One educator's pathway to increasing students' interactions with nature: An investigation into three areas of personal interest and thoughts about their pedagogical application.

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My Starting Point

My Experience and Interest in Nature-Based Education

People need nature. Over the past 20 years of my career as an educator, I have become increasingly aware of the importance of regular interaction with natural spaces to my own health and the health of my students. I began teaching science in nonformal settings, primarily science museums and camps. Soon after moving to Alaska in the mid-1990s, I began teaching part-time at the newly-built Campbell Creek Science Center (CCSC), an education facility in Anchorage managed by the Bureau of Land Management. Part of the core mission of the CCSC has always been to get people outside exploring the natural wonders of the surrounding wild spaces. However, in a mirror of my own interests, the focus of programs at the CCSC evolved during my nearly two decades working there. In the beginning, nearly all of the programs focused on science concepts, correlated with national standards. At that time, I considered myself to be a science teacher. Teaching outdoors in a natural setting was a bonus. I was able to be outside more often, and I felt that teaching the life sciences in context is a more effective pedagogy. However, teaching science concepts was still the primary goal. Eventually, program

options expanded to include environmental issues education; basic outdoor skills; teambuilding; and, as growing research supported its value, nature awareness.

While I continued to be interested in science education and, to a lesser extent, the other areas of environmental education, we all at the CCSC could not deny the profound impact that direct experience of the natural world had on our audiences—at all ages (from infants to adults). While we struggled to assess students' understanding of scientific concepts or motivation toward environmentally-friendly practice after our programs, we constantly shared stories such as the attentionally-challenged boy who, after disrupting nearly every activity, sat still for 20 minutes in the woods and wrote about listening to the wingbeats of a raven. Or the numerous inner-city children who claimed that this was the best field trip ever! Or the group of students from the high school devoted to at-risk-youth who claimed new interests in environmental careers after a half-day spent investigating the creek.

Richard Luov's 2005 book (updated in 2008), *Last Child in the Woods*, Michelle Obama's exercise initiatives, the growing body of research highlighting the benefits of outdoor exercise, and a talk Luov delivered in Anchorage in 2012 which was attended by Interior Department managers in Alaska, all contributed to local and national support from within the federal government for programs aimed at getting participants outside. This echoed our evolving position at the CCSC that providing outdoor experiences may have greater impacts on the students than the delivery of science content. Although most of our programs still had a science focus, the comments from teachers also emphasized the outdoor experience in greater proportions, and we planned more programs with the outdoor experience as the primary goal.

A Time of Transition

Around 2012, my family's financial situation was becoming increasingly untenable. For nearly two decades, I had maintained an intermittent position at the CCSC which allowed me the flexibility to travel easily for my wife's writing projects, help with homeschooling our children through middle school, and challenge myself with a variety of other teaching and science-related jobs such as developing curricula for a science museum, training teachers in outdoor education, developing education products and reports for science research projects, and substitute teaching. I was also interested in exploring classroom teaching although I was ambivalent. A classroom experience provides the potentially satisfying opportunity to connect with a group of students over a longer period of time (not to mention a more secure paycheck), but I had little interest in being a part of any educational system I felt to be fundamentally flawed. Nevertheless, I enrolled in an MAT program (secondary science) that matched my education philosophy (student-centered, constructivist) and emphasized the practicum over classes.

By the time I completed the program, our family had just gone too long without a significant travel experience. So we sold our house and took our daughter to Southeast Asia for a school year. (Our son was in university.) I completed an English teaching certificate program in Thailand. We traveled, and I took a six-month contract teaching English in Taiwan. Since we didn't feel we had had enough of travel, after a semester back in Anchorage, we went down to Mexico where our daughter attended a rural high school for a semester, I taught English in Chiapas for another semester, and we travelled for a third.

Now, our daughter has started university, and my wife and I are travelling around the U. S. for one of her writing projects while I attend the University of Massachusetts, Boston Critical

and Creative Thinking program. We probably will be resettling outside of Alaska. I will be looking for educational work in May. I am still unsure whether or not I will pursue classroom teaching or work in nonformal educational settings. However, I remain committed to advocating for nature-based education. I am also interested in expanding my knowledge in areas I feel will be important to any future teaching: science (in general and particularly ecology and the life sciences), science and society, and human/environment interactions.

My Inquiry Pathway

My interests are greatest where I know the least. I began this particular inquiry process intending to follow my interests within the intersections between the environment and human society. I searched for the latest articles and books that provided what I felt to be broad overviews of these areas. Then I traced authors referenced in those readings that seemed to be working in areas of particular interest to me.

My first readings introduced me to researchers who argued that understanding human/environment interactions requires accounting for the complexities arising from the ecological, economic, cultural, historical, global, and local forces acting in each specific case. While much of my teaching could be considered environmental education, I tend toward knowledge about science and natural systems rather than environmental issues. This area of research was both exciting (in that I had little prior knowledge) and satisfying (in that it addressed my frequent frustration with what I have perceived to be oversimplifications of environmental issues and proposed solutions). Reading in this area even called into question basic ideas I held about the science of ecology.

Linked to my readings on complexity were articles on human conceptions of nature. I began researching this area because of an interest in local and traditional ecological knowledge, but I quickly found articles examining how human conceptions of the natural world have changed over time and how these conceptions affect our basic understandings of that world. Again, this was an area in which I had little prior knowledge, and so was immediately interested.

While wide-ranging reading is, alone, a pleasurable experience, at this point in my journey, I wanted to be able to focus my research and relate it to my teaching interests. In consideration of the ways in which these subjects might have a powerful impact on students, I kept coming back to being able to motivate them to increase their time spent outside interacting with the natural world. While mine may not be the ideal research method for investigating a specific question, I was intrigued by the possibility of enriching my teaching with subject areas that were previously unknown to me.

In this vein, I added one more area of research, the benefits of nature on human health and development (and a bit into the related area of applying nature-based education). These were areas in which I was more familiar, but in which I hadn't recently conducted concentrated research.

As I continued my research with teaching in mind, I was struck by how the potential relevance of the three areas to my educational goal was the opposite of the order in which I pursued them. While there does not appear to be a large amount of research in the area of children and adolescent attitudes about natural areas and educational impacts on their motivation to interact with nature, what I did find indicated that prior experience with nature and personal connections with natural spaces were among the most important factors (Cheng

& Monroe, 2012; Williams and Chowla, 2015). This indicated that my teaching priorities should be: 1) getting students outside (while justifying it to them and to reluctant administrators by explicitly teaching about the benefits); 2) fostering students' personal connections with natural spaces (related to getting them outside, but also including helping them to explore their own and their community's conceptions of nature); and finally, 3) fostering wonder about the natural world by introducing them to the ecological and human ecological complexities.

Because I believe that my interest in these areas and their order of priority for a particular pedagogical goal are both important to my development as an educator, the structure of the rest of this paper will mirror my pathway of inquiry and the order of priority. In the following section, I will share what I have learned in these three areas and why they interest me in the order in which I pursued them (the order of my interest). Following, I will explore their pedagogical implications beginning with the last area researched (the benefits of nature), since that provides the basis for a compelling argument advocating for nature-based education, and proceeding through the other areas in the reverse order of the previous section. Finally, I will describe the possible pathways I might take in order to pursue these areas of inquiry further and develop concrete pedagogical applications.

My Areas of Inquiry

Ecological and Human Ecological Complexity

Daniel Botkin's, The moon in the nautilus shell: Discordant harmonies reconsidered (2012), is exactly the kind of work that can provoke my sense of wonder at the natural world. It questions huge areas of ecological science—areas I assumed to be basic to the field and have taught without caveat. In this update to his 1990 book on the same subject, Botkin argues that

scientists' and environmentalists' conceptions of nature as a system in a steady state or a state of equilibrium have resulted in flawed theories and research. Botkin argues for a research program that embraces the stochastic and dynamic characteristics of natural systems and meticulously outlines the evidence that has convinced him that such characteristics are dominant. Change is the norm. He also argues against ecological theories that do not include humans as inextricable ecosystem components. He provides examples, such as in fire management and clearcutting policies in forests in the western U. S. and in the conservation of sea otters and salmon, where he feels faulty assumptions about the very nature of ecosystems resulted in policies that did not have the desired effects or even the opposite effects of those intended. Regardless of whether I am fully convinced by all of his arguments (I did have some issue with his analysis of anthropogenic climate change), I find his overall thesis exciting for two reasons. First, and most importantly, it underscores all that we still don't understand about the world around us. It speaks of mystery. Second, it is not an unknowable mystery. By outlining a practical research program that might address this greater complexity, Botkin inspires, in me, an interest in following this puzzle as solutions are discovered.

In a similar manner, Taylor and García-Barrios (1995) argue for the necessity of accounting for complexities when analyzing human ecological change. Like Botkin, Taylor and García-Barrios attribute problems in understanding human ecological systems and in implementing policies that affect these systems to researchers' fundamental assumptions. They feel that researchers have relied too much on systems thinking which seeks to identify general principles with which diverse human-ecological situations can be analyzed. This focus on the system, rather than the specifics of the parts of that system, deemphasizes the particularities of

the different forces of influence to the point of ignoring them completely. The provide examples, such as the intersections between desertification and pastoralists in Africa, that illustrate how the ignorance of the particular social and historical forces involved led to incomplete understanding by researchers and poorly designed policies. They also describe analyses, such as those investigating the drought vulnerability of poor farmers in Nigeria or the links between migration patterns and soil erosion in Southern Mexico, that, by including such forces, were able to provide useful insights into current conditions and reasons for the failures of prior policies to alleviate problems. In this way, Taylor and García-Barrios share Botkin's view that much of the problem boils down to inaccurate conceptions of nature and humans' place within it, which I will address further in the next section.

Like Botkin's, Taylor and García-Barrios' paper is exciting to me because it speaks to a world of potential misunderstandings about the fundamental nature of human/environment interactions that may be corrected with a new research paradigm. As an environmental educator and in my personal life, I have been motivated more by my desire to understand the basic processes that contribute to environmental problems than by a wish to mobilize action on specific solutions. (This is the reason I gravitated toward education rather than activism.)

Science and Technology Studies (STS) and Political Ecology were two fields of research I investigated where researchers appear to be grappling with the myriad complexities inherent in human ecology. STS seeks to understand the influences and interactions between societies, social structures, and social constructions and scientific process, products, and knowledge. Yearly (2008) summarizes some of the STS research into environmental science that investigates the ways in which social forces have shaped research directions and outcomes in

the fields of climate change and genetically modified organisms (GMOs). As an educator interpreting science for students, I am always seeking a more complete understanding of the scientific process. For example, I have struggled with teaching climate change concepts in a politically charged environment for a number of years as well as being personally interested in the science. It is helpful to me to have the context provided by Yearly's descriptions of the internal and external forces acting on the Intergovernmental Panel on Climate Change (IPCC) and how those forces impacted the reports that the IPCC published, the direction of the research conducted by its members, and (of especial interest to me) how the very structure of the IPCC contributed to criticisms leveled against it.

In a similar manner, Lave's (2011) documentation of the development of a widely-adopted method for assessing stream function and conducting stream restoration and Taylor's (2011) examples of STS analysis of an agro-environmental intervention program and a European scallop fishery provided me with insight into how the tensions between academics, government resource professionals, and laypeople can play out in the development, dissemination, and acceptance of knowledge in areas that have been the basis for many programs I have taught. As an educator with a long history of teaching about climate change, stream ecology, and environmental issues, knowing about the scientific consensus without understanding the complex forces that shaped that consensus results in incomplete knowledge. Even if such background understanding is too complex to directly convey to students, it is important for me to be sure my understanding is as complete as possible. In fact, Taylor (2011) refers to the tension between the actual complexities of a system and the need to simplify them for educational purposes, and this is an issue with which I often wrestle as an educator.

Regardless of whether or not the complexities are fully taught, the educator must not be ignorant of them.

Political ecology is defined In three papers by Matthew Turner in which he describes the field in comparison to resilience studies (Turner, 2014a) and in answer to critiques about the absence of ecology in the field (Turner, 2016) and the lack of impact the field has had on conservation and development projects (Turner, 2014b). Like STS research, political ecology seeks to account for the specific particularities when analyzing human-environmental interactions, however, the field emphasizes social justice issues (Taylor, 2011; Turner, 2014a; Turner, 2014b; Turner 2016). I found this field to be of interest both for what it can tell me about the specific complexities involved in environmental issues, but also for its pedagogical potential in fostering students' personal connections with natural places which I will discuss further in later sections. Turner, like some of the previous readings mentioned (Botkin, 2012; Taylor and García-Barrios, 1995; Taylor, 2011) takes exception with other researchers' fundamental conceptions of natural and human ecological systems that rely too much on systems thinking that requires the use of general principles to the detriment of the understanding of particularities. Systems thinking assumes that natural systems are in a state of equilibrium that suffer when unbalanced by human activity. These authors feel that natural systems encompass human activity and that they are inherently dynamic and stochastic. The notion that entire scientific fields are reliant on practitioners' cultural assumptions as much as on empirical evidence intrigued me enough to begin reading more on human conceptions of nature.

Human Conceptions of Nature

My readings in this area fell into roughly three groups of increasing specificity. Readings in the most general group provided broad historical and philosophical perspectives. The second group traced the effects that such conceptions had on broad fields of research, while the most specific provided individual examples where conceptions of the natural world impacted one researcher or socio-environmental issue.

Dussault (2016) and Williams (1980) were in the most general group. Dussault (2016) provides a useful summary of historical conceptions of the natural world from the philosophical point of view of determining the proper place of humans within that world and the resulting ethical imperatives. He describes three views of nature. The first is of nature as divine creation with no resulting ethical imperatives since humans are part of that creation and all is subject to natural laws. The second viewpoint considers nature to be in opposition to the artificial, or human affected. This view implies preservationist ethics that seek to return nature to a wilderness state, prior to human intervention. The third view considers nature to be that which is normal and includes humanity. If normal functioning is applied to individuals and species, this leads to the Aristotelian ethics that require humans to behave according to their rational nature. If normal functioning is applied more globally, to ecosystems, the ethical imperative becomes the maintenance of healthy ecosystems that incorporate human activity. Dussault labels this view Ecocentrism and discusses how it may be applied to understanding dynamic natural systems and address perceived problems within them.

In a similar manner, Williams (1980) investigates the history of changes in human conceptions of nature as they shifted in support of different cultural imperatives. First, nature became conceived of as singular and personified. Humans then considered themselves separate

from this creation which allowed them to exploit it and investigate it as a means of understanding a deity, defining universal laws, or both. Eventually, a conception of nature emerged that was not only separate from humans, but perfect in its separation—the notion of an ideal, unspoiled wilderness. Williams then also makes the case for a more accurate conception of nature that inextricably encompasses humans and human activity.

As I mentioned earlier, Botkin (2012) and Taylor and García-Barrios (1995) describe how specific conceptions of nature have led to what they feel are flawed research in the fields of ecology and human ecology, respectively. Botkin describes the use of nature metaphors in different time periods, from the pre-historical conceptions of nature as organic (and thus dynamic) through the developments of more static views, first as divine creation and later as a perfectly-functioning machine. He provides numerous examples of this latest conception leading ecologists to develop faulty theories and models to test those theories. Taylor and García-Barrios also provide some historical context as they describe how post-World War II conceptions of nature led to the development of systems thinking in human ecology.

In two other related fields of research that were of interest to me, Fujimura (2011) and Hames (2007) also examine the effects of researchers' own conceptions on their scientific output. Fujimura (2011) describes the fascinating interplay between systems biologists who adopt the hierarchical assumptions of cybernetics engineers to investigate living systems and those same researchers in Artificial Intelligence who adopt systems biologists' assumptions about living systems and organisms as models for their engineered cybernetic systems. Hames (2007) describes the debate among anthropologists regarding whether or not Aboriginal societies may be considered to be conservationist and then how this changing view has affected

the relationship between Aboriginal peoples and the Western conservation community. These two papers along with the Botkin (2012) and Taylor and García-Barrios (1995), provided me with insight into how investigation into the broad philosophical idea of humans' conceptions of nature may be applied to understand the direction and output of scientific fields and environmental issues.

While I did not necessarily read all of the papers in the organized order presented here, my impulse in the course of my inquiry was to seek ever more specific examples of the application of this idea. Nadasdy (2011) provides a compelling example of an instance in the Yukon where different conceptual metaphors of wildlife management held by government resource professionals and First Nations people led to the initial cooperation and later conflict in the implementation of a predator control program. The government biologists conceived of wildlife management as an agricultural practice—whether consciously or un-, their metaphorical language reflected this view. The First Nations people's conception of wildlife management consisted of the maintenance of social networks. Both of these conceptions allowed for a predator control program (thus the initial cooperation), but led to discord when later details of the government's implementation conflicted with the First Nation peoples' concepts.

Vandergast and Peluso (2011) document how the very concept of a managed and protected forest in Southeast Asia (as opposed to jungle) is a political creation linked to governmental counterinsurgency policies. Less scholarly, but important to me for its radical implications is Colwell's (2016, October 10) account of a forest in New Zealand that is sacred to the Maori people being granted the legal status of personhood. These two articles along with

the Nadasdy (2011) paper provide important information about the underlying and often invisible forces behind conservation research and program implementation. It is important to me, as an environmental educator, to be knowledgeable about such complexities and what they imply about future possibilities in this area. In a similar manner, but applied to basic research, Worster (1977) provides insight into the social and personal forces affecting Darwin's development of his natural selection theory. In fact, Worster argues that this theory could not have been developed in any other social milieu. Whether or not I agree with this forceful conclusion, I feel responsible, as a science educator, to incorporate these ideas into my understanding of a theory that is fundamental to the life sciences. I am confident that the understandings gained in my readings on the complexities inherent in natural systems and in human ecology and the changing human conceptions of nature and their impacts on science and environmental issues are important to my development as a science and environmental educator. Less clear, however, is their application to the specific goal of motivating students to interact with nature. As I worked through readings in these areas, I began to think of connections. Before working those connections through, however, I felt that I needed to revisit the research on the benefits of nature, research I had dipped into off and on throughout my career, but not recently.

The Benefits of Nature to Human Health and Development

As I stated at the beginning of this paper, I have come to strongly believe that humans need nature through my personal and professional experiences. Increasingly, research appears to support this. Natural spaces may be critical to healthy cognitive functioning. Research on attention-based performance has demonstrated improvement after exposure to natural

settings for adults (Berman, Jonides, & Kaplan, 2008) and children diagnosed with attention deficits (Taylor & Kuo, 2009). Interestingly enough, Berman, Jonides, & Kaplan (2008) found that subjects improved performance in attention-based tasks after merely viewing photos of natural scenes versus those of urban areas.

Nature also appears to be important in emotional regulation and stress management. Wells and Evans (2003) found that stress-inducing events have less impact on rural children who live in proximity to a greater amount of natural space. Research also indicates that attachment to particular places increases the post-natural disaster resilience of youth and children (Scannell, Cox, Fletcher, & Heykoop, 2016). While this study examined the attachment to both natural and human-built places, it found that natural places were particularly important to children aged 7-12 years. Similarly, Korpela and Hartig (2001) document the restorative and emotional regulatory benefits of the favorite places of college students, the vast majority of which were natural places. Interestingly enough, Cole and Hall (2010) found that the restorative benefits of nature were not adversely impacted by a greater amount of pedestrian traffic on the wild space trails they studied and only certain aspects of perceived benefits were increased with greater time spent on the trails.

There is a fair body of research investigating the positive impacts of natural areas and the outdoors in general on physical activity. Flowers, Freeman, & Gladwell (2016) found that increased physical activity in adults correlated with increased visits to local green spaces. Interestingly enough, they also found that it was participants' subjective evaluations of the quality of these green spaces rather than the objective amount of green space that correlated with increased visits. In a review of the research specifically comparing indoor and outdoor

physical activity, Coon et al. (2011) found that there seems to be evidence for outdoor spaces contributing to a greater sense of revitalization and a decrease in tension and depression over indoor ones. However, they found a distinct lack of studies comparing the two areas' effects on overall physical well-being or adherence to exercise regimens, and they also noted the prevalence of poor research construction in the field as a whole and the wide variety of study protocols which made their meta-analysis problematic.

In general, I consider the field of research into the benefits of nature to be an emerging one. While there are some, specific areas in which there appears to be a solid argument for the benefits of interacting with nature (such as attention and emotional/stress regulation), much of the research relies on self-assessments by participants and low sample sizes and has not been widely and reliably replicated. However, these problems are also inherent in a lot of research on educational practices in general—especially when seeking to assess the efficacy of educational interventions aimed at improving holistically-focused educational outcomes such as students' critical thinking skills, creativity, conceptual mastery, well-being, and motivations. The implementation of new and unusual education practices usually involves the presentation of such formal research combined with anecdotal evidence of success, an administrative acknowledgement of the need for improvement, and an institutional open-mindedness to trying new methods in a fair and strategic manner.

Looking Ahead to Potential Applications

Challenges to Incorporating Nature into Education

Considering the barriers to implementing nature-based education in a middle or high school science classroom environment is most useful to me in light of my possible future

teaching jobs. If I am working in a non-formal education setting, it will most likely be one that incorporates outdoor education. If I work in a formal classroom environment, it is most likely to be in secondary science. In such a setting, my previous experiences working in such environments and developing nature-based programs in cooperation with secondary science teachers indicate that the greatest barrier to incorporating nature into classroom learning is the time constraints imposed by educational mandates. The increasing emphasis on standardized tests for not only general assessments of student progress, but for school and teacher assessments that carry financial consequences means that teachers are under great pressure to teach the material covered by these tests and in the manner in which that material is presented. Even when the standards on which these tests are based are thoughtful and inclusive of concept mastery, mastery of processes, and critical thinking, the tests themselves are rarely able to test much more than students' retention of basic information. Any time in which some of this information is not being imparted becomes grudgingly provided or nonexistent.

Another significant barrier is access to natural space. If the school grounds do not contain natural areas, a teacher will have to take her students off-campus. This usually requires a significant logistical effort involving parental and administrative permissions, transportation, and coordination with the other teachers whose classes the students will miss. The two challenges together—that of time and logistics—often result in institutional resistance. Administrators' suspicion of logistical challenges and other teachers' strict guard of their own time with the students can severely limit an instructors' ability to simply get his students outside. The type and degree of these barriers can vary so widely depending on the institution, however, that I will only provide some general thoughts rather than addressing them in detail.

If nature is truly important to humans, then young people with rapidly developing minds and bodies who are sitting in relatively sterile, indoor environments (classrooms) for up to eight hours a day, for about 180 days of the year are especially in need of access to it. If these young people are, indeed, missing a critical element of healthy development, then their academic performance must be suffering, and must be improvable once they are provided with this element, regardless of how that performance is measured. Of course, to determine if this is the case, that access to nature, alone, can have such a profound effect, the entire institution must be restructured to ensure access to nature on a regular basis. Educational facilities that have done this also tend to employ other, less common, progressive educational methods so it may be difficult to attribute any results to one component. For example, community-based education (CBE) is one initiative within progressive education circles that overlaps with nature-based education. CBE seeks to incorporate the wider community into the school. This may include local natural areas, but it also includes local businesses, professions, service organizations, cultural communities, and other components of the community in which the school is located (Coalition for Community Schools, n.d.). Just as I believe in the value of nature-based experience, I also feel that students' immersion within their own communities is a critical part of their education. These goals are complimentary, even if improved performace would be difficult to attribute to one or the other in such a context. A CBE-focused school would include far more opportunities for students to experience nature than are currently provided in traditional schools—even if the nature is limited to small, urban parks, since that is what is available in the students' community.

Even traditional schools can radically reorganize their seemingly inflexible schedules to accommodate a valued "nonacademic" activity. Naperville High School, in Illinois, carved out time for physical education (PE) to be linked with remedial literacy classes (Naperville Central High School's Learning Readiness Physical Education Program, Naperville IL, n.d.) even though this is a school whose faculty and community are committed to high-performing, college preparatory academics. It is important to note, however, that this was an initiative that was begun in response to an administrative quandary: how to provide extra literacy classes for below-grade level students without eliminating the state mandated PE requirements. Also, it was started by a teacher, knowledgeable in both subjects, who created zero hour PE for students in those classes and then documented, over several years, the improvements of the students whose literacy classes were preceded by PE versus those that were not. Also notable are the facts that the community support for sports and exercise (along with academics) is strong and the school is located in a state dedicated enough to providing students with exercise to have created the problem in the first place. These background factors are not in place for the vast majority of teachers wishing to implement nature-based education.

If I were a science teacher in a typical school, one strategy I might use to get my students outside more would be to link outdoor activity to as much of the content in the curriculum as possible—cover more deeply those areas such as ecological concepts, classification, botany, watershed studies, and insects that lend themselves easily to investigation in a natural environment. There is some research that supports this effort from a science learning perspective (Dhanapal & Lim, 2013). Another would be to train the students to transition efficiently between indoors and out so that short amount of time may be spent

outside, for example during group discussions, quiet writing time, and review before tests. Both of these strategies assume natural areas either on school grounds or easily accessible with a minimum of effort.

Pedagogical Applications of My Areas of Inquiry

If one's goal is focused on teaching students in a way that increases their motivation to increase their interactions with the natural world throughout their lives (or maintain their current level of involvement if it is already high), the results of a study by Cheng and Monroe (2012) suggest that children's connections with nature have the greatest influence on their intentions to engage in nature-based activities in the future. So fostering such connections would be an educational priority. But that study also lists children's perceived family values toward nature as being a factor that strongly contributes to such connections. Other factors are proximity of natural areas to the home, prior experiences in nature, perception of self-efficacy, and environmental knowledge. The last three of these are areas for potential pedagogical action, but it is not clear which might be of higher priority.

In a similar manner, Williams and Chowla (2015) examine the role of nonformal environmental education programs in the formation of participants' subsequent environmentally-oriented identities. They find that the key to the formation of such identities is immersion in the natural world along with a social group to which the participant feels a sense of belonging.

Such research and my own experience suggest that the most important strategy for motivating students to interact with nature is to foster their personal connections with nature by providing numerous opportunities for their direct experience with nature in a social context.

Simply conducting class activities and discussions outside might be one relatively easy way to do this. Research exploring the benefits of nature would be useful as the basis of material to teach to the students so that they understand the reasons behind the unusual classroom arrangement and to mollify uneasy administrators and, perhaps, other staff members. Armed with knowledge about the benefits such experiences might impart, students could be enlisted in the shaping of those experiences. Tests might be designed to take 15 minutes less time than that allotted for the class to allow students some quiet outdoor time for review or stress reduction. Students might be curious to compare their performance on tests after time spent outside versus inside.

Fostering students' personal connections with natural places will always involve both personal and social elements, with the latter being more important for adolescents. Allowing students to investigate their own ideas of nature; the conceptions of nature found in their communities, including values, metaphors, and ideas of humanity's place within the natural world; and placing these ideas in a broader, historical context can provide a solid basis for the better understanding of science concepts in general. Furthermore, encouraging students to investigate environmental issues that they determine are of importance to them and work together to take action may be a highly effective way of increasing students' senses of personal efficacy and social belonging regarding the natural world. The research I found on human conceptions of nature as well as political ecology research and, to a lesser extent, other research on the complexities of human ecology would be helpful in developing these types of programs.

All of the readings on the complexities inherent in ecological and human ecological systems are, as I stated earlier, important in the teaching of these content areas. In fact, teaching science through the lens of science, technology, and society (STS) is a growing movement within science education and research indicates its effectiveness in increasing student understanding of science (Akcay & Akcay, 2015).

Taylor's (2015) description of the engagement of students and professionals in this area through the use of participatory processes was also useful to me in beginning to picture the application of this area in an educational setting. The success of an educational program intended to affect students' motivations or affective attitudes or immerse students in areas with a great amount of complexity depends on the ability of such a program to fully engage the students. My inclination is to accomplish this through providing opportunities for the students to be involved in the learning process (through being able to choose their own areas of inquiry, for example), focus on areas that have relevance to their lives, and interact with each other. Taylor provides an example of a participatory workshop at an ecology and ethics conference from which he develops five ethical ideals that should inform the processes designed to result in stewardship-oriented action within complex systems in states of dynamic flux (basically, all human ecological systems). The ideals are: engagement, participation, cultivating collaborators, transversality (awareness about the complexity of factors affecting the situation under consideration and potential far-reaching effects of proposed actions), and fostering curiosity. Even though the processes described are intended for use when involving a community in action, Taylor's ideals mirror best practices for environmental education. A quality education program would likewise include methods designed to engage the students in the material and

as collaborators in their learning, involve members of the wider community, educate students about the complexity of factors affecting the environmental issues under study, and foster curiosity and the motivation to continue learning about the issue. One of the most obvious methods I can think of to teach students about the complexities I have been researching (as well as implementing STS-style teaching) while seeking to inspire them toward increasing their experience with natural places is to engage them through this type of environmental education.

Whether teaching environmental education or other science content in a traditional classroom, I think that my research in the area of complexity in ecological and human ecological systems may provide a strong basis for efforts aimed at promoting a deeper understanding of the scientific concepts and processes elaborated in national standards. My hope is that I will be able to use this material to communicate the wonder of the natural world and thus, foster curiosity and an interest in exploring it further. One caution, however, is that I must also be careful to not overwhelm students and leave them with the cynical impression that the world is too complicated to be fully understood and that science, in general, is faulty.

While this area may be the most removed from the goal of increasing students' motivation to experience nature, it might provide the basis for a great deal of instruction in a formal classroom. If the bulk of the content taught in a science class were taught through STS methods, I feel that students would, in fact, be better prepared for their personalized exploration into human conceptions of nature, their involvement in environmental issues, and direct experiences in natural settings.

Future Pathways of Inquiry

Research Gaps

In my formal research into most of these areas of inquiry, I feel that I have only begun. I have accumulated at least as many books and articles that I did not have the time to read as those referenced in this paper. I have also noted many more citations of works of potential interest. I have by no means exhausted the formal, published readings in any of these areas.

Additionally, there are research gaps in these areas noted by the researchers, themselves. There seems to be a need for more empirical investigation into the effect of nature on academic performance and long-term studies on the factors effecting individuals' motivations and affective attitudes toward nature. Also, research that effectively unravels the complexities involved in ecological and human ecological systems requires lengthy time frames or multiple avenues of exploration. Since these are relatively new methods of analysis, much of the areas that are of interest to me will require quite a bit of further research.

Steps toward Practical Applications

Where would I go from here if I were to begin to apply what I have learned in an educational setting? That would depend entirely on the specific circumstances in which I find myself in my next teaching position. Is it in a formal classroom or nonformal environmental education facility? Am I working with urban or rural students? What are their ages and cultural backgrounds? Regardless of where I teach, the deeper understanding I have gained in these different areas will inform my teaching, at least indirectly. However, direct application will depend on the context. The briefer the program time spent with students (for example, in a nonformal setting where instructors work with a group of students for a single day), I would rely most heavily on the benefits of nature research and somewhat on my readings on human conceptions of nature as a way to inform my approach to introducing students to a nature-

based experience. The longer I am involved with the same group of students (adventure education programs that take days to weeks all the way to traditional classroom teaching), the more I would incorporate what I've learned about human ecological complexity.

Whatever the position, in order to develop and implement an educational strategy for increasing students' motivation to interact with nature, I would need to move beyond reading in formal, published sources such as what I did for this paper. I would look first for models—other teachers or institutions that are implementing programs similar to what I envision. Many of the researchers whose works I read may also have insights into the educational implications of their work. Such interviews will be most helpful once I have the specific context in which to frame my questions. Finally, given the difficulties inherent in educational research, I may find that it is necessary to set up my own mini-experiments with my students. For example, if I were teaching multiple sections of the same class, outdoor time could be incorporated into only one class for one unit and only into another class for another unit. As long as those units were otherwise taught the same for both classes, this might provide some insight into the impact of time spent outside on academic performance. Or, I might be able to teach a unit that culminates in multiple options for final projects with some of those options being outdoors-based. I might incorporate outdoor time into one class during the unit while in the other, I would incorporate a group investigation of an environmental issue. It might then be illuminating to see if there are differences in the number of students who choose the outdoors-based options for the final project.

Regardless of where I find myself, however, I hope to continue my journey of inquiry into all of these areas of interest and into creative ways to provide students with opportunities to experience nature and the inspiration to continue to do so.

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