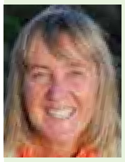
Ecoliteracy in informal science education settings



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Specific metrics for the status of US science education indicate that the country is losing its competitive edge on a global scale; among nations, the US ranks 22nd in density of broadband internet penetration and 72nd in density of mobile phone subscriptions, both of which are critical tools for science literacy and likely contribute to our international rank of 48th in quality of math and science education. Even worse, 69% of US public middle-school math students are taught by teachers without degrees or certificates in mathematics, and 93% of public middle-school teachers in physical sciences lack degrees in their subject (NAS 2010). All of these rankings represent indicators of global science leadership. In short, formal science education systems in the US lag behind those of many other countries, and our ability to train the next generation of scientists is at risk (Brewer and Smith 2010). In addition to shortfalls in public schools, US K–12 youth now watch at least 4 hours of television daily, and the average teenager spends a whopping 7.5 recreational hours daily in front of television and gaming screens (NAS 2010) – time that instead could be devoted to doing homework or experiencing the natural world through outdoor engagement. The formal STEM (science, technology, engineering, and mathematics) education metrics for US education are not keeping pace with those of other developed countries and are declining over time. Ecology education is experiencing one of the largest deficits: public schools have cut back on field trips and many K–12 students now experience nature virtually, rather than directly (Louv 2008; Lowman and Mourad 2010). Likewise, many undergraduate and graduate programs are eliminating their natural history programs, sometimes referred to as the "extinction of the ologies" (Lowman and Mourad 2010).

In contrast, informal science education (ISE) is now providing a larger compensatory component of STEM education to students as well as to citizens and policy makers. Currently, US museums tally approximately 850 million visits annually, which is more than the attendance for all major league sporting events and theme parks combined (483 million in 2011; www.aam-us.org). Along with these visits, museums are also recording a burgeoning virtual visitorship, with an additional 524 million online visitors in 2006 alone, which has escalated during the past 5 years. In the US, there are over 17 000 museums, whose visitors range from several hundred for a rural museum with a local mission to >8 million annually for larger or national museums (www.aam-us.org); many of these ISE experiences bolster shortfalls in formal STEM education. Natural history museums, with their biodiversity collections and interpretive dioramas, serve as focal points to provide ISE about ecological concepts, including biodiversity, ecosystem services, climate change, and landscapes. In many cases, K–12 students become inspired by seeing, touching, and working with collections; and increasingly, virtual technologies and social media are becoming important drivers of science education concepts for youth outside of the formal classroom setting. Both undergraduate and graduate students can gain valuable training in science communication and outreach using the public floor of museums and other ISE platforms (Trautmann and Krasny 2006; Lowman and Mourad 2010). Given the declining competitiveness of US science education on a global scale, ISE has become an important pipeline for engaging the next generation of scientists and for contributing to otherwise declining ecological literacy.

Of US adults surveyed nationally, <20% possess an "acceptable" level of scientific literacy and a majority have little knowledge of natural science, the process of research, or the results of contemporary scientific investigations, despite the importance of science to both human and ecological health (Field and Powell 2001; Miller 2004). Many ISE institutions are embracing the urgency of providing visitors with hands-on experiences to understand science and especially ecology; such efforts may translate to a healthy community through an understanding of fresh water, pollinators, clean air, agriculture, carbon sequestration, forest products, and myriad other ecosystem services. Educators often suggest "the best way to help the public understand the research process is to involve them directly through hands-on research" (Ucko 2004). Public Engagement with Science (PES) is a term used in ISE circles that emphasizes the growing importance of providing citizens with a better understanding of science as a driver of economics and health; ecology is often a conduit for science understanding, whereby museums foster a sense of wonder that leads to greater science literacy by getting kids "hooked" on science. But more analyses of PES in museum settings – including theoretically based assessments of activities – are sorely needed (Bonney *et al.* 2009).

In my former home state of North Carolina, 39% of 8th graders report they "never or hardly ever" designed a science experiment, and another 29% report doing hands-on science activities only once or twice a month. Teaching methods that were traditional several decades ago – lectures, textbooks, recipes in laboratory sessions –

continue to be the norm in science education despite national outcries calling for radical change (eg Brewer and Smith 2010). Soon, science teachers may face additional pressure to incorporate hands-on experiences into their courses. Like those of many other states, North Carolina's revised science standards call for inquiry-based learning experiences emphasizing the Next Generation Science standards. Historically restricted to museums as an outreach activity, ISE may infiltrate the public school classroom, so that "citizen-science" activities originating in museums can be virtually transmitted to classrooms for dynamic new science activities (eg Project GLOBE, Project BudBurst, and iNaturalist.org; see Trautmann *et al.* 2012; Zoellick *et al.* 2012; www.yourwildlife.org). Programs such as the National Ecological Observatory Network (NEON) have national mandates from Congress to implement citizen science (or some major and transformational capacity of ISE) to reach diverse stakeholders with data streams about North American ecosystems (Lowman *et al.* 2009). In addition, for states like North Carolina, with large numbers of practicing scientists, the mentoring of K–12 teachers by scientists has the potential to become another pathway for ISE (Lowman and Randle 2009).

To keep North Carolina competitive in science (especially given the strength of Research Triangle Park, a huge driver of technology and jobs in the state), public–private partnerships funded a new wing of the North Carolina Museum of Natural Sciences that opened in April 2012. Called the Nature Research Center, it proposed to expand citizen science (ie PES) to diverse stakeholders using four innovative platforms of ISE (Dickinson and Bonney 2012). Drawing upon ecology and especially biodiversity as major drivers (since the museum houses a collection of over three million specimens of organisms endemic to the southeastern US), several ecology-based citizen-science programs were launched with marked success. These programs serve as a case study for integrating real nature and virtual technologies, thereby raising the ecological literacy of museum visitors. Researchers from the Friday Institute for Educational Innovation at North Carolina State University initiated visitor evaluations to track the success of the different platforms of informal learning that include: (1) citizen-science programs in partnership with local scientists (eg the Belly-Button Biodiversity program [Hulcr *et al.* 2012] or the "wild life of our homes" project [www.yourwildlife.org]); (2) virtual theater to connect K–12 students directly to environmental scientists working both in laboratories and in the field; (3) public education labs (called iLabs) that illustrate natural science techniques of "how we know what we know" about ecology and natural sciences; and (4) glass-walled laboratories where scientists work in the public eye and answer questions from onlookers about the scientific process.

Will ISE platforms succeed in bolstering STEM education for students and visitors? With its myriad educational programs for diverse audiences, the California Academy of Sciences (CAS) is proving the success of ISE. Located in San Francisco, CAS's ecoliteracy programs are rooted in science learning, but take the next step to reconnect learners to the natural world and equip them with tools to foster healthy communities through environmental action (eg http://spotlight.macfound.org/featured-stories/entry/elizabeth-babcock). For example, the Academy's Teacher Institute on Science and Sustainability engages 3rd- to 5th-grade teachers in a cohort-based, 2-year training program to incorporate sustainability action in their science teaching. Using simple metaphors that make the science accessible, CAS's ocean action programs (hosted near a 200 000-gallon live coral-reef exhibit on the museum floor) acquaint visitors with the causes and mechanisms of ocean acidification, and its impact on coral reefs. Conservation-oriented stories, as well as action steps designed for individuals and families to reduce carbon emissions, are directly woven into the program's message.

California Academy of Sciences

***Figure 1.** An informal science education (ISE) laboratory at the California Academy of Sciences encourages students and the general public to pose questions to practicing scientists. This interaction also allows visitors to learn how natural history hypotheses are tested by the scientific method.*

In addition, CAS has one of the museum world's first glass-walled laboratories, where visitors can "meet a scientist" and children can interact with diverse scientists as role models (Figure 1). Such innovative attempts to strengthen ISE may ultimately inspire the next generation of ecologists. Moreover, expansion of "virtual-plus-real" natural history educational platforms into other ISE institutions – botanical gardens, zoos, parks, and even school playgrounds (eg www.schoolofants.org) – will foster exciting opportunities to improve ecoliteracy, not just for students but also for their parents, for regional policy makers, and for a diverse public who enjoy destinations that offer ecology education in an informal setting.

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Please see WebReferences

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