

CASE STUDIES

Getting to Know Other Ways of Knowing: Boundary Experiences in Citizen Science

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This article uses the concept of boundaries (Akkerman and Bakker 2011) to explore why collaboration in citizen science is sometimes difficult. The case study focuses on collaboration between project organizers and project volunteers in a single citizen science project. The volunteers, from a regional botanical society, experienced boundaries between their group's practices and the citizen science project organized by a natural history museum, despite similar ways of working. Organizers and volunteers responded to boundary experiences by defining their respective practices and suggesting how project activities could be coordinated across boundaries. Findings from this study support practitioners' efforts to implement citizen science projects that result in positive outcomes for organizers and volunteers by revealing how participation in a community of practice, such as a botanical society, affects volunteers' engagement in citizen science. Suggestions are made for how project designs can be responsive to volunteers' boundary experiences.

Keywords: citizen science; community of practice; natural history museums; interaction analysis; botany; boundary practices

Collaboration and Boundaries in Citizen Science

Citizen science brings people together. In both its democratic (Irwin 1995) and participatory (Bonney 1996) forms, citizen science is an activity premised on the participation of many individuals, often from very different professional and educational backgrounds. More than a decade of research has demonstrated that bringing together people with diverse knowledge and experiences can produce desirable outcomes for science, for socio-ecological systems, and for individuals, namely project organizers and volunteers (Shirk et al. 2012).

Given the diversity of aims, knowledge, and identities that participants¹ bring to citizen science, it is perhaps surprising that citizen science works as often as it does. Natural history museums are one context where diversity of scientific themes and people is especially notable. As places where science meets the public, and the public meets science, natural history museums have a long tradition of activities akin to participatory citizen science (Star and Griesemer 1989; Sforzi et al. 2018). Increasingly, these institutions also organize and contribute to citizen science projects (Ballard et al. 2017), particularly those that are understood to have the potential to simultaneously advance museums' scientific and educational missions (Sforzi et al. 2018). A recent study of citizen science programs at natural history museums underscores

the variety of ways citizen science volunteers contribute (Ballard et al. 2017). Museums, may, for example, engage online audiences through the digitization of collections and through crowdsourcing projects such as Herbaria@Home, where information about herbarium specimens from the Natural History Museum London is transcribed by volunteers online (Ballard et al. 2017). Museums also organize monitoring projects linked to the local environment: The Natural History Museum Los Angeles, for example, collects observations of snails and slugs in southern California with the help of users on the iNaturalist platform (Ballard et al. 2017), complementing the museum's historical collection of physical snail specimens. Although such monitoring projects may seem similar to the ways scientists and naturalists have collaborated in the past, recent studies demonstrate that they also often involve the introduction of new knowledge practices (Turnhout, Lawrence, and Turnhout 2016).

Successful citizen science at natural history museums, in the sense of initiatives that result in desirable outcomes for organizers as well as volunteers (ECSA 2015), may depend on designing projects, tasks, and infrastructures that foster reciprocity among participants (Hetland 2020). Tensions nevertheless emerge between the aims of project organizers and the interests of amateur-expert volunteers. Ellis and Waterton (2004) have, for example, highlighted the experiences of naturalists in the United Kingdom whose species observations are used in environmental policy-making. While project organizers, including staff at the Natural History Museum London, see the use

of volunteer-collected data as one way to increase citizen participation, amateur-expert volunteers who contribute data also “lament the fact that environmental planners may not consult naturalists at all during their decision-making” (Ellis and Waterton 2004, p. 99). Collaboration in citizen science is often difficult (Golombic et al. 2017; Kasperowski and Hillman 2018); outcomes are not always positive (Eleta et al. 2019); and efforts to engage volunteers sometimes fall short (Frensley et al. 2017). Heterogeneity of people and practices, it would seem, is both a condition and a challenge for achieving desirable outcomes in citizen science.

This study aims to support practitioners’ capacity to design and implement projects that result in meaningful, positive outcomes for organizers and volunteers by exploring participants’ experiences of boundaries in citizen science. This may be a boundary between the knowledge practices of volunteers and project organizers, or differences in participants’ respective understanding of a project’s goals. By identifying whether and in which circumstances participants in citizen science projects experience boundaries, and how these boundary experiences are addressed, the study contributes to a more nuanced understanding of the challenges for collaboration in citizen science. Such empirical findings can in turn inform the development of more deliberately designed projects (Shirk et al. 2012).

Using a single-case research design (Flyvbjerg 2006; Yin 2014), this empirical study explores participants’ experiences of boundaries in a pilot citizen science project. The pilot was designed by staff at the University of Oslo’s Natural History Museum and involved transcribing information about plant specimens from digital images in an online portal. Project volunteers were all members of a regional botanical society that worked on plants collected in the region of Norway where their group was active. This study explores how volunteers experienced differences between the citizen science project activities and their own group’s practices as a botanical society, and traces how volunteers and project organizers responded to these experiences. To situate the case study, the following sections give a brief overview of the complex institutional context in which citizen science projects at natural history museums are carried out, and describe how socio-cultural theoretical perspectives help to understand this complexity.

Citizen Science in Natural History Museums

As institutions with diverse civic, scientific, and educational aims (Hetland 2019), natural history museums play multiple roles in biodiversity research and conservation (Ballard et al. 2017). For example, projects that digitize collections using contributions from volunteers encompass both educational and scientific aims. In an effort to make historical information about collections more accessible for current research, natural history museums are imaging plant and animal collections, digitizing collections data at a massive scale (Ellwood et al. 2015), and making this information more readily available through participation in initiatives such as the Global Biodiversity

Information Facility (Lendemer et al. 2020). Citizen science practitioners have identified a variety of tasks through which volunteers can improve the quality of digital information about collections online, including transcribing ledger or label text, assigning geo-referencing coordinates, and annotating digital images of specimens (Ellwood et al. 2015). The DigiVol platform, for example, developed by the Australian Museum and the Atlas of Living Australia, includes online projects focused on specimen labels and collections documentation. The Notes from Nature project on the Zooniverse platform similarly involves transcription tasks associated with herbarium collections at United States (U.S.) institutions including the New York Botanical Garden and the Florida Museum of Natural History. Some digitization projects use protocols and extensive online tutorials to ensure that anyone can contribute (Hill et al. 2012). Biodiversity researchers and citizen science project developers have also, however, suggested that knowledge of the geography (Ellwood et al. 2015, p. 389) and organisms (Merckx et al. 2018) represented in a museum’s collection could result in more precise geo-referencing and more accurate transcription of place and species names. Outreach to amateur-expert organizations has been suggested as a strategy for recruiting individuals with potentially relevant knowledge for these kinds of digitization projects (Ellwood et al. 2016, p. 8; Merckx et al. 2018, p. 46).

In addition to projects that focus on specimens in a museum’s collection, natural history museums also collaborate with amateur-expert organizations on biological recording schemes (Ellis and Waterton 2004, 2005; Sforzi et al. 2018). Amateur-expert organizations, such as the British Bryological Society (Ellis and Waterton 2004, 2005) and the British Trust for Ornithology (Lawrence 2006), typically focus on a specific taxon, such as mosses or birds. Volunteers from these organizations are often involved in education and conservation activities at the local level; in addition to their volunteer activities, members may also have professional roles in conservation and formal training in the natural sciences (Ellis and Waterton 2004; Ganzevoort et al. 2017). In these collaborations, some museums serve primarily as a long-term repository for species observations that have been collected and verified by members or volunteers from other organizations. In other projects, museums act as the public face for a project and are additionally involved in recruiting and training volunteers (Sforzi et al. 2018). Previous research on the involvement of amateur-expert naturalists in such large-scale biodiversity initiatives suggests that some naturalists are ambivalent about their participation and contribution. Many amateur-experts see data sharing as an important way to contribute to conservation (Ganzevoort et al. 2017), but are nevertheless concerned about how the data they contribute to such initiatives is used (Ellis and Waterton 2004, 2005; Ganzevoort et al. 2017). Participation in these initiatives may also require that naturalists work in new or different ways, for example, by delivering observational records in standardized digital formats (Ellis and Waterton 2005). As ethnographers Ellis and Waterton have observed, for some naturalists taking

part in these initiatives represents “a challenge and a new opportunity; others decline to participate” (2005, p. 690) because they are unwilling to adopt new practices.

Citizen science in natural history museums, as elsewhere, involves the intersecting activities of project organizers and scientists, amateur-expert naturalists, and the organizations to which they contribute. In the context of citizen science projects in natural history museums, individuals who participate in amateur-expert organizations may experience tension between their activities as naturalists and what they are asked to do as a citizen science volunteer.

Sociocultural Perspectives on Citizen Science

Sociocultural perspectives (Wertsch 1994) provide one way to conceptualize the experiences of citizen science volunteers and project organizers and the ways in which institutional contexts, such as a natural history museum or a botanical society, shape these experiences (NASEM 2018, p. 77). From a sociocultural perspective, human activity is always mediated by cultural and historical tools (Greeno and Engeström 2014). These tools are not limited to the material artefacts and technologies that enable us to pursue activities like biodiversity research or habitat conservation. They also include the social norms that guide our conduct as biodiversity researchers or conservation volunteers, and the language we use to communicate with others. From a sociocultural perspective, “regular and recurring patterns” of activity are called practices (Greeno and Engeström 2014, p. 128), and a community of practice (Lave and Wenger 1991; Wenger 1998) describes “people who know how to participate in the same shared practices” (Greeno and Engeström 2014, p. 128).

Sociocultural perspectives have been used to conceptualize the boundaries between practices, and the consequences of encountering these boundaries in domains such as education, professional work, and volunteerism (Akkerman and Bakker 2011; McAllum 2018). A recent review and synthesis (Akkerman and Bakker 2011) draws on research in education, social psychology, and organization and management studies to define boundaries and to suggest methodological approaches for investigating them. The authors observe that “we move across different practices all the time, often without awareness” (Akkerman and Bakker 2011, p. 152). A boundary, therefore, is defined as “sociocultural difference leading to discontinuities in action and interaction” (Akkerman and Bakker 2011, p. 152). Identifying boundaries, by extension, involves specifying which sociocultural differences have resulted in discontinuity, and “who experiences a particular discontinuity in which interactions” (Akkerman and Bakker 2011, p. 153). In a recent empirical study of volunteers in the human services sector (McAllum 2018), boundary perspectives shed light on the ways that volunteers respond to tensions between volunteerism and professionalism.

This study uses Akkerman and Bakker’s (2011) definition of boundaries as “sociocultural difference resulting in discontinuity” as a theoretical point of departure for identifying and understanding participants’ experiences of

boundaries in a specific citizen science project. This choice has methodological implications, including the need to capture contextual aspects of participants’ involvement in the project, and the details of how participants interact. It additionally informs the research questions being posed. First, who experiences discontinuity in the collaborative activity of a citizen science project? Second, how are experiences of discontinuity handled by participants? And finally, how do experiences of discontinuity relate to the specific context or design of the project?

Project Description: The Herbarium Transcription Pilot Project

In 2017, 12 volunteers participated in a pilot citizen science project organized by the University of Oslo’s Natural History Museum. Similar to the Notes from Nature project (Averett 2015), the pilot involved transcribing information about digital images of herbarium sheets in an online portal (**Figure 1**).² The project volunteers were all members of a botanical organization located in southern Norway. The Youngs County Botanical Society (YCBS, an organizational pseudonym) was founded in the 1980s. YCBS is formally associated with the Norwegian Botanical Association, a national organization for “anyone interested in learning about wild plants, mosses and lichen” (NBF 2020). YCBS is specifically focused on flora and conservation at the level of the region or county (*fylke* in Norwegian). Yearly activities, as detailed in YCBS’s annual reports and on the public website, include excursions, lecture presentations, and the publication of a magazine about regional flora.

My involvement in the pilot began in late 2016 as part of a university-led research project on digital mediation and participation in museums. Prior to my involvement, the museum had developed the portal and completed an initial pilot project using the portal and mobilizing volunteers with the support of the museum’s public relations staff.

The herbarium transcription pilot was designed by three members of the museum staff and me, with additional input from one other museum staff member and one other social science researcher (Supplemental Table 1: Participants in Herbarium Transcription Project, Organizers and Volunteers). The pilot focused on herbarium sheets from the region of Norway where YCBS was based. The decisions to focus on these herbarium pages and to recruit YCBS members as volunteers were informed by circumstances at the museum at the time the pilot was developed, by recommendations from existing literature on public participation in digitizing natural history museum collections (Ellwood et al. 2015), and by my own research interests in volunteer engagement and practice perspectives in citizen science.

As a result of previous mass digitization projects (Blagoderov et al. 2012), high-resolution digital images of the museum’s Nordic vascular plant herbarium (more than 800,000 herbarium sheets in total) were available, but were described only with minimal metadata, such as the country and region where a plant was collected, its taxon, and the name of the collector. Early in the design of the pilot, the museum staff outlined the proposed task: volunteers

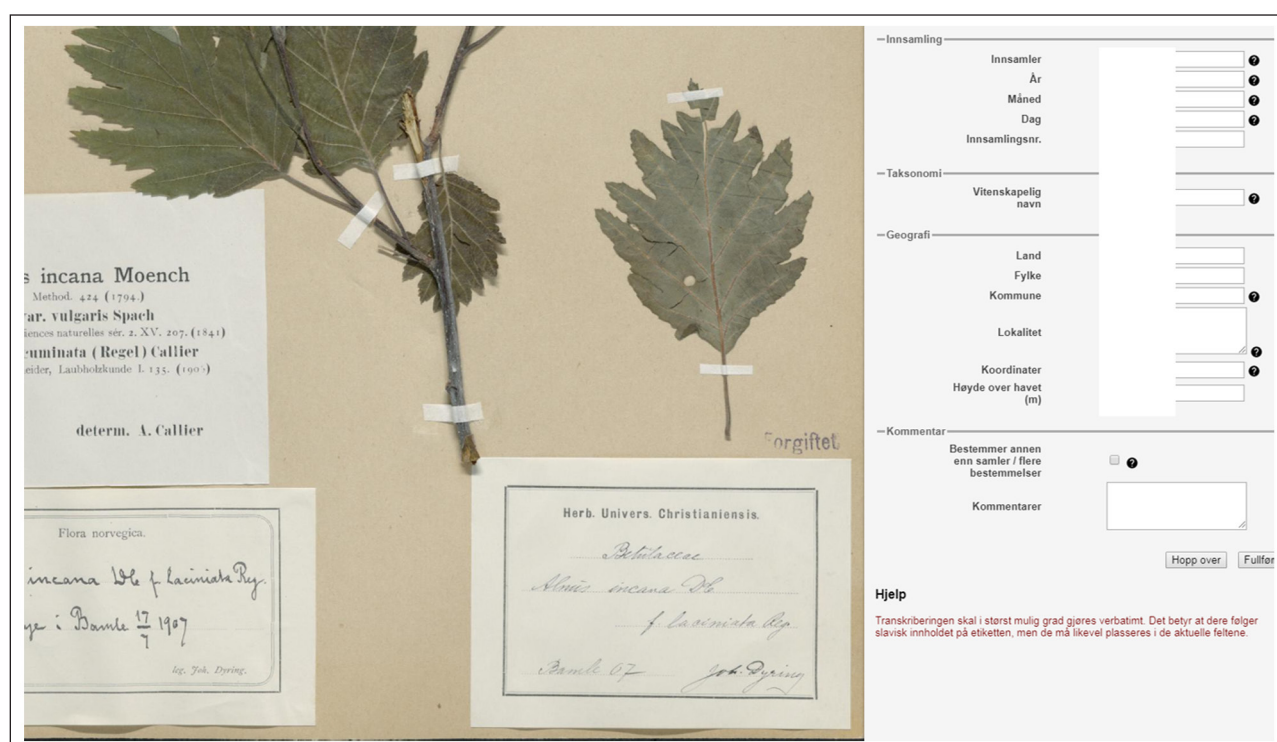


Figure 1: Natural History Museum's online portal for citizen science. Digital image of herbarium page and database fields, including where a specimen was collected, geo-referencing coordinates, and a comments section, where volunteers could include information that did not match other fields. Source: Emily Oswald 2017.

would be shown existing metadata on a digital image and asked first to determine whether additional information about the specimen could be transcribed from the image, and if so, they would be asked to transcribe it. Additional information might include details about where a specimen had been collected, such as latitude and longitude coordinates or more local place names.

Our impression, supported by research on crowdsourcing in the humanities (Causser and Wallace 2012), was that volunteers would be more willing to take part if the pilot had a clearly defined end goal that could be achieved in a relatively short time span. This suggested the need to identify a subset of herbarium sheets as the focus of the pilot. Finally, the possibility of recruiting a limited group of volunteers who might also be willing to discuss their experiences was in line with my focus on qualitative methods to explore how volunteers made sense of their participation in citizen science.

Martin (a pseudonym, see Supplemental Table 1: Participants in Herbarium Transcription Project, Organizers and Volunteers), one of the museum staff members who worked on the pilot, was himself a member of a botanical society, and knew members of other societies in southern Norway. Martin and a colleague, Roger, determined that there were a relatively limited (1,800–4,000) number of herbarium pages containing plants from the regions where the societies were active. Martin contacted a member of each group to invite the society to participate in the pilot. One society declined; the YCBS board members discussed the pilot project, accepted the invitation to participate, and provided us with email addresses of the members who planned to participate. The remainder of the pilot involved

three periods of activity (Supplemental Table 2: Citizen Science Project Activities and Case Study Data Collection). In May 2017, Martin and two of his museum colleagues led an in-person workshop for 12 society members to provide an overview of the online portal. During the workshop, volunteers also had time to work on the transcription task and to ask questions. From May to September 2017, society members completed the transcription task for the majority (1,600 of 1,800) herbarium pages from Youngs County in the online portal. In September 2017, 8 of the 12 members who had attended the first workshop and contributed to online transcriptions met with me and the three museum staff to discuss society members' experiences with the online task. Following the discussion, museum staff gave a "backstage" tour and showed society members physical herbarium pages from the collection as a gesture of appreciation to volunteers for their participation.

Methods

Research design, data collection and informed consent

This exploratory case study (Flyvbjerg 2006; Yin 2014) is bounded by the activities of a single citizen science pilot project and the volunteers and project organizers who took part. In keeping with a sociocultural perspective on practices and boundaries and my ethnographic engagement in the pilot, video recordings were the primary method for collecting data (Jordan and Henderson 1995). My participation in and observation of the museum's citizen science activities began with the design of the pilot together with museum staff and continued through the recruiting, training, transcribing, and discussion activities. My notes from meetings with museum staff, archived emails, and

log data from the online transcription portal were additionally used to document volunteer recruitment and to gain an overview of what volunteers did during the transcription activity (Supplemental Table 2: Citizen Science Project Activities and Case Study Data Collection).

The design of the study, including the data management plan for recording and storing video, the approach to informed consent, and the commitment to anonymizing volunteers and the botanical society in publication, were approved by the Norwegian Center for Research Data (project reference number 53706). My role as participant-observer was discussed with museum staff before design of the pilot began. In line with guidelines from Norway's National Committee for Research Ethics in the Social Sciences and the Humanities (2016), volunteers received information regarding the study in writing before the May workshop, including information about the use of anonymized video stills and transcripts in research publications. All 12 volunteers consented to video recording as a form of data collection before the workshop began.

Approximately six hours of video were recorded during the pilot: three hours during the volunteer training session in May, and three additional hours during the discussion and museum visit in September. In both settings, following recommendations from Derry et al. (2010, p. 48), two cameras and two external microphones were used to record the activities. Because I was an active participant in both meetings (welcoming and presenting briefly in the first and asking questions in the second) the direction and zoom for both cameras was constant. Most of the video (3 hours, 45 minutes of the total 5 hours, 55 minutes corpus) was then transcribed in Norwegian by a research assistant.³

Analytical procedures

The research focus on practices and boundaries in this study was informed by my participation in the herbarium pilot, which had left me with the impression that volunteers had completed the transcription task with relative ease and, for some individuals, apparent enjoyment. Nevertheless, volunteers seemed to be actively evaluating whether the transcription activity fit with what they, a group of botanical society members, usually did, and they made comparisons between the activities of the pilot and the activities of the botanical society. To systematically explore this observation, I developed theoretically informed research questions about who experiences boundaries, or discontinuity in interaction, as a result of sociocultural differences.

Interaction analysis (Jordan and Henderson 1995; Hall and Stevens 2015), a qualitative method widely used in the field of learning sciences, was used to answer the research questions. Interaction analysis combines the use of video data with an analytical emphasis on “locating and studying knowledge in the practical activities of people engaged together, accountably, in social and technical practices” (Hall and Stevens 2015, p. 75). The analytical procedures of interaction analysis involve exploring interaction among individuals, and between individuals

and their material surroundings, sequentially and from a participant's perspective (Hall and Stevens 2015, p. 78–80); repeated viewings of interactions or sequences of interactions by researchers, often in dialogue with peers, to explore emerging interpretations (Jordan and Henderson 1995, p. 43–45); and the inclusion of representations of interaction in the analysis, such as transcript excerpts or video stills (Hall and Stevens 2015, p. 77), with the aim of providing readers grounds for evaluating the credibility (Guba and Lincoln 1994) of a researcher's interpretations.

Empirical findings from this study are based on the transcription and analysis of three episodes (Linell 1998) selected from the full video corpus. The episodes were among several that I initially identified in which volunteers and museum staff were involved in extended sequences of questions and answers, a pattern of interaction that suggests the experience of discontinuity. Excerpts from the transcripts and video clips of these episodes were discussed with other interaction analysis researchers.

I apply the concept of stance (Du Bois 2007) to each episode to identify which activity or practice volunteers and organizers were discussing, and to trace agreement and disagreement between volunteers and among volunteers and organizers as they talked about these activities and practices. As linguist John W. Du Bois has observed, “stance is not something you have ... but something you do—something you take” (2007, p. 171), and involves a speaker expressing agreement or disagreement with others about a specific stance object. Analyzing stance in a sequence of interaction involves identifying the object toward which a speaker's stance is taken; exploring how the speaker evaluates that object; and determining whether or to what degree the speaker's evaluation is in alignment with other speakers (Du Bois 2007). For the purposes of this article, a participant's stance indicates both the experience of discontinuity in interaction through disagreement or a lack of alignment (Du Bois 2007), as well as the specific sociocultural differences that have resulted in this discontinuity.

In the results section below, the analysis of each episode is presented. Following a brief introduction of the episode, a transcript of the relevant sections of video is included, with talk translated from Norwegian to English. The stance-taking of volunteers and project organizers is described in terms of the emergence of two kind of interactional dynamics: dynamics characteristic of a community of practice, and dynamics associated with the experience of boundaries. Each episode is a rich example of how volunteers and project organizers made connections between the practices they are knowledgeable in and the activities in which they were collectively engaged, while identifying and describing differences among these practices and activities. The selected episodes, however, do not include all the practices volunteers and organizers referred to during the pilot, nor do the episodes illustrate all interactional dynamics that emerged between volunteers and project organizers. The limitations of this analytical approach, and the significance of these findings for citizen science project design and research are discussed below.

Results

The analysis of stance in volunteers' and project organizers' talk in Episodes A, B, and C can be summarized in terms of two main findings: the emergence of interactional dynamics characteristic of a community of practice and volunteers' experience of boundaries in the herbarium transcription pilot. These results are described below (see also Supplemental Table 3: Summary of Analysis for Episodes A, B, and C). Episode A took place at the first meeting between society members and museum staff; Episodes B and C took place during the second meeting, four months later.

Episode A: The Youngs County flora atlas

During the training workshop in May 2017 (Supplemental Table 2: Citizen Science Project Activities and Case Study Data Collection), Martin, a project organizer, and two volunteers, Lars and Elisabeth, discussed the botanical society's work on the Youngs County Flora Atlas. The topic of the flora atlas was raised by Elisabeth, following a presentation from Martin.

In his presentation, Martin briefly outlined how information about the museum's collections is made available through biodiversity data platforms like the Species Map and Observations System (Species Map; www.artsobservasjoner.no).⁴ Martin suggested that the convergence of the museum's digitization projects with open platforms like Species Map meant the museum was working in "a much bigger digital space" and that, by virtue of its circulation on open platforms, data about the museum's collection also "belongs to the botanical societies in many ways." He then displayed a Power Point slide showing Youngs County on Species Map (**Figure 2a**).

On the map, circular dots represent the locations where plants from the museum's herbarium were collected. Martin identifies several dots that are "out in the middle of the sea" (**Figure 2b**) and suggests that data about these plants could be improved. He implies that these

plants are poorly geo-referenced in the museum's databases because vascular plants should appear on land, not in the water. Martin then suggests that correcting geo-referencing is "something more than tonight's activity" but that the museum staff and YCBS members "can think a bit further into the future." Martin concludes his presentation and, together with his colleague David, begins to respond to questions from volunteers. Elisabeth then introduces previous work that YCBS has been doing with Species Map (**Table 1**).

The stance-taking of volunteers Elisabeth and Lars in this episode can be characterized in terms of agreement or alignment (Du Bois 2007) with each other. Lars and Elisabeth both see YCBS's prior experience with Species Map and museum specimens as relevant to the herbarium pilot and specifically to the rationale for collaboration that Martin has outlined in his presentation. Though Elisabeth initially makes the connection between Martin's presentation and the flora atlas, the way in which she does so invites Lars to elaborate on the botanical society's work (turn 1). Lars, by continuing to describe the flora atlas (turn 2), and through the use of "yes" and "ok now," signals that he agrees with Elisabeth about the relevance of the flora atlas to Martin's presentation. Collectively, the two volunteers establish the flora atlas as significant to the work they and their fellow YCBS volunteers will do in the pilot.

The volunteers' references to the flora atlas illustrate how an interactional dynamic characteristic of a community of practice emerged during the meeting. Wenger (1998) suggests one way that communities of practice are constituted and maintained is through the development of a shared repertoire. A repertoire may include "routines, words, tools, ways of doing things, stories ... that the community has produced or adopted in the course of its existence" (Wenger 1998, p. 83), and the use of a repertoire by members of a community of practice is "a source of coherence in a community" (Wenger 1998, p. 73). The flora

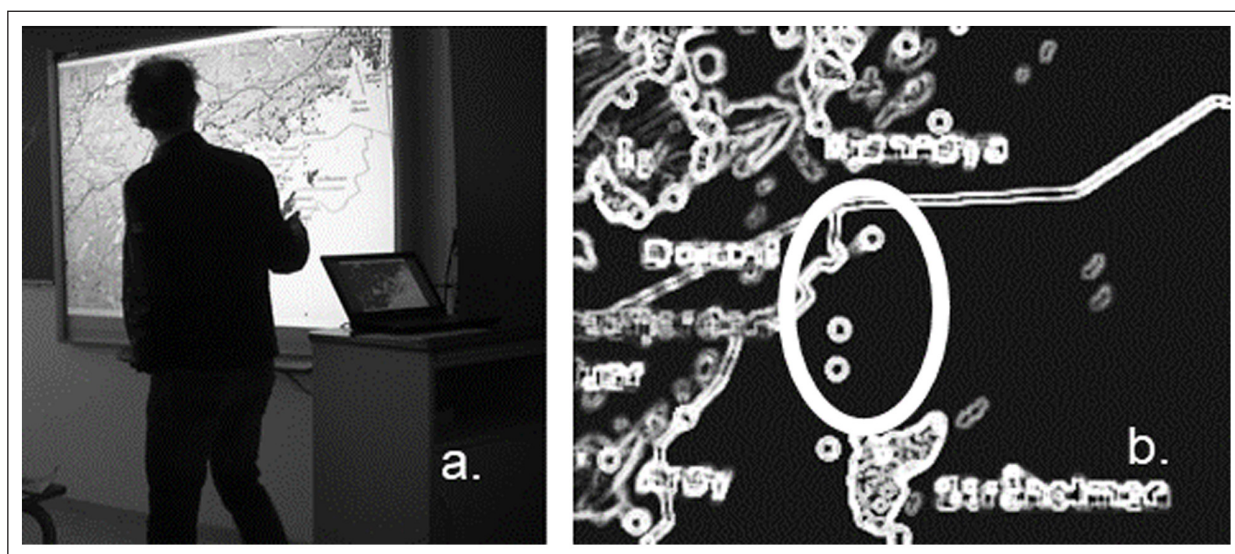


Figure 2: Video still and detail from training workshop. The stills show (a) Martin, the herbarium collections manager, as he presents a map showing plants in the museum's collections from Youngs County; and (b) dots representing vascular plants that appear "out in the middle of the sea." Source: Emily Oswald 2019.

Table 1: Transcript of Episode A.

1	<u>Elisabeth:</u>	Lars* has been working with our species map for a few years now. So he can say something about what we've had. [<i>Addressing <u>Lars</u></i>] You're probably the one with the best overview.
2	<u>Lars:</u>	Yes, ok, so now you're talking about the Flora Atlas of Youngs County. And I had it on my computer at home for a couple of years. Before we moved it over to Species Map.
3	Martin:	Good choice. [<i>laughs</i>]
4	<u>Lars:</u>	Yes. But in it, we also had things we had gotten from the museum and information from there. And we tried to improve it in the Flora Atlas of Youngs County.
5	Martin:	But was it ... hmm. But did it come back to the museum?
6	<u>Lars:</u>	No. They were very clear that we should not have double data. That we shouldn't put in herbarium specimens.
7	Martin:	Yes, I agree with that.
8	<u>Lars:</u>	So for now those dots are still just as bad as they were, as they had been. [<i>for 30 seconds, Martin and <u>Lars</u> discuss how the society worked with museum data</i>]
9	Martin:	But there, you should have contacted [<i>the museum</i>] as we did in Butlers County.
10	<u>Lars:</u>	Yes, yes.
11	Martin:	We improved the data for the museum. And then you guys get the museum's data back again.
12	<u>Lars:</u>	Yes.

* Volunteer pseudonyms are in bold and underlined. Additional comments or descriptions of relevant actions are italicized in square brackets. Turns are numbered continuously across the episodes.

atlas, and volunteers' ways of working on it, can be understood to be a part of the repertoire of the YCBS community of practice, as suggested by the ease with which Lars elaborates on Elisabeth's reference to "our species map" in turn 2, and by both volunteers' references to the society's work on the atlas over time (turns 1 and 2).

In contrast, Lars and Martin's stance-taking is characterized by disagreement or a lack of alignment (Du Bois 2007). Throughout the episode, the volunteer and the project organizer remain unaligned about the meaning of the volunteers' previous experience with museum data and Species Map. Volunteer Lars, in turn 8, makes an explicit connection between organizer Martin's presentation and the discussion of the flora atlas, taking a stance toward the rationale for collaboration that Martin has presented. In doing so, Lars signals he experiences discontinuity between the idea of museum data that "belongs" to the botanical society, and volunteers' previous experience with the museum while working on the flora atlas. Lars implies that what is needed to improve the quality of data about museum specimens from Youngs County is not additional work on the part of YCBS members, but instead different museum practices with Species Map.

Project organizer Martin responds by minimizing the discontinuity between practices that Lars refers to (turn 11). Martin's question in turn 5 suggests that he had not previously known about the YCBS practice of including museum data in the flora atlas. Learning about the volunteers' practice, however, does not cause Martin to change his stance. Instead, Martin maintains that museum data should be published on Species Map only by the museum,

not by members of YCBS (turns 7 and 9). Martin also uses "we" to refer to his own activity as a member of another botanical society (turn 9), additionally emphasizing the potential for continuity between the practices of botanical societies and the practices of the museum.

The lack of alignment between a project organizer and a volunteer demonstrates how interactional dynamics characteristic of the experience of a boundary emerged during the meeting. These dynamics include defining practices in relation to each other and describing how coordination between different practices could be achieved (Akkerman and Bakker 2011). Lars describes and defines the botanical society practice of making the atlas accessible to others through Species Map as contrasting with the museum's practices with Species Map (turn 2). Project organizer Martin similarly defines the museum practices for using Species Map, in which information about museum collections is published only by the museum, not by other organizations or individuals. Martin, however, does so in order to suggest how coordination between the practices of YCBS and the museum could be achieved, and continuity between the practices established.

Episode B: Lars' unique knowledge of Youngs County

When volunteers and project organizers met to discuss the pilot in September 2017 (Supplemental Table 2: Citizen Science Project Activities and Case Study Data Collection), Lars, Elisabeth, and Martin talk about how Lars has approached a specific aspect of the transcription task related to place names in Youngs County. The episode occurs early in the meeting, after I, in my role as one of

the facilitators of the discussion, suggested that it would be valuable to hear from all the volunteers about their experiences in the pilot, regardless of how many or few transcriptions they completed.

Lars then described how he dealt with part of the transcription task that was complicated by historical changes in the administrative boundaries of Youngs County. Drawing on his knowledge of the region's geography, as well as digital maps to locate place names he was unfamiliar with, Lars makes it clear that his "transcription" work involved reconciling discrepancies between the location information from the herbarium sheet, the metadata previously entered in the museum's database, and his own knowledge of the region (**Table 2**).

In Episode B, volunteer Lars and project organizer Martin's stance-taking is characterized by agreement or alignment (Du Bois 2007) about the significance of the transcription practices Lars describes. Lars' lengthy and detailed account of a specific aspect of his own transcription activity suggests he considers his way of transcribing to be relevant for project organizers (turn 13). Martin responds (turn 14) by affirming that the kind of activity Lars describes is valuable, and something that museum staff who work on the herbarium may not be able to do, or to do to such a degree. Martin agrees with Lars' implicit assessment of the activity as useful, and complementary to the work of museum staff. Martin's stance about a specific kind of transcription activity is in alignment with Lars' stance. Martin also, by using the plural "you guys" and "you all" (turn 14) suggests that other volunteers would be capable of similar contributions. The agreement or alignment between volunteer Lars and project organizer Martin suggest the two men experience continuity between volunteer and project organizer knowledge practices; for Lars and Martin, in this moment, there is no boundary between the two.

Volunteer Elisabeth's stance-taking, in contrast, is characterized by disagreement or a lack of alignment with both Lars, another volunteer, and Martin, a project organizer. This suggests that Elisabeth experiences a discontinuity between the transcription activity of a fellow volunteer and YCBS board member and the ongoing practices of the botanical society. In turn 15, Elisabeth contests Martin's

implication that other YCBS volunteers would be able to make similar valuable contributions by describing Lars' knowledge of Youngs County as "unique." Although she does not dispute that such transcription activity is valuable for project organizers, she seems to imply that few volunteers would be able to contribute in this way. Elisabeth also expresses her disagreement with Lars. Though she does not elaborate on the reference to Sarah (turn 15), Elisabeth is apparently reminding Lars that another society member, who did not participate in the pilot, would have difficulty identifying the correct municipality for a herbarium page, a central part of the activity the museum has asked the society members to complete. Lars has not explicitly stated that his way of transcribing is how all society members can or should contribute to the transcription project. Elisabeth nevertheless raises the issue of who among the society members would be able to contribute if a "valuable" contribution (turn 15) requires detailed knowledge of Youngs County.

Volunteer Elisabeth's disagreement or lack of alignment with her fellow volunteer and YCBS member Lars reveals an additional interactional dynamic characteristic of a community of practice that emerged during the meeting: the negotiation of a community's joint enterprise. Wenger (1998, p. 77–82) argues that the ongoing negotiation of a group's joint enterprise is characteristic of a community of practice. The joint enterprise of a community, Wenger writes, "is the result of a collective process ... [and] is defined by the participants in the very process of pursuing it" (1998, p. 77). In this episode, Elisabeth is negotiating with Lars over whether the project activities are consistent with the joint enterprise of YCBS as a community of practice. By underscoring that not all YCBS members will be able to make a valuable contribution (turn 15), Elisabeth implies that previous YCBS activities, including, presumably, the ones through which Lars and Elisabeth have come to know Sarah, have included YCBS members with diverse knowledge of Youngs County. By raising this issue during the meeting, volunteer Elisabeth raises the possibility that the discontinuity between project activities and YCBS practices will need to be addressed if YCBS as a group is to continue to participate in these kinds of activities.

Table 2: Transcript of Episode B.

13	<u>Lars*</u> :	<i>[after speaking for 45 seconds]</i> So then when it was on that side of the lake, I had to move it to Scottsville.
14	Martin:	Mhm, yes, this is the kind of job that is valuable for us when you guys have local knowledge that we don't always have. We've gotten to be good at geography here <i>[at the museum]</i> as well, but you all have even more detailed knowledge about this kind of thing, right.
15	<u>Elisabeth:</u>	But that detailed knowledge, like <u>Lars</u> has of Youngs County is unique. Many of us don't come from Youngs County you know. Don't have the same, the same knowledge. Maybe we know something about the consolidation <i>[of local administrative boundaries]</i> but in such detail like Lars. <i>[leans back, raises hands]</i> I can't. So I say <i>[turning to Lars]</i> wait until Sarah gets hers, it would be enough with the municipalities.

* Volunteer pseudonyms are in bold and underlined. Additional comments or descriptions of relevant actions are italicized in square brackets. Turns are numbered continuously across the episodes.

Episode C: Maps and habitats

At the same meeting, the discussion among the botanical society members and the museum staff moves from the transcription task in the pilot to future work. As the group begins to discuss geo-referencing museum specimens, Martin explains how museum staff compares the species of a specimen with the location description on a label to more precisely geo-reference specimens (**Table 3**).

In Episode C, the stance-taking of volunteers Frank and Erik is characterized by disagreement or a lack of alignment (Du Bois 2007) with project organizer Martin, and alignment or agreement (Du Bois 2007) with each other, about the approach to geo-referencing that Martin describes. In turns 16 and 18, Martin provides a verbal explanation of how he, as a museum staff member, checks the accuracy of the geo-referencing for a herbarium specimen; Martin describes this approach again (turn 20), using as an example the herbarium sheet that Roger, the museum's software engineer, has projected on a screen at the front of the room. Volunteer Frank, in turn 19, then takes a stance toward project organizer Martin's approach to geo-referencing, signaling his disagreement with Martin through the use of

"if" and "then" (turn 19), and "actually" (turn 20). Frank problematizes Martin's approach by describing a situation in which water plants might appear "on land:" If a water lily was collected and preserved, but the habitat was subsequently drained, even correct geo-referencing coordinates would show the plant "on land" if the map represented the drained habitat. This suggests Frank experiences a discontinuity between his own previous experiences with draining water lily habitats and the approach to geo-referencing that Martin describes using the example of a water lily.

Volunteer Erik takes a similar stance toward Martin's approach to geo-referencing. Erik initially seemed to agree with the usefulness of Martin's approach (see Erik's nod after turn 17). However, when Frank, a fellow volunteer and YCBS member, refers to "draining" (turn 19), Erik adjusts his stance, aligning with Frank and signaling his disagreement with project organizer Martin. Erik describes a specific body of water in Youngs County that was "regulated," presumably by man-made infrastructure (turn 21). Erik implies that because the level of the water changed, land plants on sandbanks would appear to be "out in the middle of the water" (turn 21). Erik reinforces

Table 3: Transcript of Episode C.

16	Martin:	Also it can be a good idea to check the species name too. If it says white water lily, for example, so there's, and then there's a name, then it's probably a pond or a lake or on the side, right.
17	<u>Petter*</u>:	Yeah. [<i>Elisabeth and Erik also nod</i>]
18	Martin:	So, it looks a bit more elegant when water plants are in the water and land plants are on the land. [<i>several volunteers laugh, nod</i>]
19	<u>Frank:</u>	If it hasn't been drained, then. [<i>for 25 seconds Roger describes the geo-referencing task, displaying the portal on a large screen</i>]
20	Martin:	There [<i>gesturing towards the screen</i>] yes it says [<i>inaudible species name</i>]. It must be in a canal or something, or in a dam. Or a water plant. [<i>for 60 seconds, Martin, Roger, and David discuss technical features of museum databases</i>]
21	<u>Erik:</u>	No, we had some water up in Lawrenceville. That was regulated. Because here I would have had some plants. Just a few, some sandbanks out there, so [<i>pauses</i>] it was right out in the middle of the water there [<i>turning to Martin</i>] y'know, when we looked at the map.
22	<u>Frank:</u>	Water lily habitats can actually be drained.
23	<u>Elisabeth:</u>	Yes.
24	<u>Frank:</u>	That kind of thing can happen too.
25	<u>Erik:</u>	Yeah.
26	Martin:	Yes, one might use old aerial photos, then. [<i>laughs</i>]
27	<u>Lars:</u>	But we should also probably note that it's more important to place some species than others. For, like, the wood anemone, for example. It's not that important to get it so exactly located, to put it that way. But the Red List** species, it is nice to get those placed as exactly as possible. So one should perhaps prioritize what one puts work into and what one doesn't put work into.

* Volunteer pseudonyms are in bold and underlined. Additional comments or descriptions of relevant actions are italicized in square brackets. Turns are numbered continuously across the episodes.

** The Norwegian Red List (Rodlista) is a list of species at risk of extinction in Norway.

the changing level of the water (**Figure 3a**) and the location of the plants on the sandbank (**Figure 3b**) with gestures. Erik underscores that this example is addressed to Martin through the orientation of his body (turn 21), and implies that the example contradicts or complicates project organizer Martin's approach.

The alignment between volunteers Frank and Erik in Episode C is an additional example of the how dynamics characteristic of a community of practice emerged during the pilot. Frank and Erik's stance-taking parallels the stance-taking of volunteers in Episode A (turns 1 and 2), when Elisabeth and Lars both refer to the flora atlas and draw on this element of the YCBS community's shared repertoire. Frank's use of the word "draining" in turn 19 seems to prompt Erik's adjustment in his stance, suggesting that experience with draining, damming, and changing habitats are also elements of the community's repertoire. Elisabeth's affirmation in turn 23 suggests that she agrees with Frank and Erik's assessment.

Volunteer Lars and project organizer Martin's stance-taking in this episode is characterized by partial agreement or alignment (Du Bois 2007) with each other and the other volunteers. Martin, through his use of "yes" (turn 26), signals that he understands the complexity volunteers Frank and Erik have described. Martin then suggests that museum practices could accommodate this complexity through the use of historical photographs to date changes in a habitat (turn 26), taking a stance that acknowledges the relevance of the practices Frank and Erik have described to the geo-referencing task the group is discussing. Volunteer Lars similarly signals, through the use of "also" (turn 27), that he agrees with Martin; Lars also implies that Martin's suggestion, while resulting in more precise geo-referencing, is likely to be labor intensive and should therefore be prioritized on the basis of a species' conservation status.

The volunteers' lack of alignment with project organizer Martin, and the partial alignment between Lars, Martin, and the other volunteers, are an additional example of how interactional dynamics characteristic of the experience of boundaries emerged. In Episode C, Frank and Erik's

descriptions of drained habitats and regulated water define the YCBS community's practice of knowing specific features of the Youngs County landscape (Akkerman and Bakker 2011); the two volunteers contrast this with the practices of the project organizer. Organizer Martin and volunteer Lars acknowledge the differences between project organizers' approach to geo-referencing and the practices of the YCBS community, but also suggest how future transcription activities could be organized to allow for coordination between these practices. Volunteer Lars specifically suggests how this coordination might be achieved by taking into account an additional aspect of volunteers' practice: the conservation status of a species, as indicated by the Red List.

Discussion and Conclusion

This case study focuses on the experience of boundaries in interaction between project organizers and volunteers in citizen science. The analysis provides an empirical basis for understanding who in citizen science experiences boundaries; how boundary experiences are handled; and how these experiences relate to the design of a project. In the herbarium transcription project, volunteers experienced discontinuity between their practices as botanical society members and the practices of project organizers. Participants handled the experiences of boundaries in two distinct ways: Volunteers and organizers identified and defined one practice in relation to another (Akkerman and Bakker 2011), and suggested how to coordinate across the boundaries between practices (Akkerman and Bakker 2011). In this project, volunteers' boundary experiences were related to their history of working together as a community of practice (Lave and Wenger 1991; Wenger 1998) and, by extension, to the project organizers' decision to recruit volunteers through an amateur-expert organization.

Discontinuity and handling boundary experiences in citizen science

Volunteers experienced discontinuity between the activities of the citizen science project and their ongoing involvement in a regional botanical society. These experi-

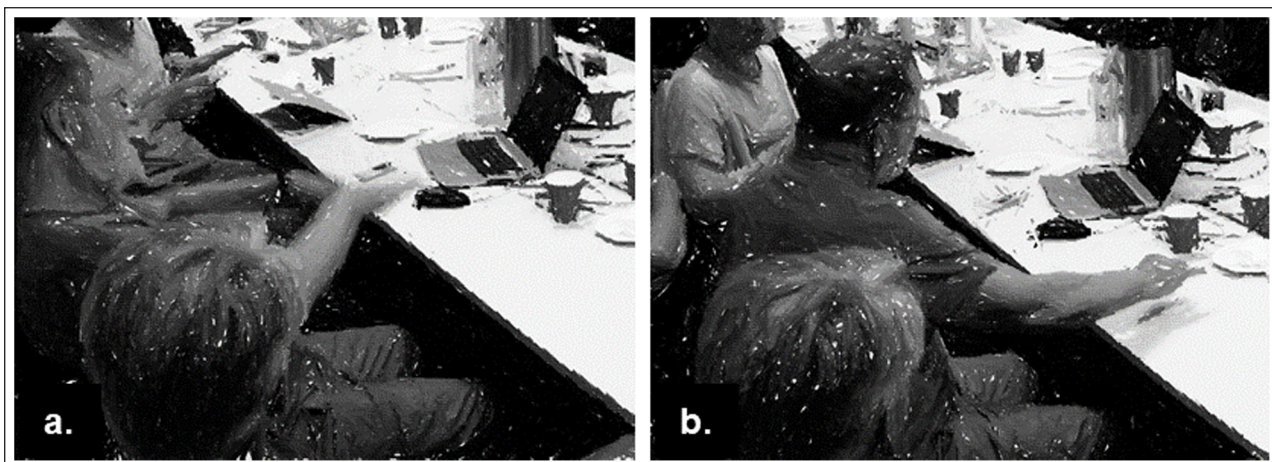


Figure 3: Video stills edited for participant anonymity. Stills show Erik (*center left*) as he **(a)** raises and lowers his hands as he says "regulated" and **(b)** touches the table with his thumb and forefinger repeatedly as he says "some plants" (turn 21). Source: Emily Oswald 2019.

ences of discontinuity emerged as volunteers drew on the shared repertoire of botanical society practices and negotiated their joint enterprise (Wenger 1998). During the project, volunteers referred to norms for organizing botanical society activities, such as ensuring that individuals with differing levels of expertise participate. Volunteers negotiated with each other about whether taking part in the citizen science project was consistent with these norms. Volunteers also made connections between the activities of the project and specific knowledge practices of the botanical society. Knowledge practices volunteers referred to included an awareness of changing flora habitats in their region, and the creation and maintenance of a flora atlas—a collection of flora observations that was accessible through the infrastructure of Species Map and included information about museum flora specimens as well as flora observations of society members.

When volunteers' experiences of discontinuity emerged, volunteers and project organizers handled these experiences in two ways. First, volunteers and organizers defined and identified (Akkerman and Bakker 2011) their respective practices in relation to one another. Project organizers, for example, identified the museum's practices for publishing information about its collections on Species Map and defined how the museum practices were different from the botanical society practices for using Species Map. Similarly, volunteers identified how their knowledge practices or ways of knowing the landscape of Youngs County differed from the museum's practices related to geo-referencing museum specimens from Youngs County.

Second, volunteers and project organizers responded to volunteers' boundary experiences by suggesting ways to coordinate (Akkerman and Bakker 2011) among the groups' different practices. A volunteer suggested, for example, that the museum's practice of using species names, place names, and digital maps to more precisely geo-reference specimens could be coordinated with volunteers' knowledge practices related to habitat conservation by prioritizing geo-referencing on the basis of a species' conservation status. Similarly, a project organizer suggested that coordination between the volunteers' and organizers' differing practices associated with Species Map could be achieved by incorporating the society's improvements to museum data into the museum's workflow, and eventually publishing the improved data on Species Map.

Volunteers and project organizers also identified continuity between the practices of the museum and the knowledge practices volunteers drew on to complete the transcription task. These practices included reasoning about place names, historical changes in geographic boundaries, and the location information associated with an observational record or museum herbarium sheet, as well as the use of digital maps to locate unfamiliar place names. This finding suggests that the specific knowledge practices of some volunteers were relevant to the ways in which project organizers at the Natural History Museum were seeking to improve metadata about the museum's specimen collections.

Findings from this study confirm and complicate previous recommendations for involving volunteers in natural

history digitization projects. Researchers and practitioners have suggested that recruiting volunteers with knowledge of geography and organisms represented in a collection could result in more accurate transcriptions (Ellwood et al. 2015; Merckx et al. 2018), and that recruiting volunteers through amateur-expert organizations would be one way to connect with individuals who may have such knowledge (Ellwood et al. 2016; Merckx et al. 2018). This case study provides some evidence that recruiting citizen science volunteers through amateur-expert organizations can lead to the involvement of volunteers with extensive knowledge of local geography. For volunteers, however, such knowledge is connected to amateur-expert organizations as a community of practice. Participating in a citizen science project can thus result in the experience of a boundary between the practices of project organizers and their community's knowledge practices.

Boundaries, communities of practice and the design of citizen science projects

In this case study, volunteers' experiences of boundaries in citizen science were related to their participation in an amateur-expert naturalist organization. The decision of project organizers to recruit volunteers through an amateur-expert organization like YCBS resulted in the participation of a group of volunteers with a history of working together. This history in turn shaped volunteers' engagement in project activities. From the perspective of project organizers, this recruiting decision was largely understood in terms of connecting with *individuals* who might have relevant knowledge to contribute; nevertheless, volunteers made sense of their participation in the project in terms of the relation between the *groups* of museum staff and botanical society members. Given the scope of this case study, it is difficult to say whether volunteers would have experienced boundaries between the practices of amateur-expert organizations like the botanical society and the Natural History Museum in the same way if, for example, volunteers from different botanical societies had participated in the project together. Nevertheless, volunteers' experiences of boundaries related to the practices of amateur-expert organizations like YCBS suggest one way in which relationships among volunteers may affect engagement in citizen science.

In this case study, interactional dynamics associated with a community of practice emerged among volunteers, not between volunteers and project organizers. The community of practice at work in the herbarium transcription pilot was that of the volunteers as botanical society members and not among volunteers and project organizers as these two groups worked together in the new context of a citizen science project. Interactions between project organizers and volunteers revealed that some project organizers participated in adjacent communities of practice, such as a botanical society based in another county, and made this participation relevant to the collaboration with volunteers. Project organizers did not, however, know about specific practices of the botanical society, such as the use of data about museum specimens in the society's flora atlas. Nor did volunteers include project organizers in the

negotiations about whether project activities were consistent with the norms of the botanical society.

By demonstrating that both boundary dynamics and dynamics associated with a community of practice emerged in a citizen science project, this case study suggests that the concept of a community of practice may be relevant for understanding participants' experiences in citizen science in several distinct ways. Some previous studies (Mugar et al. 2014; Jackson et al. 2015) have used the concept of a community of practice (Lave and Wenger 1991; Wenger 1998) and the related theory of legitimate peripheral participation (Lave and Wenger 1991) to describe the processes through which volunteers gain experience and are motivated to continue participating in citizen science projects. In other studies (Frensley et al. 2017; Liberatore et al. 2018), researchers and practitioners argue that fostering a community of practice among volunteers and between volunteers and project organizers is an important aim.

Findings from this study, in contrast, demonstrate that participation in communities of practice, such as an amateur-expert naturalist organization, affects volunteers' engagement in a citizen science project. The approach to volunteer recruitment used in this citizen science project resulted in the involvement of a group of volunteers who had a history of practicing together. Volunteers subsequently acted as members of a community of practice, even while contributing to a task that was designed to be completed individually.

Limitations and implications for project design and evaluation

The empirical findings of this study are based on the close analysis of interaction in three episodes. Selecting and analyzing these episodes allows for the identification of specific dynamics between project organizers and volunteers, including interactional dynamics related to boundaries and to communities of practice. These findings complement recent research on volunteer engagement in citizen science (Phillips et al. 2019) that has demonstrated the importance of interaction and relationships between project organizers and volunteers, and among volunteers, by specifying the kinds of dynamics such interactions may involve. This analytical approach does not, however, indicate the degree to which these boundaries or identification with the botanical society as a community of practice were relevant for all volunteers who participated in the herbarium transcription project, or the botanical society's members more generally.

This limitation does not affect the credibility of the findings (Guba and Lincoln 1994), but it does suggest the ways in which these findings can inform future research and the work of practitioners involved in other citizen science projects. For example, this study highlights the possibility that volunteers will come to a citizen science project with longstanding relationships and a history of engaging in shared practices, and that this experience will matter for their participation in a project. Project organizers should consider this possibility as they develop recruiting strategies and design volunteer tasks. Specifically, if project organizers plan to recruit through other organizations, they should clarify whether the invitation to participate

in a project extends to all members, or alternatively that the aim is to recruit volunteers with particular interests or knowledge. In line with Eleta et al.'s call to set appropriate expectations for "informed participation in citizen science" (2019, p. 1), clarity about project organizers' aims will result in clearer communication with other organizations while their members decide whether to participate.

The study further suggests that volunteers' experiences of boundaries can be an opportunity for project organizers to learn about volunteers' knowledge practices, just as volunteers, through their participation in a citizen science project, learn about practices related to science inquiry (Phillips et al. 2018). Developing projects that allow project organizers to learn about volunteers they aim to engage and adjust project or task design based on what they learn, is in line with the National Academies of Sciences' recent recommendations for the iterative design of citizen science projects, developed with input from stakeholders (2018, p. 150). Getting to know another way of knowing, in other words, can be an outcome for both project organizers and volunteers.

Notes

¹ As Eitzel et al. (2017) have previously argued in this journal, researcher and practitioners should carefully consider how they refer to the people involved in citizen science, and be explicit about their choice of terms. In this study, I use "participants" to refer to both to project organizers and volunteers. "Project organizers" are those people who make choices about how to structure the activity of a project and design the task to be completed. "Volunteers" are those who, in turn, agree to complete a task.

² A detailed description of the portal and the institutional and technological complexities its design addresses are beyond the scope of this case study. In brief, the portal provided a user-friendly, browser-based interface through which volunteers could view digital images of the collection, enter information about the images, or edit existing information provided by the museum. Museum staff could subsequently integrate the information entered or edited by volunteers into internal databases used for collections management and publishing information about museum specimens through services like the Global Biodiversity Information Facility.

³ The initial transcripts captured each time an individual spoke and the speakers' words verbatim; if a speaker's words were inaudible or it was unclear who was speaking, this was noted in the transcript. These transcripts primarily served as an indexing tool (Derry et al. 2010, p. 49), allowing me to more easily locate a sequence of talk I had previously viewed and determine when it occurred in the overall sequence of the pilot activities, and in the ongoing interaction between volunteers and organizers.

⁴ Species Map is an open database and online map interface managed by the Norwegian Biodiversity Information Center; it is widely used by individual naturalists, small organizations like YCBS, and large institutions like the Natural History Museum (Hetland 2011).

Supplementary Files

The additional files for this article can be found as follows:

- **Supplemental Table 1.** Participants in Herbarium Transcription Project, Organizers and Volunteers. DOI: <https://doi.org/10.5334/cstp.310.s1>
- **Supplemental Table 2.** Citizen Science Project Activities and Case Study Data Collection. DOI: <https://doi.org/10.5334/cstp.310.s2>
- **Supplemental Table 3.** Summary of Analysis for Episodes A, B, and C. DOI: <https://doi.org/10.5334/cstp.310.s3>

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