Bringing Nature Indoors and Online: Teaching Ecological Literacy and Fostering Pro-Environmental Attitudes and Behaviors During a Pandemic

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motivated to work towards their practice of solutionò (St
environmental education is expanding in the United States due to the adoption of the Next Generation Science Standards (NGSS) by many states, which incorporate a greater emphasis on human/environment interactions and place-based experiential education (Coyle, 2014). While there is a vast body of empirical peer-reviewed research on the outcomes of EE (environmental knowledge, attitudes, and behaviors) of children, adolescents, and adults, there is little current research on the outcomes of environmental education in the time of COVID-19, and how the switch to online learning, specifically online EE, has affected these outcomes, as well as students ô relationships with the environment. to better understand the multiplicity of outcomes of designing and teaching an online multidisciplinary environmental education curriculum to fifth graders, using contemporary online education pedagogies focused on bolstering ecological literacy and pro-environmental attitudes and behaviors. We partnered with a 5th grade science class (a teacher and 15 students) at an independent elementary school in Upstate New York to teach an online environmental education curriculum. The goal of the curriculum was to use place-based education (PBE) and experiential learning (EXL) to increase students' knowledge about local ecosystems and the natural world, as well as to increase their pro-environmental behaviors and interest in environmental stewardship.

This research incorporated pretests and posttests, measuring the environmental knowledge of a treatment group and a control group. Both groups consisted of fifth grade science classes at two different private elementary schools. Both groups took the same pretest and

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during the early 1970s. President Richard Nixon kick-started federally administered EE in the United States with the passage of the National Environmental Policy Act (NEPA) in January 1970. This act had widespread national impacts, establishing the Council on Environmental Quality (CEQ), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and led to the passage of the National Environmental Education Act (NEEA). NEEA established an Office of Environmental Education (OEE) within the EPA, whose job was to facilitate and develop EE curriculum for US schools across the country. The OEE was also assigned with training environmental educators and distributing grants to projects developing and promoting EE (EETAP, 2002). Most recently in 2013, the practice of EE has expanded in the United States due to the adoption of the Next Generation Science Standards (NGSS) by many states, which incorporate a greater emphasis on human/environment interactions and place-based experiential education (Coyle, 2014).

The Industrial Revolution significantly shifted the US population from primarily rural farmers to urban dwellers. In 1790, only one out of 20 citizens lived in an urban area; however, today, almost 80% of the total population lives in or around urbanized areas (US Census, 2010). William B. Strapp, a founder of contemporary EE, highlights this, stating in "past 50 years United States has become increasingly urbanized...As man became progressively urbanized his intimate association and interaction with them [nature] diminished, and with it his awareness of his dependency on them" (Strapp, 1997, p. 33). People under the stars and amongst the trees now find themselves in entirely manmade environments. Within the modern urban environment, humans are dissociated with many things that are fundamental to life, from where their food comes from to what happens to their waste. Today, a large portion of US society does not understand their actual ecological impact, further exacerbating environmental issues.

To counter these ever pressing issues, it is crucial to teach humans about their impact so they can make better, more sustainable decisions. David W. Orr defines a person's overall "knowledge of environmental systems" as ecological literacy and subject presumes both an awareness of the interrelatedness of life and knowledge of how the world works as a physical system" (Orr, 1992, p. 92). "Nature study is becoming more difficult, I believe, not because there are fewer books about nature, but because there is less opportunity for the direct" experience. With widespread urbanization and environmental degradation, it is paramount that the humans of tomorrow understand not only their impact, but are also taught the right information to adapt and survive in an increasingly complicated world.

Pedagogies of Environmental Education

EE is a growing field that can be used to address environmental problems. EE refers to organized efforts to teach how natural environments function and particularly, how human beings can manage their behavior and interact with ecosystems in order to live sustainably

(Smyth, 2006). It is a field of education that commonly intersects with many other disciplines such as biology, chemistry, physics, earth systems science, and ecology, as well as atmospheric science, mathematics, history, sociology, the fine arts, and more. As humans continue to use more of the earth's resources due to rapid population growth and development, our impact is becoming omnipresent. This has made EE a more crucial component of formal and informal education advents, as it has the potential to create informed citizens who understand their interactions with the natural world and strive to be stewards of their local ecosystems and the global environment.

The term environmental education is a highly debated topic, as it is a broad multidisciplinary field that can be taught in many different ways. Other terms similar to EE include ñeducation on the environmentò (Van Marte, 1990), ñenvironmental interpretationò (Smyth, 2006), ñenvironmental learningò (Smith et al., 2003), ñoutdoor educationò (McRea, 1990), and ñecological educationò (Smith et al., 2003). What separates these groups of thought is the methodology and pedagogies used to convey the knowledge as well as the different emphases placed on certain core concepts. Furthermore, many of these thinkers criticized EE as being entrenched in the values of the earth being filled with unlimited resources for human beings to exploit (Van Marte, 1990). It is important to understand when diving into the topic of EE that it is incredibly broad and can be taught in a multitude of ways.

In the book Ecological Education in Action, Smith et al. write about a different way of teaching environmental education, which they call ñecological education. The practice of ecological education requires viewing human beings as one part of the natural world and human cultures as an outgrowth of interactions between species and particular placesò (Smith et al., 2003). Ecological environmental learning addresses the criticism above by not viewing the natural world as separate from the human experience. Instead, ecological education holds the belief that the human experience is entirely influenced by the natural world. There are many benefits of this style of environmental learning when trying to teach about humans' relationship with nature. It provides important context for students to understand how their culture influences their world view. Ecological education can also help students grasp other cultural perspectives on nature and the environment, fostering a new world view. The ecological education style of teaching environmental learning follows the mission of who understand the interconnectedness of life.

Environmental education is usually taught through the pedagogies of place-based education (PBE) and experiential learning (EXL). These pedagogies seek to connect learning to the local ecological, cultural, and historical contexts in which schooling itself takes placeò (Elfer, 2011, p. 1). This style of learning echoes the experiential educational theories of John Dewey (1938), who espoused that hands-on, place-based learning in their communities can make it easier for students to contextualize material and engage in the lessons, as it is more authentic, relatable, and relevant to the immediate surroundings of young learners. EXL is a closely related pedagogy to PBE, and is

simply the act of learning while doing. Immersive EE curriculums incorporate PBE and EXL to teach ecological topics in a way that makes the material much easier to grasp and contextualize.

Another important pedagogy is outdoor education (ODE), defined as a way to provide meaningful contextual experiences in both natural and constructed environments that complement and expand on classroom instruction (Woodhouse and Knapp, 2000 p.2). It is a broader term than EE, which can be taught in and outside of the classroom. PBE and EXL can both fall within the framework of ODE. ODE can have many positive effects by allowing students a change of pace from the traditional classroom setting which usually revolves around the use of printed and electronic media in lecture-based settings.

Benefits of Environmental Education

The benefits of environmental education are wide ranging and profound. Many studies have shown that EE courses can influence students' attitudes to make pro-environmental choices. Dr. Andrew Schneller, the outcomes of experiential environmental learning on students in Baja, Mexico, found that EE as well as EXL can foster pro-environmental attitudes and lifestyle changes. His research compared an experimental group that participated in an EE course and a control group that did not take the course. Quantitative statistical analysis found no significant difference in changes to pro-environmental attitudes during the pretest and posttest. However, interviews with the students revealed more conclusive evidence of change. Shneller (2008) writes, ñAlthough the quantit significant results in the environmental action construct areas, we ascertain through interviews that the course significantly instigated social and behavioral outcomes on various levels in regards to pro-environmental actions among students (and their families) from this year, as well as students from two years agoò (p. 163). Sch the lack of significant findings from pretest to posttest can be attributed to design flaws within the test. He explains that it is incredibly hard to design a survey that captures the complexity of these issues and the changes in students' attitudes. Continuing, he discusses that qualitative and quantitative data is paramount to understanding the outcomes of experiential environmental education, as they paint a fuller picture of how the lesson impacted the students. Interestingly, the study displayed students as a gateway for bringing environmental knowledge to other community stakeholders such as their families and friends. This finding highlights the complex impacts that environmental education can have within a community and that the positives impacts can be on more than just the students themselves. His findings show that to truly measure changes in studentsô attitudes, inter (Schneller, 2008).

Kimiti Richard Peter et al. (2013), discuss the benefits of EE in a research study of Kenyan students. In the study, Peter et al. (2013) found that teaching environmental education had widespread impacts on students and community action, in regards to many different activities. Teachers interviewed at the end of the study explained that they noticed community

members shifting from using chemical fertilizers to organic manure. Almost 90% of participants interviewed in the study explained that they now had a better understanding of the importance of reducing soil and water pollution (Peter et al., 2013). Furthermore, participants gained a better understanding of how certain chemical compounds such as leaded gasoline and carbon monoxide affect their health and the health of their community. The study concludes that providing communities with environmental education allows them to better understand their impact on the natural environment and how to make choices that can reduce this impact (Peter et al., 2013). This study further highlights the importance of EE in fostering pro-environmental attitudes and behaviors, and how they can have widespread influences on the communities in which they are being taught (Peter et al., 2013).

Environmental Education in Schools

Ecosystem Education

Elementary and middle school students cover a wide variety of topics within their science courses, such as ecology, genetics, human biology, evolution, earth and space, matter and energy, and history and philosophy in science (Littledyke, 2008). Environmental education is highly relevant throughout many of these topics. Nonetheless, for years educators have often left environmental themes out of the curriculum. Food webs are a basic step in the teaching of ecology, showing the interconnectedness and interdependence of life. This is especially pertinent to consider when discussing human-animal interactions, due to human dietary patterns and how they have implications for the welfare of animals and ecosystems (Littledyke, 2008). Through the creation of food webs, students begin to understand matter cycles and how recycling is natural in ecosystems and should be more explicit in the manmade world (Littledyke, 2008). By teaching energy flow hand-in-

also found a disturbing amount of teachers who misunderstood this concept. Therefore, it is essential to use different pedagogical methods when teaching this valuable concept to young students. Kelemen et al. (2014) completed a study regarding how young students in Boston, MA were able to grasp the concepts of adaptation by natural selection using picture books. This study was conducted with a control and treatment group, giving the treatment group a 10-page story book the authors created, using realistic pictures and factual narrative about an animal's evolution. After conducting and analyzing their results through pretests and multiple posttests, the authors concluded that "young children's understanding of natural selection is more robust when it is presented in a basic, cohesive, co
This study emphasizes the importance of keeping young students focused by using visuals and tools that are captivating.

Bohlin et al. (2017) also highlights the multimedia principle when teaching science, which suggests that people learn better from
(Bohlin et al., 2017, p.976). In addition to pictures and words, dynamic visualizations such as videos can supplementally aid in communicating aspects that may be difficult to understand using static visuals (Bohlin et al., 2017). Visualizations also aid in portraying events or processes that span large or short amounts of time (longer or quicker than young students may be capable of putting into context); in this case visual representations are key in fostering an understanding of evolutionary processes (Bohlin et al., 2017).

Climate Change

In modern times, human beings are dealing with an unparalleled rate of climate change, creating risk and uncertainty regarding the future (Stevenson et al., 2017). In order to battle the ever changing environment, it is vital to educate younger generations about climate change mitigation and adaptation (Stevenson et al., 2017). Nevertheless, it is important to approach these heavy topics in a sensitive manner when educating young children. Stevenson et al. (2017) "addresses what and how students might be engaged to learn and teac
preparation for an uncertain future arising from the risks and the human ecological impacts of climate change" (p. 1). When teaching climate
creative and critical thinking is fundamental (Stevenson et al., 2017). Collaborative problem solving and cooperation help engage youth with this information in a productive manor (Stevenson et al., 2017). Climate change educ
process" which includes learning how to take
2010, p. 242). It is essential for students to explore the root of the problem as it is multifaceted, which can be achieved through discussion and debate (Stevenson et al., 2017). A key part of climate change education are the concepts of mitigation and adaptation, both at local and global levels (Stevenson et al., 2017). When discussing these ideas, some argue that individual actions are not as important to stress because climate change, at its core, is a systemic issue and requires systemic change (Gonzalez-Guardiano and Meira-Cartea, 2010). However true that may be,

These skills included the motivation to learn, the intent to apply learned information to their own lessons, the actual practice of adapting the information into their teaching, and the development of professional networks (Li et al., 2016). The authors found that participant-content interaction was the most essential in reaching their goals, followed by participant-participant, with participant-instructor interactions only resulting in the development of professional networks (Li et al., 2016). Studentsô interaction with the such as videos and games, was vital in achieving student course satisfaction and a true motivation to learn and apply the themes of the curriculum (Li et al., 2016). The pedagogical approach of participant-participant interactions is not new to online learning and has achieved beneficial results in numerous previous studies, supported yet again in this research.

Although the research conducted by Li et al. (2016) focused on the education of instructors, the results could be extrapolated to other online learning settings to understand the value and weight of these three student-focused interactions. Multi-media participant-content interaction has been successful in promoting student motivation for a topic and likelihood to apply the ideas outside of the course. Both participant-content and participant-participant pedagogical approaches should be highly considered by online educators, particularly those in the environmental field, as to maximize positive outcomes in students.

Optimal Application of Online Education

Martin (2020) covers five main ideas to keep in mind in order to optimize online learning in the age of Coronavirus: instruction, content, motivation, relationships and mental health. The first is instruction: the need for instruction to be as well organized as possible, especially when students are learning new or difficult subject matter (Martin, 2020). In a traditional classroom, it is easy for a teacher to monitor whether students are grasping the content, and are able to adjust their instruction as they go. However, in an online environment, this is lost; there is a higher risk of losing learners if too much information is delivered too early (Martin, 2020). A way to reduce this stress is load reduction, which will keep lessons manageable while also providing feedback (Martin, 2020). The second idea is content: vet your online materials to ensure students are working with the best material possible (Martin, 2020). A good idea when teaching online is to look for online textbooks that are well targeted to the education syllabus (Martin, 2020). The third idea to optimize online learning in the age of Coronavirus is motivation: you need to keep students engaged by keeping their energy and effort up (Martin, 2020). Martin discusses what he considers to be the most important area of motivation in regard to online education: self regulation. The umbrella of self regulation encapsulates task management, persistence, and planning (Martin, 2020). Online learning creates a plethora of distractions, whether it is gaming, social media or internet rabbit holes (Dhawan, 2020; Martin, 2020). It is vital to keep students from these impulses, as hard as that may be. Martin discusses the importance of content and instruction in battling a lack of motivation (Martin, 2020). Moreover, frequently reminding students of these risks, printing hard copies, parental monitoring, and negotiating a school work/freetime timetable are other ways to avoid hindered motivation (Martin, 2020). Similarly,

Kufi et al. (2020) state how difficult it is for adolescents to stay focused for long periods of time, especially when they are in a remote setting. The authors emphasize the importance of group work, discussions, and cooperative learning as an effective tool to keep students focused (Kufi et al., 2020). The fourth idea is relationships: teacher-student and student-student relationships are an integral part of learning (Martin, 2020). It is important to keep things interpersonal when possible or applicable. Martin (2020) has observed that students seem to be adequate at addressing one another online and out of the classroom, so it is also important to emphasize the teacher-student relationship. Martin (2020) further states that under-communicating is usually better than over-communicating (p. 2). Teachers can communicate with students using different modes such as email, video, blogs and class group chats. The last component is time. Support usually suffers from a lack of time (Martin, 2020, p. 2). Support is assistance for the students in an online atmosphere. This is also an anxious time for many, so it is important to consider that some students may have lost loved ones and to provide appropriate support.

order to keep up with the pace of the courseò learning is better fit for older students, posing far more difficulties to elementary-aged students who have a greater dependency on their teacher.

There are certain subjects and courses that, despite the benefits of online learning, would be most beneficial in an in-person setting, such as surgery, dentistry, and athletics (UIS, 2020). Similar to these subjects, environmental education benefits from experiential education approaches, such as field experience and outdoor learning (Jose et al., 2017). Soga et al. (2020) discuss the concept of the extinction of experience, or a person's decreased time spent in nature, studying the relationship between it and negative attitudes towards nature and biophobia. The authors used questionnaires to understand the correlation between biophobiað measured in children's dislike, fear, or perceived danger of natural things (insects and spiders) ñ and different personal and environmental factors, such as environmental knowledge, time spent in nature, and level of urbanization at home and school (Soga et al., 2020). They conducted this study in central Japan, selecting a diverse range of students from over 50 different elementary schools, totaling 5,375 participants (Soga et al., 2020). The researchers found a significant negative correlation between an aversion to invertebrates and greater environmental knowledge and experiences. Although knowing the causality between these two factors would require further research, Soga et al. (2020) concluded that environmental education, particularly that which offers experiences and quality outdoors time to students, is important in fostering positive

and has now risen exponentially on a global scale due to the Coronavirus (Liesman, 2020). Professional environmental educators throughout the nation are adapting quickly to the challenges presented by the pandemic, working to shift towards online education in a meaningful and effective way. The North American Association for Environmental Education (NAAEE) provides online workshops and courses for environmental educators as to assist in this difficult transition. These webinars provided by NAAEE offer resources and guidance on how to teach environmental education in a safe way while maintaining the use of valuable pedagogies such as place-based and experiential education (NAAEE, 2020). With benefits such as greater inclusivity, better discussions, and higher engagement (Sener, 2011), it is possible that these technological modes of instruction could influence the face of education for a long time to come (Taparia, 2020).

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			Selection			
Lesson Description	Students learned the life cycles of monarch butterflies, red-tailed hawks and spring peepers. Discussed how they are alike and different.	Students learned about the organization of animals into categories based on physical and behavioral traits. Discussed vertebrates such as mammals, birds, fish, reptiles, amphibians, as				

This research took place in Saratoga Springs, New York, a city with a population of just over 28,000 citizens (U.S Census Bureau, 2019). Research was conducted in the 5th grade science classes of two private elementary schools, one as a treatment group and the other as a control group. The treatment group class contained 15 students.

The control group, who took pretests and posttests but were not taught the EE curriculum, consisted of another 5th grade science class at a comparable school, not engaged in an online environmental education curriculum. This class was comprised of 23 students.

The treatment group students along with their primary teacher were located in the classroom together, while us teaching the curriculum taught over Zoom, as we were not

FINDINGS

Quantitative Findings on Environmental Knowledge

Using an independent samples t-test at pretest, there was no significant difference found between the knowledge scores of the treatment and the control groups ($p = 0.662$). At pretest the treatment group scored an average of 14.75 and the control group scored an average of 13.93 out of 35 total possible points.

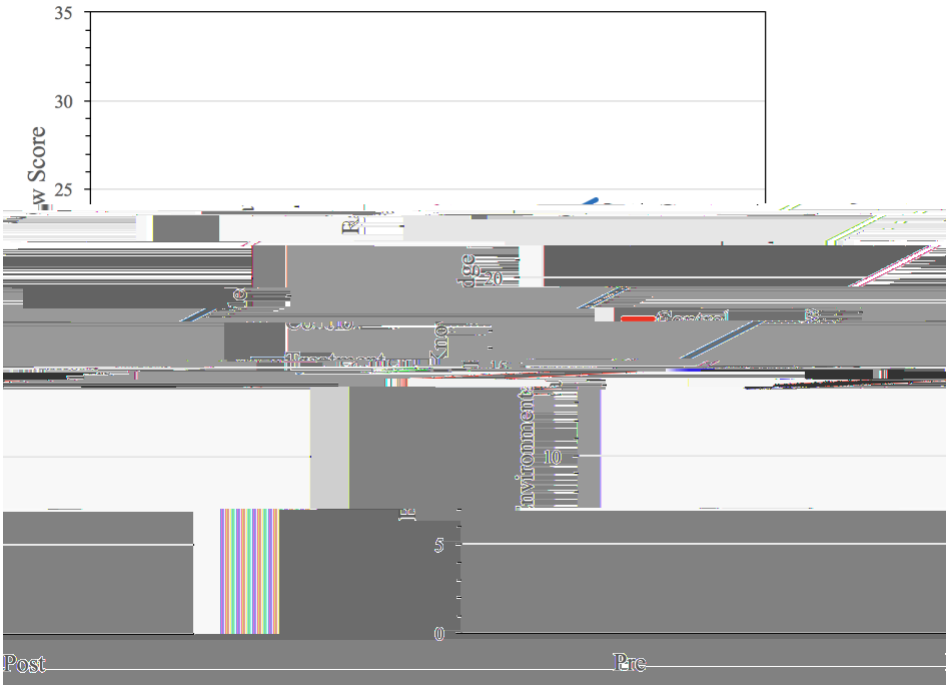

Figure 1. Environmental knowledge scores pretest vs. posttest

At posttest, utilizing a Wilcoxon signed rank test, a nonparametric test procedure for the analysis of matched-pair data, we found that the difference within both the treatment and control groups was statistically significant. Out of 35 points, the treatment group scored an average of 24.38 points ($Z=-3.069$, $p<0.002148$), and the control group scored an average of 14.87 points ($Z=-1.234$, $p<0.217203$). Based on the Wilcoxon signed rank test p-value scores, the treatment environmental knowledge scores significantly improved and control group scores did not. The treatment groups environmental knowledge scores improved by 65.3% (9.63 points) while the control only improved by 6.7% (0.94 points) (Figure 2). The improved environmental knowledge score in the control group can likely be attributed to increases in knowledge within and outside of the classroom, despite the fact that they were not treated with the environmental education curriculum. Using an independent samples t-test at posttest, we found

environmental knowledge scores statistically differed from those of the control group ($p=0.0000109$).

Qualitative Findings

Advantages and Challenges of Online Environmental Education

During the focus group interviews with the treatment group, students discussed their experience with online environmental education. The largest takeaway was the students preference for in-person education. Parents and the students' primary teacher corroborated these opinions by discussing the limitations of online student-teacher relationships and content communication. Students explained that they enjoyed powerpoint presentations in comparison to in-person writing on the whiteboard. (Table 2). Though the students had positive things to say about their online environmental experience, it was clear that there was a preference for in person education. In addition, the primary teacher felt that the students struggled with parts of the PBE element of the curriculum, which she attributed to the class taking place online.

> Teacher: The place based a s p e c t d i d n ô t c o n n e c t a s w e l l a s I w o u
> apart. If they had the opportunity to maybETQ108.eOLWWOH

I do like the slideshow because I thought it was really easy to see. I think even if they were like going to do it again in person [they should keep the slideshows].

I really like the slideshows because if they had been in person, they would have written it on the whiteboard, and they would not have had enough space to write it, so they'd have to erase some things, and it was easier with the slideshow.

> I learned about the Karner blue butterfly é the monarch butterfly. But now that I know about the Karner blue Butterfly, it's just really interesting, and to see how/if they come back or if they don't.

Multiple treatment group students, the stu parents indicated that students have spent time outside of class engaging with the issues they learned in the curriculum (Table 3). A few students stated that they chose to research environmental issues such as wetlands, runoff, and animal diversity on their own time, and have brought these discussions home to share with primary teacher noted that the students discussed an activity they did in the environmental education curriculum about watersheds amongst themselves in their free time, which allowed them to engage with the material further. ñTh the teacher. Both of the interviewed parents expressed that they believe their child will remain interested in the curriculum topics after the completion of the lessons. One of the students whose parent was interviewed has always been interested in the environment, so it is important to note that this passion may not have been a result of the curriculum, although the parent believes the curriculum gave her child tools to further her interest. The other parent stated that their child:

Broadly they have an understanding that óI could
because they werenôt given a specific óaskô to t
on that a little bit after to

Further research is necessary to evaluate the impacts of a perceived ceiling effect on the intergenerational learning of pro-environmental behaviors.

Table 3

Well, I like them all. But if I had to least favorite, it would be probably the life cycles. Because although it was all very, very interesting information.

19, overall intergenerational learning may ha
see more of their friends in person.

Although the lessons involved many PBE com
that these components may have been lost on the students as a result of the curriculum's online implementation. This was further disp

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