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Design Principles of Online Learning Communities in Citizen Science

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by Ruth Kermish-Allen

Abstract

Online communities for citizen science are expanding rapidly, giving participants the opportunity to take part in a wide range of activities, from monitoring invasive species to targeting pollution sources. These communities bring together the virtual and physical worlds in new ways that are egalitarian, collaborative, applied, localized and globalized to solve real environmental problems. Rural communities especially can leverage these learning and sharing spaces to take advantage of resources they would otherwise not be able to access. A small number of citizen science projects truly use an online community to connect, engage, and empower participants to make local change happen. This multiple case study looked at three online citizen communities that have successfully fostered online collaboration and on-the-ground environmental actions. The findings provide insight into potential design principles for online citizen science communities that support environmental actions in our backyards.

BUILDING BRIDGES BETWEEN COMMUNITY, SCIENCE, AND ACTION

As we learn to use the connectivity available to today, the definition of community changes. Community is no longer limited to those organizations and individuals in our neighborhoods or specific locations. Online communities are another way to engage in community activities, from simple friendships to civic and political engagement (Lindros and Zolkos 2006). Our society retains a sense of community that is tied to place, while at the same time it is expanding to include a new global community (Maibach et al. 2011). Imagine the possibilities, not only for how quickly we can share, but for how quickly we can learn and create change.

Maine is the perfect breeding ground for innovations using digital connectivity. Improved communication in the form of expanding cellular and internet service has benefited Maine's rural communities in many ways. Connecting isolated rural communities not only facilitates new opportunities for work and improved quality of life, but residents also see enormous opportunities for broadening the education and social experiences available to their children and for preparing them for the technological innovations to come. These connections have also opened up the world of online communities to Mainers for a variety of purposes. In addition, digital connectivity has also opened up the world of citizen science to Mainers interested in participating in local and/or global scientific investigations.

Citizen science projects have become a popular method for scientists to use global connectivity to collect data for their research as well as to communicate aspects of science to the general public (Bonney et al. 2009). But the level of citizen participation doesn't need to stop there. The involvement of local people in all aspects of scientific inquiry through citizen science can lead to faster and more reliable data collection (Newman et al. 2010). This, in turn, can inform environmental decision making at a much faster rate than more traditional scientific approaches (Mueller and Tippins 2012). Citizen science can be more than just a service that the public provides for scientists. It can also be a tool for communities and individuals to ask their own scientific questions as they work toward building healthier and more sustainable communities.

LEARNING FROM SUCCESS—A MULTIPLE CASE STUDY

This paper explores three online citizen science communities that successfully leveraged digital connectivity and the power of citizen science to foster collaboration and environmental actions. In exploring how these online communities were designed and used by the participants, design principles for programmatic and technological features of successful online citizen science communities begin to emerge.

The three projects included in the study are the Gulf of Maine Research Institute's Vital Signs project, the Maine Math and Science Alliance's WeatherBlur project, and the international Public Lab project. Vital Signs links participants—ranging from students and teachers to master gardeners—from across the state via missions that provide a structure and connections with experts/scientists for identifying and documenting invasive species in the Northeast. WeatherBlur is a citizen science project that guides participants' through the collaborative process to explore the local impacts of today's shifting climate and weather trends from identifying a common question to interpreting the data to inform local decision making. Public Lab is an international open online community where participants can learn how to investigate a wide range of environmental concerns using inexpensive DIY techniques, such as spectroscopes, air particulate sensors, water quality tests, and many others. Each of these projects resulted in online collaboration and local environmental actions.

METHODS

This two-part study attempts to understand what makes these kinds of online communities successful at transforming data collection into local action. In particular, the study focused on understanding the programmatic design elements and technological functions that support collaboration and environmental action in these projects.

To tease out the components most essential for collaboration in these online communities, a Q-methodology or QSort (Stephenson 1935) was used to assess participants' priorities about an issue. To understand each participant's experience of the functions of the site and how it enabled or limited collaboration across the online community, a semistructured interview protocol and online observation tool was used. Initial findings were then shared with the focus group for refinement and reliability.

The entirety of the study is grounded in sociocultural learning theory, specifically drawing upon the instructional theories covered by *Communities of Practice, Place-based Education* (Sobel 2005), *Funds of Knowledge* (Gonzalez, Moll, and Amanti 2005), and *Knowledge Building* (Scardamalia and Bereiter 2006). These sociocultural theories informed the development of the Non-Hierarchical Online Learning Community (NHOLC) conceptual framework (Figure 1) that identifies some of the critical elements to creating an ideal online citizen science community committed to solving local and global environmental problems.

All of the methods in this study looked specifically at how each project applies the core concepts of the NHOLC framework:

- Bringing together diverse participant groups from widely differing areas of expertise to enable multidirectional learning opportunities in which everyone who joins the community has something they can offer and teach others within the community.
- Enabling participant-driven real-world investigations that are personally relevant to participants' lives.
- Sharing project purpose and goals.
- Enabling communication structures to build relationships and roles among a diversity of participants.
- Sharing place-based data across geographic boundaries.

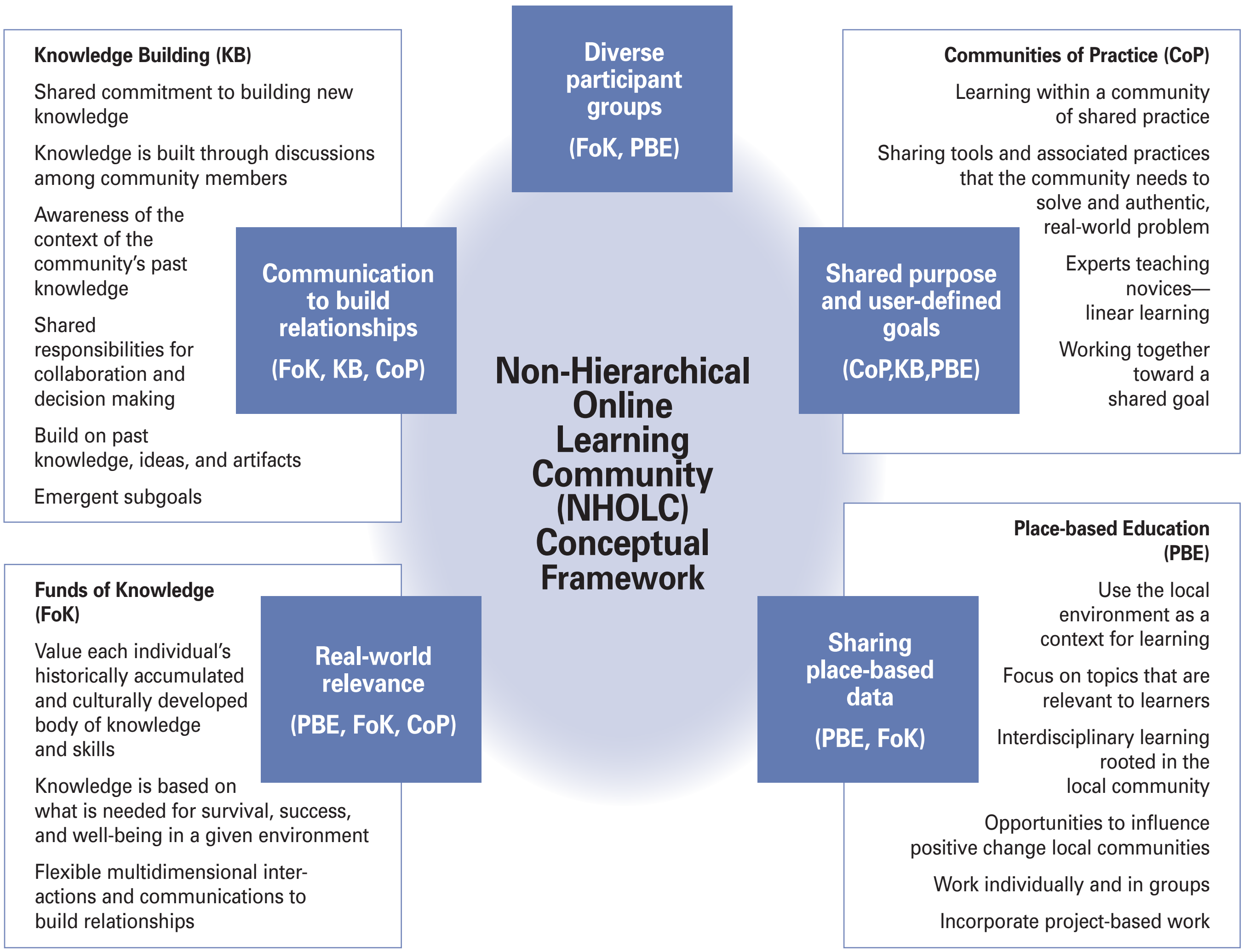
The QSort asked participants to rank 49 statements based on their personal experiences of what made the online citizen science community that they participated in successful in fostering collaboration and supporting local environmental actions. The statements can be found in the appendix, which can be found on MPR's Digital Commons site for this article.

The findings reported here emerge from 15 QSorts and 20 interviews with individuals across the three projects. Participants in this study represented the different types of groups that use each project, such as scientists or experts, project coordinators, and general citizen scientists including teachers and community advocates.

FINDINGS

Looking across the data, four themes emerge that seem to foster collaboration online to address local environmental issues. The key design principles (Figure 2) include (1) diverse groups with a wide range of expertise; (2) participant-driven real-world investigations that are relevant to participants' lives; (3) access to tools and stories about past successes and failures; and (4) online activities combined with on-the-ground activities.

Figure 1: **The Original NHOLC Framework**



Diverse Participant Groups

Participants across all of the projects agreed on a few statements. One of those statements was that "the different types of expertise present in the online learning community are a factor in making members feel like they are working toward the common goal of building knowledge together." At the same time, community members across all projects also unanimously agreed, "the online learning community does not need to connect individuals who use similar resources for work (same language, tools, experiences, definitions)."

Participants believed that projects are successful when they can connect with members who have experiences, information, or expertise that can help them reach the goals they have in mind. A Public Lab participant summed it up nicely saying,

> If it wasn't for the site, I would never have known that there was a need for the expertise I have in these different contexts. I'd be off here in the middle of North Carolina, and I wouldn't be connected with these people in Los Angeles, Peru, or India and places where they do fracking.

Figure 2: **Design Principles for Online Citizen Science Communities**

Design Principles			
Real-world Topics That Are Relevant to Participant's Lives	Diverse Participant Groups	Tools and Stories of Success and Failure	Bridge Online and Offline Activities

> I wouldn't have access to the questions they are all interested in, and I wouldn't be able to contribute.

Simply bringing together people with the same experiences and expertise will not create the type of rich, productive communities present in these projects.

Access to Tools and Stories

Across all projects, everyone agreed, "the online learning community needs to provide access to the tools and practices needed to solve authentic, real-world problems." There are two key ideas built into that statement: first, access to tools and practices to do the work of the project and, second, solving authentic real-world problems. But, what do the terms *tools* and *practices* mean? In this case, they mean the methods of data collection, stories of local citizen science projects that share the lessons learned, methods of communication within the community, and information about how to do the work of the project.

Everyone who participated in this study agreed that the online learning community needed to provide the opportunity for community members to share information with one another. Many of the participants in all three projects value a format that allows them to determine quickly if material is relevant and usable. Whether that information is provided in narratives, databases, or maps, participants need to access the past knowledge of the online community to learn from it and apply it for their own purposes.

In some cases, finding the information a member needs to advance her ideas can be difficult. To address this issue, the Public Lab and WeatherBlur use a recommendation list alert function. These online match functions connect individuals who can help each other meet their goals (for example, connect an expert in freshwater algae with someone trying to understand how algal blooms in a local lake are affecting fish). The function also highlights information related to each member's interests that are hidden in the community and difficult to find otherwise (such as examples of how others gather data on algal blooms, what they found, and what they did about it). Interviewees from the other projects alluded to needing a function like this to foster more collaboration.

In addition, all of the project participants agreed that an online community does not need to provide a variety of communication methods to connect members and build relationships. In fact, during the interviews, participants repeatedly mentioned that when there are too many options for communicating, it becomes overwhelming and actually hinders communications and relationship building. In the projects explored, it is clear that simpler is better. Providing a few targeted means of communication that are available to everyone is the best choice when designing for collaboration and action.

In summary, to foster the types of collaboration and environmental action observed in the three projects, the following technological tools and practices are important:

- Provide access to knowledge from the community's past experiences (for example, past studies, subprojects or investigations, data collection methods).
- Present information in a format that allows members to quickly determine if what is presented is relevant and usable for them.
- Connect members who have information or knowledge that others need.
- Alert members to activities (in person and online) related to their interests and goals.
- Offer a few accessible means of communication.

Relevant and Participant-driven Real-world Investigations

Relevance of the project to the community member emerges repeatedly in the data. As a Public Lab member stated, "People can work on things that are really important to them—it's the people themselves who decided that it was important to them—and they are the ones working to figure it out." The collaborations are driven by the participants' knowledge that the project could result in improving life in someone's backyard. A tool developer in Public Lab shared,

> People can ask a question about their real-world environmental problem and other people, like me, suggest ways to deal with it. People post their new tool that measures some environmental variable and other people at the site can see that and say, "Oh, I could apply this to this particular environmental problem I have."

Members of Vital Signs highlighted the importance in collecting data that they knew was relevant and needed by scientists. This was a major driver in initial and continued participation that lead to new and exciting questions. As stated by a Vital Signs member,

> Once you're going out into the field to learn about invasive species then that opens up a whole doorway of learning about what are the regulations around this species, why is this a problem, why are some invasive species desirable, what makes something invasive versus just introduced. So it's a real-world problem that you're introducing participants to, and they can have an impact on the issue at hand.

It became clear that each participant joins an online citizen science community to accomplish a personal goal.

On the other hand, when participants are uploading data but do not get any responses from experts to confirm or deny their findings, they quickly feel not valued. Many participants become discouraged when there are no comments or discussions related to their posts.

How projects highlight the potential relevance of their work to community members vary, but they all use mapping, narrative, and discourse in various formats. Essentially, both visual and narrative stories are shared to help community members ascertain whether the information and resources provided are relevant to their interests and local real-world problems.

Originally, the NHOLC framework assumed that the overall goals of the online learning community needed to be defined and refined by members. Instead, as seen in the findings from this study, there was consensus that it is not important for an online citizen science community to define and redefine its goals. To understand this better, the interview questions probed the contrast between individual goals and the project's overall goals.

It became clear that each participant joins an online citizen science community to accomplish a personal goal. While one's personal goal aligns with the overall purpose of the project itself, the participants have specific outcomes in mind that they want to achieve. For example, an individual may join Public Lab because he wants to find new uses for a tool that he has designed, while another member joins to find a tool that can address the local environmental questions she is concerned about. In WeatherBlur, a research scientist may join the community to gain access to a population of individuals interested in topics related to her research, while a fisherman may join to connect with other fishermen. And in Vital Signs, a student joins because her class are taking part in a mission to find local invasive species, but a scientist may join to mobilize a network of individuals from across the state to look for a newly introduced species.

The overall goal of the project might draw them into the community, but members need to be able to identify, share, and address their own subgoals or subprojects. When online communities provide examples or stories of how members use the community's resources to meet their own goals, new members report that they find it easier to understand how the community can help them meet their own personal goals.

Online and On-the-Ground Activities

One of the most intriguing findings from this research highlights the importance of balancing online activities and collaboration with on-the-ground activities and relationships. As expressed by a WeatherBlur participant and echoed by participants across each of the projects, "We crafted our investigations offline with members of the local community, but we grew the investigations together with online community members from everywhere." Relationships and connections built in the online community cannot exist in isolation. In Public Lab, members often design and invite others online to attend in-person meetings to talk about an issue or learn a new skill. Successful projects found ways to use the online community to continue or deepen conversations that began in person or vice versa.

CONCLUSIONS

As the digital world begins to connect the farthest reaches of the physical world, citizen science projects designed with these research-based design principles in mind can leverage that connectivity for greater impacts on local environmental activities. Applying these design principles leverages the power of online communities to gather, analyze, and share data that will shed light on ecological issues affecting communities across the globe. In addition, these design principles can connect individuals across great distances to address those issues as they share stories of success and failure. In a rural state like Maine, the potential collective power of individuals using online citizen science communities is tremendous. Citizen scientists of all ages can learn, explore scientific investigations, gather and interpret data, and solve problems together to inform wide-ranging scientific studies as well as local environmental actions and decision making. The design principles discussed in this article summarize both the overarching design elements for developers of online citizen science projects and the needed tools and practices to realize this vision.

This study adds to a growing body of literature focused on citizen science (Cronje et al. 2011; Druschke and Seltzer 2012; Newman et al. 2010). The design principles highlighted here serve as a starting point for others interested in designing engaging citizen science projects that build upon the power of both place and online collaboration to enable action in our own backyards.

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