Title

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Journal

International Journal of Science Education Part B, 13(2)

ISSN

2154-8455

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Publication Date

2023-04-03

DOI

10.1080/21548455.2022.2137706

International Journal of Science Education, Part B
Communication and Public Engagement

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rsed20

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To cite this article: Todd A. Harwell, Russanne Low, Allison Mattheis, Kelly Riedinger & Heather Fischer (2022): Is citizen science queering science? An exploration of the personal dimensions of engaging LGBTQ+ citizen science volunteers, International Journal of Science Education, Part B, DOI: 10.1080/21548455.2022.2137706

To link to this article: https://doi.org/10.1080/21548455.2022.2137706

Published online: 27 Oct 2022.

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, PART B
https://doi.org/10.1080/21548455.2022.2137706

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Is citizen science queering science? An exploration of the personal dimensions of engaging LGBTQ+ citizen science volunteers

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ABSTRACT

Citizen science, a field and practice that commonly involves 'non experts' engaging in scientific activities, is an avenue of science engagement that commonly results in increased scientific knowledge, literacy, and skills for the volunteers that participate. In recent years there have been increasing efforts to better understand the myriad outcomes for participants including how personal dimensions of these citizen science volunteers, such as their identities, background, cultures, and experiences, contribute to their relationships with citizen science as well as the broader field of STEM. While previous studies have acknowledged the lack of demographic diversity in terms of gender, race/ethnicity, education, and socioeconomic status, there remains little record of the sexual orientation and/or gender identity of citizen science volunteers. The aim of this study was to understand the personal dimensions of engaging LGBTQ+ volunteers in citizen science including the relationships between their queer and science identities. Based on the perspectives and experiences of 14 LGBTQ+ citizen science volunteers as shared in semi-structured interviews, this article suggests that citizen science practitioners have the potential to reduce barriers faced by queer citizen science volunteers by taking actions and enacting strategies that welcome, respect, involve, and retain LGBTQ+ participants.

ARTICLE HISTORY
Received 23 March 2022
Accepted 15 October 2022

KEYWORDS
Citizen science; identity; queer

Introduction

There is evidence that demonstrates citizen science not only produces meaningful scientific outcomes but also increases the general scientific knowledge and skills of participants as a result of their project engagement (Shirk et al., 2012). As the field continues to grow there are increasing efforts to better understand not only the impacts that these experiences have on the individuals that are contributing to the efforts of these projects but also gain a better sense of how personal dimensions of a citizen scientist, such as their identities, cultures, and experiences, contribute to their relationships with citizen science as well as the broader field of STEM. Haywood (2016) noted that there are a myriad of inter- and intra-personal aspects associated with participating in citizen science. Some initial motivations for participation include recreation or nature-based, personal values, personal growth, social interactions, and citizen science project organization (Wright

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et al., 2015) while some outcomes of participation include sense of place, sense of satisfaction, social/community connections, physical/mental health, learning and gaining knowledge, and connection to science (Haywood, 2016). Beyond identifying and understanding personal motivations and outcomes associated with citizen science participation, a deeper exploration of the personal dimensions of citizen scientists will allow the field to understand the interplay among a participant's identities, background, cultures, and experiences. With this deeper understanding, the field may be able to not only more personally connect with and engage participants, but also broaden the field of participants that contribute so meaningfully to a wide spectrum of citizen science projects and programs.

Broadening the field of citizen science volunteers

Addressing and prioritizing strategies and practices associated with diversity, equity, inclusion, and accessibility (DEIA) continues to gain momentum across the citizen science field both in practice and research. In recent years, the field has stressed broadening participation and inclusion in STEM as a central theme and objective (Eitzel et al., 2017; Oesterle et al., 2019). In early efforts to bring attention to the need for broadening participation in citizen science, Pandya (2012) illuminated that participation in citizen science across the United States still does not reflect our national demographics, and members of historically underrepresented groups STEM continue to be left out: statistically, volunteers that participate in citizen science projects that are initiated by research institutions are predominantly known to be college-educated and white (Evans et al., 2005; Haklay, 2015; National Academies of Sciences, Engineering, and Medicine [NASEM], 2018; Soleri et al., 2016). Additionally, prior research on the engagement and motivations of citizen science project volunteers has recognized the lack of demographically diverse project populations across projects (Domroese & Johnson, 2017; Frensley et al., 2017; Hobbs & White, 2012; Raddick et al., 2013). While previous studies and others have acknowledged the lack of demographic diversity in terms of gender, race/ethnicity, education, and socioeconomic status, to date there remains a little record of the sexual orientation and/or gender identity of citizen science volunteers.

The field of citizen science continues to make efforts aimed at diversifying the volunteer base that participates in the variety of projects and programs around the globe by prioritizing diversity, equity, inclusion, and accessibility strategies and practices. A recommended participatory approach to community-engaged citizen science that presented the notion of incorporating multiple voices and kinds of knowledge along with aligning research and education aims of citizen science with communities' priorities was presented in Pandya's (2012) framework for engaging diverse communities in citizen science in the United States. An additional example of efforts to increase the engagement of citizen science volunteers from diverse backgrounds and identities was introduced by Soleri et al. (2016). In this study, they recommended that one approach to diversifying who participates in citizen science is designing citizen and community science projects that draw upon equity-based, co-created projects that address community concerns, which would also create more equitable partnerships between scientists and the public. Other studies focused on project design and delivery elements that provide volunteers from non-dominant communities, backgrounds, and identities with more supportive and authentic experiences in citizen science, which result in more meaningful experiences and outcomes. Chesser et al. (2019) presented five approaches and considerations to engaging citizen science volunteers from traditionally marginalized groups or populations should be designed with five specific ethical considerations: inclusivity, adaptability, sensitivity, safety, and reciprocity.

LGBTQ+ citizen science volunteer engagement

Given the fact that a lack of broad participation in citizen science projects affects the quality of the projects themselves (Pandya, 2012), the field of citizen science needs individuals with multi-

dimensional identities and diverse perspectives and backgrounds. The heterosexist and heteronormative nature of science education and professional STEM fields contribute to a continued lack of engagement in STEM among LGBTQ+ individuals (Freeman, 2018; Heimlich, 2019; Letts, 1999; Yoder & Mattheis, 2015). As Freeman (2018) acknowledged, the general culture of STEM fields alienates LGBTQ+ individuals, and they are seen to be 'leaking out of the scientific pipeline,' but citizen science has the potential to engage and retain them. A more thorough understanding of the complex relationships that exist between and among the personal dimensions of citizen science volunteers is needed by the field. The overall aim of this study is to understand the personal dimensions of engaging LGBTQ+ volunteers in citizen science including the relationships between LGBTQ+ citizen science volunteers' queer and science identities. By looking at the interplay of citizen science engagement, sexual orientation, and gender identity of citizen science volunteers, the broader citizen science field will gain knowledge of how to more appropriately and authentically welcome, respect, involve, and retain LGBTQ+ volunteers in citizen science. This study is motivated to answer the following research question: What is the relationship between LGBTQ+ citizen science volunteers' science identities and queer identities?

Theoretical lens

This study is informed by sociocultural theories related to identity and informal learning and also draws upon queer theoretical perspectives in order to approach this work through a queer sociocultural lens. The notion of a science identity is rooted in sociocultural theorist Gee's (2000) conception of an individual's identity being contextual in terms of the kind of person they are recognized as. Gee also acknowledges that this form of identity, of which an individual possesses multiple, is largely unfixed and changes based on time and place in addition to other influences and factors, which aligns both with informal learning theories and queer theoretical perspectives. Falk and Dierking's (2002) Contextual Model of Learning posits that there are three interrelated contexts or dimensions in which learning, typically in informal settings, occurs and is shaped by including the personal dimension, sociocultural dimension, and physical dimension. Most relevant to framing this work, the personal dimension includes aspects of an individual's interests, motivations, prior knowledge and experiences, and their various identities. In terms of considering queer identities, queer theory also posits these identities as being ambiguous, fluid, and contextually developed. Jagose (1996) presents queer identity as an identity category beyond a label such as gay or lesbian, and, similar to Gee's (2000) consideration of identity, acknowledges that 'queer is always an identity under construction.'

Personal dimension of identity development of citizen science volunteers

Citizen science has been identified as a mechanism to support the development of aspects related to the personal dimension of engagement with science. Specifically, participation in citizen science projects and programs has been found to impact an individual's science-related identity in addition to their social and cultural identities, which are those familial and cultural backgrounds that are more inherently held by an individual and are generally viewed as stable (Gee, 2000), especially for participants from communities and backgrounds considered to be nondominant and underrepresented in STEM (NASEM, 2018). Ballard et al. (2018) posited that citizen and community science opportunities have the potential to promote the development of science identity and agency among the project designers, project managers, partner, scientists, and volunteers that participate in and contribute to the project or program activities. They claimed that these opportunities for volunteers not only allow them to engage with and learn about science, but also contribute to developing their science identities by allowing individuals to question, challenge, and address issues related to science based on their personal experiences and/or community concerns. In considering and addressing science identity and agency across a broad range of citizen and community science

programs, Ballard et al. (2018), concluded that programs should make greater efforts to incorporate aspects of volunteers' personal dimensions, including social and cultural histories and identities. They claimed that not only would this enhance project outcomes, but ultimately foster the development of the science identity and agency of volunteers. Those conclusions are reflective of Carlone and Johnson's (2007) grounded model of science identity, which noted there are a variety of ways in which an individual's racial, ethnic, and gender identities interact with and impact the development of science identity. Drawing upon these approaches to understanding and considering identities related to science, in this paper science identity is defined as how an individual sees themselves and is recognized by others as someone who understands, uses, and does science (Ballard et al., 2018; Carlone and Johnson, 2007; Gee, 2000; National Research Council [NRC], 2009).

Queer identities among multiple other identities

Sociocultural and queer theories have acknowledged an individual's identity is in fact comprised of the combination and interaction of multiple identities in addition to environmental and societal influences. Looking to sociocultural theories of identity and learning within the scope of diversity, Gee (2017) used citizen scientists as an example of what is considered an activity-based identity – those that are freely chosen and adopted by individuals in response to their personal interests or social organization influences. These were presented in contrast to relational identities, which are more akin to social and cultural identities such as race, ethnicity, ability level, gender identity, and sexual orientation. He makes the claim that a relational identity of an individual that is embraced and perhaps even celebrated can become more like an activity-based identity in that it is a chosen, adopted, and possibly cherished label and aspect of one's being.

From queer theoretical considerations, Jagose (1996) described queer identity as a sort of anti-identity – one that is more fluid and less ontologically bound compared to other social and cultural identities that an individual may possess. She acknowledges that while queer identity can be linked to other sexuality-related identities such as gay or lesbian, it is not as 'normal' as these due to its ever-evolving, fluid nature. In considering the unfixed nature of identity and the various influences that shape it, Hames-Garcia (2011) made the case for presenting the multiplicity of identity within queer individuals, which acknowledges the myriad of complexities and variabilities that exist within an individual as related to their diversity of personal experiences in addition to their multiple social and cultural identities. This concept of a multiplicity of identities along with other queer theorists' consideration of the multiple identities of queer subjects based on the concept of intersectionality as introduced by Crenshaw (1989) from the field of Black feminist studies. Crenshaw coined intersectionality in her characterization of how Black women are uniquely discriminated against based on the combination of multiple facets of their identities, race and sex.

Terminology

While queer identity has a rather broad and varied consideration, the use of the term *queer* on its own also has many interpretations and uses. In this paper, the term *queer* will be largely used to refer to queer identities and also in its form as an umbrella term for individuals that consider their sexual orientation and/or gender identities to be outside of the cisgender/heterosexual norm. It is also important to acknowledge that queer can also be considered and used as a verb that indicates a challenging or disrupting of social norms, especially those surrounding gender and sexuality (Barker, 2016). It is important to note and respect that some sexual minority individuals may not personally identify as queer or as possessing a queer identity or perhaps have an aversion to this term given the history of its derogatory usage and negative association. In the context of the present study, all participants were asked about and confirmed that they possessed a queer identity.

Queer STEM identities

This interplay of an individual's multiple identities has also been acknowledged in explorations of the relationships between queerness and science identity. In making the case for queering STEM learningscapes, which are 'the spaces of living through which the many pathways of an individual's experiences, memberships, identities, and activities run and are interpreted through the person's unique frames into meaning or lack of meaning,' Heimlich (2019) highlighted the fact that individual STEM learning and engagement occurs across the many personal and social experiences in one's life and cannot be separated within their mind. He acknowledged that a queer individual's engagement and relationship with science are directly influenced and shaped by their queer identities. Heimlich further pointed out that as with other elements of identity, being LGBTQ+ influences how an individual engages in society, and specifically the discomfort that queer individuals constantly endure, which stems from the binary power relationship of normal/not normal – one that privileges the heteronormative perspective. In their development and presentation of a model of queer STEM identity, Mattheis et al. (2019) introduced an explanatory framework for the multiple influences that shape queer STEM workplace identities including how an individual perceives and defines queer identity, the formation of personal STEM identity, and navigating a queer identity at work. They concluded that heteronormative assumptions often silence conversations of gender and sexuality in STEM workplaces, which contributes to complex negotiations of self for queer STEM professionals.

Study methods

Data collection and participant characteristics

In order to address the research question regarding the relationship between LGBTQ+ citizen science volunteers' science identities and queer identities, one-on-one semi-structured interviews were conducted via Zoom video conferencing software with a sample (N = 14) of self-identified LGBTQ+ citizen science volunteers from across the United States. Following IRB approval, participants were recruited by invitation shared via email, online forums, and through social media. Initial recruitment communications that contained study information and a brief demographic survey were shared between December 2020 and February 2021 with various citizen science-related organizations, networks, forums, and listservs including the Citizen Science Association (CSA), CitSci.org, Zooniverse, the Australian Citizen Science Association (ACSA), the European Citizen Science Association (ECSA) and the EU-Citizen. Science forum, in addition to social media posts on Twitter and Reddit. Additionally, targeted emails were sent to citizen science project contacts identified through professional connections as well as contacts that previously completed a survey for citizen science practitioners involved with another study (Harwell, 2021). A total of 32 individuals completed the demographic survey and 29 were considered to have met the study criteria of self-identifying as LGBTQ+ and at the time were or had previously been engaged with at least one citizen science project in a volunteer capacity. Purposeful sampling techniques were employed to invite 22 participants from the pool that met the study criteria to ensure adequate within-sample diversity based on sexual orientation and gender identity in addition to race/ethnicity, age, and geographic diversity, and 14 individuals ultimately responded and accepted the invitation to participate.

The 14 participants were interviewed between January and March 2021 about their experiences and relationships with science, citizen science, and aspects of their sexual orientations and gender and queer identities. To ensure confidentiality, the names of all interviewees were changed to pseudonyms, which can be found in Table 1 along with a general overview of the participant demographics including ages, locations, gender and sexual identities, and race/ethnicity.

Table 1. Participant characteristics.

Pseudonym[a]	Age[b]	Location[b]	Gender and sexual identities	Race/ethnicity
Alison	38	California	Woman/bisexual/queer	Asian/white
Bernard	31	Oregon	Man/gay	White
Cleo	72	Oregon	Two-spirit/lesbian	American Indian or Alaska Native/ white
David	38	New York	Man/gay/queer	White
Gabby	39	California	Woman/gay/lesbian/queer	Hispanic or Latinx/white
Juniper	29	Utah	Non-binary/transgender/queer	White
Kameryn	30	Tennessee	Woman/bisexual	White
Kestrel	26	Florida	Man/bisexual	Asian/Filipino
Laura	23	North Carolina	Genderqueer/queer	White
Motai	61	Oregon	Two-spirit/asexual/lesbian	American Indian or Alaska Native/ white
Penguin	73	Oregon	Woman/bisexual	White
Penny	39	Kentucky	Woman/bisexual	White
Robin	18	California	Genderqueer/non-binary/asexual/lesbian	Hispanic or Latinx/white
Syd	36	Texas	Agender/non-binary/asexual/demisexual/ queer	White

[a]Participants were given the option to select their own pseudonym; if they declined, one was assigned by the researcher that conducted the interview.
[b]Reported by participants at the time of data collection in 2021.

Participants were asked a series of questions in order to determine how aspects of their queer and science identities influence their relationships with science and citizen science. A semi-structured open-ended question protocol was used to elicit detail and depth in responses through prompted conversation. In addition to questions related to their history of engaging with citizen science projects and how they describe their sexual orientation and gender identities, four questions in particular were used to prompt discussion on the relationships among and between science and queer identities, science, and citizen science.

- What sort of role does your queer identity play in your life?
- How has your queer identity impacted your participation in citizen science?
- How do you view the relationship between science and queerness?
- What aspects of your culture, family, or background do you feel have contributed to your engagement with science and citizen science?

Data analysis

Interviews were video and audio recorded as well as digitally transcribed using features within the Zoom software platform. All 14 interview transcriptions were manually corrected by the researcher that conducted the interviews, through a series of simultaneously reading transcripts and watching/listening to interview recordings, and then used for qualitative coding and frequency analysis via MAXQDA 2020 Analytics Pro. For each interview, the coding methodology included a process of carefully reviewing each line of transcription and applying an open thematic coding process in order to isolate and identify themes within the transcribed text (Auerbach & Silverstein, 2003). This constant comparative approach involved grouping similar text segments from across interviews together into a broader theme, which was considered a parent code, and then within each of these were more specific or targeted examples of the theme, which were considered child codes (Creswell, 2003; Strauss & Corbin, 1997). This process was repeated with parent and child codes being updated and collapsed through multiple rounds of coding until the most salient thematic groupings were identified. Following the coding process, frequencies of codes by theme were calculated.

Results

Overview

A total of 14 parent codes were identified and categorized within three overarching themes associated with the personal dimensions of engaging LGBTQ+ volunteers in citizen science including the relationships between queer and science identities:

- Impacts of Queer and Personal Connections
- Opportunities for Queering Scientific Approaches
- Persisting Barriers for Queering/Queers In [Citizen] Science

The descriptions, examples, and frequencies of codes by theme are illustrated in Tables 2, 3, and 4. The theme that emerged with the most code occurrences was *Impacts of Queer and Personal Connections*, which had a total of 65 code occurrences. This was followed in frequency by *Opportunities for Queering Scientific Approaches* with 26 code occurrences and then *Persisting Barriers for Queering/Queers in [Citizen] Science* with 21 code occurrences. The two most frequently represented themes included five prevalent parent codes that were associated with similar examples or subthemes found in child codes as related to the larger categorical theme while the theme least represented by code occurrences included four main parent codes.

Impacts of queer and personal connections

Table 2 highlights the most prevalent codes associated with the theme how queer and other personal connections contribute to the personal dimensions of engagement in citizen science for LGBTQ+

Table 2. Code frequency for the theme of impacts of queer and personal connections.

Code name	Code description	Example(s) of code	# Occurrences
Family	References to how family members influenced volunteers' engagement in citizen science in some way.	'I think my father loving to be outside and taking me with him boating; he taught me how to swim in the ocean and how to fish … I was always outside.' – Cleo	25
Friendships & relationships	Remarks about the influence that friendships and relationships play in participants' lives and citizen science engagement.	'It was through the community garden association … I was in charge of monitoring emails and one day I got an email from a woman that said she and her [same sex] partner were moving [here] and wanted to be in the association and so we started corresponding and they're now my best friends.' – Penguin	15
Citizen science as a queer space	Statements about citizen science welcoming and/or attracting queer folks.	'I feel like there is a higher number of LGBTQ people in my naturalist community than the general population … there's a bunch of queer people who do this, which is great.' – Penny	10
No queer impact	Comments from volunteers about their queer identities having little or no impact on their engagement with citizen science.	'I don't know if I can connect the two strongly … I haven't had too much of a connection of being gay and doing citizen science and all that.' – Bernard	8
School & education	References to how school and other educational experiences influenced volunteers' engagement in citizen science in some way.	'I was really involved in a youth development program and there were lots of stuff that were science focused and I just feel like I was in a space where I got nerdy I was encouraged to continue to be nerdy.' – Juniper	7
Total			65

Table 3. Code frequency for the theme of opportunities for queering scientific approaches.

Code name	Code description	Example(s) of code	# Occurrences
Identities impact science/scientists	Statements about how science is influenced by aspects of scientists' identities.	'There needs to be more queer people asking [scientific] questions … it increases the diversity of questions you'll ask because you'll have different perspectives.' – Laura	8
Opportunities to queer science	Comments on the importance of diversifying and challenging traditional scientific norms and approaches.	'The way in which we conduct science is so biased … changing up the normal dialogue [is important] … like acknowledging bias or how a cisgender, straight mind can view or make observations that either don't exist or ignore things that they're observing.' – Kameryn	8
Queer approaches to citizen science	References to how volunteers' queerness has impacted their approaches to citizen science.	'I think that growing up queer makes you a bit of an iconoclast so I think [that influenced] some of the approaches [to citizen science] I have taken … and that sort of desire to figure out a third way … when it seems like there's a binary of options.' – David	4
Citizen science as a queering tool	Comments on how citizen science can contribute to diversifying and challenging traditional scientific norms and approaches.	'Community science brings out the opportunity for people who don't have access to seeing what a scientist might look like or even envisioning themselves as a scientist and allows them to put on that role.' – Gabby	3
Queer benefits of science	Remarks about similarities and/or a positive relationship between science and queerness.	'A big part of being queer is often questioning assumptions … I also think a big part of science is questioning assumptions and things in front of you.' – Alison	3
Total			26

volunteers. Twelve out of 14 participants provided examples or anecdotes about experiences and influences from family members. The vast majority of these (16 out of 25) were considered to have a positive impact on their relationship with science and eventual engagement with citizen science.

> My grandparents play a big role in [my engagement with science] and I didn't really know it until after they had passed away, but I have really distinct memories of them either teaching me how to eat wild plants or telling me stories about like crazy adventures they had gone on in the wilderness. Or like my grandfather, as he got older he photographed wildflowers to the point where it's a family joke–that he just took so many pictures of wildflowers! But yeah, that definitely got passed down. (Penny)

Table 4. Code frequency for the theme of persisting barriers for queering/ queers in [citizen] science.

Code name	Code description	Example(s) of code	# Occurrences
'Traditional' science norms	Comments about the rigid, oppressive, and/or exclusive nature of 'traditional' science.	'STEM, in general, is still very much [dominated by] straight, white men … you're still missing viewpoints.' – Robin	11
Lack of connection	References to volunteers feeling a lack of connection with fellow citizen science volunteers.	'There's nothing to bond with–my experiences are so different from theirs.' – Motai	4
In the closet	Statements about LGBTQ+ volunteers not feeling comfortable 'outing' themselves to others.	'I tend to be pretty closeted about lots of aspects of who I am … it really does make me feel like an other and alienated.' – Syd	4
Power structures in citizen science	Remarks of ways in which power structures and imbalances persist in citizen science.	'The people that I've learned citizen science from have been older white men … and so you know right there [that] has upheld those structures.' – Penny	2
Total			21

Conversely, one participant noted that their parents' beliefs toward science had a negative impact, but they credit having experienced these influences as a motivating factor related to their interest in participating in citizen science.

> My parents were very smart, and I always respected that. And then when I got older I realized that they were very smart but they had only learned things a certain way, and I began to notice how they would weaponize science to further their own beliefs and saying things as if your sexuality and your gender identity are not natural–there's a scientific, natural way to be … I've seen how science has been weaponized to further an agenda, an oppressive agenda … and citizen science, I think because it is open it goes against what people deem as "normal" science or what the public sees as like the "normal" science. And so that's why I think I gravitated towards [citizen science]–it was a different way to do science because I had seen hurtful science-based views from those within my own family. (Laura)

There were 15 occurrences of participants citing how friendships and/or relationships impacted their engagement with citizen science in some way. These ranged from connecting and bonding with fellow volunteers that also identified as LGBTQ+ and/or others from non-dominant groups, communities, backgrounds, or cultures to how they talked about or introduced their romantic partner to others that were engaged with their citizen science project. One participant even shared examples of how she and her wife, who also engaged with the same project, developed deeper bonds with their group of volunteers.

> The biggest, scary moment, I guess, would have been when my wife and I announced to the group of community scientists that, "hey, we're going to have a baby!" And just waiting for the reaction there, which was more than welcoming and in a very kind and not weird way our son became like the mascot of the program. So much so that when we stopped bringing him due to COVID there were complaints and demands to see him in other means. So that's been interesting to kind of navigate that and have that hesitancy of realizing like maybe people didn't know [about that aspect of our identities]. (Gabby)

Following family and friendships/relationships, there were 10 occurrences related to citizen science being a queer space in which participants remarked on how citizen science seemed to attract, welcome, and/or provide space for LGBTQ+ folks. There were also eight participants that made comments about their queer identities playing no role or having very little impact on their experiences as citizen science volunteers. Other personal connections included seven occurrences in which participants linked their citizen science engagement to experiences related to their education, schooling, or other academic-related involvement.

Opportunities for queering scientific approaches

The codes associated with the theme of participants' views on the need and/or opportunities for queering scientific approaches are shown in Table 3. There were eight instances in which participants expressed that they believe aspects of one's identities can and do impact not only their relationships with science but also their approaches to conducting science. They acknowledged that unique backgrounds, perspectives, experiences, and other elements related to their identities allow them to view and approach science in a way that is different from 'traditional' scientific norms or methods.

> I think for so long science was dominated by the cis[gender], heteronormative patriarchal-like norms that those questions being asked were always geared towards validating the cis[gender] and the heterosexual, white perspective. And it was something I heard a lot growing up–all of these misconceptions around sexuality and gender. Like, you can go back and look at how much Darwin's work was influenced by the Victorian social norms of the era. Like, it's going to happen. Scientists don't act in a bubble … your sexual orientation, your gender is there when you ask a question as a scientist. (Laura)

In a similar vein, participants also indicated the great need and importance to queer, or diversify and challenge, traditional scientific norms and approaches. Across the interviews were eight comments or examples in which participants described 'traditional' science and scientific approaches as

biased, harmful, and operating in a bubble. They acknowledged that 'traditional' scientific approaches are largely rooted in and shaped by Western, white, cisgender, heterosexual male perspectives, which leaves little room or opportunity for diversifying methods. Furthermore, most of these examples cited the importance and value of queer perspectives and experiences in contributing to better, more diverse science and scientific approaches.

> Well, I definitely know that there's a lot of perspectives that queer people have that the mainstream population doesn't have, and we bring a lot of innovation to the field. And that's the case with any level of diversity … so I think any time you have more diversity [in] a group, the group is going to be better and it's going to make more contributions [to science]. (Syd)

Beyond suggesting opportunities and avenues to queer science and scientific approaches, there were also four examples in which participants described how their queer identities had shaped or influenced their approaches to and experiences with citizen science specifically. Although most of these emerged as unconscious or subconscious revelations as participants reflected on if and how their queer identities contributed to their involvement with citizen science, they seemed to conclude that on some level their queer identities had an impact on aspects of how they engaged with citizen science efforts.

> The number of times I got told that we were making Grindr[1] for trees … and this was in the early days. "I heard of this dating app. It kind of sounds like what you're [doing] … " I'm not going to lie, I think that kind of community-making, if we can call it that, or that kind of low risk way of interacting with other people, might have tacitly shaped the way I thought about that platform–that there would be a way online for people who take care of trees to connect with one another and let each other know what they're doing without having to meet in person because they might not want to. Yeah, I think that might have bubbled up in there somewhere. (David)

There were also three occurrences of comments by participants pertaining to the potential for citizen or community science to be used as a tool or method to contribute to efforts to queer science. Additionally, there were also three statements made by participants in which they provided examples from their perspective or expressed the belief that there are similarities and/or a positive relationship between queerness and science, broadly.

Persisting barriers for queering/queers in [citizen] science

Table 4 displays the codes that emerged as related to barriers to engagement in both science and citizen science for LGBTQ+ citizen science volunteers. The most prevalent code was related to 'traditional' science norms. Of the 14 participants, seven provided 11 comments or examples of the ways in which they perceived or experienced scientific fields, methods, and/or communities as being generally rigid, oppressive, or exclusive. They expressed feelings of not being welcomed to engage with science based on their queer identities along with other aspects of their identifies and backgrounds.

> There's no room for fluidity [in science], and although I am a really staunch believer in science, I am disappointed that it has not found the fluidity that's necessary to properly include people. And anytime you have a science of inclusion rather than exclusion, you're going to bring more people in. But as soon as you bring more people in, the group that is the dominant culture suddenly feels threatened. (Motai)

Participants on four occasions also described a barrier related to feeling a lack of connection with other volunteers involved with their citizen science projects. The source of this lack of connection was generally cited to be in relation to their feeling like an outsider or an 'other' based on their queer identity, and not being able to establish any sort of friendship or relationship with their fellow volunteers, that were primarily presented as cisgender and heterosexual. Additionally, some LGBTQ+ volunteers feel a sense of discomfort within their citizen science groups, and are not necessarily

open to the idea of outing themselves for fear of not being fully accepted by others in these groups or within these spaces.

> I do feel like I can't really be myself sometimes when I'm with my citizen science groups … a lot of people are older, and I know that they tend to be on the very liberal side so I'm sure that most people wouldn't have an issue if I came out, but I feel like if I did I wouldn't be fully accepted in the way I wanted to be. So there always is this feeling in the back of my mind that I can't fully be who I am without fear for how people will respond to me even though, deep down, I know people probably won't care … it's difficult. (Syd)

A related barrier noted as contributing to a lack of connection by at least one participant was the notion of still being 'in the closet' to some extent. There were four cases in which participants admitted that they either were not comfortable with the idea of 'coming out' to others involved with their citizen science projects, or they were not completely 'out' to specific individuals or groups within their professional or personal lives. An additional barrier that was noted on two occasions was related to the power dynamics and structures that exist within the field of citizen science. This was also noted as being the result of citizen science emerging from more 'traditional' science approaches and methods in the ways that some projects are designed and project-related decisions are made 'from the top' by managers, leaders, or coordinators.

Discussion

Participants in this study have expressed a variety of experiences and perspectives related to the personal dimensions of engagement in citizen science as an LGBTQ+ individual. By considering this information, how can this study help to broaden the field of citizen science by reducing cisheteronormative barriers, and more appropriately and authentically welcome, respect, involve, and retain LGBTQ+ volunteers in citizen science? There are a few implications for practitioners, including citizen science project or program leaders, designers, coordinators, or managers, discussed below.

Creating connections and queer spaces

Participants indicated that personal connections played an important role in their engagement with citizen science and science more broadly. In an effort to broaden the field of citizen science volunteers, and especially engage and welcome LGBTQ+ individuals to participate, projects and programs should encourage their volunteers to engage their families and friends in aspects of their involvement. Even if those non-volunteers connected to volunteers may not have an interest in or the capacity to personally engage with the project directly, knowledge of or peripheral engagement with citizen science has the potential to create a lasting and impactful perspective of science that may influence aspects of their science identities and future science and citizen science engagement. Additionally, practitioners should provide opportunities for volunteers within their projects to form connections beyond project activities and are deeper than surface-level interactions. This can be facilitated by organizing and hosting purely social events or activities, which can be held in-person or online depending on the nature of the project and the geographic distribution of volunteers, that provide time and space for volunteers to get to know one another on a more personal level beyond the context of the project. Additionally, setting up and encouraging the use of online communication channels or platforms, such as Facebook groups or Discord servers, which were mentioned by a few participants, allow volunteers to communicate and interact more regularly and freely.

Another opportunity that would allow LGBTQ+ citizen science volunteers to feel more welcome and/or connected to fellow project volunteers would be for practitioners to take actions to make their project or program a queer-friendly space. That is not to say that projects should simply make a public claim in recruitment materials that they are open to and welcome LGBTQ+

volunteers, but they can and should make concerted efforts to directly connect with LGBTQ+ organizations and communities to invite them to participate, and recognize and respect any current LGBTQ+ volunteers, regardless of whether or not they may be 'out.' Depending on the scale of the project, it may even be possible to organize or host LGBTQ+ volunteer events surrounding project activities and/or solely engaging socially. As Friedensen et al. (2021) found in their study of queer undergraduate students in STEM, queer folks in STEM, including queer citizen science volunteers, coming together as a cohesive community has the potential to 'queer an un-queer space and create of queer future possibilities in STEM' (p. 349). Additionally, a practice that can signal to prospective and current volunteers that a project is a queer-friendly space is to encourage the active sharing and use of personal pronouns as indicated by an individual by practitioners and volunteers alike. As noted by one participant who uses they/them pronouns, Juniper, 'It gets hard sometimes … it kind of starts to hurt if they don't put effort into trying to learn pronouns and stuff … ' There is a great opportunity to engage LGBTQ+ volunteers in science via citizen science by welcoming, affirming, and respecting those with minoritized sexual orientations and/or gender identities.

Embracing queer identities and approaches

There were a number of participants that acknowledged that aspects of identities, and specifically for queer folks, play a role in and contribute to how an individual perceives and contributes to science and citizen science. Citizen science practitioners should acknowledge and communicate how valuable their perspectives and contributions are to their projects or programs based on their unique lived experiences as a queer person in addition to other personal facets related to their identities and backgrounds. As Tan et al. (2013) found in their study on middle school girls' negotiations of science-related identities among other identities-in-practice, recognizing and validating the identities of those engaging in science, including learners and citizen science volunteers alike, can be incredibly empowering and serve as a support structure for continued engagement with science. Citizen science practitioners have the potential to empower their project or program's LGBTQ_ volunteers by recognizing and validating their queer identities and lived experiences as an asset that can and should be applied to the ways in which they approach and contribute to the overall scientific aims. Additionally, by regularly communicating this sort of acknowledgement and validation, practitioners can indicate to LGBTQ+ volunteers that citizen science is a queer space that values queer perspectives and identities, ultimately not only broadening the field of citizen science but also STEM more broadly.

Beyond queer identity recognition and validation, citizen science practitioners should be open to and encourage a queering, as in a disrupting, challenging, or transforming, of traditional scientific approaches. A few participants shared examples of how their queer identities influenced the ways they approached and conducted science in more nuanced or innovative ways as a product of their experiences as a queer individual. Additionally, a number of participants expressed a desire to or need for queering traditional scientific perspectives and approaches. They noted that the field of science, and also the field of citizen science based on its foundations and roots, is grounded in Western, white, and cisheteronormative practices and norms, and there is a great need to move beyond these oppressive and exclusive ways of doing science in order to truly broaden participation as well as conduct better, richer science. A couple of participants expressed the potential for citizen science to serve as a pathway or vehicle to queering science more broadly through a queering of scientific questions and approaches while welcoming and validating a diversity of perspectives and identities. This shaping of questions and methods by queer identities related to conducting science and contributing to citizen science is echoed by Cipolla et al. (2017) in their argument for the need for queer and feminist approaches to science:

> In addition to arguing for a 'queering' of science, science studies, and feminist science studies, we argue that queer feminist approaches to reading science offers profoundly innovative and different answers [to scientific

> questions] … the ubiquity of scientific narratives and their power in reshaping the parameters of how we think about the distinctions between nature and artifice, biology and culture, time and space, mind and body, and other vital issues means that science studies must roam far beyond institutions of sciences. A queer feminist science studies must concern itself with quotidian practices in meaning making that trouble, disrupt, and reconfigure assumptions about nature, difference, species, and worldliness. (pp. 4–5)

Conclusions

Based on the experiences of participants in this study, the relationships that exist between and among the personal dimensions of LGBTQ+ citizen science volunteers reveal that there are several barriers as well as opportunities for queering, or transforming, citizen science. Practitioners across the field have the potential to reduce these barriers that LGBTQ+ volunteers face in addition to taking actions and enacting strategies that welcome, respect, involve, and retain LGBTQ+ individuals in their projects and programs. To aid in these efforts, we offer some recommendations to citizen science practitioners:

1. Create welcoming spaces that allow LGBTQ+ individuals to feel comfortable and safe.
2. Encourage and facilitate relationship-building among and between volunteers as well as project staff.
3. Acknowledge and validate queer and other non-dominant identities, perspectives, approaches, and ways of knowing.
4. Practice inclusive project and program design that allows volunteers to shape and guide project aims and activities, benefitting from their unique perspectives and approaches.

Within citizen science projects and programs, it is vital to create opportunities and spaces to forge personal connections among and between volunteers beyond surface-level interactions that solely focus on project aims and outcomes, especially for those that identify as LGBTQ+. Additionally, practitioners can and should recognize and validate the scientific value that queer individuals bring with them in the unique perspectives and approaches to engaging with citizen science as influenced by their queer identities and other aspects of their personal dimensions. By actively welcoming, valuing, and embracing LGBTQ+ volunteers in citizen science, there is great potential for not only queering, or disrupting or challenging, traditional scientific norms and practices that persist in citizen science, but also to queer traditional STEM practices and broaden participation in STEM overall.

Note

1. Grindr is the world's largest social networking app for gay, bi, trans, and queer people that uses location-based technology to allow individuals to connect and interact with one another based on proximity (Grindr, n.d.).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics statement

This study was approved for exempt status by the Oregon State University Institutional Review Board (OSU IRB #IRB-2020-0741). All study participants consented to participate in the study and are aware their responses would be used in peer-reviewed publications.

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