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Community Science as Adult Learning: Using Theory to Understand Volunteers' Experiences

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Abstract

This study explores volunteer learning in an online community science program. Findings indicate alignment with self-directed and experiential learning theory, with implications for learner feedback and engagement.

Keywords: community science, adult STEM education, self-directed learning, experiential learning

Adult STEM education is valuable for supporting “a scientifically knowledgeable population involved in making democratic decisions about the future” (Zarestky & Vilen, 2023, p. 157). One way to engage adult learners is through community science, also known as citizen science, where the public voluntarily participates in the scientific process. This study’s purpose was to explore volunteer learning in Native Bee Watch (NBW), an online community science program, through the lens of self-directed and experiential learning theory.

Literature Review

A key aspect of community science is providing non-scientists opportunities to engage in a spectrum of learning experiences ranging from data collection to advocating for social or policy change or making recommendations for solving complex problems (U.S. General Services Administration, 2020). Many programs focus on environmental issues that affect human health and biodiversity, where participants are exposed to and interact with scientists, science, and nature, ideally building curiosity, understanding, and behaviors related to conservation, sustainability, and human well-being. Contributory biodiversity monitoring programs are a common design, requiring volunteers to develop specific content knowledge (e.g., insect morphology) and engage in repeated field-based data collection using protocols that support quality longitudinal datasets. Furthermore, volunteers typically complete project-specific training online and collect data remotely from program coordinators and other volunteers (Peter et al., 2021), affording a high degree of flexibility to volunteers’ participation.

While community science has made important contributions to research, less empirical attention has been paid to programs as a context for adult learning (Follett & Strezov, 2015) and few studies utilize learning theory (Hajibayova, 2020). Instead, most studies of community science use volunteer engagement frameworks that conflate frequency of participation, engagement, and learning (Phillips et al., 2019), obscuring the nuances of individuals’ experiences. Applying adult education theory responds to an established need (NASSEM, 2018; Phillips et al., 2019) for illuminating how adults learn through community science and positions adult education as an essential partner in informal and nonformal STEM education programs.

Conceptual Framework

Experiential and self-directed learning (SDL) are theories relevant to community science as a context for hands-on, real-world learning. We draw on Kolb’s (1984) experiential learning

(EL) theory which conceptualizes learning as a cyclical process where individuals engage in an experience, reflect on the experience, construct new knowledge based on reflective processes, and apply that knowledge to subsequent experiences. SDL is the process by which individuals take control of learning through assessing their needs, identifying resources, implementing strategies, and evaluating processes and outcomes, with or without the support of others (Leong, 2020). Both EL and SDL acknowledge the influence of contextual factors, as well as learners' subjective motivation, engagement, and meaning-making.

Community science programs provide a unique setting for applying SDL and EL as analytical frameworks because the nature of the activity already aligns with SDL and EL principles: participation is voluntary, volunteers are expected to exhibit a high level self-direction, multiple cycles of data collection are performed, and participation produces differentiated outcomes due to variability in how learners engage based on prior experiences, knowledge, personal interests, and motivations.

Methods

We used a qualitative design for the present study which is appropriate for investigating individuals' experience and interpretation of complex phenomena (Merriam & Tisdell, 2015). As such, it aligns with this study's purpose of exploring volunteer learning in an online community science program. Specifically, this study was guided by the research question: How did volunteers' experiences align with self-directed and experiential learning?

Native Bee Watch Community Science Program

The setting for this study was NBW, an online community science program offered through Colorado State University Extension. NBW aims to build capacity for pollinator conservation by training volunteer community scientists to identify and monitor bees in public and backyard gardens. Originating as an in-person program in 2016, in 2020 NBW transitioned to a format utilizing online training for field-based data collection. This shift fundamentally changed the learning context and how volunteers engaged with bee monitoring and program supports. For example, volunteers joining NBW in 2020 primarily conduct monitoring sessions individually where previously (2016-2019) they monitored alongside fellow volunteers and received field mentoring from the program coordinator. The various learning activities and engagement opportunities are summarized in Table 1. Further details about NBW's activities are described, including results of related survey research, in Vilen et al. (2023).

Table 1

Comparison of NBW In-Person and Online Training and Engagement Components

Component	In-Person	Online
Training	2-hours, with specimen boxes	2-hour webinar, live or recorded
Assessment & feedback	1:1 field-mentoring with program coordinator or experienced volunteer Opportunities for direct feedback	Online photo insect ID quiz ($\geq 85\%$) No field-mentoring Limited feedback (photos only)
Monitoring context	Designated public gardens (4) Partnered-monitoring Direct instruction	Home gardens statewide Primarily individual monitoring Self-directed learning
Data collection	Paper form	Survey123, an ArcGIS tool

Component	In-Person	Online
Resources & supports	NBW field guide Email & e-newsletter Volunteer appreciate event	NBW field guide Email & e-newsletter Online resource repository Photo flashcards Supplemental webinars (2) Facebook group

Participants

We recruited 2020 NBW volunteers who (1) completed a post-training questionnaire addressing informed consent and demographics, (2) passed the online photo ID quiz, and (3) submitted data to the project by mid-July. We established these inclusion criteria to recruit participants who had engaged with all aspects of NBW; 29 volunteers met eligibility requirements and 23 consented to participate in the study. Most participants identified as female (83%), ages 55 years or older (83%), white (96%), and earned a bachelor's (43%) or master's degree (39%, $n = 23$). All human subjects' data were collected in accordance with protocols approved by Colorado State University's Institutional Review Board.

Data Collection and Analysis

Data consisted of interviews with new volunteers ($n = 18$), defined as individuals who joined the program in 2020, and past volunteers ($n = 5$), defined as individuals who participated in the program during one or more years from 2016-2019 in which the program was in-person. Interview protocols focused on the online training and monitoring experience (e.g., challenges, resources), participation factors (e.g., benefits, motivation), and volunteers' connection to science. Additionally, the past volunteer protocol asked about transitioning from in-person to online and reasons for continued participation.

We assigned pseudonyms to participants, transcribed interviews verbatim, and conducted an initial analysis with *a priori* codes corresponding to interview questions. We conducted subsequent rounds of deductive coding focused on SDL and EL concepts and analyzed coded categories and demographic data in Excel. Deductive coding is an appropriate starting point when the inquiry is theory driven and targets specific actions, experiences, phenomena, and processes that are likely to appear in the data (Saldana, 2021). In the deductive rounds of coding, we focused on concepts shared between SDL and EL, such as (a) motivations; (b) self-monitoring (e.g., self-assessment, reflection); (c) self-management (e.g., learning strategies, resources); (d) contextual factors; and (e) subjectivity (e.g., benefits, outcomes).

Findings

Themes resulting from the data analysis included learners building confidence and skills through practice and self-assessment, and evolving ability to recognize challenges and seek resources. Additionally, motivations, meaning-making, and benefits of bee monitoring varied, particularly for past volunteers with prior experience in the in-person format. These themes indicate qualities of both SDL and EL.

Self-Monitoring and Self-Management

Past and new volunteers had favorable, but different, reactions to the training webinar and online photo ID quiz. Past volunteers were not required to attend training but appreciated the quiz as a self-assessment opportunity. Jessica, a third-year volunteer, commented the quiz forced

her to “use the specific characteristics of bees to figure out what it is...and a really good way to help myself gauge if I’m ready or not”. The quiz also gave her confidence that, as a participant in a scientific project, “we’re all kind of being held to a standard”. Overall, returning volunteers found value in the optional training and quiz as a refresher and self-assessment opportunity.

For new volunteers, the training and quiz served as a springboard for further self-study and practice. Carolyn, a new volunteer, related she did not feel ready to monitor after the training and quiz “just because the difference between a photo and reality...because the bees are moving”. Amy stated she practiced monitoring a few times before officially recording data for the project, and Sharon reflected that feeling ready to monitor “was more about my practicing and studying on my own rather than anything specific from the training or quiz”. Recognizing the difficulty of transitioning from online photo-based training to field-based monitoring, volunteers took initiative and responsibility for building identification and monitoring skills.

One challenge new volunteers experienced initially was the small size of bees and how quickly they moved, making identification difficult for novices. However, volunteers developed strategies to support their learning and identification accuracy. For example, Theresa stated:

The camera was really useful in trying to go back later and really pin down the identification of some of the bees. I don’t remember that being mentioned in training as a good way to check your ID, it was just something that came naturally to try to do.

Through practice and reflection, other volunteers modified their monitoring approach, resulting in greater confidence and efficacy in subsequent sessions. For example, Tracy noticed that “shade was a big factor” in how many bees she was seeing, causing her to change the location and time of day she was monitoring.

Some volunteers experienced challenges related to the limited availability of feedback. Claire, an experienced volunteer, expressed her frustration stating “When I asked questions, when I was unsure about something in my data input form, I *never* heard back on that. I *never* heard back on anything”. Karen, a new volunteer, tried using NBW’s Facebook group for bee identification assistance, but commented the group “seemed to lack immediate feedback”, reducing its utility as a resource. In lieu of direct, in-person feedback, most volunteers found the NBW field guide and online resources, such as websites and identification apps the most helpful. However, some participants felt overwhelmed when resources contained divergent information and had difficulty knowing which resource to trust. For example, Alan commented that many identification guides are from the southeastern U.S., and misleading for what he was seeing in Colorado. Karen noted that most identification guides are organized by bees’ scientific names, which was confusing and hindered her learning process since NBW used a different categorization system. In sum, volunteers had uneven experiences balancing the challenge of learning new-to-them scientific content with the personal and material resources required to successfully plan and conduct bee monitoring.

Subjective Motivations, Engagement, and Benefits

Motivations and benefits of participation allowed volunteers to persist through initial and ongoing challenges and included scientific contributions, lifelong learning, and place-connection. Erika, a new volunteer, related that in her profession, “identifying something, even to a species level, is something I’ve done a lot”, which helped her embrace the challenges of data collection with a scientific mindset. Contributing to environmental sustainability research was a key motivator and benefit for Jessica who stated:

Citizen science is a really necessary step we need to take as a society...we need to be taking conservation and biodiversity impacts seriously as everyday people and not just at our jobs. So, I think that's a benefit, to try and set that example.

Conversely, some past volunteers expressed skepticism about data accuracy and learning bee identification in the online format, which provided little formative feedback compared to the prior in-person format. Claire related how this impacted her motivation, saying "I wasn't as motivated to collect this summer because I worried about it being a waste of time, that the data would be so unreliable,". Other past volunteers felt less motivated due to social isolation and missed the accountability of monitoring with others. For example, Jessica stated "if I'm part of the team, I'm more likely to show up", suggesting social interaction was an important contextual aspect of her NBW experience.

Others embraced at-home monitoring and its affordances for place-connection and lifelong learning. Bonnie related, "It's been absolutely wonderful...I love doing my own yard and being able to study what's working and what's not". Similarly, Carolyn and Kim expressed enjoyment in learning which plants bees prefer, and Theresa expanded her honeybee-centric beekeeping knowledge to include native species. Overall, volunteers demonstrated persistence in learning challenging STEM content and deep personal commitment to the scientific and environmental value of NBW.

Discussion and Implications

Findings from this study indicate alignment of the community science activities and process with SDL and EL. Participants personalized their engagement in this community science program in ways that exemplify qualities of SDL and EL. Volunteers were motivated by the perceived personal, social, and scientific benefits of NBW. Learners identified resources for self-assessment (e.g., field guides, identification apps) that enabled reflection on their mastery of program tasks. This contributed to meaning-making processes, subjective benefits (e.g., place connection, expanding existing knowledge), and identification of growth opportunities, impacting how volunteer continued to engage with the program through personalized learning strategies and resources use (i.e., self-management). Further, the subjective challenge and limitations of monitoring were influenced by prior experience and individual preferences for social support, interaction, and feedback.

Implications for Theory and Adult Education Research

This study's implications for adult education include further exploration of the applicability of SDL and EL to community science programs in general, and to volunteer scientific training and skill building activities in particular where outcomes rely on learners' independence. Given the importance of STEM knowledge and skills in contemporary society, this investigation of adult STEM learning may apply to other nonformal and informal STEM contexts and disciplinary content, as well as other community science program types.

Implications for Practice

NBW exemplified the affordances and constraints of online training for community science. The repetition of pollinator monitoring tasks created authentic EL cycles but required a high level of self-direction and ability to self-assess. Feedback processes were limited, impacting volunteers' motivation and engagement. Future directions should focus on developing feedback systems that support (a) volunteers' confidence, knowledge, and skills and (b) scientific data accuracy.

Conclusion

Community science in general, and the NBW program in particular, are well-established means of engaging adults in STEM learning. Not only do participants learn scientific content, they also have opportunities to connect with concepts and practices that inform social systems, policy, and our collective ability to address complex problems (U.S. General Services Administration, 2020). The alignment of adult community science with adult education perspectives such as SDL and EL provides an underexplored but fruitful opportunity to support learners and make positive contributions to environmental issues that affect human health and biodiversity.

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