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The Power of Connection: Discovering the Effects of Formal and Nonformal Environmental Education on Students' Connectedness to Nature

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ABSTRACT

This study examined the relationship between students' feeling of connectedness to nature (CN) and their exposure to environmental education (EE) experiences at formal or nonformal environmental education organizations. CN, often developed through EE programs, is a good predictor of environmentally responsible behavior (ERB) and is also an indicator of self-nature overlap (Mayer & Frantz, 2004; Erdoğan, 2011). The Connectedness to Nature Scale Revised (CNS-R) (Tugurian, 2014), and the Inclusion of Nature in Self (INS) (Schultz, 2002) surveys were administered at formal (N=3) and nonformal (N=3) environmental education organizations (EEOs), surveying students (N= 5,994) aged 7-14. Students participated in a range of program types including homeschool, summer camps, extended day, and overnight programs. Aggregated pretest and posttest survey data were analyzed to determine how students' feelings of CN were affected by their EE experience and how these scores were influenced by age, duration, and frequency.

Keywords: Environmental Education, Environmental Education Organizations, Nature-based Education Programs, Environmentally Responsible Behavior.

INTRODUCTION

This study examined the relationship between students' feeling of connectedness to nature and their exposure to environmental education (EE) experiences at formal or nonformal environmental education organizations (EEOs). It was intended to address the need for a quantitative comparison between formal and nonformal environmental education organizations in Maryland. The study addressed the influence of several variables (age, duration, frequency, and type of environmental education organization) on students' feelings of connectedness to nature. Connectedness to nature (CN), often developed at nature-based education programs, has been shown to be a good predictor of ecological behavior and to indicate self-other overlap between the individual and the natural world [4]. For hundreds of generations humans have lived in close connection with the land, learning from and feeling a part of the broader natural world. This environmental connection has been a quintessential part of the human experience throughout history [14]. Given the current environmental issues surrounding human degradation from the local (ground water pollution) to global scale (global climate change), the importance of being an environmentally aware citizen cannot be understated, especially given that humans today spend upwards of 90% of their time indoors

[8, 15]. This contrasts with the biophilia hypothesis which suggests that humans have an innate desire to rekindle the connection with the land, a connection that our ancestors once had [25,12]. When humans spend more time indoors, the disconnection from the land increases while an individual's health and feelings of life satisfaction wane [9]. But, as humans reconnect with the land through experiences such as EE, they develop a deeper appreciation for it and incorporate it more within their self-identity which in turn promotes environmentally responsible behavior (ERB) [21, 22]. This demonstrates why it is important, for both environmental and human health, that EE rekindles CN and promotes ERB. Within EE, there are formal and nonformal EEOs. Formal EEOs are a part of the county public school system, only work with public school students, and require educators to have teaching degrees/certificates. Nonformal EEOs include nature centers and other organizations like nonprofits that do not require teaching degrees for educators and work with a variety of students, not just through the public school system. However, both formal and nonformal EEOs implement EE and nature-based curricula to establish CN and deeper knowledge of the environment.

This study addresses two fundamental questions in EE. First, does exposure to an EE experience increase students' feelings of connectedness to nature? Second, to what degree are CN scores influenced by: type of EEO, age/ age range, duration of EE experience, and frequency of EE experience?

LITERATURE REVIEW

Nature-based education has for decades focused on the relationship and connection between humans and their surrounding environment [5]. It is estimated that humans have lived in connection with and learned from the land for nearly 350,000 generations. As humans' relationship to nature has changed, nature-based EE has evolved. However, the emphasis of EE has continued to be on connecting people to the land that they occupy [17]. The connections forged during these experiences have led humans to have a deeper understanding of their natural surroundings and to act more intentionally toward the land [17, 9]. This in turn promotes stewardship and conservation of the land and a desire to feel a deep connection with the natural world [9,22]. The need to form this connection is acutely apparent and necessary in the face of today's environmental issues ranging from local watershed degradation to the global climate crisis.

Aldo Leopold [13], in his foundational work *A Sand County Almanac*, outlines the significance of viewing humans as a part of the ecological community. He argues that a connection to nature has been lost and/or diluted and that it is important for the survival of humanity to rekindle the connection to the broader community to feel the sense of belonging. Leopold describes the importance of adhering to a "Land Ethic" that provides rights to the land and establishes the land as a working integral member of the community:

A land, ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity. [13, p. 258] Leopold asserts throughout his book that being in connection with nature is the solution to the ecological issues of the day. For in connecting and existing in tandem with nature, one develops an appreciation and a desire to protect.

The importance of forging this connection was further substantiated in 1976 under "The Belgrade Charter: A Global Framework for Environmental Education". This document, created by UNESCO-UNEP, established the basis and common core of environmental education. As stated in the document, the goal of outdoor and environmental education should be: To develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, and motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones. [23, p. 2]

In this way, educators will imbue their students with the attributes needed to create positive environmental change and solve the issues that we face. These objectives outlined by UNESCO-UNEP are needed to forge a deeper connection and understanding of the natural world. Of specific importance is "Attitude: to help individuals and social groups acquire social values, strong feelings of concern for the environment and the motivation for actively participating in its protection and improvement" [23, p. 2]. Attitude is another way of describing the connection that the student forms with the environment during their environmental education experience, for when attitude changes so does the willingness to act with the environment in mind.

Whether it is viewed as attitude toward or connectedness to nature, the sentiment is the same. A feeling of connection and belonging with nature and holding nature close to your own identity leads to environmentally responsible behavior (ERB) [21]. The biophilia hypothesis also takes into consideration the human need to connect with nature. The hypothesis states that there is an "innately emotional affiliation of human beings to other living organisms." [26, p.31]. Mayer and Frantz [31] expand upon the hypothesis by describing how humans have a "biologically based need to affiliate with and feel connected to the broader natural world" [31, p.509]. Other authors [37, 39, 40] support this notion that the innate need for humans to feel connectedness to nature is deeply ingrained and can be used to study the influence that connection to nature has on ERBs.

Why should we care about creating this connection? Kals et al. [25] found that emotional affinity toward nature is a strong predictor of pro-environmental behavior. The authors found that 39% of emotional affinity connects back to previous experiences in nature. This exemplifies the importance of creating emotional affinity and establishing long-term experience in nature. This emotional affinity leads to moral ethics and a sense of responsibility that are fundamental for conservation behavior (ibid). The findings of Kals et al. (ibid) further substantiate the biophilia hypothesis exemplifying the human desire for emotional connection toward nature. The authors call for this connective experience to be integrated within education.

Another avenue to instill deeper connection that many authors {3; 10; 34] have described is the importance of allowing children to experience CN with an influential adult within their lives to create an emotional bond. This, in turn, will create intergenerational connections with nature and establish long term environmental conservation behavior due to these emotional connections [25; 33]. This is crucial when considering the myriad of human caused environmental degradations that the world is currently facing.

Frantz and Mayer [16] echo a similar sentiment. They highlight the significance of measuring this connection to nature to determine how willing people will be to perform ERB. The authors

reference that on average, humans are spending 90% of their time indoors [15]. In contrast, the authors found that subjects with higher Connectedness to Nature Scale (CNS) scores experienced higher life satisfaction. They found that there was a positive correlation between subjects' well-being scale scores and their CNS score, and that Inclusion of Nature in Self (INS) scale was moderately correlated to CNS. The authors thus claim that human well-being is strongly linked to their feeling of CN. Thus, the authors concluded that to improve the well-being of the natural environment and the well-being of the human population, humans must recover their CN. Similarly, Schultz [36] found that environmental concern stems from egoistic, altruistic, and biospheric concerns. The authors found that biospheric concerns were specifically tied to the survey subject's INS score. Furthermore, Tam et al. [40] found that when nature was anthropomorphized and made to seem like another human member of society, it was easier for humans to include nature in their self-identity, making conservation and ERB more justifiable. These authors concluded that as humans become more emotionally connected to nature, they are more likely to take actions that protect the environment. In protecting the environment, they are, in turn, protecting themselves and their natural community.

This demonstrates that in forming an emotional connection to nature, humans are more likely to engage in ERB. Humans with a connection to nature are also likely to have higher life satisfaction and will be able to establish intergenerational efforts to combat the local environmental issues that will in turn reduce the impact of environmental degradation. Environmental education looks to facilitate this connection between people and the natural communities we occupy [2]. Erdoğan [12] found that EE contributed significantly to "students' responsible environmental behavior" (p. 2233). Frantz and Mayer [16] state that "environmental education is a crucial component of confronting climate destabilization" (p. 88). Otto and Pensini [33] found that 69% of the variation in ecological behavior was associated with the feeling of CN, whereas environmental knowledge only accounted for 2% of the variance. Based on these findings, a goal of EE should be to promote CN in students and attempt to extend the duration of EE experiences; for the greater the duration and frequency of the EE experience, the deeper and longer lasting the emotional connection to nature will be [3]. In turn, this will promote lifelong ERB [45]. To get the most ERB from our communities, EEOs must facilitate connections with nature across all demographics, at a young age, and for extended periods of time [13; 28; 33; 41].

For decades there have been many attempts at measuring CN. Tam [39] performed an extensive review of many of the current surveys and their intercorrelations. The New Ecological Paradigm (NEP) is a well-used scale that has been developed and improved by the authors several times over [1]. However, these iterations were associated with many flaws and were found to measure multiple factors, not just CN [11; 1]. Furthermore, Dunlap et al. [11] discussed the struggles of measuring the "amorphous" (p. 429) concept of ecological worldview, and the challenges that accompanied it. However, Anderson [1] still described it as a "widely used measure" (p. 261) for pre- and post-test surveys. Tam [39] also reviewed the CNS [31] and INS survey [36; 28]. The INS focuses on the cognitive aspect of the survey subject and how they relate themselves to nature in the form of a graphic schema representing the relationship between nature and self. The "INS is correlated with concern about the biosphere… and environmental attitude and behavior" [39, p. 65] and is thus a useful predictor of ERB especially when time is short because it consists of only one question.

The CNS [31] not only predicts ERB but is also a predictor of subjects' well-being as noted earlier. The INS and CNS surveys were found to be highly intercorrelated [31; 39] and "and share a similar pattern of correlations with behavior" [39, p.66]. The INS and CNS were shown to be "of the same underlying construct" [39, p. 74] and are often used to great success to determine subjects' feelings of connection to nature to predict ERB.

The CNS was altered for younger age groups (Connectedness to Nature Scale Revised [CNS-R]) and has been shown still to represent CN in this study population [41]. Cheng & Monroe (2012) surveyed children of a similar age using surveys like the CNS-R with marked success. They developed a connection to nature index for children designed to analyze the influences of their pro-environmental behavior. Consistent themes that authors have noted were the importance of understanding the influences on students' feelings of CN and the significance of forging these connections at a young age [8; 12; 16]. To further understand connectedness to nature in young students, Tugurian [41], included the INS in data collection. The students surveyed were able to understand and complete the survey, supporting the use of this tool with elementary and middle school age students as found by Liefländer et al. [28]. CN surveys range in quality and target audience and selecting the appropriate tool can be challenging, especially for young audiences. Many of these tools were designed for adults, but through slight modification (CNS-R) the CNS and INS have shown success when used with children [28; 41].

These tools are primed for application in place-based and environmental education. These two forms of education often work hand in hand and have similar characteristics. As outlined by Sobel [37], place-based education (PBE) emotionally ties a student to the land and connects them emotionally to the space around them. The author describes a "Russian nesting doll" technique of curriculum development that integrates the world around them before expanding to more abstract concepts beyond a child's direct perceptions. In this way PBE incorporates environmental education into the formal curriculum. Students engage with local environmental issues, community members, and develop stewardship for the natural systems around them [38; 37]. Allowing students to feel empowered creates confidence and allows young learners to tackle the issues that their generation faces [13; 37].

However, addressing these issues takes time and if addressed too early can create eco-phobia, wherein students who learn about non-age-appropriate material will lose confidence and feel less empowered, often avoiding environmental material [38]. For this reason, it is critical for EEOs to provide age-appropriate material and to connect with as young an audience as possible. Integration of place-based education into formal and nonformal EE has also been shown to have great success [38; 37]. An increase in emotional association with nature leads to greater valuing of non-human life because of an expansion of self and promotes ERB, as shown by Gosling and Williams [18]. Furthermore, the authors found an attachment to place, and nature is thought to expand self-other identity to include nature; this relates directly to the importance of PBE and EE. Respondents (Australian farmers) often had a strong tie to the land that they occupied and spent a significant amount of time on (ibid). This concept can be applied to PBE and EE, for the more that students interact with the natural and built community around them, the deeper the emotional connection to their space they will have. To increase humans' confidence in creating environmental change an emotional connection to nature needs to be developed. This emotional connection should be established at a young age through opportunities to experience

local environments and build confidence in tackling environmental and community issues. EE and PBE can facilitate this emotional connection and help to create change.

Sobel [37] describes a myriad of case studies wherein EE and PBE were used to inspire children to create change. These EE and PBE experienced improved engagement, attention, community development, health, and stewardship for the land. The impacts and significance of EE are far reaching and can stay with the students for years to come, especially when students spend long durations of time on self-motivated and successful projects related to local environmental and social issues [23].

Erdoğan [12] found that EE contributed significantly to children within the study displaying ERB but did not find a significant increase in environmental knowledge after the EE treatment. This demonstrates that EE influences the emotional connection most, and these emotions are what can be used to create change. Ernst and Theimer [13] label this emotional connection as empathy and stress the importance of EE in facilitating bonds between the land or "place" and the humans that occupy it. EE should enable this bonding through allowing young people to spend extended time outside, having fun, and feeling empowered to develop these emotional connections [4]. Just having people go outside does not automatically connect them with nature; therefore, EE needs to focus on facilitating an experience that allows participants to forge this connection [13].

Since 1949, conservationists have been quoting Aldo Leopold's "Land Ethic" in hopes of inspiring people to change their behaviors and protect the environment. As our understanding of the global environmental crisis has improved, we have grown to understand the critical importance of protecting the environment however we can. Environmental education, since the 1970s, has been working hard to create awareness of the world's problems and develop solutions to these issues [42].

EE has developed as an interdisciplinary approach of teaching, engaging emotions, and developing lasting ties to a sense of place. In this way a variety of tools have been developed to analyze the feelings of connectedness to nature in different populations. Several of these tests have been used at EEOs in the hopes of determining the significance of different EE techniques [8; 11; 36; 39; 41). Through these tools a deeper understanding of the importance of EE duration, frequency, age of target audience, and interpersonal connections have come into focus. This deeper understanding and quantitative analyses have allowed EE programs to improve their ability to facilitate connectedness to nature, and subsequently promote environmental conservation behavior. EE creates a deeper connection to nature which, in turn, creates global citizens more likely to act with ERB, who have greater life satisfaction, and who are healthier and more intellectually engaged [31; 30; 37] Using the lens of the biophilia hypothesis, it makes sense that CN produces all these benefits. The hypothesis explains a simple concept that many humans feel, the innate draw to the outdoors and a feeling of satisfaction from time spent in nature. Humans have lived in close connection with the Earth for thousands of generations and now spend upwards of 90% of their time indoors [17]. Aldo Leopold [27] described it well when he said that there is an "existence of an ecological conscience" (p. 258) that we as humans are trying to connect with. Quantifying this connection through surveys and determining to what extent young students are engaging with this "conscience", will allow for an analysis of how likely these students will be to conserve the natural world.

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MATERIALS AND METHODS

Research Design

This study included the collection of data on human subjects. Institutional Review Board approval for human subjects was given through XXX University through approval number 1643 under the category of "exempt". Since the study involved collecting data responses from minors, parental approval was obtained from all participants. The study (Figure 1) surveyed students (N=5994) aged approximately 7-14 years at three formal and three nonformal EEOs (Table 1).

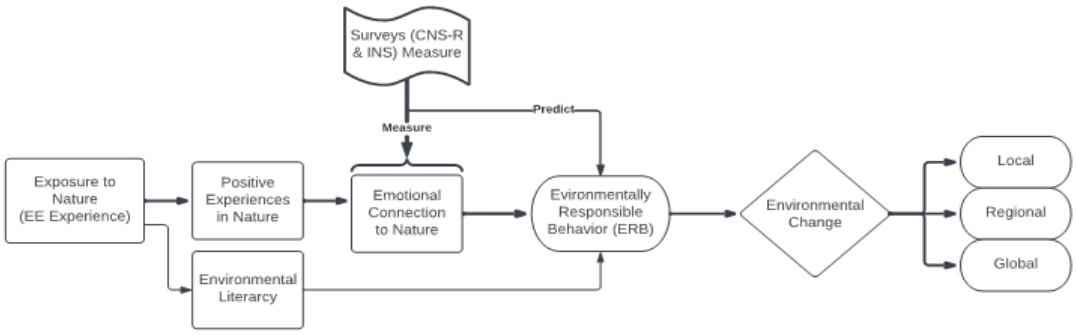

Figure 1: Graphic of Methodology and Process

Table 1: Information on EEOs used in the study and the variable levels

EEO	Type of EEO	Age Range	Duration (hrs)	Frequency	Format of Survey	Rounds Surveyed	Programs	Surveys
A	Formal	9-10, 11-12	< 16	One	Virtual	Spring and fall	Extended Day and Overnight	Pre: 1178 Post: 1145 Total: 2323
B	Formal	11-12	> 16	One	Virtual	Spring and fall	Overnight	Pre: 1311 Post: 1290 Total:2601
C	Formal	10-11	< 16	One	Paper	Spring and fall	Overnight	Pre: 1087 Post: 1068 Total: 2155
D	Nonformal	9-12	< 16	Plus one	Paper	Spring and fall	Homeschool	Pre: 421 Post: 415 Total: 836
E	Nonformal	7-12	> 16	Plus one	Paper	Spring, summer, and fall	Homeschool & Summer Camp	Pre: 365 Post: 355 Total: 720
F	Nonformal	10-14	> 16	One	Paper	Spring	Overnight	Pre: 1632 Post: 1614 Total: 3246

The study sites were selected based on their interest in participating in the survey, previous connection with the authors, and logistical access. Students within the survey groups participated in an EE experience that attempted to establish a feeling of connection to nature and enhance the students' understanding of the environment. Consistency of broad subject

material across study groups was confirmed by the authors in consultation with the staff at the cooperating organizations. EEO staff members (or a computer if students completed the survey online) read the script aloud to the students to mitigate the influence of varied reading levels. Student responses were collected and stored by the EEOs, if the student and student's guardian consented, until the authors collected and analyzed them. Other data were collected online through Google Forms (anonymously) or a school specific platform. If using a school specific digital platform, data were released to the author by the school representative for analysis.

This study was initiated in March of 2022 and concluded in December of the same year. All EEOs (excluding *F*) completed at least two rounds of surveys. Pretest (before or upon arrival) and posttest (after or upon departure) surveys (Appendix A) were administered to determine if there was a change in CN scores after the EE experience. These data were used to determine to what extent students' feelings of CN were influenced by their EE experience and if EE experiences were promoting ERB. Due to constraints placed upon the researchers by the cooperating institutions, no specific demographic data were collected (race, gender, socioeconomic background, etc.). Further, individual student surveys could not be tracked and therefore each student's pretest and posttest data were not linked. For this reason, analyses were completed at the aggregate level. The first ten questions (CNS-R) were answered on a one to five Likert scale ranging from strongly disagree to strongly agree. Two of the ten questions were inversely graded. The CNS-R is a ten-question survey; therefore, students' scores range from 10 (answering 1 on all questions) to 50 (answering 5 on all questions) points. Each student that completed this section of the survey completely provided a sum score (SS) data point, a sum of all ten CNS-R survey question responses, and the variables associated with the response regarding age/ age-range, frequency, duration, type of EEO, and pretest or posttest were compiled. The final question was the INS, a single question survey that allowed students to select the diagram that best represented their self-nature relationship. The diagram depicts two circles that incrementally move closer together until they intersect and completely overlap. This is judged to represent students' feelings of CN [28]. The INS has 7 potential options and therefore students' responses ranged from 1 to 7 (least to most connected to nature) points. Each student that completed this section of the survey completely provided a Q11 data point (Q11), which is a value (1-7) that represents their response to the INS question. Like SS data points, these points were entered into a spreadsheet and variable information as included. This multiple-choice INS question was analyzed independently from the CNS-R survey but was used to draw conclusions in conjunction with the CNS-R.

Exhaustive sampling was conducted on every student that provided informed consent and fit into the required age range for the study at each of the EEOs. Some students only completed pretests, but because pretest and posttest data were not paired, these data points could not be dropped, thus altering the total number of pretests and posttests. Therefore, random subsampling of the total dataset was used, and replicate analyses were run to enhance confidence in the conclusions. Replication of these data occurred at the EEO level where two to three "rounds" of sampling took place (excluding EEO *F*) during the spring, summer, and fall.

Subjects

Survey subjects were students from approximately age 7 to 14 who attended a program, summer camp, or other curriculum-based experience at one of the six EEOs where research was being conducted (Table 1). The only student specific information that was gathered beyond

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the survey response data was the age range or grade level, school, duration of program, and EEO.

Students aged 7 or older were selected because individuals under that age may not have had the comprehension necessary to complete the CNS-R survey, even when it was read to them, as determined by the Flesch Kincaid grade level of the questions. However, as noted by Tugurian [41], when surveying 5th grade students, the INS may have more accurately captured students' feelings of CN in groups where individuals had lower reading abilities or were English language learners. Further, this age range (7-14) also encompasses many of the students that visited the EEOs. Finally, this age range allowed for a comparison between the age group that the literature argues will have a longer lasting impact from EE (7-11) and those (12-14) that may not be as affected by the EE experience [8; 13; 28; 33; 41]. It is also worth noting that many, if not all, of the students that were surveyed were being educated in Maryland, a state that since 2011 has had an environmental literacy requirement for graduation from any public high school. Therefore, students have had exposure to environmental education throughout their prekindergarten through 12th grade academic careers [32]. This is of note if findings are compared to other EEOs where environmental literacy may not be as established in school curriculum.

Hypotheses

If students attend a nonformal environmental education experience, then they will have a larger increase in mean SS and Q11 scores than those who attend a formal environmental education experience.

- If students attend an environmental education experience for less than 12 hours during the study period, then they will have a smaller increase in mean SS and Q11 scores than those who attend for +12 hours.
- If students attend an environmental education experience more than once during the study period, then they will have a larger increase in mean SS and Q11 scores than those who only have one environmental education experience.
- If students attend an environmental education experience and are 12 years old or younger, then they will have a larger increase in mean SS and Q11 scores than those who are >12 years old.

Statistical Analysis

The SS and Q11 score data were analyzed using mean values, as demonstrated by several authors (SS: [41; 31]; Q11 score: [28;6]. These data were not normally distributed and were ordinal [29]; therefore, this study used nonparametric analyses to determine statistical significance. Wilcoxon signed rank (Wilcoxon) tests were run to determine significance between the pretest and posttest SS (N = 9910) and Q11 (N = 9952) scores using a subsample of the total data set to allow for an equal sample size for both variable levels (pretest vs. posttest). This process was repeated for every variable level to determine the difference in pretest and posttest data (paired) using the pairwise Wilcoxon tests for each variable level (e.g., nonformal pretest vs. nonformal posttest). These analyses were followed by summary statistics to determine the difference between the levels and to conclude which variable level scored higher. Mann-Whitney U (MW) tests were used to determine how the independent variable (type of EEO, age, duration, frequency) relates to the SS and Q11 scores. To determine statistical

significance between the variable levels, MW tests were run for factors with two variable levels (e.g., old vs. young). Using a for loop these analyses were completed 12000 times to build confidence that conclusions were not due to a type I or type II error. These analyses were run in RStudio 2022.07.2 using R version 4.2.2. In addition to measuring statistical significance, the data were used to determine meaningful change. An increase of one unit between pretest and posttest scores was set as the threshold to be a meaningful increase from the treatment. To determine if a meaningful change occurred, when pretest and posttest data were compared using a Wilcoxon test, 12000 iterations of the analysis were run. The difference between the paired pretest and posttest were stored in a vector and one was subtracted from these values, if the resulting difference was greater than or equal to zero then the treatment demonstrated a meaningful increase. The percent of the 12000 iterations that demonstrated this meaningful change was then calculated. Additionally, to determine the impact of this meaningful change the percentage of students scoring above neutral (30 for CNS-R and 4 for INS) before and after the EE treatment was calculated and the overall mean pretest and posttest data were compared for each variable level.

RESULTS

Significant Difference

A statistically significant shift from pre to post (Figures 2 & 3) in both SS and Q11 data was observed, supporting the hypothesis that EE would have a significant impact on students' CN.

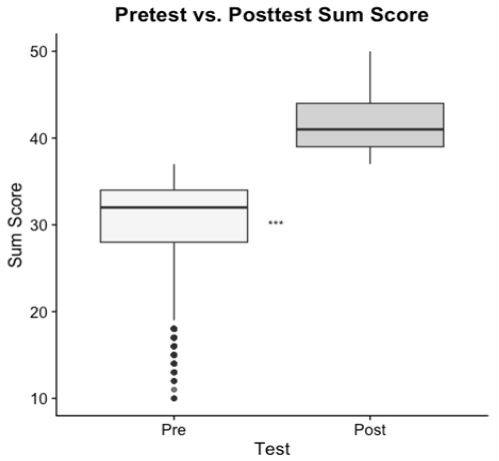

Figure 2: Pretest vs. posttest sum score data (N= 9910; mean= 30.5 [pre], 41.6 [post], p-value <<<0.001).

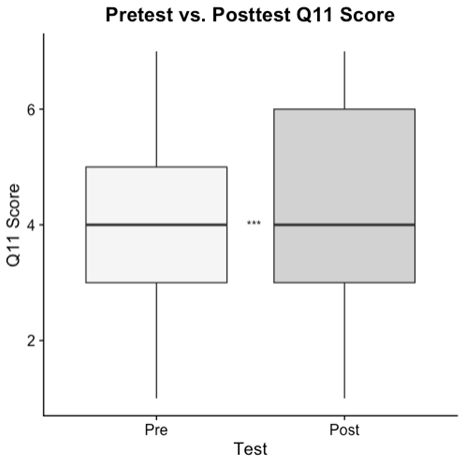

Figure 3: Pretest vs. posttest Q11 score data (N= 9952; mean= 3.91 [pre], 4.12 [post], p-value <<<0.001).

This shift demonstrates that there was a significant impact of the EE experience on student's feelings of CN as demonstrated by CNS-R and INS surveys. All organizations and all sample rounds were included in this data set. The six EEOs feel were split into two variable levels, formal (N=3) and nonformal (N=3) (Table 1). MW tests demonstrated that the formal EEOs scored significantly higher than the nonformal counterpart for both SS and Q11 data (Figures 4 & 5) Therefore, the hypothesis that the nonformal EEOs would score higher on the CNS-R and INS surveys was rejected.

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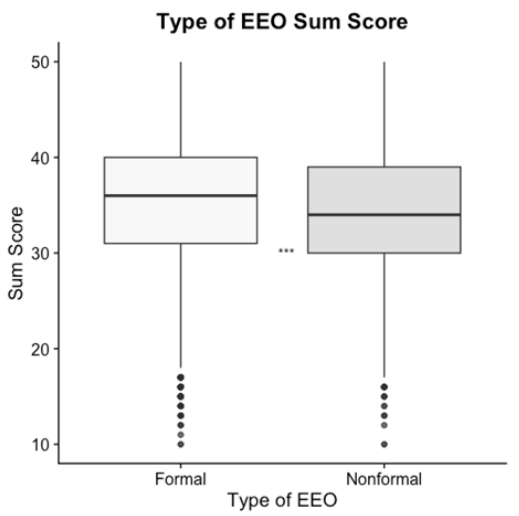

Figure 4: Formal vs. nonformal EEOs SS comparison (N= 11988; mean= 35.4 [formal], 34.2 [nonformal], p-value <<<0.001).

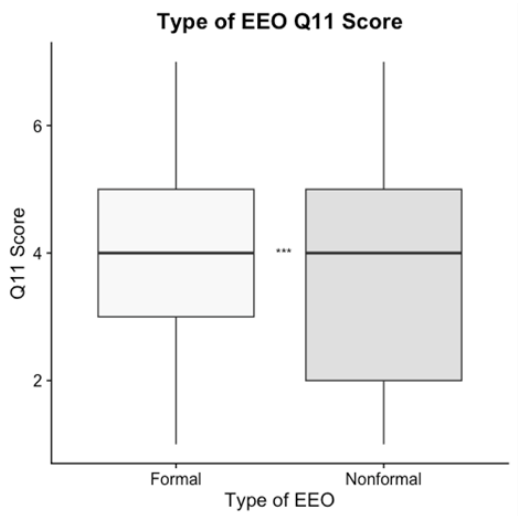

Figure 5: Formal vs. nonformal EEOs Q11 comparison (N= 11950; mean= 4.06 [formal], 3.80 [nonformal], p-value <<<0.001).

Wilcoxon tests demonstrated a significant shift between pre and post data for the nonformal and formal variable levels respectively, for both SS and Q11 data (Figure 6 & 7).

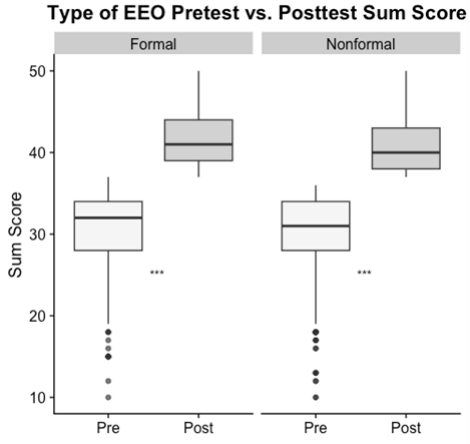

Figure 6: Type of EEO SS pre vs. post data comparison (N= 2732 (683 each); mean= 30.6 [pre-formal], 30.0 [pre-nonformal], 41.8 [post-formal], 41.1 [post-nonformal], p-value <<<0.001).

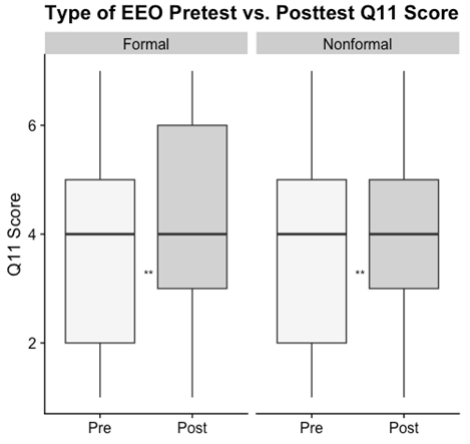

Figure 7: Type of EEO Q11 pre vs. post data comparison (N= 5328 (1332 each); mean= 3.88 [pre-formal], 3.62 [pre-nonformal], 4.11 [post-formal], 3.97 [post-nonformal], p-value <<0.05).

These findings demonstrate that both types of EEOs had a significant impact on students' CN, but that students experiencing environmental education in a formal setting scored higher overall and thus were more connected to nature as determined by the CNS-R and INS surveys. The data were broken down into two age groups, those who were twelve or younger (young) and those who were over the age of twelve (older) (Table 1). A MW test was used to compare these two variable levels. Both Q11 and SS demonstrated a significant shift (Figures 8 & 9), with the younger age group scoring higher than the older age group. This is consistent with the

hypothesis that younger students would score higher on both tests, as has previously been shown by several authors [8; 13; 28; 33; 41].

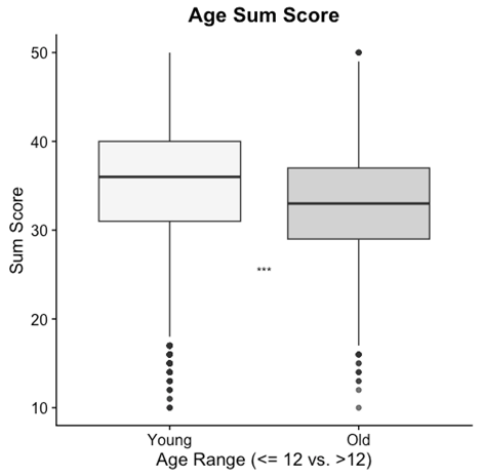

Figure 8: Old vs. young SS comparison (N= 11746; mean= 33.1 [old], 35.4 [young], p-value <<<0.001).

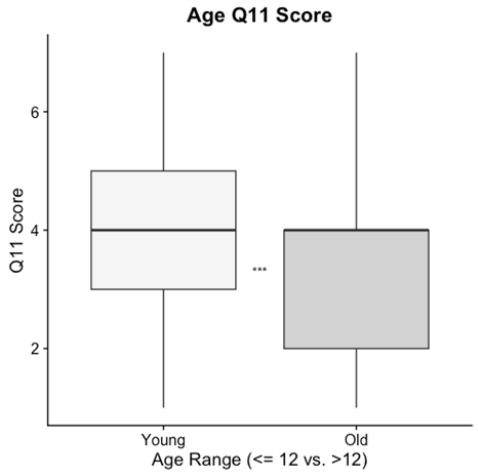

Figure 9: Old vs. young Q11 comparison (N= 11739; mean= 3.52 [old], 4.06 [young], p-value <<<0.001).

Wilcoxon tests were used to compare the pre and post data for both the young and older age groups, and a significant shift was detected for both tests and variable levels (Figure 10 & 11).

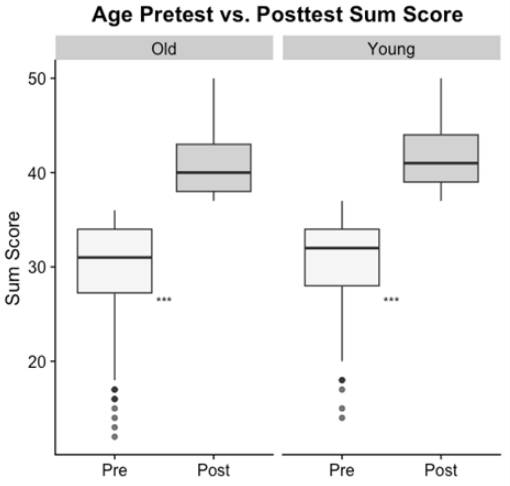

Figure 10: Age SS pre vs. post data comparison (N= 2732 (362 each); mean= 29.9 [pre-old], 30.8 [pre-young], 40.8 [post-old], 41.7 [post-young], p-value <<<0.001).

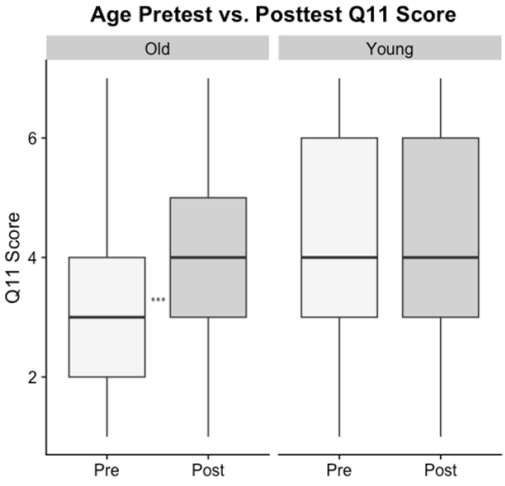

Figure 11: Age Q11 pre vs. post data comparison (N= 2136 (534 each); mean= 3.26 [pre-old], 4.14 [pre-young], 3.79 [post-old], 4.18 [post-young]; old p-value <<< 0.001; young p-value > 0.05).

Student samples were also broken into two duration variable levels, less (< 16 hours) and more (>16 hours). The threshold of 16 hours was used because it split the EEOs equally into each variable level (Table 1). MW tests were used to compare the variable levels for both test data and, contrary to the hypothesis, the students who attended for less time scored significantly higher than those students who attended for a longer duration (more group) (Figures 12 & 13).

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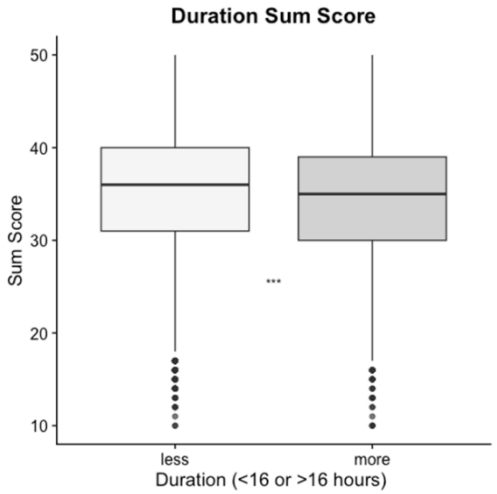

Figure 12: Less vs. more SS comparison (N= 11988; mean= 35.4 [less], 34.5 [more], p-value <<<0.001).

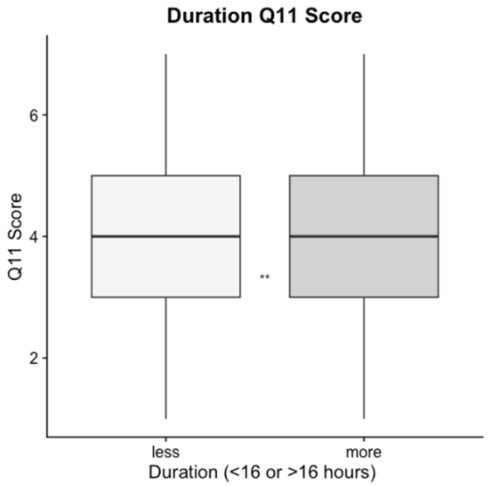

Figure 13: Less vs. more Q11 comparison (N= 11950; mean= 4.03 [less], 3.92 [more], p-value <<0.05).

When using a Wilcoxon test to compare the pre and post data for each variable level, the more and the less variable level demonstrated a significant shift for both Q11 and SS data (Figures 14 & 15).

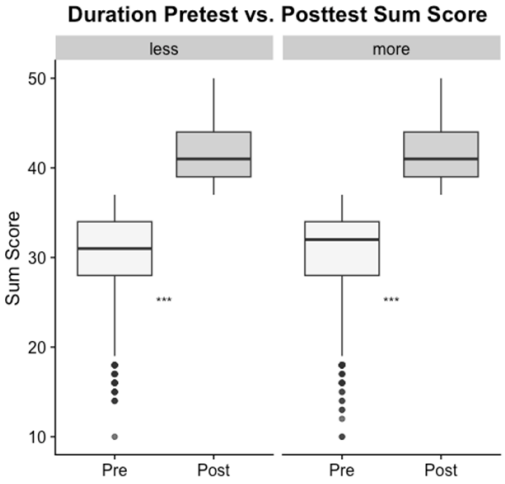

Figure 14: Duration SS pre vs. post data comparison (N= 5644 (1411 each); mean= 30.6 [pre-less], 30.4 [pre-more], 41.6 [post-less], 41.4 [post-more], p-value <<<0.001).

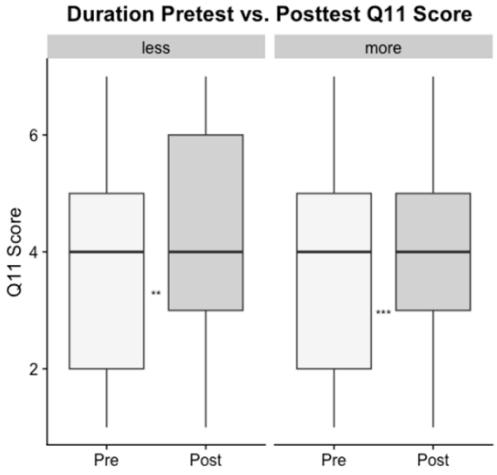

Figure 15: Duration Q11 pre vs. post data comparison (N= 6100 (1525 each); mean= 3.92 [pre-less], 3.78 [pre-more], 4.12 [post-less], 4.04 [post-more]; less p-value <<0.05; more p-value <<< 0.001).

The frequency variable, students who attended the EEO only once during the study period were grouped within the one variable level and students who attended more than once were grouped within the plus variable level (Table 1). D and E are small EEOs that worked with homeschool and summer camps students and did not service many students during the study period. Therefore, this variable level comparison was restricted by having the smallest sample sizes.

MW tests were used to compare the one and plus variable levels and, as hypothesized, the plus group scored significantly higher on both SS and Q11 data (Figures 16 & 17).

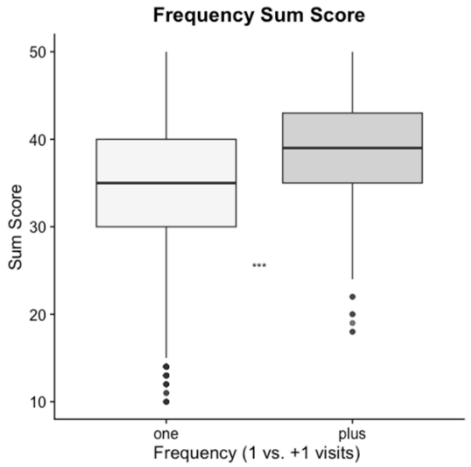

Figure 16: One vs. plus SS comparison (N= 11988; mean= 35.0 [one], 38.7 [plus], p-value <<<0.001).

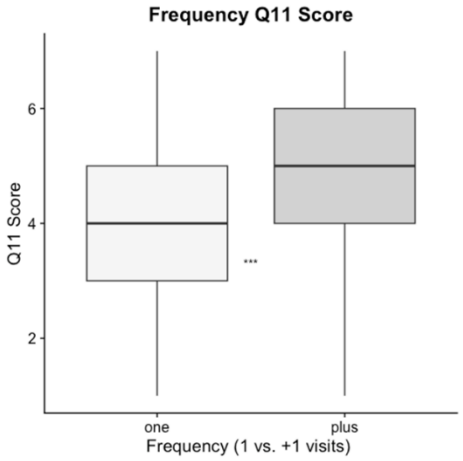

Figure 17: One vs. plus Q11 comparison (N= 11950; mean= 3.96 [one], 4.98 [plus], p-value <<<0.001).

When comparing the pre and post data, the one and plus variables level demonstrated a significant shift for the SS data (Figure 18) but not the Q11 data (Figure 19).

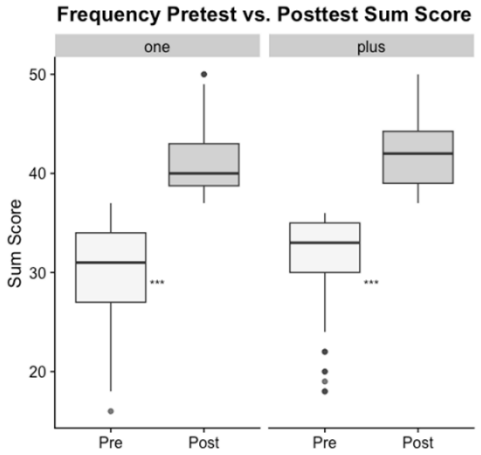

Figure 18: Frequency SS pre vs. post data comparison (N= 544 (136 each); mean= 29.6 [pre-one], 31.7 [pre-plus], 41.0 [post-one], 42.0 [post-plus], p-value <<<0.001).

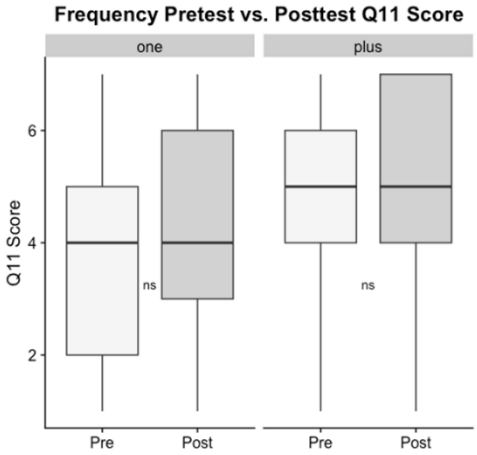

Figure 19: Frequency Q11 pre vs. post data comparison (N= 716 (179 each); mean= 3.96 [pre-one], 4.96 [pre-plus], 4.21 [post-one], 5.14 [post-plus]; one p-value >0.05; plus p-value >0.05).

Meaningful Difference

In addition to determining which variable levels were significantly higher and which demonstrated a significant shift between pre and post data, analyses were run to determine if the data demonstrated a meaningful change. The first approach to determine if there was a meaningful change was to find what percentage of the students were scoring above neutral (30 for SS; 4 for Q11). When comparing the percentage of Q11 pre and post data above neutral

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(Table 2), all variable levels saw an increase greater than 3% excluding young, with the older and nonformal variable levels demonstrating the greatest difference. The percentage of SS pre and post data demonstrate an increase of more than 1% for all variable levels excluding formal and plus (Table 2), with the older and nonformal variable levels demonstrating the greatest difference.

Table 2: Percentage of pretest and posttest data for each variable level where students scored above neutral for Q11 (score of four) and SS (score of 30)

Percentage of Pretest and Posttest Data Above Neutral for Each Variable Level

Variable Levels	Q11 Pre	Q11 post	Q11 Difference	SS Pre	SS post	SS Difference
Formal	49.89	53.31	3.40	78.74	79.08	0.34
Nonformal	42.11	49.42	7.30	68.64	78.55	9.90
Young	51.78	52.47	0.69	75.64	78.72	3.10
Old	32.22	44.77	13.00	66.22	72.85	6.60
Less	49.00	53.89	4.90	77.37	78.78	1.40
More	45.98	50.97	5.00	73.27	76.11	2.80
One	44.92	49.33	4.40	75.21	77.78	2.60
Plus	70.62	76.34	5.70	90.85	91.42	0.57

The resampling protocol described above was utilized as an additional test to determine if the change in the data set met the threshold of being meaningful. By subtracting one from each of these differences stored in the vector, the percentage of the iterations that had a difference greater than or equal to zero was determined. Based on SS data, all variable levels demonstrated a meaningful change of greater than 50% (Table 3).

Table 3: Percentage of SS and Q11 data that demonstrated a meaningful change (increase of >= 1 unit) between pretest and posttest data for each variable over 12,000 iterations.

Percentage of Iterations that Demonstrate a Meaningful Change Between Pre and Post Data For Variable Levels

Variable Levels	Q11	SS
Overall	46.32	51.13
Formal	45.39	51.00
Nonformal	47.31	53.22
Young	44.95	51.08
Old	50.97	55.38
Less	46.43	51.19
More	45.75	51.42
One	45.96	51.81
Plus	46.16	51.07

By this standard, most students experienced a meaningful change in SS data from their EE experience. For the Q11 data, only one variable level (older) demonstrated a meaningful change greater than 50% (Table 3). However, all variable levels demonstrated a meaningful change greater than 44%. This may be due to the smaller range in potential Q11 score (one to seven) when compared to the SS data (10-50). Once again, the variable levels that demonstrated the largest percentage of meaningful change were the older and nonformal groups.

One-sample Wilcoxon tests were also used to determine if the true mean value of the meaningful change [(post-pre)-1] vector was less than zero (Table 4). The variable levels that were significant are those whose vectors of meaningful change had a mean value significantly less than zero. This demonstrates that, for these variable levels, a significant proportion of the 12,000 iterations demonstrated a meaningful change and had a mean value significantly less than zero. If the true mean was not significantly less than zero, then the one-sample Wilcoxon test returned a p-value greater than 0.05. Based on this, the Q11 data demonstrated the meaningful change (shift of one unit) better than the SS (Table 4).

Table 4: Variable level (12,000 iterations) vectors ((posttest-pretest)-1) that had a mean value significantly below 0, determined by single sample Wilcoxon tests.

Signficance Values For Variable Levels If: True Mean Value is Less Than 0		
Variable Levels	Q11	SS
Overall	p<0.001	p>0.05, NS
Formal	p<0.001	p<0.05
Nonformal	p<0.001	p>0.05, NS
Young	p<0.001	p<0.05
Old	p<0.001	p>0.05, NS
Less	p<0.001	p>0.05, NS
More	p<0.001	p<0.05
One	p<0.001	p>0.05, NS
Plus	p<0.001	p<0.05

The simplest way of determining meaningful change was to subtract the mean pretest value from the mean posttest value for each variable level. Finding the difference between pre and post data for Q11 did not reveal a significant shift for any variable levels (Table 5). However, when comparing the SS pre and post data, nonformal and older variable levels demonstrated a meaningful change (Table 6).

Table 5: Difference in mean score between pretest and posttest Q11 data.

Mean Q11 Score for Each Variable Level			
Variable Levels	Pretest	Posttest	Difference in Score
Formal	3.976	4.176	0.1999
Nonformal	3.633	3.975	0.3417
Young	3.971	4.177	0.2065
Old	3.276	3.787	0.5101
Less	3.941	4.157	0.2154
More	3.821	4.043	0.2216
One	3.870	4.084	0.2137
Plus	4.867	5.140	0.2727

Table 6: Difference in mean score between pretest and posttest SS data.

Total Mean Sum Score for Each Variable Level			
Variable Levels	Pretest	Posttest	Difference in Score
Formal	35.08	35.86	0.7802
Nonformal	33.53	34.89	1.3560
Young	35.04	35.81	0.7727
Old	32.29	34.14	1.8460
Less	35.03	35.86	0.8302
More	34.09	35.00	0.9082
One	34.61	35.47	0.8663
Plus	38.46	38.98	0.5192

DISCUSSION

This study provides a comparison between formal and nonformal EEOs' influence on students' CN scores, filling a knowledge gap by quantifying the impact of different EE variables. This study has helped determine the influence of duration, frequency, and age on students' feelings of CN at six EEOs in Maryland. These findings will, in turn, allow these organizations to improve their programs, facilitate greater feelings of connectedness to nature, and allow other organizations to design curriculum and programs that will have the greatest impact. Further, this study provided valuable evidence on how we can improve the ways we analyze EE and CN by measuring the meaningful change in student scores surrounding an EE experience. This study found that EE was having a significant effect on students' feelings of connectedness to nature (Figure 2 & 3). These findings concur with those of Hoover [22], demonstrating that EE and other nature-based experiences will lead to deeper feelings of CN in the participants. Further, these authors demonstrated that the positive emotional effects of nature-based experiences were brought about by CN (Figure 1). In turn, this CN will lead to greater ERB as shown by Mayer and Frantz [31] and Erdoğan [12].

Contrary to the original hypothesis, the surveyed students scored significantly higher in the formal variable level (Figures 7 & 8). Nonformal EEOs often implemented alternative teaching styles that promoted engaging and hands-on nature-based experiences that previous authors [43] have described as leading to greater feelings of CN. However, because the formal EEOs scored higher than their nonformal counterparts this may demonstrate that the techniques used at the surveyed formal EEOs may be having a greater impact on students' CN. A comprehensive review of educational techniques utilized by each EEO was not conducted in this study, nor did it include student interviews that could be used to determine which techniques were more impactful; therefore, future research should focus on determining which environmental education pedagogical techniques and factors produced higher scores among the formal EEO participants.

As hypothesized, students who were 12 years old or younger scored significantly higher on their surveys than the students who were over the age of 12 (Figures 8 & 9) supporting the idea that the CN of younger students, particularly those under the age of 11, is more greatly impacted by EE experiences. The relationship between age and connectedness to nature is complex and multifaceted, however. While some studies suggest that younger children may exhibit a natural affinity and curiosity towards the natural world (e.g., Sobel [38]), others propose that this connection may diminish with age due to factors such as increased screen time and urbanization [43]. For example, Kahn Jr. et al. [24] observed a decline in children's engagement with nature as they transitioned from early childhood to adolescence, highlighting the importance of fostering a sense of environmental stewardship during formative years. Overall, while age may influence the trajectory of children's connectedness to nature, environmental education and experiential learning opportunities hold promise in fostering and sustaining this connection across different developmental stages.

Several studies have indicated a positive correlation between the frequency and duration of exposure to nature and children's connectedness to it. For instance, Chawla [7] found that children who spent more time in natural environments exhibited higher levels of environmental awareness and empathy towards nature. Similarly, Wells and Lekies [43] demonstrated that regular and extended exposure to natural settings was associated with increased affinity and concern for the environment among children. These findings collectively suggest that the frequency and duration of exposure play pivotal roles in shaping children's connectedness to nature. However, contrary to these previous findings and this study's hypothesis, the data demonstrated that students who attended for less time scored higher on both surveys (Figures 12 & 13). Many of the previous studies compared programming at the same EEO with different durations. Although students who attended for less time scored significantly higher, this may be in part due to the specific EEO or other variable (age, frequency, etc.). The only organization where a comparison between duration values was possible was at EEO A. During the study period, the programming for their fourth-grade students transitioned from a day program to an overnight program. When 12,000 iterations were run comparing students' tests who attended for more than 16 hours (overnight) and less than 16 hours (day trip) at A, 98% did not demonstrate a significant difference. Furthermore, because of a very small sample size (less: 80; more: 80) confidence in these conclusions is low. Future studies should compare different program durations within each organization with only one age group.

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It was hypothesized that students who attended more frequently would score higher on the surveys. As hypothesized, the students who attended more frequently scored significantly higher on their surveys (Figures 16 & 17), corroborating the findings of previous authors [24] This study found a similar trend to that described by Liefländer et al. [28], that as the affinity and frequency (more variable level) of exposure to an individual's natural surroundings increases, so too does their CN.

Several conclusions deviated from the original expectations as outlined in the hypotheses: formal scoring higher than nonformal, the shorter durations scoring higher than the longer, and the lack of significant difference between pre and post (Q11 and SS) data for the plus variable level. As described previously, the formal variable level scored higher than the nonformal. This may demonstrate that the type of programming occurring at the formal EEOs promoted fun, engaging, hands-on nature-based experiences more than the nonformal EEOs. Additionally, the less duration variable scoring higher than the more duration, as stated previously, may be due to the specific EEO, the type of programming, and the age of the students. Alternatively, this may be evidence of a saturation point for the students where students become overstimulated from the EE experience (Tables 5 & 6). Further, the lack of a significant difference between pre and post data for the plus variable suggests a potential flaw in the data and the survey. The EEOs within this variable level were D and E, two nonformal EEOs with small sample sizes. This small sample size may have affected the ability to detect a difference if one occurred. These programs primarily worked with students being homeschooled. E also surveyed summer camp students. Students who attended these programs had high CN scores from the start and their scores may have reached the "ceiling" of the survey, like that noted by Ernst and Theimer [13]. In other words, student responses could only be scored so high, and unless students' scores decreased, a significant difference was unlikely to be detected.

This study found that students within the formal, younger, less, and plus variable levels had higher levels of CN as measured by both the CNS-R and INS surveys. With the rationale that students who scored higher on their surveys are more likely to act with ERB and or include ERB in their lives [16], then we can conclude that students within these variable levels are most likely to act with ERB than their variable level counterparts (nonformal, older, more, and one). However, this study also demonstrated that it is important to not only consider the highest overall CN score, but also the greatest difference and the most meaningful change. Tables 5 and 6 depict the difference between average pretest and posttest scores for Q11 and SS data. For both datasets, the older and nonformal variable levels demonstrated the greatest difference. As mentioned previously, the threshold to be deemed meaningful was an increase of one unit. These variable levels (older and nonformal) met this threshold for the SS, but not the Q11, data. This is likely due to the Q11 data only ranging from one to seven causing score differences to be more restricted. This demonstrates that these variable levels (older and nonformal) were having the greatest influence on students' CN scores. Although these variable levels may not have scored highest between the two variable options (e.g., formal vs. nonformal) they demonstrated the greatest difference between pre and post data. This shift shows that EE experiences are impacting students at all CN levels. This impact on the students is an important factor when considering what the best EE techniques are and how to raise the bar for students' levels of CN and ERB. It is also worth noting that all students within the older variable level and many students within the nonformal variable level attended EEO F. Although F participants did

not score very high as a collective whole, the students demonstrated a large and meaningful shift between pre and post data.

Another way to consider measuring meaningful change is looking at the proportion of responses above a neutral (Q11: 4; SS: 30) score. As shown in Table 2 overall, the proportion of students scoring above neutral increased between pre and post Q11 and SS data. The percentage of students scoring above neutral for overall Q11 data increased by 4.47% and the overall SS data increased by 4.41%. This may appear to be a small change, but when considering that over 5,000 students were surveyed, even that increase can be substantial. Table 2 provides a breakdown of the change in percentage of students scoring above neutral for each variable level and survey. Nonformal, older, and young SS and the nonformal, older, and plus Q11 variable levels had the greatest increase in percentage above neutral. This supports the conclusions that these variable levels had the greatest impact on creating meaningful change in students CN.

The final method of determining meaningful change was to find the percentage of each variable level that demonstrated an increase of more than one unit between pre and post data. Because each individual student response was not paired between pretest and posttest, pre and post data were randomly assigned and subtracted over 12,000 iterations. Table 3 shows the percentage of these comparisons that demonstrated this meaningful shift. As shown previously, the variable levels with the highest percentage of combinations demonstrating meaningful increase of one or more were nonformal and older. Based on these analyses, the data demonstrate that these variable levels created the most meaningful change in CN for both Q11 and SS data.

Limitations

Based on the experimental and study design several limitations and biases were present. One limitation is that students surveyed were not a random subsample of the entire population of students their age, nor were they a subsample of all students who attended EEOs. However, these conclusions can be used as a case study or examples of potential trends in the broader population. Another challenge, based on the need to maintain student anonymity and organizational logistics, was that the student responses were not paired between pretest and posttest. Further, this study has a level of geographic bias, for the state of Maryland has required students in public K-12 schools to demonstrate environmental literacy as a contingency for graduation since 2011 [32] and therefore, these students have likely had more EE exposure than students in other areas of the country or internationally. Another challenge posed by the importance of maintaining student anonymity was not being able to track students' exact age, rather grade level and age range data were collected. This limited the clarity of determining age specific influences as demonstrated by previous authors. This study seems to have demonstrated that a ceiling in student scores on INS survey can be reached, similar to that stated by Ernst and Theimer [13]. Students may have felt more connected after their EE experience, but if they had previously scored high on their surveys, this increase may not have been detectable. The small range of the potential responses for Q11 (one to seven) may have had an influence on the visibility of a meaningful change if it existed. This demonstrates a potential limitation in the use and application of the INS survey. Finally, the lack of student response, moods of the children, influence of peers or surroundings, and a variety of other

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specific student factors may have influenced the study. The inclusion of these biases and limitations within the study must be considered when conclusions are drawn.

The key influences on student scores that caused the largest shift in data were the type of EEO, the age of the students, and the duration of the EE experience. These variables provided the largest change between pre and post data, as stated previously. The more variable level demonstrated the lowest influence on both Q11 and SS data. This was consistent across all three tests of meaningful change.

Conclusion

The implications of this study are clear. The study demonstrated that students at formal EEOs scored higher overall than nonformal organizations. The formal EEOs were serving more students as well; therefore, funding and enhancing formal EEOs will have the greatest impact on the largest number of students. However, nonformal EEOs are facilitating a high level of meaningful change, and these organizations raised CN scores more than the formal organizations. Therefore, the techniques used at these organizations should be applied at formal EEOs to have the greatest impact on CN from EE experiences. The study further implied that younger students scored higher than older students, thus further supporting the claims from the literature that EE should target these age groups. The older students did demonstrate a large increase in CN (meaningful change) even though they did not score as high overall. Therefore, it may also be beneficial to target older age groups for further EE experiences to create more connected young adults that have not lost their emotional affinity toward nature as they grow up. This study demonstrated that program duration has a significant impact on students' CN, and that programming lasting for less than 16 hours was more impactful than the longer programs. This is helpful information to consider when EEOs are planning and gathering funding. Further, students who attended more frequently felt deeper CN than those students who attended only once. Thus, EE programming that is more frequent but occurs for a shorter duration may have the greatest impact on students' CN. Overall, students felt more connected to nature after their EE experience. This demonstrates that EE is leading to deeper CN, which, in turn, promotes more ERB and stewardship, thereby improving local and global environmental conditions. Therefore, in order to empower the next generation and facilitate more environmentally responsible behavior, environmental education must work to instill a deeper feeling of connectedness to nature.

Future Work

This study advanced the field of EE by demonstrating that looking at meaningful change and determining ways of measuring it may be a more impactful way of studying CN. The field of EE should work to develop a more robust way of determining how impactful an EE experience is by looking at how student scores change from pretest to posttest. This study sets out a process to analyze aggregate CN data and determine the amount of meaningful change using the INS and CNS-R survey scales. Further research should determine the level of ERB that occurs from the meaningful change, more appropriate thresholds of meaningful change, and ways to promote the greatest level of meaningful change.

Questions from this Study

These influences and biases introduced into the study present a variety of further questions. What might have caused these round variations? Was there a seasonal influence on student

responses or an impact from the format of the survey (paper vs. electronic)? How might these results have been influenced by the "return to normal" processes in schools and at EEOs as we progress through the COVID-19 pandemic? Would long term studies show these variations as peaks on an otherwise more consistent trend? How might extended studies help to measure long term trends at EEOs? How can we design studies to measure the residual impact of EE and if it truly influences ERB? Is an increase of one unit truly meaningful or is there a better way of quantifying meaningful change? Can we measure fatigue of EE experiences?

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Appendix A: Survey questions

The first ten questions are from the CNS-R survey [21]and final question is the INS survey [11].

	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I often feel a strong connection to nature	(1)	(2)	(3)	(4)	(5)
I think of nature as a family that I belong in	(1)	(2)	(3)	(4)	(5)
I see myself as a part of the greater circle of life	(1)	(2)	(3)	(4)	(5)
Humans are more important than plants and animals	(1)	(2)	(3)	(4)	(5)
I feel related to animals and plants	(1)	(2)	(3)	(4)	(5)
I feel I belong to the Earth and the Earth belongs to me	(1)	(2)	(3)	(4)	(5)
I feel that all living things in this world are connected, and I am a part of that	(1)	(2)	(3)	(4)	(5)
There is something that every living thing shares	(1)	(2)	(3)	(4)	(5)
Like the tree in the forest, I feel I belong to nature	(1)	(2)	(3)	(4)	(5)
I don't feel part of nature	(1)	(2)	(3)	(4)	(5)
How interconnected are you with nature? Choose the picture which best describes your relationship with nature.