Is naturalness of elementary school sites linked to student's academic performance?

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ABSTRACT: A growing body of research has linked the environmental qualities of a school to students' academic performance. Previous studies showed that air quality around school buildings influences standardized test scores and attendance rates of students. One particular study revealed that views with greater quantities of trees and shrubs from classroom windows are positively associated with standardized test scores and graduation rates in high school students. In many other contemporary studies, increased contact with nature was found to be positively correlated with better performances of children. However, very few studies have investigated how the overall naturalness of a school building site may relate to its elementary school students' performance. Studies investigating such relationships with younger children in elementary schools are even rarer. Aim of this study is to address this gap in research and investigate empirically whether overall naturalness of elementary school environment links to children's academic performance.

This study investigates the potentials of available online resources to build a research strategy that can investigate the relationship between school surrounding *naturalness* and children's academic performance. A pilot data consisted of 20 randomly selected elementary schools located in Raleigh, North Carolina is used to demonstrate the proposed methodology.

KEYWORDS: School Building, Naturalness of School Sites, Academic Performance, I-Tree

INTRODUCTION

Although the underlying pathways of the effects of green spaces on health are not fully understood, a number of benefits including improved conditions of physical and mental wellbeing are linked to greenness/naturalness of surrounding environment. These benefits from exposure to green spaces can be expected to translate into a supportive environment for academic achievement in children as well. However, studies investigating the specific effects of school-site *naturalness* on students' academic performance are rare. When it comes to matters of elementary or preschool children, it is difficult to find a single study which has investigated this phenomenon. The objective of this study is to propose a methodological pathway to investigate this under-researched phenomenon of the influences of school-site naturalness on elementary school children's academic performance.

1.0 LITERATURE REVIEW

Child advocacy expert Richard Louv, in his influential work about the divide between children and the nature, discussed the lack of nature in the lives of today's wired generation. He calls it "nature deficit disorder"—and he points to it as a cause of some of the most disturbing childhood trends, such as the rises in obesity, attention disorders, and depression (Louv 2008). Having visual access to nature is known to be beneficial across a wide range of contexts. Two studies have given evidence (Taylor 2002, Wells 2000) that views of nature contribute to self-discipline of adolescent girls and cognitive functioning of children. The first study investigated the role of near-home nature on three forms of self-discipline among children (Taylor 2002). The aim to the research was to provide empirical evidence of the power of nature for *attention restoration*. The sample of the study was composed of 169 inner-city children randomly assigned to 12 architecturally identical high-rise buildings with varying levels of nearby nature. The results showed that the more natural a girl's view from home was, the better her performance scored in the tests of self-discipline. The second study (Wells 2000) showed that children who relocated to homes that improved the most in terms of surrounding naturalness tended to have the highest levels of cognitive functioning. The study had a small sample size (N = 17) and the author admitted that since the study was longitudinal (same group of children), the role of naturalness/greenness on cognitive functioning might have been temporary.

View of nature or surrounding naturalness is found to be associated with adults' physical and mental wellbeing. Kaplan (1993) reported two separate studies on the presence versus absence of natural window views. In the first case, workers with natural views reported fewer common health ailments in the preceding six-month period and higher job satisfaction. In the second study, natural views were related to increased feelings of privacy and satisfaction; natural views were also associated with lower frustration and increased patience and task enthusiasm. In a similar line of research, having a view of forested settings was related to greater job satisfaction and lower stress in a South Korean sample (Sop Shin 2007). Research in the area of healthcare and physical well-being has shown that window views can influence health outcomes (Devlin and

Arneill 2003). Seminal work by Ulrich (1984) showed that patients recovering from gall bladder surgery who had views of trees recovered from surgery significantly faster, had fewer negative interactions with nursing staff, and used fewer analgesic medications when compared with those recovering in rooms with a less scenic brick wall window view. It was also shown that nature views promoted residential satisfaction and overall resident well-being (Kaplan 2001). Most of these studies were conducted in different work environments such as office spaces, residences or hospitals; but findings indicate that similar positive effects of greenness/naturalness are also likely to motivate children's performances classroom environments. However, research studies linking surrounding naturalness of school sites and children's academic performances are rare.

Few studies were found which investigated the role of surrounding *naturalness* or *greenness* on the academic performance of students. One recent study (Benfield et al. 2013) examined differences across multiple sections of a college writing course in two types of identically designed classrooms—those with a view of a natural setting and those with a view of a concrete retaining wall (Figure 1). Results showed that students in the natural view classrooms were generally more positive rating the course. Students in the natural view condition also had higher end of semester grades. This particular study provided methodological insight and it is among few studies which adopted natural experimental design.
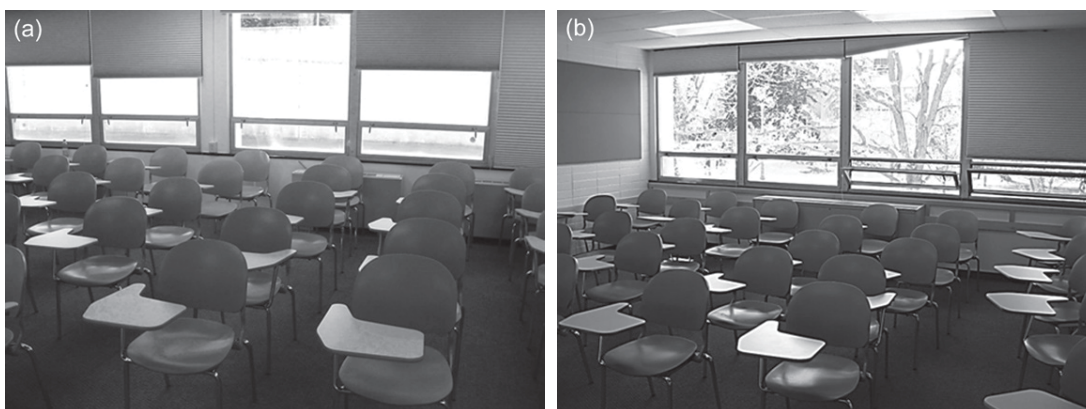
Figure 1: Natural view classrooms had higher end of semester grade (Source: Befield et. al 2013).

Another study showed that in high school students, views with greater quantities of trees and shrubs from classroom windows were associated with positive academic performance outcomes (Matsuoka 2010). This study revealed interesting findings regarding the greenness/naturalness of environment. Greener view and surrounding greenness of campus were found to be positively associated with standardized test scores, graduation rates, percentages of students planning to attend a four-year college, and fewer occurrences of criminal behavior. In addition, large expanses of landscape lacking natural features were found to be negatively related to these same test scores and college plans. On the other hand, the study by Tanner (2009) reported that when a student needed to take a break from learning, it was easier to get back on track after taking a quick look outside at a pleasant view than after doodling on paper. Tanner (2009) also qualified these views and indicated that not all views were beneficial. He differentiated those views indicating that while a view of a wall or parking lot was not desirable, *unrestricted views of nature, wild-life* and *human activity areas* may provide students and teachers with the much needed *quicker* mental break.

Table 1: Summary of findings of literature review

Finding	Source	Scope
Near home nature contributes to self-discipline and cognitive functioning of children	Taylor, 2002; Wells, 2000	Similar studies are needed for school environment
Classroom windows were positively associated with standardized test scores and graduation rates in high school students and test scores in college students	Matsuoka, 2010, Benfield et. al, 2013	Similar studies are needed for elementary school children
Natural view contributes to health and wellbeing of adults	Devlin and Arneill 2003, Kaplan, 2001, Sop Shin 2007, Ulrich, 1984; Walch et al., 2005,	Similar investigation is needed for health and wellbeing of children

The most important study on the similar topic has only recently been published. This study investigated the association between the "greenness" of the area surrounding a Massachusetts public elementary school and the academic achievement of the schools' student body based on standardized tests with an ecological setting (Wu et al. 2014). Researchers used the composite school-based performance scores generated by the Massachusetts Comprehensive Assessment System (MCAS) to measure the percentage of 3rd-grade students. Surrounding greenness of each school was measured using satellite images converted into the Normalized Difference Vegetation Index (NDVI) in March, July and October of each year according to a 250-meter, 500-meter, 1,000-meter, and 2000-meter circular buffer around each school. Spatial Generalized Linear Mixed Models (GLMMs) estimated the impacts of surrounding greenness on school-based performance. Overall, the study results supported a relationship between the *greenness* of the school area and the school-wide academic performance. While Normalized Difference Vegetation Index (NDVI) is a useful tool, it could not be differentiated between different *greenness* of surfaces like grassy areas, urban forests or large/small tree covers, etc. Although, the current research also uses online resources for collecting data, it adopts a very different technique for data collection of school-surrounding vegetation data which has more precision in differentiating among different *green* surfaces and has more statistical accuracy.

2.0 METHODOLOGY

The pilot data collected for this project used mainly 2 web-based sources. All dependent variable data related to children's academic performance was collected from a website called NC School report Cards (http://www.ncreportcards.org/src/). This web source was used also for many different other control variable data. Naturalness of a school site is measured by an online urban forest analysis tool called the i-Tree (www.itreetools.org). The i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. Data was collected from randomly selected 20 elementary schools located in Raleigh, North Carolina. IBM SPSS software was used to conduct a multiple linear regression analysis on collected data of dependent variables (academic outcomes), independent variable (school-site naturalness) and control variables.

2.1. Data on academic performance
From NC School report Cards (http://www.ncreportcards.org/src/), the overall math percentage scores were collected for the 20 selected schools. This data was treated as the outcome variable (academic performance of students) in this pilot research project.

2.2. Data on school-site naturalness
The i-Tree software interface allowed the researchers to quantify the school-surrounding environment in different criteria. The system allowed entering specific land-cover types at the beginning of data collection and then based on the land-cover type entered for randomly selected data points of the selected site area, i-Tree can give an estimated percentage measurement for those different land-covers. The biggest advantage of using i-Tree instead of the NDVI technique used in the Wu et al. study (2014) is that, instead of just measuring the *greenness* parameter, it allowed the researcher to differentiate between different *natural* land-cover types such as grassy surface, urban forest, water surface, large or small tree areas etc. The statistical accuracy of i-Tree depends on the number of random points entered for a given area. For demonstration purposes, only two land-cover classes were created for this project namely *tree* and *non-tree*. As more random points are entered into the system classifying different land covers, the statistical accuracy also increases. For this pilot project a 500 feet buffer area from the school building was considered as the *school-surrounding* site. It is usually recommended to enter at least 500 random data points for a selected site. However, the purpose of this pilot survey was focused in demonstrating the methodology rather than providing empirical findings. Therefore, 100 data points were randomly entered for each of the 20 school's site buffer area.
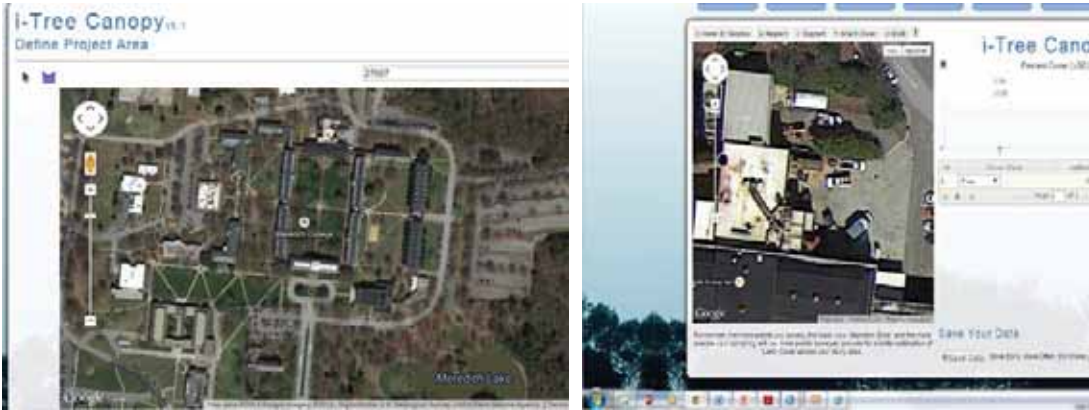
Figure 2: i-Tree interface.

Figure 2 shows screenshots of the i-Tree software interface for entering random data points for a selected site.

2.3. Data on school-site naturalness

Data on several controlling variables were also collected from NC School Report Cards (http://www.ncreportcards.org/src/) for the 20 selected schools. The controlling factors included crime per 100 students, school attendance, number of books per student, number of students per digital device, number of teachers, teachers percentage with advanced degree, number of board certified teachers, teacher experience, and total number of tests taken.

3.0 RESULTS

A multiple regression analysis using the *forward* technique in the IBM-SPSS software was employed. No statistically significant association was found between tree land cover (%) and elementary school students overall math score percentage. In the regression model, the only statistically significant predictor was *number of student per digital device* (at $p < .05$ level). The association predicts that when there are more students using a single digital device, it is likely that their overall math score would improve. However, the data presented in the analysis consists only a small sample of 20 schools, and the associated statistical power is very low. The purpose of this analysis is a demonstration of the methodology rather than establishing statistical relationships.

Table 2: Multiple regression analysis.

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	school_size	.041[b]	.182	.857	.044	.863
	crime_per_100_student	.130[b]	.615	.547	.147	.962
	school_attendance1	.192[b]	.937	.362	.222	.996
	number_of_books_per_student1	.040[b]	.162	.873	.039	.709
	number_of_teacher1	-.238[b]	-1.145	.268	-.268	.950
	teacher_percentage_with_advance_degree1	.132[b]	.613	.548	.147	.927
	board_certified_teacher1	.131[b]	.555	.586	.133	.777
	teacher_experience_0_3	.029[b]	.133	.896	.032	.940
	teacher_experience_4_10	-.153[b]	-.739	.470	-.177	.998
	teacher_experience_10_over	.077[b]	.355	.727	.086	.926
	number_of_test_taken	.050[b]	.227	.823	.055	.921
	Tree land_cover_percentage	-.056[b]	-.260	.798	-.063	.944

a. Dependent Variable: overall_math_percentage
b. Predictors in the Model: (Constant), number_of_student_per_digital_device1

CONCLUSION

The aim of this exploratory study is opening a new line of investigation in the field of architecture-human behavior research. The methodology demonstrated in this paper with the small sample of 20 schools has a lot of potentials for investigating the *unknown* associations between school-site characteristics and students performances. It provides an alternative technique for assessing the naturalness of a site area which can be used to validate the results found in previous the previous study (Wu et al. 2014) which used NDVI technique. There are approximately 135,000 public schools in the United States containing more than 53 million of its young citizens. Large scale studies investigating the value of naturalness of school sites may contribute heavily to the design guidelines and design standards of school architecture to improve health and performance of young children. It is expected that findings from this pilot study will be valuable for establishing base findings regarding the argument and provide opportunities for large-scale studies in the related field of research.

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