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RESEARCH ARTICLE



Is naturalness associated with positive learning outcomes during environmental education field trips?

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ABSTRACT

Do more natural settings improve students' learning? We collected surveys immediately following 283 U.S.-based environmental education (EE) field trip programs for youth and used land cover data to examine the relationship between levels of naturalness, defined as the percentage of natural land cover of the EE field trip site, and student learning outcomes. We also examined whether differences in levels of naturalness between students' day-to-day environment and the field trip setting were related to student learning outcomes. When controlling for grade and race, both levels of naturalness and novel levels of naturalness accounted for approximately 4% of the variance in student outcomes suggesting that other field trip characteristics are more influential.

KEYWORDS

environmental education; naturalness; novelty; greenspace; learning

Introduction

Every year, thousands of middle school-aged (roughly, ages 10–14) children participate in environmental education (EE) field trip programs throughout the United States. Many of these EE field trip programs seek to meet curriculum-based standards while also creating an environmentally literate student population with the knowledge, skills, dispositions, and ability to address current and future environmental challenges (Gillett, 1977; Hofstein & Rosenfeld, 1996; Powell et al., 2019; Stern et al., 2014). A hallmark of EE field trip programs is that they often occur in natural settings and provide immersive hands-on experiences (e.g., McCrea, 2006; NAAEE Guidelines for Excellence, 2021; Simmons, 2018). Researchers suggest that this exposure to nature and natural settings during middle childhood and early adolescence (ages 10–14) can positively impact youths' learning, academic performance, and cognitive and moral development (e.g., Kuo et al., 2019; Kellert, 2005; Kahn & Kellert, 2002; White & Stoecklin, 2008). Thus, it is assumed that an important component of a successful EE field trip program is immersive and interactive experiences in natural environments. However, recent research specifically focused on cognitive development, student learning, and exposure to green or natural settings has shown mixed or inconclusive results, suggesting that the relationship may be more complex than previously thought (Browning & Rigolon, 2019; Browning & Locke, 2020). Researchers have also suggested that novel levels of naturalness—where the levels of naturalness are greater than what is usually encountered in day-to-day life—may enhance students' learning outcomes in field trip settings (e.g., Berman & Davis-Berman, 1995; Dale et al., 2020; Garst et al., 2011). However, some researchers disagree and argue that too much novelty (or in this case novel levels of naturalness) may impede or distract students' learning in educational field trip settings (Falk et al., 1978), especially without adequate preparation (e.g., Boeve-de Pauw et al., 2019; Lee, et al., 2022). Thus, our research focuses on assessing 1) whether the level of naturalness of an EE field trip setting, *defined and measured using the percentage of natural land cover*, is associated with middle

school-aged students' learning outcomes across a large sample of EE field trip program sites in the United States; and 2) whether novel levels of naturalness, defined as the difference in levels of naturalness between students' day-to-day environment and the field trip setting, are related to student learning outcomes during EE field trip programs.

Literature review

Naturalness & positive learning outcomes: Theoretical underpinnings

Research on exposure to nature and associated positive learning outcomes have traditionally been underpinned by several related theories: Biophilia, Attention Restoration Theory (ART), and Stress Reduction Theory (SRT) (Kaplan et al., 1998; Kellert, 2005; Kellert & Wilson, 1993; Ulrich, 1983; Ulrich et al., 1991; White & Stoecklin, 2008). Biophilia, based in sociobiology, suggests that people have a genetic predisposition and an innate tendency to draw psychological, social, and spiritual benefits from the natural world (Kellert, 2005; Kellert & Wilson, 1993; White & Stoecklin, 2008). Biophilia also suggests that because humans evolved in nature, interacting with the natural world underpins children's healthy physical, emotional, and intellectual development (e.g., Kahn & Kellert, 2002; Van Dijk-Wesselius et al., 2018). While conceptualized as a genetic predisposition, the theory also emphasizes the need for regular opportunities to learn about and have positive experiences in natural environments throughout childhood to ensure the full development of biophilia (Kellert, 2005; Kahn & Kellert, 2002; White & Stoecklin, 2008; Chawla et al., 2014; Kellert, 1997; Sobel, 2002).

Related to biophilia, Stress Reduction Theory (SRT) suggests that, based on human evolutionary history and personal experiences, certain natural environments that are esthetic, familiar, engaging, and non-threatening can alleviate stress (Browning & Locke, 2020; Ulrich, 1983; Ulrich et al., 1991; Hodson & Sander, 2017; Bowler et al., 2010). In these natural settings, individuals may experience emotional and psychological restoration, which allows for rapid, short-term recovery from stress and an increased sense of well-being and ability to learn (Ulrich et al., 1991; Hartig et al., 1991).

Attention Restoration Theory (ART) seeks to explain how certain natural environments can lessen the typical effort required for directed attention, thus restoring attentional capacity (Kaplan, 1995; Kaplan et al., 1998). Natural environments that (1) allow for thoughtful reflection and attract involuntary attention; (2) are non-threatening and welcoming; (3) encourage exploration; and (4) create separation from stressful environments and normal attentional demands are thought to restore attention (Kaplan et al., 1998; Hodson & Sander, 2017). Results of recent studies suggest that increased exposure to these natural environments can positively impact children's working memory and attention (Bagot, 2004; Bagot et al., 2015; Dadvand et al., 2015; Kelz et al., 2015; Larson et al., 2018; Li & Sullivan, 2016; Taylor et al., 2002; Tennessen & Cimprich, 1995; Wells, 2000). Additionally, research suggests that even after brief exposure to nature, cognitive capacity and the ability to focus attention are increased (Larson et al., 2018; Kaplan, 1995; Li & Sullivan, 2016). EE field trips often take place in these types of natural environments, thus potentially restoring attention in students and positively impacting students' learning outcomes. However, more recent research investigating the effect of exposure to nature on students' academic success in formal educational settings has produced inconsistent results (e.g., Browning & Rigolon, 2019).

Naturalness & learning outcomes in formal education

Studies focused on the relationship between naturalness and academic performance have been primarily conducted in formal educational settings using remotely-sensed landcover data pertaining to naturalness or greenspace, which is considered a subset of naturalness and is often operationalized as remotely-sensed tree and shrub cover or vegetation in urban environments (e.g., Browning & Locke, 2020; Taylor & Hochuli, 2017). Others conceptualize naturalness more broadly to include most or all of the non-built environment (e.g., Dallimer et al., 2011), and use remotely sensed measures like the inverse percentage of an area with developed impervious surface coverage (e.g., Larson et al., 2018).

Generally, these studies find that students in formal learning environments with higher levels of naturalness/green space perform better on cognitive tasks and have better grades and standardized test scores (Li et al., 2019; Benfield et al., 2015; Donovan et al., 2020; Kweon et al., 2017; Leung et al., 2019; Spero et al., 2019; Tallis et al., 2018; Wu et al., 2014). However, other studies have found null or even negative relationships between naturalness and student learning outcomes. For example, a study conducted by Beere and Kingham (2017) using a measure of greenspace based on New Zealand's national land cover database found that students' academic success negatively correlated with the level of naturalness around New Zealand schools. Browning et al. (2018) also found a statistically significant negative relationship between student academic performance and normalized difference vegetation index (NDVI) around Chicago public schools. Additionally, a study conducted in Germany using NDVI, tree cover, and proportion of agricultural land, forest, and urban green space found no significant relationships between naturalness around students' schools and academic performance (Markevych et al., 2019). Thus, the relationship between naturalness and student learning in formal educational settings appears more complex than previously thought.

The relationship between student learning outcomes in formal educational settings and naturalness exposure also appears to be influenced by sociodemographic and contextual factors including urbanity, socioeconomic status (SES), gender, and student-teacher ratio, among others (Browning & Rigolon, 2019; Browning & Locke, 2020). Schools and neighborhoods in urban areas with high degrees of poverty tend to also have less vegetation cover, fewer natural areas and parks compared to wealthier areas (Kuo et al., 2018; Rigolon et al., 2018a; Rigolon et al., 2018b). A recent study addressing the relationship between academic performance and naturalness (using tree cover, total vegetation cover, agricultural cover, and urban intensity) in the United States found that the impact of certain vegetation types (e.g., tree cover, grass) on student success varied based on socioeconomic context as well as urbanity (Hodson & Sandar, 2019). Such findings allude to the importance of considering and controlling for students' demographic and social context when investigating the influence of naturalness on academic performance (Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020; Hodson & Sandar, 2019).

Naturalness & environmental education

While research on naturalness/green space and learning outcomes in formal education has produced mixed results, in EE settings, the relationship remains understudied and unsubstantiated, despite the field's strong assumption that naturalness is an essential component of successful EE programs and is linked to positive learning outcomes. Research conducted by Ballantyne and Packer (2002, 2009) using observational data and in-depth interviews of educators, teachers, and students found support for a positive linkage between natural environments and positive learning outcomes during EE-type programs. Further, Dale et al. (2020) found that there was a significant, but weak, positive association between researchers' assessment of the naturalness of EE sites (as measured by researchers' observations) and positive learning outcomes for middle school children in the United States. Despite the assumed importance of naturalness, to our knowledge, no studies have used remote sensed landcover data to assess the relationship between naturalness of EE sites and students' learning outcomes.

Novel levels of naturalness and learning outcomes

One potential alternative explanation regarding the proposed relationship between naturalness and students' learning outcomes is that it is not related to the absolute level of naturalness but rather that being exposed to *novel* levels of naturalness may enhance outcomes during EE field trips (Dale et al., 2020; Garst et al., 2009; Garst et al., 2011). Novelty can be defined as an individual perception of something that is unique, unfamiliar, or new (Garst et al., 2009). Thus, novel levels of naturalness at EE field trip settings can be defined as meaningfully greater levels of naturalness at an EE site than a students' everyday environment (D'Amato & Krasny, 2011; Simmons, 2018).

Research suggests that novel natural settings may improve focus and attention (White & Stoecklin, 2008), reduce stress and anxiety (e.g., Berman & Davis-Berman, 1995; Garst et al., 2011), increase intrinsic

motivation, inspire collective action, and challenge perceptions (DeWitt & Storksdieck, 2008; De Waal, 2008; Orion, 1989; Orion & Hofstein, 1994).

However, there is also research suggesting that some familiarity and prior exposure to a setting can reduce stress and distraction and improve cognitive learning outcomes (Falk, 1983; Falk et al., 1978; Falk & Balling, 1982; Orion & Hofstein, 1991). Many children lack exposure to wild or natural settings (Orion & Hofstein, 1991; Simmons, 2018) and when these children are immersed in natural environments, a sense of disequilibrium can form that may potentially negatively influences learning outcomes (Falk, 1983; Falk et al., 1978; Falk & Balling, 1982; Orion & Hofstein, 1991; Boeve-de Pauw et al., 2019). Such research suggests that novel levels of naturalness between EE field trip sites and student's day-to-day environments may only lead to better learning outcomes when the disparity in naturalness is small or moderate (e.g., Boeve-de Pauw et al., 2019).

Methods

Thus, this study seeks to examine the relationship between middle school-aged students' learning outcomes and both the absolute and "novel" level of naturalness across a large sample of EE field trip programs/settings in the United States while accounting for the potential influence of students' grade level, race, and SES. We do so by pursuing two specific research questions: (1) Controlling for grade, race, and SES, what is the relationship between the level of naturalness of an EE field trip setting and middle school-aged students' learning outcomes? and (2) Controlling for grade, race, and SES, what is the relationship between student learning outcomes and novel levels of naturalness? We operationalize the naturalness of a site as the percent of its land cover that is natural, calculated using remotely-sensed land cover data. Novel levels of naturalness at a field trip site are calculated by taking the difference in percent land cover naturalness at EE field trip program sites and students' school attendance zones (SAZs).

This study is part of a larger research effort designed to examine EE field trip programs and the linkages between a range of program characteristics, pedagogical approaches, and positive student learning outcomes (see: Stern et al., 2022; Powell et al., 2022; Dale et al., 2020; Lee et al., 2020; O'Hare et al., 2020). Clemson University's Institutional Review Board reviewed all procedures described below prior to data collection and determined that procedures were Exempt. Verbal informed consent was received from program providers, educators, and students prior to all data collection procedures per guidelines outlined under approved protocols (IRB00000481; FWA00004497).

Site selection

We collaborated with the North American Association of Environmental Education (NAAEE), the U.S. National Park Service (NPS), and the Association of Nature Center Administrators (ANCA) to identify a broad range of organizations that offered EE programs. We identified over 300 potential program providers, including national parks, state and local parks, nature centers, botanical gardens, wildlife reserves, farms, public forests, science museums, and other environmental organizations. Our selection criteria dictated that potential organizations must offer programs that were: (1) field trips taking place away from school; (2) EE-focused; (3) a single day or less in duration; (4) served grades 5–8; (5) and offered by providers that expressed a willingness to participate and had programs scheduled during the research period. Ultimately, 345 programs provided by 90 unique organizations were observed between January and June 2018 (see Dale et al., 2020; Lee et al., 2020 for more information).

Survey design & administration

Immediately following each program, all attending students were invited to complete a retrospective survey to assess student learning outcomes. For all programs, researchers attempted a census of all eligible attendees. No time limit was given for the students to complete the survey, but the average completion time was approximately 8 minutes. The student survey was composed of the Environmental Education Outcomes for the 21st Century (EE21) scales, which were developed with extensive collaboration and review by the

EE field and followed scale development procedures recommended by DeVellis and Thorpe (2021) and others to ensure validity and reliability (see Powell et al., 2019 for details). EE21 is comprised of 10 sub-scales that measure outcomes identified by the field as relevant and important (Place Attachment, Learning, Interest in Learning, 21st Century Skills, Self-Identity, Self-Efficacy, Environmental Attitudes, Environmental Behaviors, Cooperation/Collaboration Behaviors, and School Behaviors) (Table 2). All but two of these sub-scales were measured using retrospective questions asking students to reflect on how much the program influenced them. All items were scored on an 11-point Likert-type scale. The remaining two sub-scales, Self-Efficacy and Environmental Attitudes, used retrospective pre/post questions to ask students to, first, reflect on how they felt about given statements before the program, and then, how they felt after as a result of the experience. The mean scores for these two subscales represent the difference between pre and post responses. After data cleaning (see below) we conducted confirmatory factor analysis to confirm the structure and measurement of EE21 ($S-B\chi^2 = 2732.0996$, 496DF, CFI = 0.973, SRMR = 0.027, RMSEA = 0.036 (.034, .037)). Results indicated that the EE21 scale was an excellent fit of the data and cross-validated the structure and measurement from previous research (see Powell et al., 2019).

Data cleaning and aggregation

Data from the 345 observed programs were entered into Microsoft Excel and then transferred to SPSS for data screening and analysis. We first removed any EE field trip programs with a response rate below 50%. We then screened and removed individual surveys missing responses to more than 25% of items along with those demonstrating clear patterns of invalid responses, such as a lack of variability in answers, strings of consecutive numbers, or the use of a single circle to indicate responses for multiple items (Dale et al., 2020; Lee et al., 2020; O'Hare et al., 2020). Survey data was then screened for multivariate outliers using Mahalanobis Distance (Field, 2018). This produced a sample of 334 usable programs and 4,376 valid surveys. We then aggregated the outcomes data to the program level. To test the validity of aggregating to the program level, we calculated the ICC (1) and ICC (2), which were 0.21 and 0.78, respectively. Each value suggests that most of the variance exists at the group level rather than the individual level and that aggregation is thus valid (Woehr et al. 2015).

To develop the sample for our first research question, we then removed any programs that were attended by multiple schools or grade levels, occurred entirely indoors, or did not have an identifiable location (e.g., EE field trips occurred on a moving bus or took place on water). These inclusion criteria were developed to remove programs that occurred at sites whose relative naturalness could not be assessed using our methodology. 283 programs met these criteria and constituted our sample for our first research question (Table 1).

In order to answer the second research question, we needed to establish the level of naturalness of student's home and school environment, which we operationalized as SAZs. SAZs are local political boundaries that represent the "catchment area" for a single public school (NCES, 2020) and encompass both the school as well as attending students' homes and neighborhoods (Browning et al., 2018; Hodson & Sander, 2017; Hodson & Sander, 2019). For this analysis, we removed an additional 64 programs that were attended by groups from private schools, as SAZs only exist for public schools. We then aggregated our program-level data to the school level (i.e., mean EE21 score for all EE programs attended from a single school), producing a final sample of 106 public schools representing 219 programs from which we collected survey data.

Grade, race, & SES of participating students

Previous studies (e.g., Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020), as well as our own research (Stern et al., 2022), indicate that students' background can impact learning

Table 1. Program inclusion criteria for research question 1.

Criteria	Programs removed	Programs remaining
Starting point	N/A	334
Removed programs attended by multiple schools or grades	3	331
Removed programs that occurred entirely indoors	9	322
Removed programs without identifiable location	39	283

Table 2. EE21 means & standard deviations.

Constructs and Items	RQ1 (n=283) M(SD)	RQ2 (n=219) M(SD)
Connection/Place attachment	7.76 (1.23)	7.91 (1.18)
Knowing this place exists makes me feel good.	7.62 (1.24)	7.79 (1.22)
I want to visit this place again.	7.61 (1.46)	7.78 (1.39)
I care about this place.	8.04 (1.19)	8.16 (1.14)
Learning	7.56 (1.04)	7.67 (1.02)
How different parts of the environment interact with each other.	7.15 (1.10)	7.27 (1.09)
How people can change the environment.	7.56 (1.21)	7.67 (1.22)
How changes in the environment can impact my life.	7.57 (1.13)	7.71 (1.07)
How my actions affect the environment.	7.94 (1.11)	8.02 (1.09)
Interest in Learning	6.53 (1.39)	6.66 (1.38)
Science.	6.57 (1.45)	6.68 (1.45)
How to research things I am curious about.	6.68 (1.51)	6.80 (1.24)
Learning about new subjects in school.	6.33 (1.51)	6.51 (1.50)
21st Century Skills	6.43 (1.38)	6.57 (1.38)
Solving problems.	5.86 (1.50)	6.01 (1.50)
Using science to answer a question.	6.44 (1.40)	6.57 (1.40)
Listening to other people's points of view.	6.86 (1.39)	6.98 (1.37)
Knowing how to do research	6.54 (1.55)	6.71 (1.56)
Meaning/Self Identity	6.87 (1.32)	6.99 (1.31)
Taught me something that will be useful to me in my future.	6.94 (1.39)	7.08 (1.39)
Really made me think.	6.96 (1.41)	7.11 (1.39)
Made me realize something I never imagined before.	6.71 (1.50)	6.83 (1.49)
Made me think differently about the choices I make in my life.	6.81 (1.47)	6.94 (1.45)
Made me curious about something.	6.90 (1.28)	6.97 (1.27)
Self-Efficacy (Retrospective pre-post)	.98 (.58)	1.03 (.58)
I believe in myself.	0.91 (.76)	.97 (.78)
I feel confident I can achieve my goals	0.85 (.62)	.90 (.62)
I can make a difference in my community.	1.18 (.67)	1.21 (.68)
Environmental Attitudes (Retrospective pre-post)	1.04 (.50)	1.04 (.49)
I feel it is important to take good care of the environment.	0.81 (.52)	.80 (.50)
Humans are a part of nature, not separate from it.	1.05 (.64)	1.06 (.65)
I have the power to protect the environment.	1.26 (.68)	1.27 (.62)
Actions: Environmental Stewardship	7.42 (1.14)	7.53 (1.08)
Help to protect the environment.	7.61 (1.21)	7.72 (1.18)
Spend more time outside.	7.34 (1.22)	7.45 (1.12)
Make a positive difference in my community.	7.31 (1.21)	7.43 (1.16)
Actions: Cooperation/Collaboration	7.06 (1.26)	7.16 (1.25)
Listen more to other people's points of view.	7.06 (1.30)	7.18 (1.26)
Cooperate more with my classmates.	7.05 (1.30)	7.15 (1.30)
Actions: School	7.34 (1.43)	7.48 (1.43)
Work harder in school.	7.35 (1.42)	7.47 (1.42)
Pay more attention in class.	7.33 (1.48)	7.49 (1.47)
EE21 Composite (chronbach's alpha=.962)	5.90 (.98)	6.01 (.96)

outcomes in formal education and EE settings. As such, to control for their influence, we group mean centered the EE21 outcome by grade and race and used linear regression models to control for SES for each research question.

Grade levels were reported by the on-site educators, but were also collected on student questionnaires. Most groups were comprised of a single grade. Although student surveys contained a question about racial identity using standard Census Bureau categories, we observed that students often experienced discomfort or misunderstood this question. Many left the question blank or wrote an invalid response. Because of these problems, we took steps to verify the racial majority of participating school groups. We began by determining the overall racial make-up of the school of each attending group using various internet sources (www.elementaryschools.org; www.greatschools.org; www.schooldigger.com, and individual school websites). We recorded the racial majority of attending students (> 50%) as: majority White, majority Black, majority Hispanic, or no majority. We then compared self-reported racial data from the

student surveys to these school figures to identify potential mismatches. The school-wide data matched self-reported data in 88% of the cases. We examined each mismatched case and usually the mismatch could be explained by low response rates on the surveys (i.e., it was possible that the racial majority of the group could match the racial majority of the school). In cases of mismatch with higher response rates, we recorded the group as “missing data,” rather than assigning a specific racial make-up to the group. We did this to be as conservative as possible and avoid misclassification. This only happened in four cases. In some cases ($n = 35$), school-wide data was not available. In these cases, we coded the majority of the student group using self-reported racial data only when a clear majority ($>50\%$ of all students in the group, regardless of the response rate) identified as a specific race. Other cases ($n = 4$) were coded as missing data. This resulted in eight cases in which the racial majority was not clear enough to use in our analyses.

To establish the SES of the students, we used the percentage of students with access to free and reduced lunch prices within a school. These data were collected from the 2018 National Center for Education Statistics database. While SES encompasses a far broader array of characteristics, percent free and reduced lunch reflects the general context of a school's attendance zone in terms of the concentration of low-income students (NCES, 2020). Nationwide, approximately 58% of public-school students participated in the National School Lunch program that provides free and reduced lunch prices (Bauman & Cranney 2020; USDA Food and Nutrition Service, 2020).

Natural land cover

We used the 2016 National Land Cover Database (NLCD) “Percent Developed Imperviousness” dataset for the continental United States as our measure of naturalness because of its wide-use and continuous and sufficiently granular measurement (e.g., Larson et al., 2018; Kuang, 2019). The 2016 NLCD “Percent Developed Imperviousness” dataset is a raster dataset derived from 30-meter Landsat imagery created by the USGS and the Multi-Resolution Land Characteristics Consortium (MRLC, 2020). This is a continuous metric that represents the continental United States as a grid of 900-m² pixels with values ranging from 0–100, indicating the estimated percent of each area that is covered with built impervious surfaces. The inverse of this metric is the operational measure of naturalness used for this study, which allowed us to calculate the percent of natural land cover at EE sites and SAZs.

Mapping EE sites & SAZ boundaries

We mapped the spatial extent of each EE field trip site where students engaged in activities. Researchers who observed programs used ArcGIS Survey123 to outline the specific areas where students engaged in activities during the EE field trip program (Figure 1). This was important because some EE field trip destinations (like national parks) occupy very large areas, but a single field trip program only actively uses a small portion of that area. It is for this reason that we did not simply use parcel data to represent the spatial extent of each field trip site.

The shapefiles were then loaded into ArcGIS Pro and we applied a 25-meter “visual buffer” around each site following recommendations by Browning et al. (2018) and Browning and Rigolon (2019). This visual buffer is intended to account for any features that students may have seen beyond the site boundary that could have influenced their experience (Browning & Rigolon, 2019; Browning et al., 2018).

For our second research question, we mapped public school groups' day-to-day environments using their respective SAZs (Figure 2). SAZ data were gathered from the publicly available 2020 National Center for Education Statistics dataset (NCES, 2020).

Data analysis

Because grade and race are factors that may influence learning outcomes (e.g., Stern et al., 2022), we began by group mean centering (GMC) EE21 outcomes to control for these variables (Enders & Tofighi,



Figure 1. Example outline of EE program site using ArcGIS Survey123.



Figure 2. Students' school locations ($n = 106$).

2007; Tabachnick & Fidell, 2018). We then conducted Pearson correlations of all variables under consideration and a series of linear regression models for each of our research questions.

Results

Learning outcomes: EE21

Table 2 displays the program-level mean and standard deviation for the composite measure of EE21 and each sub-scale before group mean centering by grade and race. Note that our analysis used the group mean centered composite EE21 score, where each variable is equally weighted and aggregated to the program level and then group mean centered by grade and race.

Table 3. Demographic & descriptive data.

S	N	Percentages & frequencies			
Grade Level	263	5 44.1% (116)	6 31.6% (83)	7 19.4% (51)	8 4.9% (13)
Racial Majority	277	White 43.7% (121)	Latinx 33.2% (92)	Black 8.7% (24)	No Majority 14.4% (40)
% Free & Reduced Lunch	239	M = 59.3 (SD = 24.1)			

Table 4. Description of EE sites & naturalness (n = 103).

	Area (Hectares)	2016 NLCD impervious surface naturalness %
Mean (SD)	8.5 (8.7)	85.2 (17.8)
Median	5.9	91.2
Minimum	0.6	6.9
Maximum	55.7	100

Table 5. RQ1 bivariate correlations.

	1	2	3
1. EE21 Outcome (GMC for Grade & Race)	–	–	–
2. 2106 NLCD Impervious Surface Naturalness %	.187**	–	–
3. % Free & Reduced Lunch	.316**	–.054	–

**Correlation is significant at the .01 level (2-tailed).

Table 6. RQ1 linear regression results.

Variable	Standardized Beta Coefficients	t	Sig.
Model 1 ($r^2 = .035$)			
(Constant)		–3.00	.003
% Naturalness	.187	3.04	.003
Model 2 ($r^2 = .138$)			
(Constant)		–4.56	.000
% Naturalness	.184	2.93	.004
% Free & Reduced Lunch	.322	5.12	.000

Research question 1

A diverse population of students attended the 283 programs (Table 3). Approximately 44% of programs were attended by 5th graders and student groups from majority-White schools. The average eligibility for free and reduced lunch was 59.3% across the sample (Table 3).

The average area of the EE field trip site was 8.5 hectares. The smallest area utilized for a field trip program was 0.6 hectares and the largest area was 55.7 hectares. EE sites contained, on average, 85.2% natural land cover, ranging from 6.9% to 100% natural (Table 4).

Correlations: There was a positive, significant relationship between EE21 and naturalness of EE sites ($r = .187, p < .01$). There is also a significant, positive correlation between percent free and reduced lunch and EE21 outcomes ($r = .316, p < .01$) (Table 5). However, there is not a significant correlation between percent free and reduced lunch and natural land cover at EE sites ($r = -.054, p = .40$).

Regression Models: The first linear regression model ($F(1254) = 9.24, p < .003; R^2 = .035$) examined the relationship between EE21 and naturalness. The results suggest that a significant, positive relationship between land cover naturalness of EE sites and EE21 exist ($B = .187, p = .003$) (Table 6). The second linear regression model ($F(2220) = 16.981, p < .001; R^2 = .134$), examining the relationship between EE21 outcomes, land cover naturalness, and SES found a significant, positive relationship between land cover naturalness at EE sites and EE21 outcomes ($B = .184, p = .004$), and between SES

and EE21 outcomes ($B = .322, p < .000$) (Table 6). While both percent free and reduced lunch and land cover naturalness were found to be significant predictors of positive EE21 outcomes, percent free and reduced lunch is a much stronger predictor.

Research question 2

We also investigated the relationship between student learning outcomes and the difference in the percent natural land cover between the SAZ and EE field trip site. To examine this question, we aggregated data to the school level ($n = 106$ schools representing 219 EE field trip programs). Approximately 45% of programs were attended by student groups from majority-White schools and 50% were fifth grade groups. The average eligibility for free and reduced lunch was 60.5% (Table 7).

SAZs on average were 12,648 hectares and contained on average 67.6% natural land cover, with SAZs ranging from 13.4% to 99.6% natural (Table 8). EE sites were 87% natural—almost 20% more natural than the average SAZ.

Correlations: Results of Pearson bivariate correlation analysis suggest that there is a positive, significant relationship between EE21 and the difference in natural land cover between SAZs and EE sites ($r = .203, p < .05$). There is also a significant, positive correlation between percent free and reduced lunch and EE21 ($r = .311, p < .01$) (Table 9). However, there is a significant relationship between percent free and reduced lunch and novel levels of naturalness of the EE field trip site ($r = .311, p < .01$).

Regression Models: The linear regression model 1 ($F(1, 98) = 4.197, p < .043; R^2 = .041$) suggests a significant, positive relationship between EE21 and novel levels of naturalness $B = .203, p = .043$ (Table 10). Controlling for SES by including the percentage of students eligible for free and reduced lunch in the regression equation, linear regression model 2 ($F(2, 95) = 5.799, p = .004; R^2 = .109$), indicates that novel levels of naturalness was not a significant predictor of EE21 ($B = .115, p = .263$) and only percent free and reduced lunch was significant in this model ($B = .276, p = .008$), with an R^2 of .109 (Table 10).

Table 7. Description of students from attending schools.

S	N	Percentages & Frequencies			
		5	6	7	8
Grade Level	102	50% (51)	31.4% (32)	12.7% (13)	5.9% (6)
Racial Majority	105	White	Latinx	Black	No Majority
		44.8% (47)	37.1% (39)	4.8% (5)	13.3% (14)
% Free & Reduced Lunch	104	M = 60.5 (SD = 24.3)			

Table 8. Descriptive statistics for SAZ area, SAZ naturalness, EE field trip site naturalness, & SAZ-EE site naturalness difference.

	SAZ Area (n = 106) (hectares)	SAZ Naturalness %	EE Site Naturalness %	Naturalness Difference %
Mean (SD)	12648.7 (45704)	67.6 (23.4)	87.0 (15.2)	19.4 (24.5)
Median	1065.3	64.9	94.8	17
Minimum	94.1	13.4	34.1	-33.3
Maximum	368580.6	99.6	100	80.1

Table 9. RQ2 bivariate correlations.

	1	2	3
1. EE21 (GMC for Grade & Race)	—	—	—
2. Novel Levels of Naturalness Difference %	.203*	—	—
3. % Free & Reduced Lunch	.311**	.311**	—

**Correlation is significant at the .01 level (2-tailed).

*Correlation is significant at the .05 level (2-tailed).

Table 10. RQ2 linear regression results.

Variable	Standardized Beta Coefficients	t	Sig.
Model 1 ($r^2 = .041$)			
(Constant)		-.809	.421
Novel Levels of Naturalness % (Difference between SAZ & EE field trip site)	.203	2.05	.043
Model 2 ($r^2 = .089$)			
(Constant)		-2.762	.007
Novel Levels of Naturalness % (Difference between SAZ & EE field trip site)	.115	1.126	.263
% Free & Reduced Lunch	.276	2.710	.008

Discussion

We investigated the relationship between naturalness of EE field trip site and student learning outcomes and found that naturalness accounted for 3.5% of the variance in EE21. However, when we also controlled for SES, as measured by percent free and reduced lunch, we found that SES is a stronger predictor of positive learning outcomes. Similarly, novel levels of naturalness accounted for 4.1% of the variance in learning outcomes during EE field trips. However, when controlling for SES, novel levels of naturalness was not a significant predictor of EE21 outcomes. The correlation results suggest that the percentage of students receiving free and reduced lunch is a covariate with novel levels of naturalness and account for shared variance in EE21. This result is supported by other research that suggests that greater percentages of free and reduced lunch are associated with urban schools that typically have lower levels of naturalness (e.g., Berman et al., 2018; Kuo et al., 2018; Logan & Burdick-Will, 2017).

This is not to say that the naturalness of the setting or novel levels of naturalness aren't important, but rather many other factors and pedagogical approaches also contribute to outcomes during EE field trip programming (e.g., Stern et al., 2014; Powell et al. 2022; DeWitt & Storksdieck, 2008; Storksdieck, 2001; Lee et al., 2020; O'Hare et al., 2020). These results suggest that practitioners should place EE programming in as natural a setting as possible but recognize that being reliant on such features is not enough to produce positive student learning outcomes. For program practitioners in urban or less novel natural environments, our findings indicate that a successful EE program is still entirely possible, and it is best to focus on effective pedagogy and teaching strategies to promote positive learning outcomes (DeWitt & Storksdieck, 2008; Storksdieck, 2001; Powell et al., 2022). Thus, our results suggest that EE field trip programs may occur anywhere and still deliver positive student learning outcomes. This is especially important when considering equitable access to environmental education. Students may not need to travel hours into extremely novel, natural locations to receive the benefits of an EE field trip program. Rather, our results suggest that effective EE field trip programs could occur in students' neighborhoods, at local nature centers, and in familiar environments.

However, when considering the results of our study, it is also important to understand its limitations. For example, this study of EE programs and SAZs is post hoc in nature. Sites were not selected and sampled for this purpose, but rather to maximize diversity in EE approaches and audiences in general (see Powell, et al., 2022). Future studies could purposefully select programs based on natural attributes of their settings. Moreover, in order to identify the areas where field trips occurred, we used spatial outlines drawn post hoc by researchers who observed EE programs. In the future, researchers could carry GPS units and directly track the areas where programs occurred. Doing so may yield more precise estimations of the area where EE field trips occur. Additionally, while we ultimately used the 2016 NLCD "Percent Developed Imperviousness" dataset, which has been used in past naturalness research (e.g., Larson et al., 2018), it may be advantageous in the future to use this dataset in tandem with other imagery (NDVI, for example) or observational data, to "triangulate" the data and help overcome land cover misclassification (Wickham et al., 2021). Furthermore, the pixel size of the 2016 NLCD "Percent Developed Imperviousness" dataset is 900 m², which is quite large, and as this is a raster dataset, each individual pixel is assigned a percentage of relative imperviousness. This means that our naturalness metric could be improved by using imagery with higher resolution or by pairing with other metrics such

as expert or student perceptions of naturalness and novel levels of naturalness. The addition of students' or experts' perceptions would potentially account for the quality and special environmental characteristics of a site and allow for a more holistic understanding of the role that natural and novel environments play during EE field trip programs (e.g., Ballyntine & Packer, 2002). Another potential limitation pertains to the outcome measure (EE21), which is intended to measure a broad spectrum of outcomes relevant to all EE field trips. However, this measure and associated outcomes may not have reflected the specific goals of specific programs within our sample. The last potential limitation pertains to our treatment of the data. We aggregated data to the program level for research question 1 and the school level for research question 2 and controlled for grade, race, and SES; this removed potential variance at the individual level.

While these limitations exist, this study offers compelling evidence to counter the common assumption in the field that simply having an EE lesson outside, in a natural environment, will automatically produce positive learning outcomes. Our results suggest that natural and novel natural environments must be paired with effective pedagogical approaches and program implementation in order to create truly impactful experience for students (e.g., Powell, et al., 2022; Duerden & Witt, 2012; Durlak & DuPre, 2008; Morgan et al., 2016).

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