Cultivation of Local Botanical Knowledge or Knowledge of Nature Using Interdisciplinary, Innovative and Mind/Brain-Based Techniques.

CHAPTER · APRIL 2014

DOI: 10.1007/978-1-4939-0422-8_7

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Chapter 7
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7.1 Introduction

Botanists and their respective professional societies have lamented the seemingly concomitant loss of interest in and support for botany at least since the early 1990s (Drea 2011; McClatchey et al. 1999; Uno 2009). As a subset of ecological knowledge and similar to it, botanical knowledge is also in decline (Coyle 2005). The lack of botanical knowledge (Wagner 2008; Cooper 2008) and particularly local knowledge of nature sets up a disconnection between people and place and, therefore, may mean the loss of an important survival tool for the future of humanity.

Though we do not always realize this, all humans ultimately depend on natural materials to live. Residents in the USA are largely non-resource dependent. They often rely on natural materials grown, harvested, managed, and manufactured sometimes great distances away from the point of use. This lack of direct experience with materials contributes to the lack of local knowledge. Even if the larger populace could name plants, other organisms, or ecosystems from which the products they use every day are derived, they still would not have the nuanced, in-depth, tacit knowledge associated with daily direct experience with nature in one's own environment. This type of tacit knowledge is often unwritten and undervalued, though it represents the adaptive, dynamic relationships we have with nature and, thus, our coevolution with the systems in which we are embedded (Alexaides 1999; Berkes et al. 2000; Pilgrim et al. 2007; Scoones and Thompson 1994; Scoones et al. 1992). Resource-dependent communities within and outside the USA are supplying our demand for natural materials; as a result, people may believe that knowledge of nature is not necessary. However, as the growth of urban centers continues, cognitive issues associated with reduced contact with nature also arise, owing to what has

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C. L. Quave (ed.), *Innovative Strategies for Teaching in the Plant Sciences*,
DOI 10.1007/978-1-4939-0422-8_7,

been termed “extinction of experience,” as described by Nabhan and St. Antoine in 1993 and generally popularized as “nature deficit disorder” by Louv in 2005. As experience in nature declines or is no longer present, questions and interest in the local environment disappear and, therefore, our ability to share, adapt, and advance knowledge of our situated place becomes severely limited. Though more specific studies are needed (Atran et al. 2004), there are indications that a lack of knowledge of nature correlates with unsustainable practices that could directly impact survival.

7.1.1 Connectivity and Environmental Education

Environmental education (EE) situated outside of an individual’s community may not provide the kind of opportunities for connections to previous knowledge that researchers know are necessary for learning to occur in meaningful, lasting ways. As an example, escalating deforestation in the Amazon, beginning in the late 1970s, led to the development of massive amounts of EE content to help students and adults understand and connect using charismatic megafauna among others in tropical forests around the world. As classrooms focused on forests that experienced such devastation, far-removed children were left with a feeling of despair upon realizing they could do little about this distant problem. Since most had never or likely would never see a rainforest in their lifetime, the despair led to an increased sense of disconnectedness.

A populace disconnected especially from the local natural world of which it is a part may not understand the importance of ecoliteracy for health, resiliency, food security, biodiversity, water/air/soil quality, cultural/personal enrichment, policy, and more. Many researchers lament the challenges associated with continued development and environmental degradation (Rickinson 2001; Pilgrim et al. 2007; Atran et al. 2004). One group of people with the potential to help us understand the challenges are natural resource managers. Because they are dependent on resources, their (assumed) ecological literacy can help protect the resource, though, of course, not all practices are sustainable. The management decisions they make, varied as they are over time and place, positively affect natural systems. Taken as a whole, these practices may be more resilient than a singular reliance on state systems that are devised to protect ecological health (Pilgrim et al. 2007). Local knowledge of landscapes allows for a much more rapid response to sudden perturbations or small changes in the environment as compared to state systems that are better at detecting large-scale shifts. Since state systems also tend to ignore or devalue local knowledge, they neglect this important tool in conservation. Thus, to increase the number of ecologically literate people, even those who are not managing resources, is to also increase our resilience to a level greater than that which is possible through reliance on state systems alone.

However, creating an environmentally literate populace is no small challenge. Coyle (2005) discusses the difficulty in achieving true environmental literacy in students of all levels, stating that after three decades of school-based environmental education, only one-third of adults can pass a basic test of EE. After 35 years of effort in promoting widespread environmental curricula and acknowledging its importance, EE has yet to achieve core subject status (Coyle 2005; Rickinson 2001). Additionally, long-term studies of pro-environmental behavior and/or awareness are virtually nonexistent (Rickinson 2001).

Part of the issue of efficacy (Coyle 2005) in EE may be related to the kinds of knowledge imparted. EE content often focuses on big-picture knowledge of the environment in an effort to change behaviors related to pollution, energy usage, and consumerism. While behavioral change in these issues is desirable, focusing on them alone may not provide enough local and social relevancies to stick. Uzzel et al. (1995) found that students in a 1-week residential program could not bridge the gap between the scientific and familiar understanding of the environment, including the social worlds of which they are a part.

They further had difficulty connecting to problems in the environment, even though they may have directly participated in measuring some symptom of the problem. Rickinson (2001) argues that such an approach does not connect the problem to society (the creators of the issue) nor does it offer an opportunity for challenging societal norms or changing values.

7.1.2 The Role of Traditional Ecological Knowledge in Environmental Education

Studies of natural resource managers and holders of traditional ecological knowledge (TEK) can provide clues in understanding how such knowledge is structured and functions in an adaptive and resilient capacity. Vadala et al. (2007) studied natural resource-related adult professionals and hobbyists in order to ascertain how they became socialized to the environment. They and others point to the importance of guided or unguided play (Caine and Caine 2008; Pert 1997) in creating environmentally literate adults (Vadala et al. 2007). Louise Chawla (1992, 1998, 2001) and her colleagues have studied significant life experiences (SLEs) of modern-day environmental educators and environmental activists for over two decades. These contemporary decision makers (natural resource related adult professionals) and social activists from both studies have SLEs in common. Typically, SLEs were made of multiple outdoor activities taking place over a long period of time.

After analysis of TEK holders largely outside the USA, Berkes (1999) states that TEK is a "knowledge–practice–belief complex" that is "handed down through generations by cultural transmission," evolving and therefore adaptive. However, if students in EE programs cannot spend enough time outdoors in the same environments repeatedly, how can they understand the subtle changes over time in their own place? If they cannot create this basic connection, how can we expect them to understand greater complexity in these nested natural and human systems? One suggestion taken from work by Berkes et al. (2000) proposes a framework used by TEK holders, later partially analyzed by Pilgrim et al. (2007). After analysis of multiple cultural groups, Berkes proposes that TEK holders analyze ecosystems based on the following social and ecological parameters:

1. Local knowledge of land, animals
2. Land and resource management systems
3. Social institutions
4. Worldview

Each of these four nested dimensions of knowledge is utilized to manage resources needed by the human community over time and space, conveying the "embeddedness of local knowledge" (Berkes 1999) that comprises TEK. These dimensions require knowledge, reflection, critical thinking, and if considered as nonlinear processes, are adaptable and situated to place (both cultural and natural). Inasmuch as these parameters represent a path to intimate connection to place, we propose that they may be used as a scaffolding to include these broad-based recommendations for EE content:

1. **Create experiences in nature.** Although one of the least researched areas of EE (Rickinson 2001), experiences help create opportunities to build the nuanced, in-depth, tacit knowledge associated with ecologically literate people. It is through these experiences (Dewey 1938) within our sociocultural communities (Vygotsky 1978) that we gain and construct new knowledge. These experiences must be sociocultural in nature for optimum learning to occur (Caine and Caine 1997; Rickinson 2001; Vygotsky 1978). A subset of this is creating process skills. Particularly in botany, this is an excellent way for students to think critically while creating something made from natural materials.
2. **Name organisms only after exploration.** Though naming alone is not enough, it is a critical step in layering further information to help encode information in the brain, thereby increasing the chances of its persistence. Naming should be done outside and, as often as possible, with live organisms. When teaching naming, it is not enough to mention the key characteristics of the organism as a means of identification. Connect the organism to place with as much ecological and cultural information as possible (to what other organisms does this one relate, what organisms depend on this one, what relationship do humans have with this organism, etc.). It is for this reason that exploration of the phenomena prior to naming is essential. The student must have the opportunity to connect and provide a base within the brain to add new terminology (Caine and Caine 1991, 1997).
3. **Create a local connection** (Louv 2006; Nabhan and St. Antoine 1993; Nabhan 1995; Sobel 2004). We must provide students of the natural environment the opportunity to interact with their natural environment over time. Isolated experiences are not enough. Students of all ages must have the opportunity to see how their environment changes over time and in response to specific actions. This involves the repeated observation of a local environment over time as well as those activities that support the crucial "patterning" that is a critical part of all learning (Caine and Caine 1994, 1997).

4. **Connect content to culture**. Worldviews frame the philosophical underpinnings of relationships with nature, and actions upon the landscape are reflective of it. Start students learning about the cultures who have impacted an area—both historical and contemporary. Look for evidence of their impact on the landscape through uses of plants and other biota. Find evidence of culture in place names, in material goods in flea markets, grocery stores, and roadside stands. Openly discuss cultural assumptions about practices and beliefs about nature and impacts upon human inclusive nature.

McClatchey et al. (2013) additionally argue for core concepts of awareness, change, integration of knowledge and methods, information flow, exchange and storage, and systems to be included in curricula throughout the K–16 pipeline as appropriate. They additionally provide examples of learning outcomes and assessments that teachers on this path will find useful.

7.2 Case Studies

7.2.1 K–12 Example: Experiential Field School

Despite the evidence that botanical education is notably absent in most of our K–12 classrooms, there is evidence that this need not be so in this example. Teachers and administrators can be educated about the importance of botanical education in our schools, and in turn provide advocacy to bring it back into the curriculum. But this education need not and *should* not take the traditional route where teachers are lectured to and given directives about what to teach when and how to teach it. If teachers are treated like professionals, and given experiences from which they can make their own meaning, they can and will expand their teaching horizons. It is through these experiences that humans learn. This is a fundamental part of the Mind, Brain, and Education movement (Tokuhama-Espinosa 2010). Consider the following example in which mentor teachers became students of botany and EE, through their experiences in a project-based field school environment:

> This past Spring, 25 middle and high school students were welcomed to the campus of a botanical research organization blessedly housed in a brand new LEED platinum building in an urban area of Texas. Students were chosen from local schools with exceptionally high needs. Our goal was to bring in students and expose them to botanical and environmental issues, encouraging teamwork, communication, data analysis, and interpretation—all while in an immersive outdoor setting. These students did not come alone, they brought with them teachers from their school. These teachers were selected from the schools to serve as mentor teachers throughout the field school experience. We expected to see dramatic changes in the students, in fact this was our goal. We did not expect to see dramatic changes in the teachers, but were thrilled when we did.
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> Throughout the field experiences, each participating teacher grew and changed in his or her own way. Some were more cautious than others about these teaching techniques they were observing and the environments in which they were being taught. At first, they were

> concerned that students were not being "given clear instructions" before an activity as opposed to being allowed to simply experience the environment and discover the necessary skills. But as time passed, so did their concerns. In fact, they began to ask questions about the ways in which we were exposing students to natural phenomena. They commented that they wanted to teach more like this but need guidance… from us. They now had a reason to learn, a reason to want to make deeper connections. Their minds were engaged and learning could now take place.
>
> One particular school that had a new vision for what education could look like on their campus and asked, "Why can't we become a center for environmental and botanical education?"… and so a relationship began based on mutual desires to bring students to a greater understanding of their natural world. These teachers now had a reason to want to learn. Through a grassroots effort, the administration eventually approached our institute with a request for us to guide them through the process of becoming an academy for environmental and botanical science. We gratefully accepted the challenge.
>
> We then began a process of collaborative work on the curriculum. The school receives a standard curriculum for the district but we had the opportunity to work within the curriculum to find appropriate places to introduce plant science and outdoor education. In the end, we found that the best way to include botanical science is through student exploration of systems and the places of humans, plants, and other biota within these systems. Through interviews and focus groups with these teachers, we learned it was the quality and types of experiences they had that truly made the difference.

7.2.2 Undergraduate Example: The Cherokee Worldview Garden as a Place for Biocultural Embeddedness

"Sense of Place" has been called various names by differing disciplines and authors such as topophilia, place attachment, community sentiment, setting, and others (Cross 2001). However, it is most often left out of discussions in the science classroom, despite the fact that outdoor lab activities happen in "place." Building this sense of place into curricula can begin to help students recognize that the "place" where they are located has been through myriad temporal and spatial changes layered with culturally bound human interactions.

The Cherokee Worldview Garden was a 10-year project initiated by the first author, involving students, faculty, community members, Cherokee people, and garden staff in an exploration of the meaning of place to another culture. The garden is located in the South Carolina Botanical Garden on the campus of Clemson University, on land that once belonged to Cherokee people.

> Frustrated with the lack of accurate and respectful interpretive material about Cherokee culture in the Upstate region of South Carolina, I began a multi-year project focused on connecting students, faculty, and community members to the culture that came before—through the development of a garden. Though most Cherokee people were driven out of this region in the mid- to late 1700s, reminders of their influence in both cultural and natural systems abound. Rather than a primary focus on plants used for a particular purpose, the intent was to demonstrate worldview of Cherokee people within the context of design of the garden. Making worldview explicit in design provides a substrate for understanding that: (1) There is such a thing as worldview and this may be different, culture to culture and

person to person; (2) Worldview impacts how we act upon the landscape; (3) Some actions may be more resilient than others; and (4) Worldview is malleable and, therefore, new ways of relating to the environment are possible.

In addition to many other "situated" projects around the garden, small groups of students enrolled in my (Hall) "Creative Inquiry" classes and developed Digital Stories in collaboration with Cherokee people. The classes created these stories to provide interpretive videos that extended the value of the garden to a virtual world. Elders and cultural experts from the tribe agreed to be interviewed by students interested in particular topics such as medicine, weaponry, basketry, and food. After weeks of preparation on uses of technology, techniques (including human subjects training), specific cultural knowledge, and cultural sensitivity, students developed a more detailed topic around the broad topics and identified a person of interest to be interviewed. Students conducted interviews during a couple of weekend sessions with the whole class—each group helping the other along the way. Artifacts were collected to support stories. These included typical plant photos, end products made from plants (blowguns, etc.), and basic habitat photos. Tribal participants were interviewed and filmed.

Perhaps the most meaningful learning for these science students took place during the interview sessions followed by analysis of these interviews. In one case, students interviewed an important tribal elder whose reputation as a spiritual leader was well known. However, this individual challenged their culturally bound notions of power, expertise, spirituality, and even leadership. Despite preparation regarding cultural differences, this individual, so giving of his time and knowledge, provided them an opportunity to understand deeply that other people have different ways of knowing the world.

As students went on to assemble stories based on these experiences, they had to analyze, synthesize, and evaluate their own work and the work of their colleagues. It was difficult for them to pull away from creating a story that was about their own experience to creating a story focused on Cherokee perspectives with deep meaning for others. Though we ultimately chose not to use the videos, the struggle to create them provided much opportunity for growth and students emerged with a greater understanding of the specific knowledge of place that Cherokee people have and how this affects the natural world in which they are embedded.

7.3 Teaching Strategies

7.3.1 Mind/Brain Connections

Both the *Vision and Change in Biology* (Brewer and Smith 2011) and the more recent *Vision and Change in Ethnobiology* (McClatchey et al. 2013) stress the importance of making multiple connections between plants in our environment and our human selves as another integral part of these integrated and complex systems. These documents also stress the importance of authentic, problem-based, experiential education in immersive outdoor settings as best practices in botanical and biological education. Current research in mind/brain education (MBE) strongly supports these pedagogical approaches. The following are aspects of both *Vision* *and Change* documents that are strongly supported by emerging research in MBE and EE:

- **Authentic**: meaningful to the student on an emotional level
- **Problem based**: there is a reason to learn a skill or develop understanding
- **Experiential**: involving multiple senses, emotions, and intelligences
- **Immersive** (outdoors): elicit emotional responses multiple times to avoid fear

7.3.1.1 Authentic

The learning experience must be meaningful to the student on an emotional level. Traditional approaches to botanical science including lecture and rote memorization are not aligned with best practices from EE and MBE techniques. They do not lead to the development of local knowledge of nature. If their experience in the learning environment only involves sitting, listening, and watching the clock tick away the minutes, there is likely no connection made. There is certainly no connection made to the natural environment. The first step, therefore, is to get them out of the schoolroom and into authentic learning environments in which they may contribute—such as in citizen science programs. Additionally, Caine (1997) says that people need to be supported while doing their work and that this will lead to better flexibility in thinking, creative problem solving, and decision making. When students are working authentically in collaborative groups, we must give them every opportunity to experience the success of being supported in their current workspace and their current *place*. These are the kinds of meaningful experiences that may contribute to a "significant life experience" and outcomes associated with pro-environmental behavior in the future (Chawla 1998).

7.3.1.2 Problem Based

Though we are born with inherent thinking and creativity capabilities, a delicate balance between genetics and environment may determine the ability to develop these talents and skills in deep and enriching ways. Problem-based learning may assist us with this, by centering on a specific problem, helping us to find relevancy, build creativity skills, connect with each other and build deeper understanding. This is powerful as we move ahead with education for twenty-first century skills that employers now demand. In light of this realization, the old models of education fall apart. We are natural born learners—we want to solve problems and we want to do it in groups. So what is stopping that process? Why are schoolchildren not learning effectively within the traditional schooling models? They lack collaborative experiences and the emotional support that allows them the freedom to think again, as they did when they were newborns and toddlers—discovering their world of wonder in play-based learning (Caine and Caine 1997). This collaboration is a survival skill—historically and for the twenty-first century—particularly as our environment changes and becomes more challenging for us to live in. These skills must be learned early, not after college graduation. Great teachers know this and place students directly in a position in which they must immediately put their skills to work. In order for this intrinsic motivation to learn to be activated, a shift must occur. This shift means a transition from a teacher-centered to a truly learner-centered environment.

This immediate use of skills has a historical connection to Dewey for what began as the progressive education movement of the 1930s. John Dewey (1938) called for a "cultivation of individuality" as well as an acquisition of skills that could be put to use immediately, providing for meaningful experience relevant to the learner. Dewey also was a proponent of the learner being directly involved in their ever-changing (and now global) society in a way that allowed them to experience present life as opposed to some abstract remote future.

7.3.1.3 Experiential

There is strong evidence that the amygdala provides for a primacy of emotions over logic in learning environments (Bixler and Floyd 1997; Caine and Caine 1991, 1994; Damasio 1994, 2005; Jensen 2008). Things like thought and emotion cannot be separated; in fact, they *are not* separated in our brains (Caine and Caine 1991). Therefore, all aspects of a person must be considered. This notion was popularized by Gardner (1983) in his landmark book, *Multiple Intelligences*. "Good learning engages feelings rather than viewing them as add-ons, they are a form of learning" (Caine and Caine 1997); thus, we know emotions are critical to learning. In fact, emotions cannot be separated from the experiences that produce them. It is through experience that the brain learns and these are inherent ties to emotion (Tokuhama-Espinosa 2010).

Professor Damasio (1994, 2005), a neurologist and author of *Descartes' Error: Emotion, Reason, and the Human Brain*, describes a "mid-ground" of emotions as ideal in a learning situation. Coupled with our knowledge that emotions and thought are deeply interconnected (Pert 1997), these emotional experiences help us to tap into that "relaxed-alert" phase (Caine and Caine 1997) that our brains are seeking in order to allow us that direct access to higher-order thinking throughout the complex routes of our coveted cortex. Eric Jensen, a student of and a champion for the application of neuroscience research in mind/brain learning techniques, encourages us to consider that "Without context and emotions, information is considered meaningless to the brain" (Jensen 2008).

According to Daniel Schacter of Harvard University (1996), stress hormones tag events in our brains, making them emotionally important and possibly creating a negative-feedback loop. When we encounter stress it actually prevents us from using our higher-order, creative thinking skills and triggers a feeling of helplessness and fatigue (Caine and Caine 1997). In this situation, you can memorize isolated facts but cannot access higher-order thinking to synthesize and generate. However, in some instances, accessing higher-order functions can happen even if there is stress—*if* real *choice* is involved. In fact, under stress, this is the only pathway to the coveted "relaxed-alertness" (Caine and Caine 1997) that the brain requires to perform those higher-order skills.

In a fear-free environment, the fight-or-flight response of the amygdala is not engaged and, thus, free access to higher-order thinking can be more readily achieved. But if we avoid stress and, therefore, avoid the pathway to the amygdala, we can head straight for the promised land of higher-order functions located throughout the cortex. These findings are significant for creating safe, supportive, and fear-free environments—essentially pathways to cortex access.

7.3.1.4 Immersive (Outdoors)

In addition to the lack of outdoor experiences discussed elsewhere in this work (Nabhan and Antoine 1993; Nabhan 1995), emerging brain science constantly points to the importance of experiences out of doors (Caine and Caine 1991), particularly in our own local environments (Sobel 2005). Additionally, these outdoor experiences should involve as much play as possible for children (Caine and Caine 1991; Vadala et al. 2007). In best-case scenarios, immersive experiences must generate emotional responses but without causing fear. This may be more challenging in populations such as urban youth who are disconnected from the landscape. In these instances, students may have a higher-fear expectancy, disgust sensitivity, and stronger desire for modern comforts (Bixler 1997). The goal is to achieve the coveted relaxed-alert phase as described above. However, if the focus is to be botanical science, it is imperative that students have the opportunity to learn about plants where they reside—the outdoors.

One of the hallmarks of MBE is that the brain learns by connecting new knowledge to old knowledge (Tokuhama-Espinosa 2010). Students of all ages must, therefore, have the opportunity to observe plants in their natural environments multiple times, and *over* time. By observing a place over time, students can create an emotional connection (Sobel 2004) that will help them create brain connections (Caine et al. 2008) for learning about plants in their environment.

7.3.2 The Importance of a Philosophical Framework

EE research that makes explicit the philosophical frameworks that guided the design of the original research is needed (Rickinson 2001). In part, this is because of disparate disciplines that have contributed to the literature, but also because there are not clear delineations of the intersections of EE, ecological education, botanical knowledge, knowledge of nature, and so on. In general, the bulk of research on outdoor education literature is more often focused on emotional learning and connection to nature. Therefore, further work is needed in this area to determine what the knowledge-based outcomes are (Nicol 2003). Conversely, research on EE is often more focused on learning outcomes related to changing personal and social behaviors. If evidence demonstrates (as we believe), that learning about nature includes the cognitive, affective, psychomotor, and interpersonal domains, then perhaps the hybrid approach that we have recommended will connect students more deeply to their environments, though this is untested as of this writing.

We recommend that institutions responsible for environmental and botanical education identify a firm philosophical foundation upon which to measure their own message to the community. In our case, this includes a belief in the empirical data from the emerging field of neuro-education, as well as those methodologies supported by both *Vision and Change* (Brewer and Smith 2009; McClatchey et al. 2013) documents. The most salient aspects of these documents are strongly supported by research into brain science. Our philosophical framework is clear and constantly at the forefront of the educational content and pedagogy questions we have to answer daily. Our philosophies may be dated back to the progressive education movement sparked by John Dewey in 1938, though, of course, not all of Dewey's recommendations are followed. Regarding modern thought and empirical evidence, we point to the emerging disciplines of MBE and neuro-education, which is an exciting combination of multiple disciplines with one goal: improving education. MBE has been popularized by Eric Jensen (2008) and Gardner's (1983) *Multiple Intelligences*, and both provide excellent practitioner strategies for classroom and out of classroom implementation.

George W. Bush declared the 1990s as the decade of the brain (Jones and Mendell 1999) with the hope that this would usher in changes in systems (including education). However, over a decade later, experiential education still lies on the fringes, perhaps too closely connected to the original progressive education movements, rather than standing as its own unique learning theory. Though some progressives, including Dewey (1938), may have overreached, suggestions that education must directly connect to the learner's world is still supported by brain research today. This fundamental need to be immersed in an environment for optimal learning has not changed in theory since Dewey published *Experience and Education* in 1938. Now, the emerging fields of MBE and neuro-education may finally be the new platform upon which real change may be launched. Researchers from diverse fields such as neuroscience, biology, and psychology now have the opportunity to fast-track research to the practice pipeline by involving the educational community in current conversations and the search for understanding of how the brain learns and the learner's experience during the process.

7.3.3 Interdisciplinarity

Just as with culture, academic disciplines operate on mental models of their area and thus, practitioners of the discipline "understand the world in terms of the cognitive models they possess" (Davies et al. 2007). To be sure, throughout the careers of both authors, this has been true. However, what we mean to inspire through the inclusion of disparate disciplines in the context of science classrooms is: (1) using interdisciplinary tools to understand, investigate, document, and reflect on problems; (2) using supportive information from different disciplines to provide relevance and meaning; and (3) helping students hone higher-order thinking skills by making the cognitive model explicit. In particular, these may well help students learn about nature in a similar way that holders of TEK do, by providing contextual information layered on local knowledge, management techniques, social institutions, and, ultimately, their own worldview or mental model. In other words, embedding interdisciplinary knowledge and ways of knowing provides a scaffold for local knowledge of nature that may help provide relevance, meaning, and, therefore, become more easily embedded in the brain.

These inspirations also support the whole brain perspective, inasmuch as interdisciplinarity offers students a greater opportunity to connect wholes and parts (Caine et al. 2008) in meaningful ways. Teachers of young children have known this for a long time, linking art projects with the layering of new knowledge and ideas. A group in Connecticut created an explicit project about sustainability integrating science and art. They engaged university students, academics, and community members in a cycle of community engagements that led all toward a deeper and broader understanding of the impact of humans on the landscape (Clark and Button 2011).

7.3.4 Emerging Studies

The emerging field of neuro-education allows us opportunities like never before. Researchers at the Center for NeuroBiology of Learning at the University of California, Irvine and the Johns Hopkins University School of Education (Carew and Magsamen 2010) describe neuro-education as a "nascent discipline that seeks to blend the collective fields of neuroscience, psychology, cognitive science, and education" and which is "opening critical new dialogue between teachers, administrators, parents, and brain scientists." This new field brings together researchers and practitioners to share wisdom and challenge paradigms (Fischer et al. 2007; Goswami 2006). Additionally, these new findings lend dramatic support to educational philosophers (Dewey 1938; Piaget 1952; Vygotsky 1978) upon whom many of our modern best practices are based.

Experiential education is integrally connected to any educational pedagogy that requires immersion experience in a particular environment, as MBE does. Understanding and naming of plants requires a situational context of place. Experiential education seeks to provide these innovative, meaningful, student-centered, emotionally connected significant experiences for learners of all ages. The literature about SLE is robust and, although not without controversy, experts in the field have long been looking to SLE research to show that critical experiential events play a role in developing adults with environmental (including botanical) awareness (Chawla 1998, 2001; Dillon et al. 1999; Gough 1999b; Payne 1999; Tanner 1980). Some of the controversy surrounding SLE research concerns differences in ages of participants. Chawla (2001) says that she "enthusiastically supports Annette Gough's argument (1999a) that we need to understand the environmental experiences that young people themselves consider significant." But she differs in that she believes we should not restrict our observations to children, but people of all ages. This is necessary if we are to help learners of all ages understand the value of plants in their lives and their critical place in the environmental systems in which they live. SLE research suggests that students who have these significant experiences—particularly outdoors—tend to have pro-environmental awareness. In fact, it appears that outdoor experiences may be far more vital than cognitive outcomes alone—upon which most programs are currently evaluated (Cachelin et al. 2009). There is a need to examine the SLE research as it applies to the significant life experiences of students in our programs.

7.4 Conclusion

7.4.1 K–12 Example: Experiential Field School

One of the key elements to the experience of the teachers in the example described here (Sect. 7.2.1) is that they were being exposed to areas of their city they had never seen before. This became an important part of the experiment. Many of the local places the teachers traveled to with the students were "right in their own backyard" and yet they were unaware of their existence. The goal of these experiences is to encourage teachers to utilize these areas that are in their place. As demonstrated by the research discussed above, it is only through these immersive experiences that learners (of any age) can connect to local knowledge of nature and ultimately engage in more pro-environmental behavior. MBE again provides dramatic support for this initiative. We continue to document the positive influences of outdoor education through disciplines such as cognitive psychology (Berman et al. 2008) and EE research (Rickinson 2001).

In the example provided, teachers came to their new knowledge through their own path. They found a need for more knowledge and deeper understanding and then sought after that knowledge because of this need. As teachers and students came to know the place through study—naming of organisms, the management regimes that brought about the system under study—they began to question prevailing norms that influence the landscape. This is an example of nested nonlinear domains of knowledge about nature that require critical thinking, reflection, and adaptability. Therefore, though teachers were learning about "science," they were doing so in a manner more aligned to the way that TEK holders construct, reflect on, and adapt their knowledge as new information is acquired.

As McClatchey et al. (2013) have delineated, the Experiential Field School actively demonstrated the core concepts of: (1) change (in environments, from one location to another); (2) integration of knowledge and methods (by teaching methodology in the field and teaching structure/function of organisms); (3) information flow, exchange, and storage (through connections up and down the web of life); and (4) systems (by connecting living systems with abiotic parameters).

7.4.2 Undergraduate Example: The Cherokee Worldview Garden as a Place for Biocultural Embeddedness

In order for students, faculty, and community members to understand "place" from alternate perspectives, new information about the influence of other cultures onto already familiar landscapes had to be acquired. In addition to direct experience with tribal members, I regularly employed metaphor and other forms of analogy, including storytelling to achieve this. This is also in keeping with how TEK is conveyed (Berkes 1999).

In support of McClatchey et al. (2013), the Cherokee Worldview Garden (see Sect. 7.2.2) actively demonstrated the core concepts of: (1) awareness (recognizing differences in cultures, practices, and more); (2) change (diversity of organisms by habitat and forest practices); (3) integration of knowledge and methods (teaching skills and methods in context); (4) information flow, exchange, and storage (through connections with nested natural and human systems); and (5) systems (by active discussion of interactions).

7.4.3 Final Remarks

As we move forward in teaching science and specifically local knowledge of nature and botanical knowledge, new mental models of nature are needed (Bang et al. 2007). Since culture impacts cognition, behavior, and social relations relative to habitat (Atran et al. 2004), and because our mobile, technologically oriented society has a severely reduced common-sense understanding of the living world, we may not be able to respond in a responsible manner to changes in ecology without these new models. However, local knowledge of nature is declining; at the same time, a moral consensus to improve the environment or at least avoid doing damage is emerging. This chapter argues that our ability to reverse this trend and live sustainably is ultimately directly tied to more time in nature, more direct experience with nature, and a more in-depth nested nonlinear process of knowledge acquisition and growth, similar to TEK holders of the past and present. In this way, we may become more adaptable and thus reduce our long-term effects on nature.

Additionally, using brain-based, interdisciplinary techniques can help us achieve a greater connectivity to local environments. This is supported by information in the (1) *Next Generation Science Standards K–12* (NGSS) by the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science (AAAS); (2) *Vision and Change in Undergraduate Biological Education* by AAAS and the National Science Foundation; (3) *Vision* *and Change for Undergraduate Ethnobiology Education in the USA,* informed by the development of number 2; and (4) *How People Learn* by the National Research Council (Brown and Cocking 2000), documents written largely to increase the number and quality of students within STEM disciplines. However, environmental literacy is not just about increasing the number and quality of students within STEM. It is about our survival as a species and, thus, important to us all.

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