SCIENCE EDUCATION

Convergence Between Science and Environmental Education

Citizen science and concerns about sustainability can catalyze much-needed synergy between environmental education and science education.

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Urgent issues such as climate change, food scarcity, malnutrition, and loss of biodiversity are highly complex and contested in both science and society (*1*). To address them, environmental educators and science educators seek to engage people in what are commonly referred to as sustainability challenges. Regrettably, science education (SE), which focuses primarily on teaching knowledge and skills, and environmental education (EE), which also stresses the incorporation of values and changing behaviors, have become increasingly distant. The relationship between SE and EE has been characterized as "distant, competitive, predator-prey and host-parasite" (*2*). We examine the potential for a convergence of EE and SE that might engage people in addressing fundamental socioecological challenges.

Since the end of World War II, SE has been driven primarily by a need to develop a sufficient pool of science and engineering talent to accelerate innovation and to remain competitive. EE emerged in the early 1960s out of a need to respond to emergent environmental crises. It tried to do so by developing the ecological and environmental literacy required to understand the sociopolitical, value-laden, place-based, and emotional contexts in which environmental issues arise and need to be resolved. An example of the difference between early SE and EE is that, while the former might teach students how to monitor water quality, identify pollutants, and understand technologies that can reduce pollution, EE would involve an analysis of circumstances and behaviors that caused the pollution, as well as identifying ways to clean up a river involving the local community, policy-makers, and industry.

The complex nature of current sustainability challenges, and the need for competent citizens who can adequately respond to them, is such that EE and SE need to develop a mature symbiotic relationship. The recent *International Handbook of Research on Environmental Education* (*3*) describes a trend in favor of such convergence, which, in combination with increased interest in citizen science supported by information and communications technology (ICT), may make education more responsive to current global challenges.

Science education and environmental education do not have to clash. The Harlem Success Garden in New York City is a living classroom where students grow their own produce.

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Research in Environmental Education

Initially, much research in EE (especially in the United States) focused on the effectiveness of EE activities in changing individual environmental behaviors. This approach contributed to the persistent but ill-founded assumption that there is a simple linear relationship between knowledge, awareness, attitude, and environmental behavior. Research, most notably from social psychology, has long revealed that this is far too simplistic an explanation of what affects people's actions (*4*).

Today much EE research focuses on investigating the conditions and learning processes that enable citizens, young and old, to (i) develop their own capacity to think critically, ethically, and creatively in appraising environmental situations; (ii) make informed decisions about those situations; and (iii) develop the capacity and commitment to act individually and collectively in ways that sustain and enhance the environment (*3*).

This new focus implies less emphasis on establishing linkages between educational interventions and behavioral outcomes. More attention is now being given to an understanding of the learning processes and the capacities of individuals and communities needed to help resolve complex socioecological issues. This focus also calls for a better understanding of people's cognitive and emotional responses to environmental issues. These responses are influenced by their worldviews and belief systems, which in turn are linked to identity (*5*). For example, recent research has rendered problematic a focus solely on better comprehension of the science of climate change owing to "identity-protective cognition theory," which indicates that many people's positions on climate change are largely shaped by their political and religious affiliations and identities (*6*).

EE research currently offers insights into how to engage the public with environmental issues through participatory action,

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whereas SE research has traditionally provided insights into learners' understanding of the natural systems and processes that are at the heart of these issues (*7*). The necessity of connecting the two has been recognized by the North American Association for Environmental Education (NAAEE) in a joint initiative with Underwriters Laboratories to link environmental education with science, technology, engineering, and mathematics (E-STEM) (*8*). Recently, a number of prominent SE researchers have stressed the importance of science educators engaging with sustainability issues by complementing disciplinary understanding with more integrative thinking and linking scientific knowledge with other forms of knowledge such as indigenous knowledge and local (place-based) understanding (*9*). So, although SE may have evolved separately from EE, recent research and developments in both EE and SE converge toward generating an interdisciplinary and contextual approach to integrating research in science, education, and the environment (*3*).

Citizen Science

At the same time, the rise of citizen science (CS) also enables for people to engage with science on relevant environmental issues in collaboration with scientists working in local contexts (*10*, *11*). In a recent review, Dickinson *et al*. reported that the primary impacts of CS are seen in biological studies of global climate change (*12*). The authors conclude that CS and the resulting ecological data can be viewed as a public good that is generated through increasingly collaborative tools and resources. They consider public participation in science a critical component of what they call Earth stewardship.

Citizen science most often refers to community-based local monitoring of changes in the environment using simple data acquisition devices and communication tools. More recently, CS has taken advantage of the Internet, social media, and mobile applications in crowd-sourcing scientific data (*13*)—resulting in what we refer to as ICT-supported CS. This trend connects well with recent EE research that identifies the use of social media as well as technology-enhanced citizen data acquisition as a way to enhance the interaction between research in science, education, and the environment (*3*).

Linking EE, SE, and CS

Creating synergy between EE and SE through ICT-supported CS provides opportunities for new forms of education that can lead to the engagement of seemingly unrelated actors and organizations in making new knowledge and in taking the actions necessary to address socioecological challenges. An example of such synergy emerges from so-called "whole-school approaches" to sustainability and the creation of eco-schools, where different forms of learning (e.g., inquiry-based, disciplinary, and social learning) blend with the use of ICT, citizen science, and community engagement (*14*). Such approaches may involve redesigning school grounds using knowledge from SE—to give such spaces a more central place in teaching about health, food, and ecology—as well as using EE to strengthen community involvement and develop a sense of place.

For instance, by creating "edible gardens" (see the photo), schools can, with the involvement of a wide range of societal actors (e.g., a local garden center, a restaurant, a community organization, and the local government), simultaneously improve the quality and relevance of their education and transform their relationship with the local community (*15*). Soil preparation, seed selection, planting, maintaining, harvesting, and preparing a meal require basic scientific knowledge that connects with the SE curriculum while also creating other benefits, such as community engagement, learner empowerment, improved personal health, and a better connection with food and place (*16*).

Recent EE research indicates that the use of CS in these blended or hybrid learning configurations helps learners contribute to the quality of their local environment (*3*). This process can be enhanced by projects such as YardMap, an ICT-supported CS project, funded by the U.S. National Science Foundation, which enables members of the public not only to increase their appreciation of their local "yard" through the use of mapping software but also to take action for improving the habitats of birds.

Place and Identity

The examples of SE and EE converging, supported by CS, emphasize the importance of place and place-based identity in determining our relations with the planet. The focus on identity is timely: The complexity and uncertainty brought on by globalization and the rapid pace of technological and social change result in substantial cultural shifts, including a search for meaning and affiliation in locally defined identities (*5*). The reasons for the recently established disconnect between people and place that results from a preoccupation with and dependency on ICT (*17*) are underresearched, but there is some evidence that such technologies can actually reconnect people and places (*18*). Numerous examples exist of citizens monitoring changes in the environment (e.g., bird migration patterns and quality of water, soil, and air) using geographic information systems, cell phones, and specially designed monitoring applications (*11*). As such, ICT devices actually get people to go outdoors, even those who normally are not inclined to do so. Participation in scientific studies through ICT-supported CS offers the potential to deepen the experience of the physical place of which people are part and to develop their understanding of how science works.

Society has to learn how to address sustainability challenges. Creating synergy between EE and SE mediated by ICT-supported CS provides an opportunity for such learning. We advocate support for collaborative research efforts among scientists, educators, and the public, linking science and society with place and identity, through more effective processes of public engagement and learning that can result in meaningful socioecological outcomes. The data gathered and shared using ICT can provide useful input to environmental scientists while simultaneously empowering citizens to engage in ongoing debates about local and global sustainability issues and what needs to be done to address them.

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