Youth environmental science learning and agency: A unifying lens across community and citizen science settings

Conference or Workshop Item

YOUTH ENVIRONMENTAL SCIENCE LEARNING AND AGENCY: A UNIFYING LENS ACROSS COMMUNITY AND CITIZEN SCIENCE SETTINGS

Abstract: *This study addresses an existing gap in our understanding of how participation in environmental Community and Citizen Science (CCS) projects may impact young volunteers' environmental science learning across a wide variety of settings. We examined youth learning across four settings which we represented as cases: 5 short-term field-based events (BioBlitzes), 3 longer-term field-based monitoring programs, fully online projects (Zooniverse), and a hybrid format that combines participation in the field and online spaces (iNaturalist). This multiple-case study uses the Environmental Science Agency framework to interpret learning evidence of 33 young CCS volunteers (aged 10-13 years) in post-participation surveys, semi-structured interviews, and in ethnographic field notes for the field-based participants. Across the cases, we found particular features of the CCS projects and the scientific framings that may have encouraged aspects of ESA. Design features such as access to new knowledge, training, and scientific tools provided by the CCS projects encouraged youth to learn rich and varied understandings of disciplinary content, scientific skills and practices. An increased sense of confidence and competence in youth around the scientific practices of the projects were stimulated by scientific framing of CSS and ongoing participation. Overall, these aspects also supported small manifestations of youth agency with science.*

INTRODUCTION (SUBJECT/PROBLEM)

Community and Citizen Science (CCS) involves voluntary participation of the general public to obtain, manage, or analyse information for authentic scientific purposes, creating opportunities for new scientific knowledge, science learning, and social empowerment (Bonney et al., 2014; Dickinson et al., 2012; Harris et al., 2019; Shirk et al., 2012). Only in the last decade researchers began to understand what science learning may CCS volunteers develop (Bela et al., 2016; Bonney et al., 2016; Dillon et al., 2016; Kieslinger et al., 2018; Phillips et al., 2018), although we know little about how science learning might manifest across different CCS settings. This study contributes to this growing body of knowledge by examining environmental science learning evidence of young volunteers across environmental CCS projects led by Natural History Museums (NHM) in field-based, fully online, or in hybrid settings that combine nature settings and online spaces. NHM-led CCS is of particular interest because it integrates environmental science and informal science learning many times across field-based and online settings (Author, 2017b). We studied environmental science learning,using a unifying learning framework, termed Environmental Science Agency (ESA) (Author, 2017). The research questions were: a) How does ESA learning manifest in young people participating across the field-based and online CCS settings? And b) What aspects of the CCS learning settings supported ESA learning in young people? The CCS projects we studied shared the goal of generating observations of nature and biodiversity monitoring as well as engaging the public in environmental science, however, they varied in design, participation modes, facilitation, the context of delivery and location. These conditions provided rich and varied contexts to study youth environmental science learning, offering an innovative angle to what may encourage learning in different CCS settings since research across CCS settings is scarce.

ENVIRONMENTAL SCIENCE AGENCY IN INFORMAL LEARNING SETTINGS

Influenced by democratic science pedagogy researchers Basu and Calabrese Barton (2010), and socio-cultural theorists Lave & Wenger (1991), the ESA framework encompases youth understanding environmental science content, science practice, and science norms (hereafter termed ESA 1); identifying their own expertise within environmental science (ESA 2); and using their CCS experiences as a foundation for individual and collective change (ESA 3). These three components act as indicators of a learning process that might altogether encompass more specific aspects of developing an understanding and identity with environmental science to the extent these processes influence environmental stewardship in youth (Author, 2017), with early evidence not only in CCS contexts but also school gardens and science labs (Harris et al. 2021). Developing or reinforcing ESA, similar to ways that youth develop practice-linked identities (Nasir & Hand 2008) and agency with science (Calabrese Barton and Tan, 2010), involve generative and recursive processes shaped by conditions such as the context of participation in learning settings and the features of the learning settings themselves.

METHODOLOGY AND ANALYSIS (DESIGN/PROCEDURES)

We designed a multiple-case study focused on three ESA learning across eight CCS projects and four learning settings (Yin, 2018). The cases, outlined by each of the learning settings, encompass the following CCS events and projects, all which involve youth generating or classifying observations of organisms that may be used for biodiversity research and monitoring: five short-term and field-based Bioblitz events across the NHMs; three longer-term and field-based monitoring programmes (Science Action Club, Super Project, and Big Seaweed Search), one from each NHM; one crowdsourcing entirely online platform (Zooniverse) populated with multiple citizen science projects for at-will participation; and one crowdsourcing platform (iNaturalist) that includes both field-based and online participation. We applied a purposeful selection strategy to form a youth cohort from each CCS setting (Patton, 2015).We included youth in our target age range (10-13 years) and those that had multiple data sources, resulting in 33 young people (20 females and 13 males) (Table 1). We obtained parental consent in person at the events, over the phone or via email in accordance with Ethics Board protocols.

Table 1 Data sets of participant cohorts across learning settings

CCS settings	Youth cohorts	Data sets			
Bioblitz events*	8 youth	7 pre-surveys	7 post-surveys	8 field observations	1 one-to-one semi-structured interview
Longer-term* programmes	14 youth	14 pre-survey	11 post-surveys	47 field observations	14 one-to-one semi-structured interviews

Zooniverse	7 youth	3 surveys	7 one-to-one semi-structured interviews
iNaturalist	4 youth	3 surveys	4 one-to-one semi-structured interviews
*In addition to ethnographic observational data of implementation for all field-based projects			

All instruments focused on the three components of ESA as well as youth interest and participation activities. We employed Dedoose (Version 8.0.45) for the qualitative coding analysis of interviews, ethnographic field notes and surveys. Two researchers developed a codebook using both *a priori* codes and emergent codes (Saldaña, 2016). They coded 50% of the interview data and reached 90% inter-rater agreement (Campbell, 2013). After this, each researcher separately coded the rest of the data, iteratively checking agreement. The subsequent analyses involved a series of constructivist-interpretivist exercises to gain a semantic understanding of the data (Holstein and Gumbrion, 2011), eventually triangulating the learning evidence across all the data types cohort by cohort (Flick, 2018), then focusing on the distinct learning aspects of each ESA component per cohort and these across the 4 settings.

FINDINGS

With respect to our first research question, we found unique differences and important similarities in the way that ESA manifested within and across the four settings, both for the separate components of ESA and overall. Table 2 highlights learning outcomes we saw that were common in all the CCS settings, emphasising the specific differences that we found within particular settings, when present.

Table 2 Shared Environmental Science Agency (ESA) learning outcomes across 4 settings and specific differences between settings, with examples of evidence.

Environmental Science Agency	Shared learning outcomes across settings and specific differences between settings	Examples of evidence
ESA 1. Scientific skills	**Youth learned to make careful observations, identify organisms and classify images.** *For specific settings.* In BioBlitz and ongoing field-based settings, youth learned how to produce accurate photos and execute the survey protocols. In Zooniverse and iNaturalist, youth learned how to collect data, identify, and classify using the platforms.	*When asked how to take an accurate photo:* *Make sure [the organism] isn't blurry. Get close to see details. (Jesse, 11, BioBlitz, post-survey)*
ESA 1. Content knowledge	**Youth learned disciplinary science content, mostly taxonomic and local ecological knowledge of species.** *For specific settings.* Youth in Bioblitz events learned to identify organisms while volunteers of ongoing monitoring and iNaturalist users also gained biodiversity and habitat information about the species they observed. Zooniverse users learned broader science content, sometimes different to the environmental sciences.	*… I thought species were like two or three different things, that's it. But it turns out I was wrong. (Li, 11, ongoing monitoring, interview)*

ESA 1. Purpose of their contributions	**Understanding their contributions can be used to study the biodiversity of the surveyed areas.** *For specific settings.* Their understanding only varied in terms of who in science might use their contributions (museum scientists, researchers, or scientists) and what kind of contribution would make (help science and/or help the plant)	*... My pictures are being identified and it's helping them [scientists] figure out what's around in Los Angeles. (Andrea, 11, iNaturalist, interview)*
ESA 2. Sharing with others	**Sharing small or bigger knowledge gains, skills or interests with CCS peers, family, or friends.** *For specific settings.* Field-based volunteers shared survey findings and occasionally used their skills to guide others. Zooniverse and iNaturalist shared focalised and related science interests with others.	Amy, in explaining how to use the app to her parents, said, *"yes, you just press this 'observe' button in the app." (Amy, 11, BioBlitz, ethnographic fieldnotes)*
ESA 2. Perceived competence in/with in CCS	**Youth identified skills they could do well in CCS and perceived their own activities as doing or contributing to science.** *For specific settings.* No real differences between settings.	*I just feel like a scientist because I'm giving them information (Jet, 10, Zooniverse, interview)*
ESA 2. Ownership in participation	**Youth showed involved and committed behaviour to follow survey protocols and identify organisms.** *Only in ongoing monitoring projects.*	*Jan was often overseeing that correct identifications of seaweed were recorded in the form. (Jan, 13, ongoing monitoring, ethnographic fieldnotes)*
ESA 2. Undertaking New Roles in CCS	**Assuming responsibility, and, occasionally, leadership to perform and complete a task.** *Only in ongoing monitoring projects.*	*When asked about his role Brian said, "I explore, because I like going out where most people haven't been" (Brian, 13, ongoing monitoring, interview).*
ESA 2. Appreciation for science and/or nature	**Showing a renewed understanding or interest in relation to the object of study or the scientific context of the programmes.** *Only in ongoing monitoring projects and Zooniverse.*	*I've always been interested in some kind of science and Zooniverse really helped me to find out which part of science I was most interested in. (Dorian, 12, Zooniverse, interview).*
ESA 3. Foundation for change	**Envisioning how to use field-based survey skills and knowledge to find out about an organism.** *For specific settings.* No real differences between settings, except for Zooniverse volunteers who showed signs of using their experience to further their science interests.	*I would probably capture [bug], put it in the glass container and then look at it for a second with a microscope. Then, I would look it up on a science website. (Wally, 12, longer-term monitoring, interview)*

With respect to our second research question, we examined the influence of the CCS framing and the specific project settings on the learning outcomes in Table 2. When the learning evidence showed evident differences across the settings (e.g. scientific skills), features of the educational design and delivery were notable (e.g., location, duration of participation, being given access to training and tools to use them scientifically). In contrast, for learning outcomes that were shared and relatively consistent across all settings (e.g., feeling confident in/with science), we found youth described how the scientific rationale of the CCS project (e.g., clear scientific purpose, contributing to authentic science) was an inspiring or influencing factor for their sense of identity and roles in the CCS endeavor. This may indicate that the emphasis on the purpose of CCS as authentic science is a unifying feature of CCS that supports developing identity with science. We noticed that learning aspects related to identity development were also encouraged by project features such as guided training and repeated participation intervals. As such, we saw additional unique learning outcomes (e.g., undertaking a role and a sense of ownership in their participation) in participants from the Ongoing monitoring programs and Zooniverse, as they both allowed long-term and ongoing participation.

CONTRIBUTIONS TO THE TEACHING AND LEARNING OF SCIENCE

This study contributes to ongoing work in the science education field which explores, through the ESA framework, the fine lines between expressions of knowledge, identity, and agency with science that may flourish in informal learning settings. We identified that design features of the projects were a generalised influence for young people who gained different science knowledge and skills across the settings. Comparably, researchers of youth-based citizen science forestry programs reported that similar learning outcomes, such as to the ones we found for ESA 1, were influenced by the objectives of the CCS projects (Pitt and Schultz, 2018). Regardless of the differences, youth's gain in science knowledge and skills may similarly reinforce their explanatory powers and scientific reasoning (NAS, 2018), supporting them in becoming participants in science. Young people see themselves, or are recognized by others, as someone who understands and is able to use science may develop an identity with science (Carlone et al., 2015). In this sense, the CCS framing of the projects contributed with a significant purpose and context for the projects which inspired people to identify their competence and give sense to their participation in authentic scientific work. Additionally, ongoing participation in CCS and knowledge exchanges with others may also influence young people to develop an identity in/with science. Overall, these results corroborate previous research studying the ESA framework in school and other field-based CCS settings (Author, 2017; Harris et al., 2019; Harris and Author, 2021), which also found that the development of agency and identity with science for young people is highly dependent on how program designers and educators frame the purpose of the activities, and for CCS, as contributing to authentic and relevant environmental science. This study provides evidence of the particular aspects of environmental science learning that occur regardless of the learning setting, yet it highlights specific features of the CCS that can support environmental science learning differently. Project design in CCS contexts as well as other informal science learning contexts may benefit from considering that an explicit CCS framing and specific settings that provide access to science knowledge and scientific practices for ongoing participation create supporting learning environments and meaningful contexts for environmental science learning.

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