Building local environmental knowledge in undergraduates with experiential wilderness skills and awareness training: the case of environmental sentinels

Jacob C. Brenner, Jason G. Hamilton, Tim Drake & Jed Jordan

Journal of Environmental Studies and Sciences

ISSN 2190-6483
Volume 3
Number 4

J Environ Stud Sci (2013) 3:404-415
DOI 10.1007/s13412-013-0145-9

Springer

J Environ Stud Sci (2013) 3:404–415
DOI 10.1007/s13412-013-0145-9

Building local environmental knowledge in undergraduates with experiential wilderness skills and awareness training: the case of environmental sentinels

Jacob C. Brenner · Jason G. Hamilton · Tim Drake · Jed Jordan

Published online: 24 July 2013

Abstract Undergraduates in environmental studies and sciences today receive an increasingly global education but often suffer from a lack of knowledge about their local environment. As a result, they often have an unclear sense of their place in the ecosystems they will soon be called on to manage. We developed a course to address these related problems called Environmental Sentinels, which integrates experiential wilderness skills and awareness training with subject matter about local natural history, ecology, and environmental management. We used mixed methods to ascertain the potential in this approach for local environmental knowledge transmission and transformation in students' relationships with their local environment. Pre-and post-tests addressing local ecology, natural hazards, land use, and skills show that this course effectively delivers local environmental knowledge. Mean (n=48) scores increased threefold over the course of the semester. These quantitative results complement more ample qualitative results in a case study conducted from 2008 through 2011 that illustrates the specific activities, assignments, and pedagogical techniques by which the course fosters local environmental knowledge and personal transformation. This study demonstrates great promise in wilderness awareness training for transformative learning in environmental studies and sciences. Nevertheless, this approach faces some key instructional and administrative challenges regarding academic rigor, expertise, resources, and risk that should be addressed in future applications.

Keywords Environmental education · Wilderness survival · Primitive skills · Experiential learning · Transformative learning

"A positive, rigorous, imaginative learning environment ...I would have thought creating a sustained, engaged four-hour learning experience was almost impossible. But I did not once observe students disengaging ...and most seemed genuinely intrigued ...I have little doubt that most 'will never see the world in the same way again.' Many of us promise something like this on our syllabi—this course delivers."

-Independent Peer Teaching Evaluator

Introduction

Environmental problems today are complex (Millennium Ecosystem Assessment 2005), demanding integrated, interdisciplinary solutions (Kates et al. 2001; Vincent and Focht 2011). The upcoming generation charged with addressing these problems must have a sophisticated, global environmental awareness (Schellnhuber 1999; Peet et al. 2011; Wiek et al. 2011). However, while today's undergraduates receive an ever-more global education in environmental studies and sciences, they often lack fundamental knowledge of the local environment in which they live and work (Louv 2008). Moreover, they lack the skills and perspective necessary to build this knowledge. Also labeled traditional environmental knowledge, local environmental knowledge (LEK) is now recognized as critically important by conservation scientists and planners (Faust and Smardon 2001). It is usually considered the domain of indigenous and other laypeople native

J. C. Brenner (✉) · J. G. Hamilton
Department of Environmental Studies and Sciences, Ithaca College, 953 Danby Road, Ithaca, NY 14850, USA
e-mail: jbrenner@ithaca.edu

T. Drake · J. Jordan
Primitive Pursuits, Cornell Cooperative Extension of Tompkins County, 615 Willow Avenue, Ithaca, NY 14850, USA

to a place (Fischer 2000). We welcome the collaborative and community-based environmental management that have arisen from this respect for LEK in laypeople, but we worry about the erosion of LEK among rising environmental experts. This paper discusses our attempt to address this concern. It reports on the development and evaluation of an experiential field course that uses wilderness skills and awareness training to teach local ecology, natural history, and environmental management to undergraduate environmental studies and science majors.

This LEK deficiency among today's undergraduates is not lost on the students themselves. As one junior put it, "As an environmental science major I often learn about the effects of humans on the environment or how the environment affects humans, but I rarely learn about the environment itself." We believe the self-awareness evident in this comment suggests a more widespread problem that could be resolved by making LEK a fundamental component of undergraduate environmental studies and sciences curricula. As a pilot project, we developed an experiential field course called Environmental Sentinels aimed at laying a foundation of LEK for first-year students in the interdisciplinary Department of Environmental Studies and Sciences at Ithaca College in upstate New York, USA. The course is predicated on the definition of a "sentinel" as one who watches over something. An "environmental sentinel," then, is one who watches over the local environment with an elevated awareness that enables the detection, judgment, and management of change. The basic logic we present to our students is that, until they become intimately familiar with the environment in which they live, they can only pretend to manage it. Furthermore, we argue, global environmental knowledge cannot be achieved without LEK serving as a frame of reference and comparison across scales.

Recognizing the limits of conventional classroom-centered pedagogy (Powell 2003) and aiming for integration of multiple disciplinary perspectives, we employed experiential wilderness skills and awareness training (EWSAT), also called wilderness awareness and traditional or ancestral skills, to teach concepts of local ecology, natural history, and environmental management. A case study of the development and implementation of Environmental Sentinels was the research basis for this paper. Our study addressed two questions. First, what is the potential of EWSAT for teaching LEK to undergraduates? This question concerned a straightforward definition of learning as the accumulation of new knowledge and skills. Second, what is the potential of EWSAT for transforming undergraduates in terms of their sense of their place in the local environment? This question concerned a change in individual students' attitudes and posed a challenge for systematic assessment. Transformation has been discussed in depth elsewhere (Taylor and Cranton 2012), including in the context of Environmental Studies and Sciences (Sipos et al. 2008), but here it simply meant changes in how students view their relationship with their environment. We hypothesized that teaching LEK through EWSAT would deliver unique benefits in both learning and transformation.

Background

The outdoor experiences necessary to generate knowledge of the natural environment in which one lives have diminished in recent decades, particularly for young people in the U.S. This "nature deficit disorder" is well documented (Louv 2008). We found very little in the literature, on the other hand, discussing the impacts of nature deficit disorder on the consciousness and behaviors of undergraduates. Indeed, our approach is novel in part because there is minimal recognition of LEK loss as a problem afflicting undergraduates. Perhaps this is because undergraduates are transitory, doing their work in an environment neither where they grew up nor where they will later settle. Strong cases have been made recently for re-cultivating a sense of place and for place-based education in an era of globalization (Gruenewald and Smith 2008). The focus, however, is usually on children and adolescents (Smith 2007; Smith and Sobel 2010), not young adults in college.

While undergraduates come to college with minimal learning experience in nature, the nature of the undergraduate learning experience is changing (Powell 2003). Acknowledging fundamental limitations in conventional instruction, scholars of teaching and learning seek to define and promote powerful (Rowland and DiVasto 2001) and transformative (Wilson and Parrish 2011) learning experiences. Resulting from "an especially meaningful engagement with the world that leaves a lasting impact on a person's sense of themselves and their relationship to a subject matter," these experiences are often facilitated by unconventional teaching methods, particularly field work (Bostock 2005). In part, movements toward powerful and transformative learning are attempts to deliver students an improved educational experience. They are also, however, about fostering personal and social change.

Sustainability in many ways is predicated on social change, and social change is not likely to occur absent some kind of transformation at the individual level (Moore 2005). As such, transformative learning is seen as essential in sustainability education (Sterling 2001). Considering how best to teach sustainability to undergraduates, it has been argued that transformative sustainability education should involve not only intellectual development but also physical and emotional development (Sipos et al. 2008). In other words, the progressive education we seek theoretically takes place in multiple learning domains.

The premises of the Environmental Sentinels course were thus the following: the importance of place, the value of powerful, transformative learning experiences, the utility of integrating multiple learning domains, and their relevance to undergraduate education in environmental studies and sciences. With these things in mind, the course was conceived in 2007 as a partnership between the Ithaca College Environmental Studies program (now the Department of Environmental Studies and Sciences) and the Cornell Cooperative Extension of Tompkins County's Primitive Pursuits program. It was designed as the first required course for the new Environmental Studies and Environmental Science curricula.

Data and methods

Our story is the product of the first four offerings (fall semesters 2008–2011) of Environmental Sentinels. Early on in this period, we anecdotally observed unique student learning benefits, and later, we examined them systematically with a quantitative assessment and a qualitative case study (Table 1).

Novel educational environments such as we created in Environmental Sentinels lend themselves well to case study, in which researchers use a variety of information types to "make sense of" unfamiliar situations (Shrader-Frechette and McCoy 1993). These situations may not be adequately represented by more reductionist social–scientific approaches (Leedy and Ormrod 2009). In this instance, a survey or another quantitative assessment of student learning outcomes could address learning (knowledge) but struggle to characterize transformation (attitudes), obscuring the subjectivity of students' experiences. Unquantifiable details, produced in a personal context, could reveal richness and meaning in transformative learning experiences. Our dual focus on learning and transformation thus required a mixed methodology.

Table 1 Multiple sources of evidence (data, insight, and information) used in the case study

Source	Author/creator	Dates
Participant-observation field notes	Instructor (JB)	2010–2011
Unstructured ad hoc student interviews	Instructors (all)	2010–2011
Course field notes	Students	2008–2011
Course assignments	Students	2008–2011
Course evaluations	Students	2008–2011
Teaching evaluations	Peer faculty	2010–2011
Course development and proposal documents	Instructor (JH)	2007–2008
Institutional curricular and planning documents	Administrators	2004–2011

We collected quantitative data with standard pre- and post-tests administered to the three-section cohort of 48 students on the first and last class meetings of the fall 2011 semester. The instrument was called the "Tourist Test," and while it served for learning assessment, it was originally conceived as a pedagogical device (Young 2001). Asking students, "Can you pass the tourist test?" the exam challenged them to provide basic knowledge that an inhabitant of our local environment would need to survive without modern amenities. The questions covered four themes: local ecology, natural hazards, land management, and skills (Table 2). Revealed as tourists in their own home place, students are usually surprised and challenged to learn from upcoming course work. Our adaptation of the Tourist Test consists of 40 questions; for this study, we selected 15 for analysis.

The quantitative assessment of student learning served as a starting point and complement for a more comprehensive and nuanced portrait of both learning and transformation afforded by the case study. Qualitative insights were derived from engagement by three of us as instructors (JH, TD, and JJ) since the course's conception in 2007, and from participant–observation since 2010 by the fourth (JB), first as an apprentice and later as an instructor. The participant–observer recorded detailed field notes while fully engaged (as a student) with each week's course activities. The instructors then met for 3 h each week outside class to discuss the participant-observation notes and interpret strengths and weaknesses of activities. Other qualitative information came from reviews of students' portfolios at the middle and end of the semester. Portfolios contained field notes from class meetings and field-based homework as well as longer-term assignments. Much of the portfolio material was reflexive journaling, requiring students to evaluate their work throughout the semester. At the end of each semester, we harvested portfolio quotes as evidence of learning and transformation. To corroborate our interpretations, we conducted unstructured interviews with students, asking informally how things were going in the course. As a result of the intimacy and intensive interaction in the course, by semester's end, instructors had a clear understanding of the principal issues—positive and negative—from the students' perspective. Also useful, but far from the student experience, were the vision and planning documents codifying the institution's prioritization and support for experiential, interdisciplinary, and field-based education. All together, these multiple information sources helped us see where the course products (both student work and statements about that work) supported our hypothesis that the integration of EWSAT and LEK

Table 2 Questions from the Tourist Test selected for local environmental knowledge (LEK) assessment

Question	Theme	Supporting activities[a]
Which direction do general weather patterns come from around here?	Local ecology	Daily group routine, homework sitspot routine
Name a plant found locally that will kill you if you eat it.	Natural hazards	Group instruction, homework sketching assignments
Name a delicious, edible plant native to this area with a poisonous look-alike.	Skill	Group instruction, homework sketching assignments
What do foresters consider the major threat to Eastern forests today?	Land use/management	Group instruction, course readings
How can you distinguish tracks of a bobcat from those of a domestic dog?	Skill	Intensive workshops
You see a tree deep in the woods with many low, well-developed branches that are now dead. There is no other tree like it nearby. What conclusion should you make about this tree?	Land use/management	Group instruction, course readings, intensive homework assignments
You notice an old stone wall in the woods. How can you discern what the land on either side of the wall was historically used for?	Land use/management	Course readings, group instruction, intensive workshops
How do you best protect yourself against Lyme disease?	Natural hazards	Homework routine, group instruction
Name two exotic plants taking over the habitats of native plants and animals on South Hill.	Local ecology	Intensive workshops, group instruction
How would you know poison ivy when you are looking at it?	Natural hazards	Homework sketching assignments, field quiz, peer-to-peer instruction
Name two native sources of tinder that can be used to turn a coal into flames.	Skill	Intensive workshops, group instruction
How could an eastern white pine tree help you survive in the forest?	Skill	Group instruction, intensive workshops
What type of bedrock is predominant in this area?	Local ecology	Group instruction
What kinds of rocks are safest to arrange around a fire?	Skill	Group instruction, intensive workshops
Name one edible-nut-producing tree common in this area.	Skill	Intensive homework assignments, group instruction, intensive workshops, peer-to-peer instruction.

[a] Group instruction consisted mostly of field lecturing to the whole class. Intensive workshops varied greatly, but all involved hands-on learning and one-on-one consultation with an instructor. Intensive homework assignments spanned several class periods and were supported by numerous activities during and outside class time. Routines involved weekly activities and reminders during class and homework activities. See the text for discussion of "sitspot routine"

has potential to deliver unique benefits in student learning and transformation.

Results and discussion

Quantitative results: pre- versus post-test scores

As one Environmental Sentinels student claimed, "I don't know even 50% of what I should as a human being, but this class has significantly raised that percentage by providing me …new tools for looking at and interacting with the natural world." First, we investigate the significant percentage increase in knowledge that this student (as one example) thought took place during the Environmental Sentinels course. Later, we examine the tools that enabled students like this one to observe and interact with the natural world in new ways.

All 48 students across three sections of the fall 2011 class took the pre-test, and by conventional academic grading standards, no student passed. The mean pre-test score, measured by the percentage of the 15 questions answered correctly, was 26% (Fig. 1). When scores are disaggregated by topic (Table 2 and Fig. 2), the performance in local ecology, land use and management, and skills areas (19%, 19%, and 20%, respectively) are below the aggregate score. Only questions about natural hazards were answered correctly more than half (53%) of the time.

Post-test scores showed striking improvements, with a mean aggregate score of 76% correctly answered. Similar to the pre-test, the mean score on natural hazards questions in the post-test (83%) was higher than on other types of questions (74% for local ecology, 74% for land use and management, and 75% for skills). Students had greater prior knowledge of natural hazards, so this theme showed the smallest improvement over the semester. Score improvements among local ecology, land use, and skills questions were similar.

We expected to see low scores on the pre-test showing ignorance on the four themes. A separate issue with important implications for our research questions is that of misinformation or misconception. We were curious about the extent and depth of students' misunderstandings about local ecology, natural hazards, land management, and wilderness living skills, i.e., the degree to which students thought they understood something but did not. Furthermore, we wondered what effect the course would have on students' confidence to answer questions related to the four LEK themes.

To help us understand students' misunderstanding, the Tourist Test was administered with explicit parameters: Students had exactly 20 min to complete the 40 questions, and guessing was prohibited. The latter helped us control for effects of the ordering of the questions given a strict and challenging time limit. Considering first the percentage of the 15 selected questions that students attempted, we see a general increase in confidence (Fig. 1, "Answered" column), with students answering more than twice as many questions in

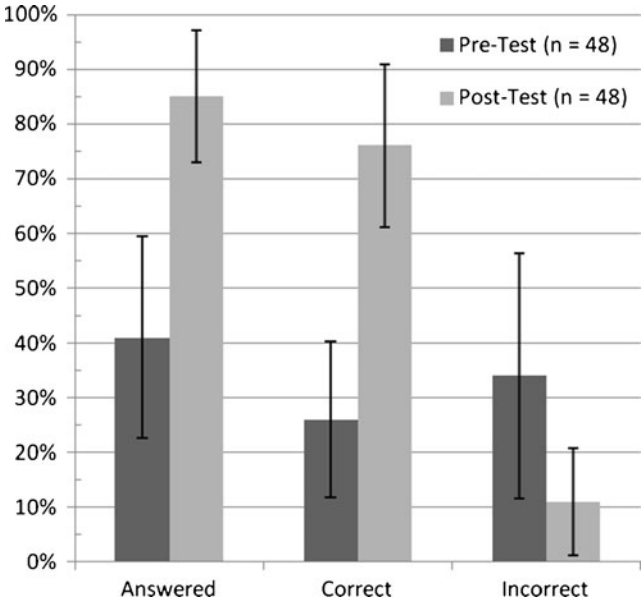

Fig. 1 Results of the Tourist Test, administered in three sections of the Environmental Sentinels course at the beginning and end of the fall 2011 semester. Bars show mean percentages of questions attempted (*left column*), answered correctly (*center column*), and answered incorrectly (*right column*). *Error bars* show +/− one standard deviation from the mean. Correct answers, divided by 15 total answerable questions, represent the overall test score. Incorrect answers were divided by a variable denominator depending on the number of questions attempted, and these calculations were intended to assess incorrect guesswork. Thus, the sum of correct and incorrect answers is not 100%

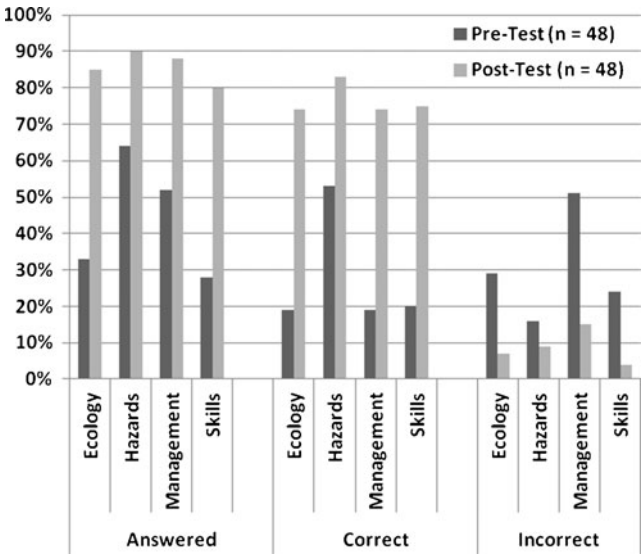

Fig. 2 Results of the Tourist Test, administered in three sections of the Environmental Sentinels course during the fall 2011 semester, disaggregated by theme (see Table 2). As in Fig. 1, *bars* show mean percentages of questions attempted, answered correctly, and answered incorrectly. Calculations of incorrect answers used a variable denominator depending on the number of questions attempted. Thus, correct and incorrect answer calculations do not add up to 100%

the post-test as in the pre-test (85% versus 41%). Meanwhile, the percentage of questions answered incorrectly declined. In other words, increased student confidence in answering questions about LEK after having taken the course was well founded, since students at the end of the course were less frequently wrong on questions they attempted (Fig. 1, "Incorrect" column). Furthermore, over the course of the semester there was an evening across the four themes in both the confidence to answer and the percentage of incorrect answers (Fig. 2, "Answered" and "Incorrect" columns). A similar evening across the four themes was also apparent in the overall test scores (Fig. 2, "Correct" column), suggesting that the course served to balance students' knowledge of the four LEK topics during the semester.

In sum, the quantitative results suggest that over the course of the semester: (a) students' LEK increased threefold, (b) students' LEK became more well rounded, and (c) students' confidence in their own LEK increased. Thus, it appears that the Environmental Sentinels course was highly effective in terms of LEK content delivery. Quantitative data such as these, however, say nothing about the mechanisms underlying student learning, and they can only hint at the course's role in fostering transformation in students' perceived relationships with their local environment. To examine transformation and address our second research question, we analyzed the case study. The following findings illustrate underlying mechanisms of learning and transformation in specific course activities.

Qualitative results: case study findings

Sitting still enables active learning

A fundamental course activity is a field-based homework routine called "sitspotting" that is theorized to elevate environmental awareness (Brown 1986; Young et al. 2010; Young 2012). The "sitspot" is simply a place in nature where one sits alone quietly to observe. We require 10–30-min periods, sometimes several times a week. Students are trained throughout the semester how to tune each of their senses, and during each sitspot session, they are required to record in writing "what I see, what I hear, what I smell, what I feel" as evidence of a full-sensory engagement. Next, they record feelings and reflections on the process. In many respects, sitspotting is the central practice in the course, preparing students' minds for a new type of learning.

Many are put off at first by the sitspot routine, having never sat quietly alone in a natural area. However, these same students are often positively—indeed, the most profoundly—influenced by the process. One student commented, "In the beginning, it was difficult to let everything go and live in the moment … Gradually I mastered this skill more with each visit, and now I can go to my sit-spot and instantly switch into a meditative state." Another explained, "I have spent so much time in this area and learned so much about it …As I journeyed through the area slowly picking apart each aspect of it I began to …even see a story behind the landscape." This student testifies to both content learning and personal transformation. Bits of new knowledge derived from sensory observations usher her beyond superficial description to include interactions and dynamics, an underlying "story" (Young et al. 2010). The metaphor implies integration—the story is one in which the student observer plays a role—and this new awareness of the story and her place in it suggests transformation. Another student reported on transformative learning benefits in more literal terms: "Even though sometimes part of the homework is to sit, I always feel as if I accomplished something that sitting in a classroom would not teach me." Comments like this help to confirm our hypothesis that the learning and transformation delivered by fundamental EWSAT traditions such as sitspotting stand out from what typically accrues in the classroom.

Mapping and navigation awaken a sense of space and place

Given our pedagogical focus on local environments and the practical imperative to know always where one is in wilderness situations (Young and Morgan 2007), we use sketch mapping as another course routine. Throughout the semester, students create sketch maps of resource-rich black walnut trees (*Juglans nigra*), wildlife habitat requirements, or physical evidence of historical land use, and these become important components of larger assignments. For example, after completing Tom Wessels's (1997) *Reading the Forested Landscape*, students are charged with mapping remains they observe to be consistent with a hypothesized land-use history. They plot stone walls, fence wire, feral fruit trees, and other features as evidence of an underlying land-use story explaining how their sitspots came to be.

Students complain about the tedium and challenges of mapping by hand, and the quality of their work varies greatly. The act of mapping is important, however, as maps serve as frameworks for integrating primary observation data with secondary historical interpretation. Students often commented that mapping makes them think "spatially." In an age when the ubiquity of Geographic Information Systems and digital spatial data allow people to make beautiful and compelling maps with minimal actual knowledge of the area in question, the tedium of sketch mapping takes on particular value. Mapping becomes a way of observing, understanding, and interacting with a landscape, in the same way that sketching encourages close attention to, understanding of, and interaction with organisms and other natural features (Gallentine 1968; Lavoie 2005). Mapping thus serves as a powerful tool for teaching concepts important in environmental studies and sciences (Wise and Kon 1990), such as attention to context,

relationships among features and processes, and cross-scale interactions.

Spatial awareness is further reinforced by natural navigation exercises (Gooley 2011). One example is "songlining," a technique borrowed through EWSAT from indigenous cultures all over the world that involves vocalizing landmarks to record a route through unfamiliar terrain (Young et al. 2010). We first discuss generic orientation techniques and send students home to ask elders about their strategies against getting lost. We then introduce songlining at the start of a 4-h night class, just prior to entering a section of unfamiliar forest. Students surrender their electronic devices, divide into small groups, and are instructed that their return to safety depends on their ability to navigate by songlining. A real fear of becoming lost sets in, piquing students' interest in mastering the songlining skill. According to EWSAT theory, "edge experiences" such as this use fear constructively (Mueller et al. 2009: 9; Young et al. 2010) to pave the way for new learning and encourage the development of new neural pathways (Jensen 2008). These are immediately put to work learning—in this case the characteristics and meanings of landmarks. We believe that not only the songlining technique, but also the spatial awareness it fosters, are learned better by virtue of the high stakes involved. Students must take seriously the song as well the landscape features it represents or they risk really getting lost.

Seeking shelter reveals natural hazards and resources

Within the EWSAT community, a well-established framework for prioritizing fundamental wilderness necessities is Shelter, Fire, Water, and Food (Brown 1987). While all four elements are arguably vital, their prioritization depends on the local environment. In the temperate forests of eastern North America, shelter is paramount, given the probability and consequences of extreme weather. Exposure is the greatest hazard in these environments, so we teach shelter-building to encourage students to expand their sphere of awareness of potential hazards upward and downward. The upper and lower strata of the forest (canopy and ground) often go unobserved or discounted, yet they present serious hazards as well as resources for mitigating them.

As with songlining, shelter-building is a challenge. Students have 10 min to build a miniature shelter to protect a valuable item during a sudden storm. Students usually build these preliminary shelters out of hard, heavy materials like wood and stone. These materials effectively protect against falling tree limbs but not against cold air or water. With a 5-gal bucket, instructors soak the students' gloves, wallets, and mobile phones, simultaneously offering feedback on shelter construction. By the end of the exercise, students have not only wet and cold belongings, but also new knowledge of the principles of shelter building, and an inspiration to make improvements. They learn to look upward, to observe cloud types and movements, and to discern wind directions. They learn to look downward for the most valuable resource for shelter against cold air and water: tree leaves. Instead of spending great time and energy building heavy infrastructure, students learn to invest in large piles of fallen dead leaves, which have high insulation value. Students thus see themselves as a part of a forest ecosystem, reliant on its waste products for their survival.

Fire sparks interest in forest products

Fire follows close behind shelter as a priority for wilderness survival. Both maintain vital warmth, enabling acquisition of secondary necessities such as water and food. Fire has symbolic meaning as well. In the history of human–environment relations, the control and management of fire was as a watershed event (Turner and McCandless 2004), in some sense exemplifying society's interaction with nature (Pyne 1997).

We teach students to build and maintain fires as survival skills using two-person friction kits consisting of a hand-hold, a baseboard, a spindle, a piece of cordage, tinder, and kindling (Brown 1987). Students start by building their own kits, in the process facing a practical imperative to learn forest ecology and the recognition of local trees and herbs as resources. For example, coniferous softwoods are optimal for the spindle and baseboard because they disintegrate under friction and repetitive motion, becoming dust that coalesces into an ember. Broadleaf hardwoods such as ash (*Fraxinus spp*.), oak (*Quercus spp*.), and hickory (*Carya spp*.) are better suited for hand-holds, because they are durable. When lubricated with oils from local nutmeats and conifer needles, they transfer friction through the spindle to the baseboard, concentrating heat where the wood is most likely to disintegrate. Once an ember coalesces, students have approximately 2 min to create a nest of tinder for coaxing their ember into flame.

The elation of producing a coal can be quickly spoiled by the harsh realization that tinder and kindling resources are not in sufficient supply or condition to ignite or sustain a fire. A crucial learning opportunity ensues, where students awaken to the critical importance of LEK. Where do tinder-producing plants grow?[1] Which parts will combust when in contact with an ember? In what places and conditions are these plant parts kept dry enough to use? Without knowledge of all these local environmental details, fire is impossible. We run this exercise at least once during the semester in threatening weather conditions such as cold rain or snow to drive home the importance of these facts. Building individual kits assures that students master the underlying knowledge of forest resources and inspires ownership in the learning

[1] Tinder, technically, transforms an ember into a flame; kindling builds a small flame into a larger flame.

process. Students work with these kits throughout the semester, relying on them in several situations, from survival simulations to small-group competitions. In one student's opinion, these fire-building trials were transformative learning experiences: "In our daily lives, we take heat and light for granted since it is always readily available to us. This activity helped me feel closer to nature as I was physically part of the process, more appreciative of heat and light as a resource."

Water purification invokes local geology

Fresh water is abundant in the forests of eastern North America, but potable fresh water is not—nor was it always in the past. We teach students to boil water in a pine-bark bowl using rocks heated in a fire (Brown 1987). The exercise not only adds a practical survival skill to the students' toolkit but also introduces local geology and landforms.

The landscape of the southern Finger Lakes Region of central upstate New York owes its current form to two major glaciations over soft local bedrock during the past few million years. The circumstances and dynamics of these glaciations were extraordinary, and the landforms that resulted—deeply incised linear lakes surrounded by hundreds of tributary gorges—are unique "without parallel elsewhere in all the wide world." (Von Engeln 1961, 2). We believe that students ought not to leave Ithaca College with a degree in Environmental Studies or Environmental Science without a basic understanding of how this peculiar surrounding landscape came to be.

In order to boil water with hot rocks in this environment, students must understand some basic local geology. First, the majority of available rock, Devonian shale, is soft and porous, formed by long processes of sediment deposition on a prehistoric seafloor. This hardened mud contains water and air in its interstitial spaces.[2] It is thus extremely dangerous when heated in a fire. Trapped moisture expands, vaporizes, and fights to escape, producing explosions that send shards of rock in all directions. Notwithstanding the obvious risk involved, these explosions offer terrific teaching opportunities as students are jolted by the importance of correct rock identification. Once again, edge experiences outside the typical undergraduate's comfort zone enable students to learn LEK in new ways.

The second important lesson comes from finding rocks that are safe for boiling. All igneous and most metamorphic rocks are pure crystalline solids, forged by heat and pressure, and free of the pore spaces prevalent in sedimentary rocks like shale. These rocks have no trapped water or air, and they are safe to heat in a fire. They are also, to the trained eye, easy to find, since they are different in shape and color from the ubiquitous shale. While shale is gray or black and sharp and splintery, safe boiling rocks are multi-colored, usually smooth-polished, cobbles. Their strikingly different characteristics beg questions about how these rocks got to where they are. The answer lies in the local glacial history. These igneous rocks, called "erratics," are often river cobbles (sometimes larger boulders) carried far from their place of origin to the Finger Lakes Region by enormous volumes of flowing ice. On careful inspection, they appear obviously out of place, yet they are abundant enough to be available in any given locale with some searching. The story of these erratics and their new shale homeland provides entrée into the complex, multi-chaptered geologic history that underlies the forest in this region and is visible almost everywhere.

Food, community, and transformation

The fourth and least urgent (but nevertheless important) element in wilderness living is food. Wild edible plants are ubiquitous in eastern North American forests (Thayer 2006; Elias and Dykeman 2009), and their uses throughout the history of human occupation here are well documented (Parker 1910; Roza 2003). Nevertheless, most undergraduates are unaware of them. Undergraduates are also unaware of the ecologies associated with wild edibles: where they can be found, during what times of year they can be harvested, with which other species they co-occur, and which other species they sustain.

Students tend to be naturally intrigued with harvesting wild edible plants, and their ability to do so provides immediate gratification and evidence of learning. The preparation and sharing of food from these plants is also important in ways students do not immediately recognize. Preparing and sharing food is a fundamental social experience linking personal emotions to shared notions of community (Sutton 2001). We use these activities to help students become accustomed to their new-found life in the woods with their peers. Although we spend much of the semester ushering students out of their comfort zone into edge experiences, we recognize on the other hand that the kinship we hope students will build with their local environment and each another can be promoted within students' comfort zone. While many of our EWSAT activities forge solidarity—against the elements, the instructors, or other small groups—food preparation and sharing (usually around a fire) inspire community.

This time spent building community and kinship delivers several clear benefits at critical points in the course. First, it gives students the downtime necessary to process new knowledge in the environment where they acquired it. New neural networks get a much needed rest in situ. Second, group reflection time complements individual reflection time spent sitspotting. Circled around food and fire, we introduce

[2] We also point out that this same geologic history produced the natural gas that is currently at the center of worldwide debates about energy sustainability and the environmental risks and benefits of the process known as high-volume slickwater hydraulic fracturing, or "fracking."

storytelling to bridge students' personal experiences at sitspots with group experiences during class. We also point out the ubiquity of oral traditions in indigenous cultures throughout the world and the importance of stories for collective processing and transmission of LEK. Third and finally, we spend this group reflection time discussing the future and how students will apply or share the knowledge gained in the course. Several made good on outreach commitments before the course was even finished, teaching friends and family their new knowledge and skills as part of self-designed homework assigned during breaks. We believe that this coupled routine of self-reflection and group bonding, executed with an eye toward application of new knowledge, is a critical mechanism of self-transformation that makes the course an extraordinary learning experience.

Integration through everyday activities

A primary programmatic objective in the Ithaca College Department of Environmental Studies and Sciences is mastery of integrative approaches to human–environment interactions. We therefore create focused activities throughout the Environmental Sentinels course to integrate themes and concepts, skills, and multiple learning domains. One good example among many is a semester-long engagement with black walnut trees (*J. nigra*).

Black walnut is a conspicuous native tree, identifiable by the trained eye through different types of observations made at different scales. Close up, the bark has distinctive texture, the leaves show distinctive morphology, and the ubiquitous fruits have distinctive qualities (e.g., a good size and shape for throwing, a pungent stench, a hand-staining resin). At a moderate distance (~10–100 m), the tree exhibits a unique growth habit, distinguishable from neighboring trees with or without its leaves. At a greater distance (~100–500+m), the tree's phenology (as an early senescer) reveals its tendency to occur in clusters, which in turn indicates underlying environmental patchiness that would otherwise be invisible. Thus, black walnuts serve as an entry point for "reading" the landscape through its trees. We use black walnuts also as the starting point for a semester-long leaf collection project.

Black walnut trees serve in a more specific way to teach LEK through hands-on skills. Early in the semester, we require students to collect ~1 kg of fruits. They must learn these fruits' physical properties, timing, and pattern of distribution. Next, students sketch a map of where black walnut trees occur. They then share maps and hypothesize where other trees might be found. The hunt then continues in the field with guidance based on collectively identified environmental conditions favoring black walnut growth and productivity. By midway through the semester, each student has a working knowledge of black walnut trees and their habitats, and the group has about 50 kg of fruits. The project culminates when students stomp the walnut fruits, extract the brown syrup, and use it to dye their clothing.

Thus, a semester-long, everyday engagement with black walnut trees integrates naturalist observation with tree identification skills, mapping, and traditional knowledge of forest resources. The importance of LEK becomes apparent to students through their many interactions with these trees, and the dyed clothing that students wear throughout the semester serves as a durable reminder.

Integration through survival

A different opportunity for integration of skills and concepts is an end-of-semester survival challenge conducted in a forest parcel 10 km from campus. In a sense, the whole course is about wilderness living, but the authenticity and gravity of the survival challenge make this the consummate experience. By the end of the fall semester, cold and snowy weather conditions make shelter urgent. Fire building, requiring gross physical strength as well as fine motor coordination, becomes difficult. Working with stream water becomes dangerous. Wild food is sparse and especially rewarding.

We as instructors stay out of the operations; our work by this time is done. Students break themselves into two groups and choose a base camp, considering its location relative to prominent landscape features such as a steep hill, a partially eroded logging road, and two small streams. A thicket of grape vines potentially provides tinder, kindling, fiber, and food. Within 2 h, each group builds a shelter for at least two members and starts a fire for purifying water. With the fire built, the groups are allowed access to a supplementary food bag, and the shelters undergo the 5-gal water dump. Whereas in the beginning of the semester the students protected a valuable item in their mini-shelters, at the end, their own bodies are at stake. Rescue is only 15 min away, but the remote, unfamiliar setting of the survival challenge inspires students to take the exercise very seriously. They could spend much of the 4-h period in extreme discomfort.

Remarkable group dynamics emerge that we suspect would not be possible had the students not collectively experienced the challenges of the course up to that point. The students by this time are firmly bonded over a unique suite of knowledge, skills, and transformative learning experiences, and those bonds are durable. Years later, as students move through the program, they comment on this course and activities such as the survival challenge. These students speak a common language, which the rest of the student body (and most of society at large) does not. Perhaps the successful completion of the survival challenge is the best proof of the learning and transformation that take place in this course. In this activity, new knowledge, skills, and a sense of place in the natural world are integrated and put to work.

Learning and transformation in summary

The questions guiding this research concerned the potential of EWSAT for building LEK and ushering undergraduates toward personal transformation in their sense of place in nature. Our quantitative and qualitative results corroborate each other, confirming that EWSAT is a highly effective means for developing LEK in undergraduate environmental studies and science majors. New practical skills and their conceptual underpinnings are learned through activities structured around securing the four essential elements of wilderness living. This case suggests further that LEK can be generated through hands-on, experiential learning in the field, particularly through activities that induce edge experiences where undergraduates find themselves in unfamiliar terrain, facing danger, and reliant on the application of new knowledge and skills. Transformation occurs during these edge experiences, when students are challenged to adapt to novel situations and their passage becomes synonymous with academic success. Learning and personal transformation are thus intertwined, producing one another in dynamic fashion. Indeed, had we not recognized some analytical value in addressing LEK learning and transformation separately with mixed methodologies, we might have presented them as two faces of the same research question.

In our search for clarity and resolution of these twin questions about LEK learning and personal transformation, we found student statements about the Environmental Sentinels experience very illustrative. For example, one student claimed, "I can walk through the woods now and name most of what I see." He achieved a personal connection to the forest through his new knowledge of it. Another commented on having incorporated her knowledge in a daily routine: "I couldn't stop looking at leaves wherever I went. Whether I was walking, driving, or hiking, I was trying to identify trees. I realized that there was so much going on around me." It is one thing to make the realization that there is a lot going on in the local environment, and another to recognize one's place in it. One student said, "I learned so much in this class, not just about the world around me, but also about myself and how I fit into this bigger picture." Several reported growing acquaintance or kinship with nature, saying, for example, "I feel like less of a stranger in the forest the more I learn," and "I felt vulnerable and afraid when I ventured into the woods . . . but now I take comfort in my heightened awareness." It thus appears that in cultivating LEK, EWSAT helped students see their local environment and their place in it in new and valuable ways.

These pedagogical benefits were at least matched—if not exceeded—by the practical benefits. In one student's words, "I have skills and tools that I can list and display as proof that I learned." Students apparently appreciate acquiring skills applicable outside academia. For example, one student attested that "I have learned lessons that can be used and can bring greater understanding through any experience of my life." Another explained, "These skills will not only help me survive, but to be aware of my surroundings throughout my life. These skills are not only applicable in the outdoors, but in my daily life as well, helping me become a better student, leader, and person in general." Many of the EWSAT skills taught in Environmental Sentinels are generic and widely applicable, with the best example being multisensory observation. But even the skills most specific to wilderness living, such as water purification or fire-building, find analog or application in other contexts.

The broad applicability of the LEK and skills acquired in this course has special value for the students. As one commented, "The activities and assignments in this class provided opportunities for hands on learning, and …forced us to use our knowledge in a way that makes it more than just inert knowledge." With a healthy disrespect for "inert knowledge," we as instructors set out to build this course on a foundation of practical utility and hands-on experience. Students are promised by our department that experiential learning, or "learning by doing" will be a key part of their program, and one striking pattern in the student responses to this course was an appreciation for its experiential nature. As one student put it, "I retained this knowledge better than I have in any other class because it was so hands-on and that's how I learn best."

Conclusions

Becoming environmental sentinels

At the end of the spring 2012 semester, Ithaca College graduated its first cohort of environmental sentinels—students who as freshmen had taken the first offering of the course in fall 2008. An independent survey unrelated to this study was administered to this cohort seeking comments on the overall experience in the department. One fourth of the respondents reported Environmental Sentinels as the best experience during their 4-year career. Of course, results such as these must be interpreted with caution. Nevertheless, they speak to the power of this type of learning to leave a lasting impression.

The student response to Environmental Sentinels in course evaluations has been overwhelmingly positive, an observation that led us in 2010 to systematically investigate specific benefits and the mechanisms by which they accrue. The results of our case study illustrate that EWSAT shows great potential to teach LEK to undergraduates and furthermore that students are transformed to feel a greater degree of familiarity, comfort, and kinship with their local environment. The idea behind the course was (and our hope continues today) that the combination of learning and transformation involved in becoming

environmental sentinels translates into future environmental stewardship.

Challenges ahead

Serious challenges attend this type of instruction, however (Moore 2005; Vincent and Focht 2011), which fall into two general categories: instructional and administrative. The future of Environmental Sentinels at Ithaca College, not to mention the applicability of the model outside this context, depends on surmounting both types of challenges.

The instructional challenges we encountered involve balancing dual objectives of content learning and personal transformation. We have observed, for instance, a tendency for students to feel less accountable for experiential field work than for conventional classroom work. We have dealt with this by crafting explicit, rigorous learning objectives and strict course participation protocols. Everything the students do is graded, including weekly homework in field notebooks and weekly participation in the outdoor classrooms. Evaluating participation, particularly in skill-building events, ramps up the investment in experiential learning, and encourages students to take ownership. Intensive participation grading, however, also presents challenges for students and instructors. Many students complain that the workload in this course is disproportionately large for an entry-level course. Meanwhile, instructors take on a significant grading burden. Standardizing the structure and organization of the field notebook and portfolio has helped us redress these secondary problems, as it greatly facilitates evaluation and only minimally restricts creativity.

Following the rigor issue, the most pressing instructional challenge is expertise. Wilderness awareness skills are difficult to master, and they fall outside the typical environmental professional's training. Learning this particular new content and teaching approach requires large investments of personal time and energy (see the exemplary body of work by Tom Brown, Jr., as well as Young et al. 2010). Three of our instructors (TD, JJ, and JH) spent several years of formal training and informal practice prior to launching this course. The partnership between Primitive Pursuits and Ithaca College has thus far been mutually beneficial, and we suggest that academic institutions interested in implementing this teaching model consider partnering as Ithaca College did with practitioners outside of academia.

Administratively, a course like Environmental Sentinels requires large investments of institutional resources, some of which many colleges simply cannot provide. For example, the four-person instructional team deployed at all times with sections of 18 students is costly from a departmental staffing perspective. A related resource issue is land. Environmental Sentinels makes extensive use of the Ithaca College Natural Lands, a 227-ha system of four protected areas located on and off campus (see http://www.ithaca.edu/naturallands/). While a large land estate is not a prerequisite for place-based, experiential learning (Smith and Sobel 2010), in this case, the Natural Lands served us every day, and they significantly broadened our opportunities for transformative learning experiences. Indeed, we are currently making a case to the administration for even greater protection of its undeveloped open spaces, based principally on their value to Environmental Sentinels and other courses that involve experiential field learning.

Another important, but manageable, issue is risk. Fire-building, night-time wandering in the forest, cooking with hot rocks, wood carving, and eating wild plants that students at first know nothing about can raise red flags with risk management officers. Our approach to resolving the risk issue has been one of common sense and respectful dialog. For example, on the issue of fire, we demonstrated that we deal with fires safely (under control, never unattended, extinguishers nearby). An additional benefit from the risk management perspective is the opportunity to teach students in their first semester about fire rules, responsibilities, and safety principles. Clandestine fires do occur on the Natural Lands, but we attempt to diminish their frequency by taking advantage of this teachable moment. Thus far, our approach has worked. At present, we are not restricted in any significant way from doing what we need to do in the course because of the risks involved.

Thus, while there are considerable challenges and issues raised by a field course based on wilderness living within a conventional environmental studies and sciences department, the potential for transformative learning in this model is great and worth pursuing. Future work by practitioners and researchers alike should grapple with the issues of rigor, expertise, resources, and risk. Seriously engaging these issues could turn this unusual approach to undergraduate education into something that can be implemented at many colleges and universities.

Acknowledgments Our work is supported in numerous ways by Ithaca College, its School of Humanities and Sciences, its Department of Environmental Studies and Sciences, the Cornell Cooperative Extension of Tompkins County, and Primitive Pursuits. It was also funded in part by a grant from the HSBC in the Community (USA) Inc. Foundation to the Ithaca College Department of Environmental Studies and Sciences. Special thanks go to Dean Leslie Lewis and Professor Susan Allen-Gil for administrative vision and support. We owe much, of course, to our students, who provide faith, patience, critical insight, creativity, and general good cheer on a day-to-day basis.

References

Bostock S (2005) Powerful learning environments. Brit J Educ Tech 36:347–348

Brown T. (1986) Tom Brown's field guide to nature observation and tracking. Berkeley Trade, New York, NY

Brown T. (1987) Tom Brown's field guide to wilderness survival. Berkeley Trade, New York, NY

Elias TS, Dykeman PA. (2009) Edible wild plants: a North American field guide to over 200 natural foods. Sterling Publishing Company, Inc, New York, NY

Faust B, Smardon R (2001) Introduction and overview: environmental knowledge, rights, and ethics: co-managing with communities. Environ Sci & Pol 4:147–151

Fischer F. (2000) Citizens, experts, and the environment: the politics of local knowledge. Duke University Press, Durham, NC

Gallentine JL (1968) Biological drawing: opinion vs. research. Am Biol Teach 30:110–113

Gooley T. (2011) The natural navigator: a watchful explorer's guide to a nearly forgotten skill. The Experiment, New York, NY

Gruenewald DA, Smith GA (2008) Place-based education in the global age: local diversity. Lawrence Erlbaum Associates, New York

Jensen E (2008) Brain-based learning: the new paradigm of teaching. Corwin, Thousand Oaks, CA

Kates RW, Clark WC, Corell R, Hall JM, Jaeger CC, Lowe I, McCarthy JJ, Schellenhuber HJ, Bolin B, Dickson NM et al (2001) Sustainability science. Science 292:641–642

Lavoie C (2005) Sketching the landscape: exploring a sense of place. Landsc J 24:13–31

Leedy PD, Ormrod JE. (2009) Practical research: planning and design (with MyEducationLab). 9th ed. Prentice Hall, Upper Saddle River, NJ

Louv R. (2008) Last child in the woods: saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill, NC

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: synthesis. World Resources Institute, Washington, DC

Moore J (2005) Is higher education ready for transformative learning? A question explored in the study of sustainability. J Transform Educ 3:76–91

Mueller M, Bardy H, Bannister B, Drake T, Hall D, Jordan J (2009) Not your typical classroom: an introductory guide to primitive pursuits. Cornell Cooperative Extension-Tompkins County, Ithaca, NY

Parker AC. (1910) Iroquois uses of maize and other food plants. University of the State of New York, New York, NY

Peet R, Robbins P, Watts M (eds) (2011) Global political ecology. Taylor & Francis, New York

Powell K (2003) Science education: spare me the lecture. Nature 425:234–236

Pyne, SJ. (1997) World fire: the culture of fire on earth. University of Washington Press, Seattle

Rowland G, DiVasto T (2001) Instructional design and powerful learning. Perform Improv Q 14:7–36

Roza G. (2003) The Iroquois of New York. The Rosen Publishing Group, New York, NY

Schellnhuber HJ (1999) "Earth system" analysis and the second Copernican revolution. Nature 402:C19–C23

Shrader-Frechette KS, McCoy ED (1993) Method in ecology: strategies for conservation. Cambridge University Press, Cambridge and New York

Sipos Y, Battisti B, Grimm K (2008) Achieving transformative sustainability learning: engaging head, hands and heart. Int J Sust High Educ 9:68–86

Smith GA (2007) Place–based education: breaking through the constraining regularities of public school. Environ Educ Res 13:189–207

Smith GA, Sobel D. (2010) Place- and community-based education in schools. Taylor & Francis, New York, NY

Sterling S. (2001) Sustainable education: re-visioning learning and change. Schumacher Briefings. Schumacher UK, CREATE Environment Centre, Seaton Road, Bristol, BS1 6XN, England Available from: http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED464791

Sutton DE. (2001) Remembrance of repasts: an anthropology of food and memory. Berg, Oxford, NY

Taylor EW, Cranton P. (2012) The handbook of transformative learning: theory, research, and practice. John Wiley and Sons, San Francisco, CA

Thayer S. (2006) The forager's harvest: a guide to identifying, harvesting, and preparing edible wild plants. Forager's Harvest Press, Birchwood, WI

Turner BL II, McCandless SR (2004) How humankind came to rival nature a brief history of the human–environment condition and the lessons learned." pp 227–243 in Earth System Analysis for Sustainability. MIT Press, Cambridge, MA

Vincent S, Focht W (2011) Interdisciplinary environmental education: elements of field identity and curriculum design. J Environ Stud Sci 1:14–35

Von Engeln, OD (1961) The finger lakes region: it's origin and nature. Cornell University Press, Ithaca, NY

Wiek A, Withycombe L, Redman C, Mills SB (2011) Moving forward on competence in sustainability research and problem solving. Environment 53:3–13

Wilson BG, Parrish PE (2011) Transformative learning experience: aim higher, gain more. Educ Tech 51:10–15

Wise N, Kon JH (1990) Assessing geographic knowledge with sketch maps. J Geog 89:123–129

Young J. (2001) Exploring natural mystery: Kamana One. OWLink Media, Shelton, WA

Young J. (2012) What the robin knows: how birds reveal the secrets of the natural world. Houghton Mifflin Harcourt, New York, NY

Young J, Morgan T. (2007) Animal tracking basics. Stackpole Books, Mechanicsburg, PN

Young J, McGown E, Haas E. (2010) Coyote's guide to connecting with nature, 2nd ed. OWLink Media, Shelton, WA