

**Conceptualizing and evaluating transformative environmental education: Nature-based citizen science as a platform for experiential learning and collective action on climate change**

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## PROJECT BRIEF

The study discussed in this report was conducted under the 2015 Social Sciences and Humanities Research Council (SSHRC) Knowledge Synthesis Grant program. The report explores 'New Ways of Learning' in the context of promoting climate change mitigation and adaptation. International and national assessments agree that effective action on climate change is no longer a future priority. Climate change impacts are already apparent and are leading to severe social, economic and environmental disruptions in both developing and developed nations (IPCC, 2014; Warren & Lemmen, 2014).

This report adopts the increasingly common perspective that an approach to environmental education that is based on the principle of environmental literacy is unlikely to contribute to the types of transformations that are needed to avoid potentially catastrophic environmental crises like climate change (Hargreaves, 2011; Kyburz-Graber, 2013). What may be needed is a transformative approach to environmental education that can open the doors of science to the public; close the gap between conceptions of self and nature; and disrupt institutional and social structures that prevent citizens from adopting sustainable lifestyles (Diduck et al., 2012; Sterling, 2011).

It is within this perspective that this report examines citizen science as a potential model of transformative environmental education. More specifically, a systematic review of studies exploring nature-based citizen science in the area of climate change is paired with a matrix review of on-the-ground citizen science programs that also focus on climate change. This pairing provides a broad review of learning outcomes related to climate change focused citizen science, and explores how these learning outcomes relate to the design and operation of on-the-ground programs.

Results from a systematic review of 64 peer-reviewed academic articles suggest that there is limited focus on environmental education and learning outcomes within the literature examining climate change through a citizen science lens. Overall, 56% (n=36) of articles examined do not provide any evidence that nature-based citizen science programs addressing climate change support transformative learning, and only one article was explicitly designed to assess learning outcomes from a participant perspective. Instrumental outcomes (e.g., new knowledge) were covered by 42% of reviewed articles. By comparison, communicative outcomes (e.g., new relationships) were covered by 33% of reviewed articles, although 70% of references to communicative outcomes came from only six sources. Results from the matrix review of 17 citizen science programs that are related to climate change were similar. Explicit research objectives were documented from available secondary sources for all 17 programs, while explicit learning objectives were present in available secondary data sources for only 7 programs. Program evaluations were conducted for only two of the 17 programs covered by the matrix review.

Overall, findings suggest that there is much room to strengthen priorities around environmental education and learning outcomes within climate change related citizen science. While there is little current evidence that citizen science is contributing to transformative learning around climate change, this does not mean these outcomes are not present. Instead, the current lack of evidence may be attributable to a lack of research in this area. As program evaluation research and work was also limited among the peer-reviewed articles and programs that were assessed, partnerships across the science-social science divide should be fostered in order to address this gap.

## EXECUTIVE SUMMARY

The study discussed in this report was funded under the 2015 Social Sciences and Humanities Research Council (SSHRC) Knowledge Synthesis Grants (KSG) program. The 2015 call for the KSG program asked: “What new ways of learning, particularly in higher education, will Canadians need to thrive in an evolving society and labour market?” In response to this question, this report examines new ways of learning within the context of an evolving global environment, and the pressing need to promote widespread societal action on environmental issues. To scope this rather broad objective, this report focuses on the issue of climate change. More specifically, it raises questions about the ability of dominant environmental literacy based models of environmental education to spur actions necessary for effective climate change mitigation and adaptation (IPCC, 2014; Warren & Lemmen, 2014). Finally, it asserts that a transformative approach to environmental education may be better positioned to promote the types of perspective transformations that are needed to mobilize climate action (Diduck et al., 2012). Rather than simply critiquing current models of environmental education, citizen science is examined as a potential model for transformative environmental education by exploring learning outcomes in climate change related citizen science programs.

In keeping with the scope of the KSG program, the findings in this report are based on the collection of secondary data only. To overcome the potential challenges of a single method study design, two complimentary methods were used. First, a systematic review of the peer-reviewed academic literature examining citizen science in a climate change context was conducted. Although they are often associated with the meta-analytic review of evidence in the medical field, systematic reviews are an increasingly popular tool for assessing the state of knowledge in the environmental field, and for communicating that knowledge to policy-makers. A pool of 64 peer-reviewed academic articles was ultimately assessed to determine what learning outcomes are currently associated with citizen science participation (in a climate change context). In keeping with the objective of examining opportunities for transformative environmental education, transformative learning theory guided the assessment of this literature.

The second method employed in this study was a synthesis matrix review. This component of the study was smaller in scope and was designed to add context to findings of the systematic review. Synthesis matrix reviews develop a list of relevant assessment criteria that are used in an overall evaluation framework. The objective of a synthesis matrix review is to provide a structured process to compare a range of similar sources (e.g., programs) and to assess differences and similarities in key areas. In this report the synthesis matrix review extends the systematic review by reporting on the structure and practices of 17 citizen science programs that are both related to climate change and active in Canada. In total, 47 variables covering four themes (Organizational Structure; Project Details; Project Outputs; Participant Involvement) were assessed.

Results from this study are organized into three related themes covering:

- 1) General uses of citizen science in the area of climate change
- 2) Learning outcomes within climate change related citizen science
- 3) Knowledge creation within climate change related citizen science

Findings from the systematic review indicate a strong bias toward monitoring the distribution of flora and fauna populations, of which climate change is an important driving factor. Among papers that had a singular empirical research focus (i.e., not broad review papers), studies related to bird identification, distribution and phenology (31% of pool) were the most common, followed by studies of plant phenology (9% of pool), and studies related to butterfly identification, distribution and phenology (6% of pool). Findings from the matrix review reflect a similar emphasis as 15 of the assessed programs had a long term monitoring focus, sometimes in conjunction with other modes of inquiry (e.g., hypothesis testing). Despite pointed discussion of issues related to data utility within the citizen science literature (e.g., Peters et al., 2015), program documentation related to such issues was limited. It was generally clear from program documentation which projects or databases participant data ultimately fed into. However, only a few projects reported on specific contributions to the advancement of policy or to published studies.

The transformative learning literature was used to create a coding framework that was applied to citizen science articles during the systematic review. It was not anticipated that transformative learning theory would be explicitly referenced in the citizen science literature. Rather, this framework provided a means to examine learning outcomes currently reported within the citizen science field and to assess whether there is evidence of perspective transformations. Overall, there is little evidence to suggest that citizen science related to climate change is promoting transformative learning. The majority (56% of the pool) of studies did not provide any evidence of learning outcomes and only one article within the study pool was explicitly designed to assess learning outcomes related to CS participation (Lawrence, 2009).

Among the remaining articles, references to instrumental learning were more common than references to communicative learning. Instrumental learning outcomes were discussed in 42% of the articles. The most common instrumental learning outcomes discussed were 'new knowledge' (34% of articles) and 'new skills or practices' (16% of articles). By comparison, communicative learning outcomes (e.g., new social interactions and community engagement) were discussed in 33% of articles, although of the 67 coded references a total of 70% came from only six articles. Importantly, these findings do not suggest that learning outcomes that are indicative of perspective transformation are not present among participants in the citizen science programs covered by the systematic review. Rather, the research focus of many citizen science studies simply does not seem to encapsulate a strong emphasis on learning outcomes and/or environmental education. Results from the synthesis matrix review reflect a similar finding. While all 17 assessed programs documented detailed research objectives, only seven programs (~41%) had learning objectives available in documented secondary sources. Among these, only two programs conducted a program evaluation.

Findings related to learning outcomes in climate change related citizen science programs should be interpreted within the broader context of how citizen science contributes to knowledge creation processes. There is recognition within the citizen science literature that putting participants in contact with nature in experiential learning environments has the "potential to deepen the experience of the physical place of which people are part and to develop their understanding of how science works" (Wals et al., 2014, p. 584). Despite this recognition, the lack of focused studies examining citizen science from an environmental education (or even learning outcomes) perspective suggests there is little empirical support of these benefits (as of yet) in a climate change context. Opportunities for nature-based experiential learning to support perspective

transformations may also relate to questions of program design and governance that shape the knowledge creation process. The leadership of the citizen science programs assessed in the matrix review was spread across academic institutions (~29%, n=5), government agencies (~24%, n=4), non-governmental organizations (~17%, n=3), and government-NGO partnerships (~29%, n=5). Likewise, the design and implementation of the vast majority (n=14) of the assessed studies were contributory in nature, whereby participants collect data that is then fed into a larger research program or database. Only one program utilized a collaborative design, while two utilized a co-created design.

Citizen science has the potential to foster a transformative model of environmental education by providing opportunities for knowledge co-creation, by placing learners in nature-based experiential learning environments, and by lowering the barrier for participants to access new social and institutional networks. Despite these strengths, evidence garnered from academic literature and on-the-ground programs suggests the current capacity for citizen science to inform a transformative model of environmental education is highly limited. At least within the context of climate change, there is a dearth of academic studies explicitly designed to assess citizen science from an environmental education and learning outcome perspective. Among the programs assessed in this study, learning outcomes and in particular the evaluation of learning outcomes seem to be a low priority, at least compared to the promotion of scientific research objectives.

This does not suggest that scientific research objectives should not drive citizen science programming. However, there does seem to be a considerable opportunity both within the realm of academic research and on-the-ground program design and delivery for increased partnering across the science-social science divide. Such partnerships would increase our understanding of the true transformative potential of citizen science, likely without the need to significantly disrupt on-going programs. A short-term priority should be to increase the number of program evaluations, and to increase the scope of such evaluation to incorporate a strong focus on communicative (or community – see Jordan et al., 2012) learning outcomes.