



Research paper

Impact of views to school landscapes on recovery from stress and mental fatigue

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HIGHLIGHTS

- The effect of window views on attention and stress were tested using randomized controlled experiment.
- Window views to green landscapes promote high school students' attention restoration.
- Window views to green landscapes speed high school students' recover from stress.
- Attention restoration and stress recovery are separate pathways.
- Exposure to daylight alone did not improve student performance.

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ABSTRACT

Previous research has demonstrated positive associations between the greenness of high school landscapes and school wide academic performance. We do not know, however, if green landscapes cause better performance or if the association between the two is a product of self-selection. If there is a causal relationship, the pathways through which green school landscapes affect student performance remain unclear. We hypothesize that views onto green landscapes help students recover from mental fatigue and stress. To test these hypotheses, we conducted a randomized controlled experiment with 94 high school students at five high schools. Participants were randomly assigned to classrooms without windows or with windows that opened onto a built space or a green space. Participants engaged in typical classroom activities followed by a break in the classroom to which they were assigned. Attentional functioning was measured using Digit Span Forward and Backwards. Physiological stress levels were measured by skin conductance, body temperature, pNN50 (the proportion of the number of pairs of successive NNs that differ by more than 50 ms divided by the total number of NNs) and LF/HF (the ratio between low-frequency peak and high frequency peak). Results demonstrate that classroom views to green landscapes cause significantly better performance on tests of attention and increase student's recovery from stressful experiences. A lack of mediation effect demonstrates that attention restoration and stress recovery are two distinct processes. Implications for school site selection, design and renovation are discussed.

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1. Introduction

Context impacts learning. It is well-documented, for instance, that physical characteristics of school environments such as lighting, noise, indoor air quality and thermal comfort, building age and condition all impact learning (Aturupane, Glewwe, & Wisniewski, 2013; Cheryan, Ziegler, Plaut, & Meltzoff, 2014; Roorda, Koomen,

Spilt, & Oort, 2011). There is growing evidence that we have overlooked the impact school landscapes have on student academic performance. The cost of this oversight is that millions of children are trying to learn in settings that may be significantly less supportive than they might otherwise be.

Recent studies examining students' exposure to nature found the amount of vegetation on and surrounding campus significantly predicted school-wide student performance (i.e., standardized test scores, graduate rates) (Matsuoka, 2010; Wu et al., 2014). These exciting findings are correlational and thus the extent to which exposure to green school landscapes causes increased student performance remains unsubstantiated. We also do not know the mechanism or pathways through which green landscapes

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might influence student performance. Finally, if there is a causal relationship, we lack information regarding when the benefits of exposure to green campus landscapes might occur for students. The study reported here is designed to address these questions.

We begin by examining theory and evidence suggesting two possible pathways through which exposure to landscapes might result in better student performance—attention restoration and stress reduction. Next, we report a new study involving a randomized controlled experiment and end by discussing the implications of the findings for a variety of stakeholders.

2. Theoretical framework on nature and student performance

2.1. The influence of green space on children and adolescents

Exposure to green space has been shown to have a variety of positive impacts on children and adolescents. These benefits include enhanced physical activity and play (Barton, Sandercock, Pretty, & Wood, 2014; Dyment & Bell, 2008), reduced chances of obesity and other chronic diseases (McCurdy, Winterbottom, Mehta, & Roberts, 2010), enhanced mental health and resilience (Chawla, Keena, Pevac, & Stanley, 2014; Corraliza & Collado, 2011; Flouri, Midouhas, & Joshi, 2014; Wells & Evans, 2003), improved environmental awareness (Chawla, 2009; Cheng & Monroe, 2012; Collado, Staats, & Corraliza, 2013; Wells & Lekies, 2006), and enhanced self-discipline and ability to concentrate (Faber Taylor & Kuo, 2009; Faber Taylor, Kuo, & Sullivan, 2002).

In education settings, recent studies have described a restorative effect associated with direct or indirect exposure to trees and other forms of vegetation on students across age groups. For elementary school students, the perceived restorativeness of school playgrounds is positively associated with vegetation volume and naturalness (Bagot, Allen, & Toukhsati, 2015; Collado & Corraliza, 2015). In a quasi-experimental study, middle school landscape renovation that increased the amount of vegetation was associated with reduced stress levels and enhanced psychological well-being (Kelz, Evans, & Röderer, 2013). Real and simulated views of natural elements were positively related to measures of attention and perceived restorativeness of college campus settings (Felsten, 2009; Laumann, Gärling, & Stormark, 2001; Tennessen & Cimprich, 1995). These studies suggest that students show objectively measured and anticipated restoration when exposed to greenness.

Green space offers restorative potentials, but to what extent does exposure to landscapes containing vegetation impact student performance? Two recent studies shed light on this question. One examined the relationship between vegetation condition surrounding schools and school-based student performance on math and English as measured by the Massachusetts Comprehensive Assessment System and found a positive association between vegetation cover and academic performance (Wu et al., 2014). Another study measured high school environments including the amount of vegetation visible from classroom and cafeteria windows, the size of the windows, and the density of vegetation in each part of the campus, to predict student performance (i.e., standardized test scores, graduate rates, percentage of students planning to attend college). The findings demonstrated a positive relationship between nearby nature and school-wide academic performance (Matsuoka, 2010).

Although these two studies reveal a promising association between green campus landscapes and student academic performance, they are cross-sectional, correlational studies that cannot draw conclusions regarding the causal impact of greener campuses

on student performance. Thus, building on previous findings, we conducted a randomized controlled experiment to examine how green space affects academic performance. Why do students perform better when they were exposed to greener views? Two pathways seem most promising.

2.2. Possible pathways between landscape and student performance

Two theories have been proposed that might explain the effect of exposure to green landscapes on student performance: Attention Restoration Theory (ART) (Kaplan, Kaplan, & Ryan, 1998; Kaplan, 1995) and Stress Reduction Theory (SRT) (Ulrich et al., 1991).

Sustained attention is the most important resource for learning. For students, inattention often results in academic underachievement (Demaray & Jenkins, 2011; Rapport, Scanlan, & Denney, 1999), and access to nature has been demonstrated as crucial for restoring attentional capacities (Schuttle, Torquati, & Beattie, 2015). Therefore, restored attention may be a pathway through which green landscapes lead to better performance.

ART proposes that people use voluntary control to inhibit distraction and remain focused, and this capacity to remain focused fatigues over time. After a short exposure to a green space, the cognitive capacity to focus attention is renewed because contact with nature enhances the inhibitory mechanism on which directed attention depends (Kaplan et al., 1998; Kaplan, 1995). Exposure to nature has been found to restore the cognitive resources supporting both executive functioning and self-regulation (Kaplan & Berman, 2010), which are also critical to learning.

Stress is predictive of reduced performance for children and adolescents. Studies have repeatedly shown that students who report lower personal and school-related stress attain higher GPAs (Gillock & Reyes, 1999), show more academic achievement (Grannis, 1992), and are less likely to engage in behaviors that lead to lower performance (e.g., truancy, dropping out of school) (Hess & Copeland, 2001). Therefore, reducing the stress that students experience might be a pathway through which green landscapes impact student performance.

SRT proposes that exposure to nature supports psychophysiological stress recovery, resulting in reduced blood pressure and lower levels of stress hormones (Ulrich et al., 1991). Recent studies also show positive physiological responses to nature including better neuroendocrine functioning (Van Den Berg & Custers, 2011), immune system functioning (Li, 2010), meditative brain wave activities (Aspinall, Mavros, Coyne, & Roe, 2013), and recovery from stressful experiences (Jiang, Chang, & Sullivan, 2014a; Jiang, Li, Larsen, & Sullivan, 2014b). A study involving elementary schools in Baltimore, Maryland, reported that students find green schoolyards a safe retreat from stress, because the natural areas allow students to build competence and form supportive relationships (Chawla et al., 2014).

The possible relationship between attention restoration and stress recovery has been mentioned but not empirically tested. One theory is that attentional fatigue is an aftereffect of stress (Ulrich et al., 1991), and therefore the attentional restoration effect is based on emotional and physiological changes. Kaplan (1995), on the other hand, argue that stress can be caused by the human perception of inadequate resources. When one's attentional resources are reduced by a demanding task, an individual's appraisal of inadequacy may trigger physiological stress. To date, however, no research has tested the mediation effect of stress recovery on attention restoration, or vice versa. Therefore, in addition to testing the two potential pathways, we might advance our understanding of the relationship between these two mechanisms by testing the extent to which the relationship between

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