

A Case Study for Fostering CIVIC Engagement: Theory for Developing Environmental Stewardship in Adolescents through Outdoor Recreation and Student-Driven Long-Term Research in Science Classes

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Abstract² This case study explores an application of the theory that practicing science outdoors empowers students to be agents of change and later identify as environmental stewards. Decades of research in the scientific community have contributed to an understanding of the value of nature for child and adult development. However, millennia of research from Indigenous communities around the globe have already identified the value of the human-to-land connection. Scientific exploration that incorporates Traditional Ecological Knowledge could provide an opportunity to connect students to the land in a concrete and sustainable way, encouraging future student involvement in global ecological issues. This case study, from the perspective of a non-Indigenous author in a predominantly non-Indigenous population of adolescents, explores implementation, data collection, and establishment of procedures for student research and long-term data sets in an ever-changing project. In addition, it will discuss the benefit of outdoor place-based education in fostering environmental stewardship in students.

Keywords² place-based education, environmental stewardship, sustainability, indigenous science, outdoor recreation, traditional ecological knowledge, civic action

I. INTRODUCTION

³, I ZH ZDQW FKLOGUHQ WR yIOPXJKVN WROERHFRPOMGUXORRFN 1D WKHP WR 1JVDYH LW

empowered, let us allow them to love the earth before we ask them to protect it. Changing climates, pollution, and biodiversity loss in the 21st century have forced us to consider our place in the community, nation, and planet. As we reflect on next steps, it is important for each educator to ask themselves how their classrooms will inspire the necessary reform. What do we want our youth to gain from being present in our classrooms? What do we hope for them in the future? What role can we play in this journey? Through outdoor recreation, student-led research projects and a strong connection to ancestral and modern Indigenous ways of knowing, we can influence the future of our youth by asking these complicated questions.

It is well-documented that a connection to nature and wild places can enhance physical and emotional health [2], [3]. But in a rapidly changing climate, how can we empower students to become agents of change and environmental stewards? Educators must first provide students with opportunities to interact with and embrace nature. The fun factor. In conjunction with these activities, educators must provide opportunities for long-term data collection and a respectful study of Traditional Ecological Knowledge. This can be

achieved through coupling outdoor recreation and long-term student-driven ecological research.

II. LITERATURE REVIEW

Wisconsin-born conservation ethicist Aldo Leopold provides one of the best examples of this type of data collection from settler history, and how it can inspire policy change [4]. Through careful observation and wilderness appreciation, his phenological data spans over half a century. His family turned this type of data collection into a hobby, WDNLQJ ZHHNHQGV DW WKHLU IDP relationships amongst species [5]. This multigenerational data collection spanned over 70 years and became one of the most important local documentations of climate change and its effects on the local flora and fauna [4]. Starting first with outdoor joy, Leopold inspires us to expand our classroom walls and make conservation a constant, careful and record-driven practice.

But of course, Aldo Leopold was not the first human to note changes over time amongst species in Wisconsin. Specifically in the land referred to as Wisconsin by settlers, at the very site where this case study occurred, members of the POKXJKVN WROERHFRPOMGUXORRFN 1D studied ecological relationships and used this information to make decisions about land use. Evidence of their ancient occupation on ancestral lands, mostly in the form of burial or effigy mounds and fluted points, can be found all over the University of Wisconsin Madison and Edgewood College campuses, dating back 12,000 years [6]. Prior to settler arrival, Native ancestors practiced living in harmony with the land, taking many lessons from the plants and animals that called this land home before them. According to Aaron Bird Bear, Recruitment and Retention Specialist at the School of Education, UW Madison, observation of the landscape near the shores of the lakes influenced their policies and beliefs. One Chippewa love(d) it because they live(d) alongside this species (bur oak) of so long that they are culturally known as Bur Oak educators, it is important to learn from this careful and

¹ Using ecology to influence decision-making and policy has been happening for millennia through Indigenous traditions. This instance (Aldo Leopold) is one of the first documented examples from settler history. As Leopold was one of the first to write about and document it, he is referred to here, but it is certainly not the first time this has happened in this land's history.

constant practice of observation and emphasize its role as stewardship in students. Doing so requires understanding how environmental science in understanding the world around us. Students can then move away from only indigenous science (also known as Western Science), which focuses on written records and scientific methods and spans a few hundred years. This goal [7] to incorporating aspects of Indigenous science which does not simply include sustainability in a way that sustains nature alive and well, but also sustains our own independent existence, which in turn is not independent of knowledge sharing exclusively through written books, quantitative data, or journals.

While outdoor education has gained tremendous popularity since the start of the COVID-19 pandemic, learning through nature play and the outdoors has been a global tradition for millennia amongst Indigenous communities. Under the umbrella term of Indigenous science sits the term Traditional Ecological Knowledge which has been a key part of this case study. Traditional Ecological Knowledge differs from Indigenous science as it can be experienced and learning and behavior in Swiss adults. In this study, Finger [12] identifies a paradox between the high level belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another calls the Lifeworld approach to environmental behavior. Ecological Knowledge should not be seen as separate from Western or Indigenous science, however. Instead, it should be explored as a collaborative approach. Why? Explains this collaborative approach:

3, W VHUYHV WR LQYLWH GLYHUV... from one another about how each approaches the very different approaches can work together to better steward and side the scope of this paper; sufficiently the research was PDQDJH WKH HQYLURQPHQW. DQG QDWXUHLWHUHQWLYH. After performing

As students of science, we know that large datasets three regression analyses from the data, the author concluded make a huge difference in understanding ecosystems at large and tracking changes over time. How can this dream become a classroom reality? What outcomes can you expect? This paper explores the evidence behind this practice and shares tips for success based on a decade case study from Madison, Wisconsin, USA in an adolescent learning community.

Richard Louv describes the relationship between potentially result in greater environmental behavior. In other words, this disorder is characterized by a lack of knowledge about the natural world (including natural processes, food origin, and biodiversity) and insufficient outdoor playtime. Symptoms include diminished senses, attention problems, and physical/emotional illnesses. As future generations of young people are faced with multiple environmental concerns, one could reasonably assume that the next generation will require a deep understanding of, and respect for, the natural world. As outdoor enthusiasts, educators involved with the project outlined in this case study have identified one outcome of the program: the development of a sense of environmental stewardship in students. Stewardship involves more than knowledge of a need or topic; it requires engagement, action and cooperation. It encourages community involvement and promotes a deeper understanding of the natural processes. Although only a small portion of our students may become professional scientists, each one is already a citizen of the Earth. Because of this, it is vital that we continue to foster a sense of environmental stewardship in students.

enact change, and policymakers are interested in and grateful for their input as they represent the future consumers and users of shared spaces. By valuing the perspective of adolescents and pairing them with urban planners, they saw their work and opinions visualized in their neighborhood landscape.

III. MATERIALS AND METHODS

Lake Wingra is 321 acres with an average depth of 9 feet and a shoreline of 3.6 miles, making it the smallest of the Yahara Chain of Lakes in Madison, Wisconsin, USA. Edgewood Campus School sits on the shores of the north side of the lake and offers private schooling for students in 4K through 8th grade (ages 4-13). Since 2014, this school has employed a place-based approach to science education that incorporates lake science and specifically Lake Wingra as well as ancestral Indigenous occupation of the lake before the arrival of European settlers. In the greater Madison area, public and private organizations (including Friends of Lake Wingra, the Department of Natural Resources, and the University of Wisconsin-Madison Center for Limnology) have provided research on and resources for the study of the local lakes and their relationship to the human population of this area. Citizens who are active in the community of scientists and policymakers have a history in Madison, Wisconsin; Earth Day celebrations originated here over 50 years ago.

Middle school science standards for the state of Wisconsin reflect a wide range of inquiry-based scientific practices including those in ecology, chemistry, earth sciences, and scientific experimentation. Obstacles to learning projects in schools center around commitment and buy-in from instructors. Tying projects directly to standards has been fundamental to Edgewood Campus School's success. Students in seventh and eighth grades participate in this study during the introductory unit on Ecology. Seventh grade students look at the Ecology of the Lake through the biotic components and overall geography. An introduction to limnology. Students in eighth grade take a second look at the lake in a unit on the Ecology of the Lake through the abiotic factors that influence the lake's chemistry.

The Wisconsin Science Standards (closely linked to the more globally known Next Generation Science Standards, 2013) are:

- SCI.SEP4.m Students extend quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- SCI.SEP5.m Students identify patterns in large data sets and use mathematical concepts to support explanations and arguments.
- SCI.SEP7.m Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- SCI.LS1.C.m Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.
- SCI.LS2.A.m Organisms and populations are

dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.

- SCI.LS2.C.m Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.
- SCI.ESS2.A.m Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources.

At its birth in 2014, the lake sciences program at Edgewood Campus School required students to survey and gather samples from the lake environment on foot. This included terrestrial and aquatic sampling; boardwalks and piers were used for access to obtain aquatic samples. A map of the campus can be seen in Fig A roughly .5km walk brings students from the classrooms to the lake shore riparian zone. Within the first year, the program added the use of kayaks and canoes to bring students into the lake to gather samples of water and plant material. A nearby boat outfitter was utilized to help with this. This required a full day of students getting to and on the lake. It was a challenge to have students missing other courses so frequently, as this was only a part of science class curriculum.

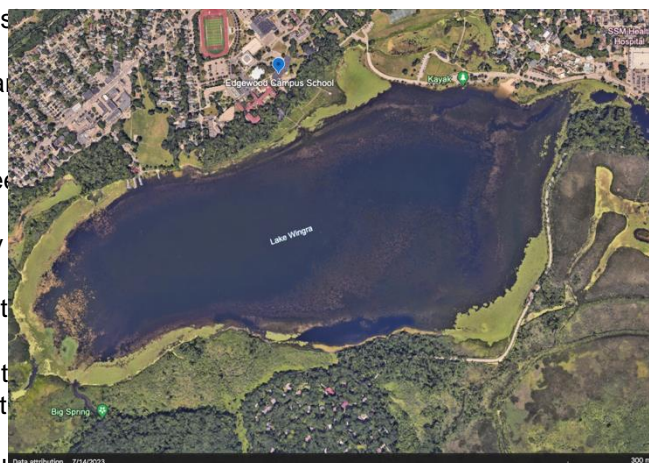


Fig. 1. Google Earth imagery of Lake Wingra marked for Edgewood Campus School [16].

As data collection continued and developed with the help of University Wisconsin Limnology Department experts and Department of Natural Resources guides, Edgewood Campus School teachers began to apply for outside funding to outfit the school with their own fleet of kayaks for student data collection. Currently, the school has enough kayaks to have 19 students on the water at a time. The kayaks are now stored on site near the water, decreasing travel time dramatically and allowing data collection to happen more frequently. Eliminating the time requirement has allowed students to focus on high quality data collection methods, frequency in sampling, and data analysis. A group can get on and off the water for data collection with sufficient time for safety and precision in a 50-minute class period. Once the initial obstacle of accessibility was eliminated, focus turned to enhancing the research to be student and consistent over many years. With support from the Hasler

Laboratory at the University of Wisconsin protocols were ecosystems [19]. In our scenario, Lake Wingra provides a established for data collection including zooplankton home base for students to consider the entire ecological analysis, macroinvertebrate sampling, macrophyte sampling, community (aquatic and terrestrial). Students are presented conductivity, pH, dissolved oxygen, carbon dioxide, turbidity with the tools used (a majority of the tools used come from nutrient analysis (phosphorus and nitrogen) and temperature the LaMotte Water Quality assessment kits), provided (both surface and at 1 meter depth) opportunities to practice these techniques in a laboratory setting, and then asked to make predictions about the levels of each parameter they explore. Hypotheses are based on local findings [15]. However, because the focus of this research is existing research (from studies gathered data over the last ten Edgewood was to celebrate and explore the Indigenous years) as well as more global data (from lakes throughout the knowledge and science of this sacred space, emphasis Great Lakes Region of the United States) This process of also given to incorporate concepts from -Ojibwe tribes prediction-making based on existing data is key in helping both historical and current. As literary references are not students explain how these levels impact humans and wildlife part of traditional Indigenous communities, we use like. Samples are brought back into the classroom and alternative sources of information like lectures, podcasts, and analyzed. Data is recorded on paper first and then input into a guest presenters to learn about the significance of Lake Wingra for both ancestral and modern HoChunk people. Students regularly look at data to determine Lake Wingra is famously a springed lake with roughly two dozen springs still active today [17]. The connection between native HoChunk tribal members and the springs of Lake Wingra can be seen when considering the original name support of a math teacher during both math and science this lake from HoChunk, Kichunkochheperrah, meaning classes. Teachers reported greater student interest in these 3 3 ODFH : KHUH WKH 7XUWOH & RPH WINDS' and were valued. Attribution Doc use in still are places of sacred importance for ceremonies to multiple classes (both math and science) explore pathways between the animal and human worlds. This process of sampling, testing, and analyzing is carried Students begin their year by observing the shorelines of Lake Wingra and exploring the multiple burial mounds along the shorelines and parameters each time. While efforts are made to shorelines. We ask questions about the sacred significance eliminate any additional variables aside from the date change, the land (for example: Why did ancestral-Ojibwe tribes we acknowledge that there are situations out of our control choose to put effigy mounds in this location?) and look at what might impact our data (namely human error). Students accounts of the mounds and springs from settlers in the early worked in teams to gather data for specific parameters and years of Wisconsin statehood [18]. We also explore the very SUHVHQWHG WKLW GDWD LQ D IRUP DO nature of science as a way of knowing. Most students SWDWH RI WKH /DNH \$GGUHV V' ZKLFK involved with this case study, at this point in their education about their analysis of the overall health of Lake Wingra. have experienced science to mean only -Indigenous Influential policymakers and individual scientists who science. We work as a group to ask whether types of provided support for this opportunity are invited. The city of information are valuable and necessary to include Madison holds an annual State of the Lakes addressed extensive history of this area beyond the temporal scope by the Clean Lakes Alliance. Scientists, community members, starting at Wisconsin statehood. By beginning the unit of and policymakers gather to discuss and plan for the future of study with the HoChunk people, students are reminded that the Yahara Watershed [20]. the land they know as Wisconsin has changed many times it should be noted that to perform the data collections throughout human history and will continue to change. students engage with Lake Wingra through outdoor Inquiry continues for students as they are asked to consider recreation. As previously mentioned, experiencing joy the focus question for this unit: What is the health of our lake outdoors and the discovery of nature could be key to ecosystem? Lake Wingra is part one of the most studied enhancing stewardship among students. Although kayak trips lakes in the United States due to its multiple property and are, at first glance, designed to acquire samples for analysis in presence as an urban lake. University of Wisconsin the lab, their dal purpose is to allow students an opportunity Arboretum, private golf courses, public and private schools to embrace and experience nature from a new and exciting and residential units sit on its shores. Students explore the perspective. While many students have experienced some multiple uses of the lake for recreation, drainage, and sort of lake excursion with family, not all students have educational opportunities in addition to its value in nature and addition to kayaking, the image in Fig 2 shows students a wildlife corridor. By making visual observations of this using gas-powered ice augers to reach the lake water for multi-use resource, students begin the process sampling during winter months. As a class we regularly understanding multiple stakeholders and using civil observe (with the help of binoculars) green heron nests when discourse to explore needs. Their end goal is to be able they return during late spring, float above bluegill nests answer this initial question with data they have personally sites in the summer, and even identify seemingly magical taken, compare it to existing data, and participate in a civil subjects in the lake as freshwater bryozoans. All of these engagement activity where they make an effort to influence activities combine as a socially joyful experience for the health of the lake in the future by practicing adolescents under the guise of science. Fig. 3 demonstrates environmental stewardship. the value of these experiences during COVID-19

Parameters for water sampling are established for lake pandemic when social interactions were limited.



Fig. 2. During winter months, students use ice augers to drill holes when the ice is thick enough (7+ inches) to gather samples to analyze (February 2021)



Fig. 3. The pandemic provided a unique opportunity to have students outside and learning instead of learning online or on screen. Students were still able to meet for regular data collection throughout these years following the recommended safety protocol. A student is pictured with a Secchi disk. (October 2021).

The final and perhaps most important component of this unit of study is a student-led civic action project. During this time, students identify an area where they can make a difference in their community based on the information and data they and their teammates have collected. Sample civic action projects have included group and individual activities and ranged from contacting and speaking with local members of government to starting neighborhood campaigns to remove excess leaves from gutters (minimizing nutrient runoff into lakes). The student-driven nature of this process is key. As they have already participated in the six steps above, they are well versed in issues that surround the lake and major stakeholders that can be impacted. Students can take their own interest (social engagement or education, physical activity, written word, art as a message of change) and influence their immediate community. The following is a list of student-driven civic action projects that were carried out during October 2019:

- Help neighbors by volunteering to remove leaves from the street/sidewalks
- Educate the community with flyers about issues that impact the lake
- Interview the maintenance staff at schools and churches about their road salt use
- Educate peers on the effigy mounds on campus and how to treat them with respect
- Create information warning about invasive species and their removal
- Assist community members in signing up for Rain Alerts to avoid runoff from leaves into the lake
- Start or improve a compost pile
- Write to policymakers about lake pollutant concerns, specifically road salt and nutrient loads from agriculture and leaf runoff

IV. RESULT AND DISCUSSION

At the end of the unit, students were required to take formal assessments to demonstrate they had met the goals set forth in the standards at the beginning of the unit. Each student was also asked to reflect on the unit by answering the TXHVWLRQ³: KDW VWDQGV RXW WR \R HQMR\HG" 5HVSRQVHV ZHUH UHFRUG. Several responses from October 7, 2021 were as follows:

- 30\ IDYRULWH SDUW ZDV JHWWLQJ will help the community we are in. I felt like in this unit we were able to do science that seemed very similar to what real scientists do in their fields. Making our presentations, lab reports, and other projects on what we found in our lake felt good because we were greatly contributing to knowledge on how to help Lake :LQJUD
- 3, UHDOO\ OLNHG ZULWLQJ P\ 6WDV liked this because I enjoyed writing about a Lake that I have been to and kayaked in. I thought it was cool that in this unit we were actually doing something to help RXU SODQHW DQG ODNH
- 3We might've helped actual research on the lake, and it IHHOV JRRG WR PDNH D GLIIHUHQFH
- 30\ IDYRULWH SDUW RI WKH XQLW I thought it was fun to collect data on the oxygen, turbidity, pH levels, etc. When kayaking, it not only was fun but it also was for a good purpose. It made me feel good to know that I was making a strong impact for the IXWXUH RI /DNH :LQJUD
- I liked writing the letter to the mayor because I want to learn more of what people are doing in the real world to prevent lakes from dying. I also liked when we gave the state of lakes an address because it felt very professional and! HQMR\HG LW

Unedited responses from Google Forms by 8th grade students taken on October 7, 2021. Although the previous responses are student-written, they are not complete confirmation of fostering stewardship or agency to last a lifetime. They are, however, confirmation that student interest was sparked. They also tell us that despite the growing number of studies into outdoor education, there is a lot still to be explored. Just as the conversations between Western or non-Indigenous science and Indigenous science encourage us to look at data that is

not only qualitative or quantitative, we too must look to our research on the lake ecosystem provided many hands our success in school. Joyful students look to the future opportunities and field trips for students in this case study. possibilities as something that can be influenced. By giving their involvement allowed students to connect their students a chance to dive into a topic on ecology in their classroom work to active, ongoing scientific research. They neighborhood and introduce a civic action to help, we also provided resources to compare existing data to giving students a voice and agency for a future of support more accurate analysis. environmental obstacles.

Educators in the 21st century have obligations to prepare this program the funding to purchase an entire classroom set their students for a changing climate. Understanding the binoculars, allowing students to gather data on bird science behind these changes and how to study them is migration and populations as well as identify bird nesting part of the process. An integral part of this preparation should be strategies. Putting real tools into students' hands is integral to focus on solutions that can be achieved by collaborating with making this project exciting and fun for students.

community members and learning from existing. Lastly, this case study and the entire place-based education non-Indigenous science and Indigenous science alike programming described here was a collaborative effort with Placebased programs like the one described in the case study by support of the Edgewood Campus School, primary and above prepare students for a world where they will be making secondary school educators, and program directors (Dr. Amy decisions about land use and ecosystem management by Schiebel, Jennifer Koziar, Heidi Pankratz, and Bridget demonstrating the intrinsic value of the landscape and the Moylan). The strong community of educators who believe in providing students with the tools necessary to make the vision of outdoor place-based education is vital to the impact in local communities. long-term success of this program.

dependency on the soil animal (human) food chain, and of the fundamental organization of the biota. Civilization has so cluttered this elemental (human) earth relation with gadgets and middlemen that awareness of it is growing.

This case study suggests that this cluttering can be achieved through outdoor recreation activities like hiking and kayaking coupled with long-term data collection. By implementing a place-based research program in adolescent formal education, students were able to see long-term impacts and make connections to themselves and their communities. Although data for this research is not quantitative in manner, it demonstrates a need for more placebased education research in fostering environmental stewardship and suggests that perhaps this way of looking at success (written, quantitative, focused on Western science) could be expanded to include, more philosophically, attitudes towards civic engagement projects and individuals, self-identified place within the natural world.

CONFLICT OF INTEREST

The author declares no conflict of interest

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In addition, the University of Wisconsin Hasler Laboratory

The National Resources Foundation of Wisconsin granted this program the funding to purchase an entire classroom set of binoculars, allowing students to gather data on bird migration and populations as well as identify bird nesting strategies. Putting real tools into students' hands is integral to making this project exciting and fun for students. Lastly, this case study and the entire place-based education programming described here was a collaborative effort with the support of the Edgewood Campus School, primary and secondary school educators, and program directors (Dr. Amy Schiebel, Jennifer Koziar, Heidi Pankratz, and Bridget Moylan). The strong community of educators who believe in the vision of outdoor place-based education is vital to the long-term success of this program.

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