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INSIGHTS

Digital rendering
of Rhino to come

POLICY FORUM

SCIENCE EDUCATION

Digital nature: Are field trips a thing of the past?

Expand the reach of science education, but choose tools

By **Douglas J. McCauley**

I awoke in my cabin by the pond. Weighing my options for the day, I decided to do some bird watching, winding between white pines and blackberries along the east shore of the pond. By their songs, I was able to identify a Mourning Dove, Blue Jays, an American Crow, and perhaps a Northern Cardinal. A mink, alarmed by my approach, dove into the pond and swam off. Unable to resist on such a sunny day, I waded into the pond and watched the sunlight play around me in the shallows. My mood that morning was appropriately reflected by my status indicators: moderately inspired, tired, and hungry. My hike took place in *Walden, a Game*, a video game recently launched on the 200th birthday of Henry David Thoreau (*1*). With a widening niche of such nature-themed video games and simulations and a rapidly growing audience of online/digital learners, the capacity to reach new audiences and carry environmental education beyond the confines of schools and universities may be a game changer, but one that perhaps comes with perils.

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Gamers no longer need to confine themselves to stealing cars or building new worlds. Players can SCUBA dive on coral reefs (*Endless Ocean* for Nintendo Wii), indulge in a weekend of virtual bird watching in Spain (*Birding Game* by Swarovski Optik), or do ecological research with their PhD father in the Amazonian rainforest (*EcoQuest 2: Lost Secret of the Rainforest* by Sierra Gamers). Walden isn't even cyberspace's first digital pond. Harvard researchers created a virtual rendition of Black's Nook Pond in Massachusetts, in which players can take photos of pond wildlife and catch bugs in the mud (*2*).

From an ecologist's perspective, this expanding class of opportunities for electronic engagement with nature represents an interesting and positive shift. Wildlife in video games have historically been typecast as agents hell-bent on consuming the gaming protagonist. Lara Croft, the archaeologist in the original *Tomb Raider* (1996), had to shoot and kill a diverse array of biodiversity (from bats to gorillas). The video game *Afrika* (for Sony Playstation 3), released a decade later, requires the gamer to maneuver in to take the perfect photo of a mother elephant lovingly nudging her calf.

IDENTIFY, OBSERVE, EXPERIMENT

But the ambitions of many of these new nature-centric games and simulations are grander than simply breaking down stereotypes about the hostility of wildlife; they're increasingly about identifying species, observing ecological processes, and even experimenting in scientifically accurate ecosystems. *Walden, a Game* includes numerous species recorded by Thoreau at Walden. Interacting with them yields inspiration points needed to sustain play. Interactions with rare species, such as the mink I spotted, provide bonus

ILLUSTRATION: V. ALTOUNIAN/*SCIENCE*

points. Users of the Black's Nook Pond simulation can go even further by measuring the virtual weather, collecting population data, and sampling water chemistry (*2*).

Virtual reality and augmented reality platforms are rapidly adding richness to the genre. This includes offerings marketed as electronic field trips. "Field trips are a great way for teachers to engage students and give them a first-hand understanding of a subject—but they're not always practical," says Google Expeditions, an operation that curates its own brand of electronic field trips (*3*). This logic is hard to argue with. It is likely to be impractical to take a high school science class from Panama City snorkeling on the Great Barrier Reef, or to see the Brazilian Amazon, leopard seals in Antarctica, or redwoods in Big Basin State Park, California, all of which are offerings in the Google Expedition electronic field trip portfolio. Private vendors sell virtual reality hardware to access these experiences—at approximately $9500 USD to equip a class of 30 students (*4*).

As a professor of ecology at a university that emphasizes the value of encouraging students to thoughtfully interact with biodiversity and ecosystems, these new technologies are intriguing. Their penetration makes them even more so. Video game markets serve more than a billion people worldwide, and electronic media are known to profoundly shape civic literacy about science and the environment (*5*). Children in the United States are estimated to spend approximately 7 hours a day in front of electronic media—but only 4 to 7 minutes of unstructured play outdoors (*6*). Stark reports about disconnectedness between young people and nature redouble the imperative to vet new nature learning tools (*7*). A survey, for example, conducted in the United Kingdom by the National Trust reported that one out of three children could identify a magpie, but 9 out of 10 could recognize a Dalek (cyborg aliens from the television program *Dr. Who*) (*8*).

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PHOTO: MINDEN PICTURES/GETTY IMAGES

EVOLUTION OF INTERPRETATION

Evaluating the role of these nature-centric technologies in education requires placing them in historical context. They are perhaps best viewed as the latest stage in the evolution of the quite ancient human toolkit for sharing and teaching about the environment and ecology. Attempts at biodiversity interpretation can be traced back to the earliest human artists who incorporated images of ungulates, felids, ursids, and other species into their rock art. Nature continued to be sequentially reinterpreted by using new media and technologies, from early Roman mosaics, to richly illustrated Middle Age bestiaries, to the dioramas of natural history museums that emerged in the 1800s. Nature interpretation then came further to life with wildlife filmmaking. The bards of nature cinema, such as David Attenborough, made lion kills and flamingo migrations regular occurrences in living rooms across the world.

What, if anything, is different about these emerging forms of nature simulation in this historical sequence? One key difference is that designers of these new technologies are, arguably for the first time in history, moving away from simply interpreting nature toward actually replicating nature. And in some instances they are doing a good job. I involuntarily ducked when a humpback whale swam over my head during a sample virtual reality SCUBA dive I trialed at Google headquarters. I have vivid memories of standing enraptured in front of wildlife dioramas in the Smithsonian's Museum of Natural History as a child—but none of them ever made me duck.

PERILS OF SIMULATION

Pedagogical research has made it clear that there is special value in field-based experiential learning in the sciences (*9*). A UK study of the widespread cancellation of field trips associated with an outbreak of foot-and-mouth disease found that the grades of students lacking field experiences were largely unaffected, but both students and instructors consistently reported that the loss of field experiences created a diminished learning experience (*10*). In Slovakia, it was found that after a 1-day field trip, students positively shifted their attitudes toward biology, the environment, and careers in science while also displaying a better understanding of ecological concepts (*11*).

Can these benefits of field learning be replicated by electronic field trips and simulated laboratories? Research that has explored the general substitutability of nature with standard technological mimics suggests that electronic nature can generate some but not all of the benefits of real nature (*12*). Results from the learning sciences suggest that virtual- and augmented-reality nature experiences may improve on these impacts but still reveal limitations. Immersive experiences have been shown, for instance, to foster interconnections and emotional linkages to nature that can be effective in promoting learning and engagement. In one such simulation, students undertook a "body transfer" with a coral and watched as one of their arms eroded in a virtual acidified ocean and fell to the floor with an audible and palpable thud (*13*).

Tests of augmented-reality field trips (such as a Grand Canyon field trip designed to be run on campus quads or soccer fields) have illustrated that these tools increase student interest in science. However, virtual–field trip participants performed no better than students who received classroom-based lectures, and the experiences were generally less effective than field trips into nature (*14*, *15*). Studies of the impact of the Black's Nook Pond simulation suggested that the students improved their understanding of ecosystem concepts but did not show improvement in ability to recognize nonobvious causes for ecosystem change (*2*).

One class of distinct educational affordances of virtual nature learning is that it can take students to time points in the history and future of the environment that cannot otherwise be experienced. For instance, there is a virtual-reality experience designed to bring the Hell Creek fossil formation alive for students as it was during the Cretaceous (*16*). The retention of concepts learned and experiences derived in virtual field experiences remains an active research area. Perceptions of interconnection to nature derived via virtual reality experiences have been recorded to persist for at least 1 week (*13*), although impacts from real field trips may last at least 1 year (*17*).

Some of the differences measured between real and virtual nature field trips may derive from the fact that learning in live nature typically happens with live humans. Research has very clearly shown that learning with role models and peers can substantially enhance the impact of environmental education (*18*). Such opportunities can be lacking in virtual nature experiences. Other possible side effects of simulated nature learning are worth considering: Hyperinteractive and stimulus-rich digital nature experiences can make real nature experiences feel dull (for example, real-world whales do not allow themselves to be pet on every dive), player-centric nature gaming experiences may propagate the fallacious notion that humans are distinctly different from nature, and synthesized environments can provide dangerously simplistic views of the complex structure and function of nature.

NONBINARY, NON-LUDDITE

Is it far-fetched to assume that teaching ecology and biology in the field could ever be replaced with electronic field trips? Temptations to make these kinds of shifts are real given the high costs, high staffing requirements, and risk-management complexities associated with field learning. Large-scale replacement of field learning perhaps feels less outlandish when one recalls that other formerly irreplaceable elements of pedagogy, such as classrooms and even entire universities, are being avidly replaced with online learning spaces. Similar parallels for digital replacement can be found in the increasingly widespread substitution of animal dissections with virtual dissections.

The future, however, may not be as binary as taking students outside on field trips or running field trips from computer labs. Augmented-reality teaching tools that are more lightly enhanced than the Grand Canyon experience, and as such more similar to the wildly popular *Pokémon Go*, create a hybrid species of technology-enhanced field trips. Technology-infused outdoor nature learning presents many advantages: It can allow students to see and interact with otherwise invisible features in nature, collect and analyze situationally relevant data, and safely undertake hazardous field sampling (such as field tests for pollutants) (*19*). For example, in an augmented-reality follow up to the Black's Nook Pond simulation, students hike around the real pond while a digital park ranger on their smartphones chimes in at trigger stations to offer tips on water sampling and points out virtual carbon atoms floating through photosynthesizing plants (*20*).

Ecologists and environmental scientists are not and cannot be Luddites. If, in our research, we are willing to replace costly and challenging field expeditions by using remote sensing technologies such as satellites to count penguins, drones to study the behavior of Serengeti wildebeest, and acoustic sensors to go wirelessly whale-watching from our offices, we should not thoughtlessly turn our backs on next-generation environmental teaching tools.

PRETTY TOYS, SERIOUS THINGS

How should the environmental education community move forward? We are the first generation of educators for which digital substitution of field learning is a real choice. This capacity for replacement will only increase as emerging immersive technologies become less expensive and more within reach. Recognizing the exciting place in which we now stand in history empowers us to strategically, rather than haphazardly, select technologies that advance environmental learning.

We need to ensure that the pace of tech-facing pedagogical research keeps up with the rapid development of these environmental technologies. It will become increasingly important that environmental educators have high-quality data from rigorous research about which new tools and which functions of those tools promote learning and how those gains compare with those of conventional field education. Environmental researchers and educators must become more actively involved with technology developers and education researchers to constructively shape the evolution of these new technologies.

Last, environmental educators must eschew temptations to simply choose the sexiest, newest, or easiest teaching tools. In an era when gains in environmental literacy are needed more than ever, we must commit to prioritizing the use of whatever methods yield the best learning outcomes. It is no secret that funds for environmental education are limited. We must continue to search for opportunities to make smart investments in new digital learning technologies.

However, we must also be willing to responsibly reject these tools and preserve or extend our investments in increasingly endangered traditional field learning opportunities when they create superior learning opportunities. Google is mostly right: Field learning is not always practical. However, that cannot become the mantra that prevents us from asking hard questions about the structures of our educational institutions that have contributed to making traditional field learning seem increasingly impractical. Possible interventions include reversing declines in the number of field-based natural history courses now required in degree programs, streamlining bureaucratic pathways for permitting and executing field learning, and investing in the human and physical infrastructure required to make field learning tenable. Faculty job advertisements in the environmental sciences seem increasingly likely to seek applicants that can teach students to sequence, simulate, or model nature, but perhaps robustness can be added to pedagogical communities by also actively recruiting educators that don't mind taking students out to stand knee-deep in nature.

Thoreau's own relationship with technology, as revealed in *Walden*, was in its own way complex. His musings on the value of "modern improvements" communicate a cautionary observation with resonance: "[T]here is an illusion about them…. Our inventions are want to be pretty toys, which distract our attention from serious things." ■

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