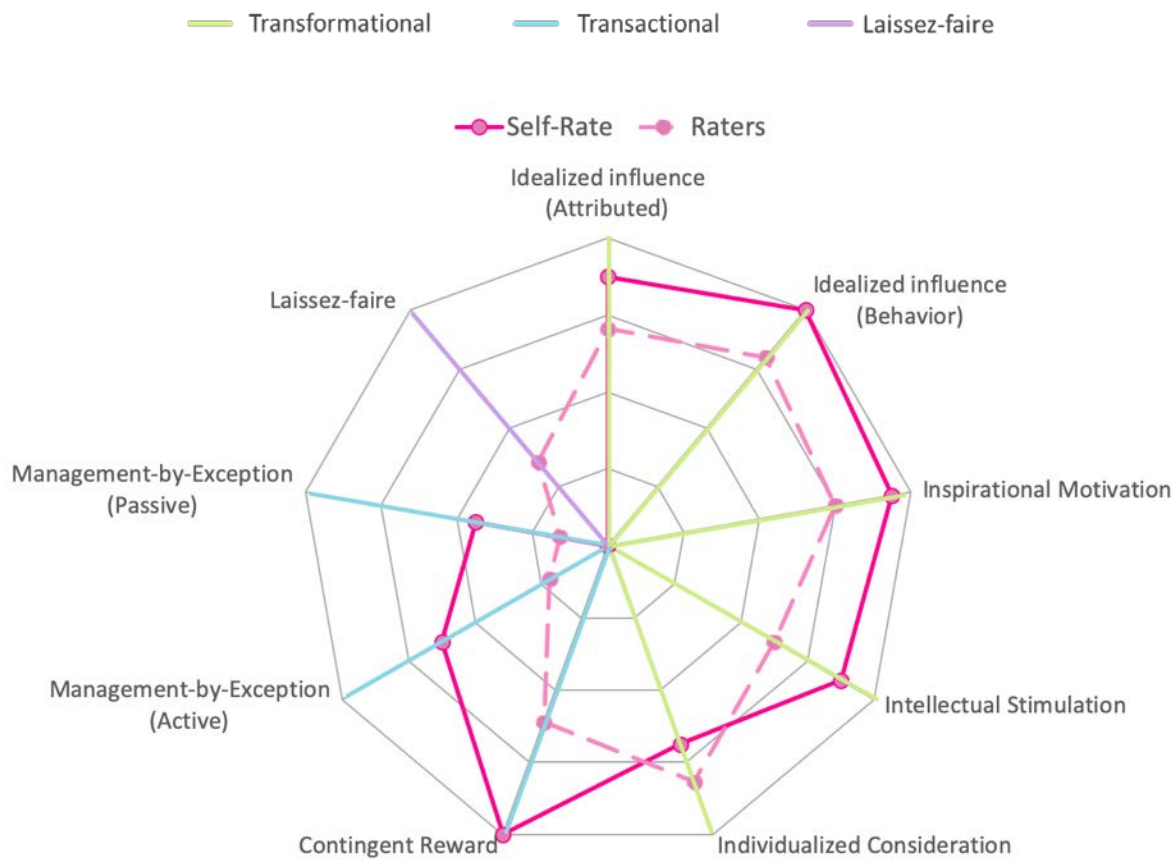


Fig. 12 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Shado

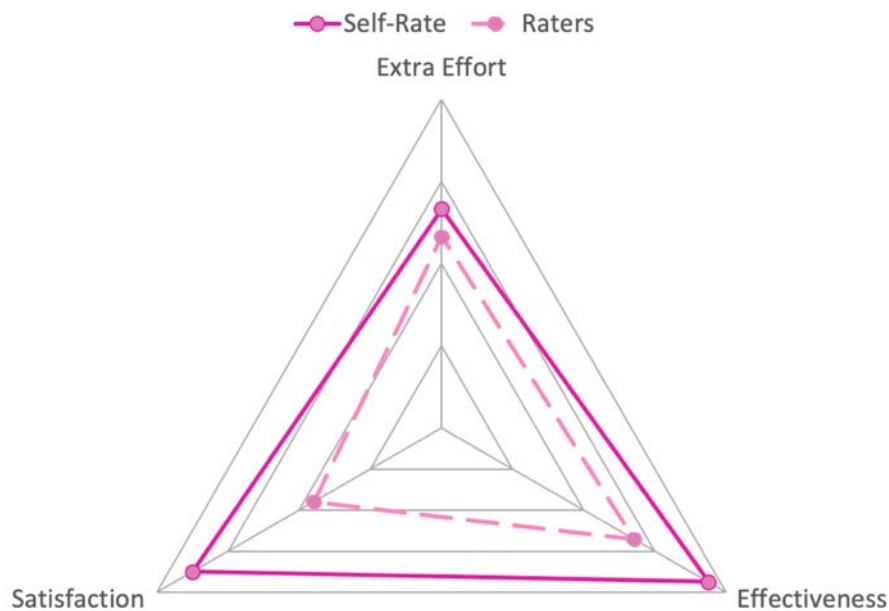


Fig. 13 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Shado

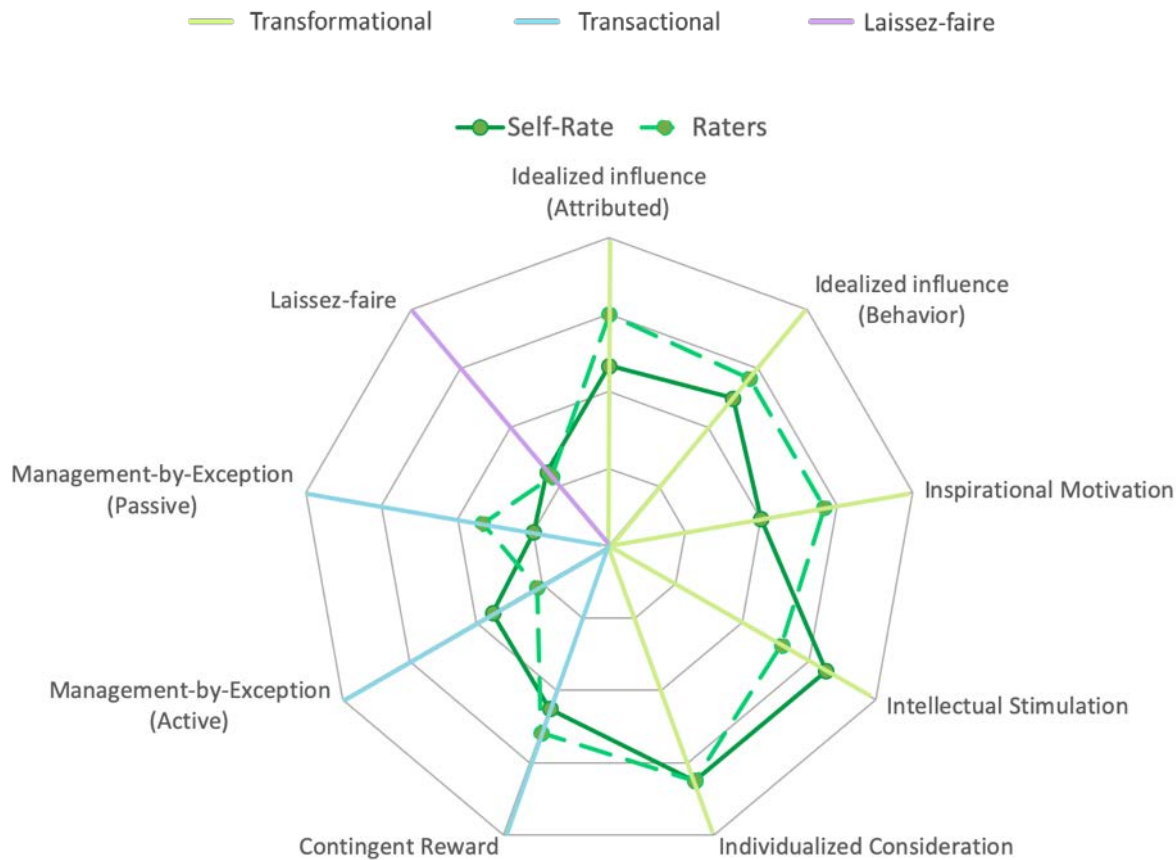


Fig. 14 Radial plot for self-rate and rater results of MLQ-leadership behaviors for Amanda

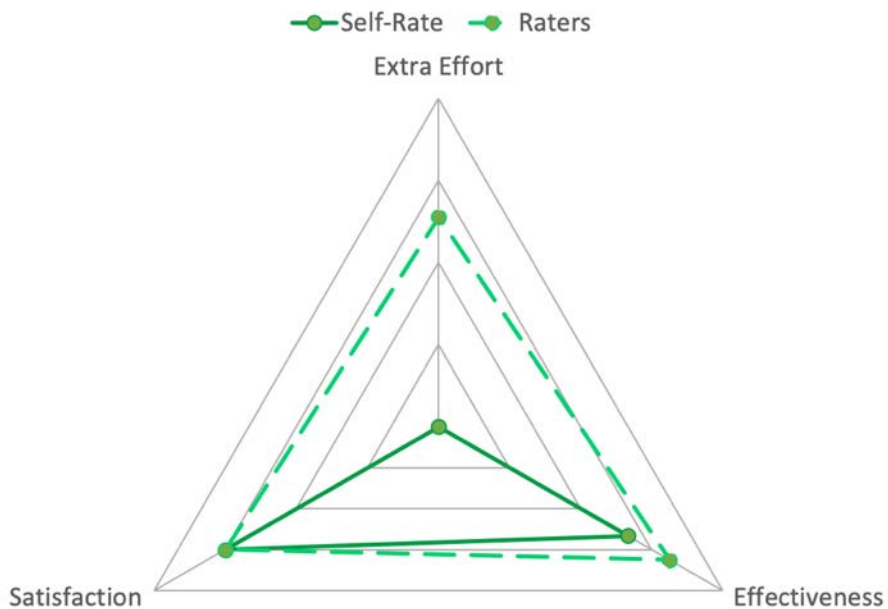


Fig. 15 Radial plot for self-rate and rater results of MLQ-leadership outcomes for Amanda

Table 1. Student organizations participating in chemistry communication activities as a community of practice (CoP)

CoP Constructs	Definition of construct informed by different literature sources ^a	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
Community	The process to understand and learn more about the domain that happens by interacting with those who share the 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 domain; “a way of acting in the world”	The organization participating of outreach events to better understand chemistry in informal learning environments
Boundary Processes	Brokering – consists of creating connections between members of different CoPs; mainly happens between CoPs to introduce components of one practice into the other	A student organization collaboration with education practitioners or researchers to adopt practices that improve chemistry outreach
	Boundary Objects – resources 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 students to pursue degrees in STEM fields
Leadership	A community needs multiple forms of leadership to play their role and help the CoP develop. Examples: thought leaders, networkers, people who document the practice, etc.	Officers or committees of a student organization; faculty advisors of the student organization

^aSources include (Wenger, 2000; Wenger and McDermott RA, 2002; Smith *et al.*, 2017)

Table 2. Coding scheme for leadership styles and data examples

Code (Abbreviation)	Description	How code is present in data
Idealized influence (attributed) (IIA)	Socialized charisma, whether the leader is perceived and viewed as confident, powerful, focusing on high-order ideals and ethics	*As absent/missed opportunity
Idealized influence (behavior) (IIB)	The charismatic actions of the leader that are centered on values, beliefs and a sense of mission	*As absent/missed opportunity
Inspirational motivation (IM)	The ways leaders energize their followers by viewing the future with optimism, stressing ambiguous goals, projecting an idealized vision, and communicating to followers that the vision is achievable	*As absent/missed opportunity
Intellectual stimulation (IS)	Leader actions that appeal to the followers' sense of logic and analysis by challenging followers to think creatively and find solutions to difficult problems	Interviewer: "Do you think the responses from the leaders or leader helped you figure out--?" Participant: "Not really, but I think in that moment it was kind of the panic of like, "Oh, we changed the experiment, and now it's not working." And then I think the one before that didn't work, so having the first experiments not work, I think there was just a little bit of panic going on and just like, "I don't know why it's not working, but let's move on." So that's why I was trying to explain why it was happening and be like, "Well, even if this doesn't work," I said, "Let's try it with the solids and see if it does anything different. Let's try the unknown." Yeah. "What's baby powder made of?" That's what I was trying to figure out - would it have the same reaction? So just kind of approaching the problem and problem solving through it."
Individualized consideration (IC)	Leader behavior that contributes to follower satisfaction by advising, supporting and paying attention to the individual needs of follower, which allows them to develop and self-actualize	[In reference to having another leader explain experiments in event] Participant: "But I also want to give everyone the opportunity to learn and improve. Just because you're not good at something, doesn't mean that you have to stay not good at it forever. We can also work on that. So I try to give everyone an opportunity to step up and improve."
Contingent reward (CR)	Leaders behaviors focused on clarifying role and task requirements and providing followers with materials or psychological rewards contingent on the fulfillment of contractual obligations	[In reference to recruiting volunteers for event] Email communication: "[...] All materials will be provided along with a free T-shirt and pizza party [...]."

1 2 3 4 5 6	Management-by-exception, active (MBE-A)	Active vigilance of a leader whose goals is to ensure that standards are met	"[...] we (the board) had to basically choose time slots so that other volunteers could come pick up their materials. I interacted with them. It was just they tell me their name and what school they're going to and I give them a bag. [...] I come in, I fulfill my task, my job is done."
7 8 9	Management-by-exception, passive (MBE-P)	Leaders only intervene after noncompliance has occurred or when mistakes have already happened	"The issue is when you plan things so close to milestones, things become even more hectic. Because now you are not able to do your natural functions as part of this group. So a lot of us had to go and reach out to a lot of people outside the board to get the help we needed."
10 11 12 13	Laissez-faire (LF)	Leader provides no meaning or clarification of events for followers which is interpreted as lack of communication, undermining the follower's trust in the leader; characterized by delays of action, absence and indifference	Participant: "[...] they've (other leaders) been here before and they know what to expect. So I had expected them to give them more of an idea what to do or how to go about planning it, which I don't think they did it. So it was more of a kind of figuring out as you go along."
14 15 16 17 18 19 20 21	Absent/Missed Opportunity	Instance in which the participant displayed a specific behavior, but the volunteer expected a different behavior; or, the interaction presented an opportunity to display another behavior; or, the participant presented a different approach to a specific situation	"[...] what I think was even more helpful, they didn't really talk about it until I specifically asked them, is what are the steps to take when you go to the school for people who've never been there. [...] I was surprised at my first day because I was basically in charge of the classroom. I thought the teachers come and help you and are part of it. [...] I was really worried for the undergrads who volunteered who didn't really have much experience doing this." Missed opportunity to display <i>Individualized Consideration</i>

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