IMPACT OF NATURE WINDOW VIEW ON HIGH SCHOOL STUDENTS STRESS RECOVERY

BY

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THESIS

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ABSTRACT

Although a number of studies demonstrate that direct or indirect exposure to green space is associated with reduced symptoms of stress (Grahn & Stigsdotter, 2003; R. S. Ulrich et al., 1991), few studies have investigated the impact of a view of nature from school classroom windows on students’ stress recovery. We do not know whether a natural classroom window view has significant impacts on students’ stress recovery. Does a natural window view help students recover from stress faster than a barren window view or no window view?

In this thesis, 94 participants were randomly assigned to three different window view conditions in high school classrooms: 1) nature window view, 2) barren window view, and 3) no window. Then participants completed the standard Trier Social Stress Test (TSST) to induce stress. We measured stress three times throughout the experiment by asking students to self-rate their stress levels using a visual analog scale (VAS) questionnaire and by taking skin conductance and temperature measurements. Analyses revealed that classroom window view has a significant influence on students’ stress recovery. Even though the participants’ self-reports do not show a relationship between the window view conditions and stress recovery, the two physiological measurements revealed a significant relationship between window views and stress recovery. The findings indicate that a natural window view has a stronger impact on stress recovery than barren or no window views.

Key words: landscape, high school, stress, nature window view
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High school students and stress

Stress is taking a toll on students. High school students in particular are experiencing unprecedented school-related stress (Ainslie & Shafer, 1997; Byrne, Davenport, & Mazanov, 2007; Stuart, 2006). Some claim that most stressors young people face are school-related. These stresses sometimes come from students’ own high expectations but often stem from teachers and parents who urge students to maintain a high grade point average, score well on academic tests, participate in a wide variety of extracurricular activities and gain admission to top colleges (Byrne et al., 2007; Cech, 2008; Conner, Pope, & Galloway, 2010; D. S. Kaplan, Liu, & Kaplan, 2005; Pope, 2010; Ramirez, 2009; Suldo, Shaunessy, Thailji, Michalowski, & Jessica, 2009). A US nationwide survey conducted by the Kaiser Family Foundation (2005) found that 63% of teenagers between fourteen and eighteen years of age felt that school was the greatest cause of stress, and that 27% of teenagers reported they had frequently suffered stress in their daily lives. In addition, the Horatio Alger Association of Distinguished Americans surveyed a sample of over 1,000 students ages 13-19 and found that almost 79% participants said they experienced pressure to get good grades in school ("The State of Our Nation's Youth," 2008).

A certain amount of stress is good and has been found to foster motivation and healthy competition and improve one’s performance (Sedere, 2010; Selye, 1984). But chronic stress has been consistently associated with negative outcomes, such as physical illness, anxiety, depression, decreased academic performance, social withdrawal and drug or alcohol experimentation.

Physical illness. When students experience high levels of stress, they are more likely to have physical illness, like headaches and tiredness (Alfven, Ostberg, & Hjern, 2008; Sundblad, Jansson, Saartok, Renstrom, & Engstrom, 2008) According to Conner’s study (2010), 44% of 3,645 students from seven high
schools in the California Bay Area reported that they experienced three or more physical symptoms of stress, including headaches and stomach problems, in a typical month in the school year. Low sleep quality is also an obvious physical problem caused by chronic stress(Conner et al., 2010; Furutani, Tanaka, & Agari, 2011; Schraml, Perski, Gtossi, & Simonsson-Sarnnecki, 2011). Conner and colleagues (2010) also found that over half of the respondents reported difficulty sleeping (54%) and exhaustion (56%) due to academic stress.

**Anxiety and depression.** Students in high-stress environments often demonstrate increased levels of anxiety and depression(Hjern, Alfven, & Ostberg, 2008; Huang & Guo, 2009; Moksnes, Moljord, Espnes, & Byrne, 2010). A study of 1508 Norwegian adolescents found that school-related stress was positively associated with depression, and stress from peer pressure was positively associated with anxiety (Moksnes et al., 2010).

**Decrease in academic performance.** Studies indicate that high-stress school environments lead to decreases in academic performance(D. S. Kaplan et al., 2005; Peterson, Duncan, & Canady, 2009; Sedere, 2010). Kaplan et al.’s 3-year study of 1034 high school students showed that stress can impede students’ academic performance(D. S. Kaplan et al., 2005)

**Social withdrawal.** Students exposed to high levels of stress often withdraw from family and friends. It is said they prefer spending more time alone and staying away from social activities(Conner et al., 2010; Schraml et al., 2011). A 3-year study in Sweden found that stress is significantly related to feelings of loneliness in students(Sundblad et al., 2008).

**Drug or alcohol experimentation.** Research also shows that stress drives drug and alcohol abuse(Camatta & Nagoshi, 1995; Digdon & Landry, 2013; Windle & Windle, 1996). McCormack (1996) found that students reported that their drinking motivation increased from 23% to 36% when they were
stressed. The Partnership for a Drug-Free America’s (2008) nationwide survey of 6,511 students in grades 7-12 found that the top reason for students to use drugs was to cope with stress.

**Theory of nature window view and stress recovery**

Fortunately, a growing body of research has sufficiently linked contact with nature to the benefits of stress recovery. Roger Ulrich’s Psycho-Evolutionary Theory has described the mechanisms to explain this connection (R. Ulrich, 1983). This theory proposes that individuals prefer some natural scenes over urban scenes and that natural views elicit more positive feelings and reduced fear than primarily built scenes. These positive feelings have been shown to be related to lower levels of stress and to foster recovery from anxiety or stress. Visual environments tend to be categorized broadly as 'natural' if the content is predominantly vegetation and/or water, and if human-made features such as buildings and cars are absent or inconspicuous (R. Ulrich, 1983).

The literature suggests that there are three levels of contact with nature. The first level is viewing nature from a window or seeing pictures in a book or video. The second level is being in the presence of nature, perhaps while participating in another activity, and would include sitting on a bench in a park while reading a book, talking to friends in an outdoor space or biking along a green bike path on the way to work. The third level is more active participation or involvement with nature, such as gardening, farming, running or other physical exercising (Pretty, 2004). Interestingly, researchers have found that all of the levels of contact with nature can yield psychological benefits (including stress recovery benefits). Matsuoka and Sullivan (2011) list the benefits as follows: 1) enhanced capacity to pay attention, 2) greater ability to cope with life stressors and crises, 3) improvements in overall psychological well-being, and 4) greater satisfaction with their neighborhoods and their lives.
Indeed, the positive benefits on stress recovery have been established in over 100 studies in settings of wilderness and urban nature areas. On the whole, the work in this area demonstrates that stress mitigation is one of the most important self-reported benefits of contact with nature (Driver & Knopf, 1975; Knopf, 1987; Schroeder, 1989).

Evidence of nature window view and stress recovery

Any level of contact with nature, including merely looking at nature from a window view, can yield psychological benefits, including stress recovery. Evidence for the benefits of windows comes from buildings where people work and live, as well as health and recreation places, such as hospitals and rehabilitation centers (R. Kaplan, 2001; Raanaas, Patil, & Hartig, 2012; Shepley, Gerbi, Watson, Imgrund, & Sagha-Zadeh, 2012; Shin, 2007).

Views of nature out of an office are associated with increased job satisfaction and reduced levels of frustration and stress (R. Kaplan, 1993; Leather, Pyrgas, Beale, & Lawrence, 1998; Shin, 2007). Those in offices without windows are more likely to have indoor plants or put up some paintings or pictures of natural scenes to compensate for the lack of a natural window view (Heerwagen & Orians, 1993). Leather and his colleagues (1998) demonstrated that a view to nature elements (i.e., trees, vegetation, plants and foliage) decreased job stress and employees’ intentions to quit.

At home, views of nature are also important. However, for most green neighborhood studies, stress recovery isn’t the main focus. Researchers still revealed some stress-related benefits. For instance, nature window views from home can improve the sense of peace and quiet (Day, 2008; Yuen & Hien, 2005) and neighborhood and satisfaction with one’s neighborhood (R. Kaplan, 2001; Kearney, 2006; Taylor & Kaplan, 1991).
Research has also investigated therapeutic settings to study the health benefit of green window views. Perhaps the most famous study is Ulrich’s (1984) work on the different impacts of green views vs. brick wall views for individuals recovering from surgery. He found that patients with a view of the green space had fewer complaints, took fewer self-administered pain medication and were released from the hospital sooner than those who were viewing to a wall (R. S. Ulrich, 1984). A recent quasi-experimental study that examined the health benefits of a bedroom window view of nature for patients in a residential rehabilitation center found that nature window views had improved people’s physical and mental health (Raanaas et al., 2012).

Another study explored people’s stress response when exposed to green corridors and barren roadside on their commute to work. It was found that people driving on a nature-dominated road will have less stress than those on roads dominated by human artifacts (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998).

High school nature window view and stress recovery

Although there is some evidence supporting the idea that window views with natural views should produce lower levels of stress, relatively little is known about the effect of natural window views in school classrooms on students’ stress recovery.

Most school-related landscape research has focused on the outdoor campus environment, such as natural playscapes in elementary schools or general accessibility to outdoor green space (Herrington & Studtmann, 1998; Lindholm, 1995; O’Brien, 2009). Only a handful of studies have directly investigated how window views of nature can impact students’ physical and mental wellbeing. Tennessen and Cimprich (1995) conducted research on the effect of natural window views from a classroom on elementary students’ attention ability. They claimed that natural window views can help students
recover from mental fatigue and restore their directed attention (Tennessen & Cimprich, 1995). A study evaluating the effect of natural views from college dormitories on students’ psychological adjustments to college life found a positive association between the two (Campbell, 1998). Previous literature also assessed the attention restoration effects on university students of different photo-simulated settings, with self-reported restorative rating and attentional tests. Students’ attentional capacities improved after viewing a set of nature photo simulations, but those who viewed non-nature scenes didn’t exhibit similar improvements (Berto, 2005).

In 2010, Matsuoka investigated 101 public high schools in southeastern Michigan to examine the role played by the availability of nearby nature in student academic achievement and behavior. The results show that cafeteria and classroom window views with greater quantities of trees and shrubs are positively associated with standardized test scores, graduation rates, percentages of students planning to attend a four-year college, and fewer occurrences of incivilities (Matsuoka, 2010).

There is, however, no evidence that helps us understand the relationship between natural window views and students’ stress recovery. Due to the heavy study loads, high school students spend most of their time in classrooms, not in the outdoor green space around the high school. It is therefore much more meaningful to investigate the benefits of visual contact with nature through a classroom window than through direct exposure to outdoor green space. And it is also urgent to understand whether a classroom with a natural window will be a supportive setting for dealing with high school students’ stress. We want to know whether a natural window view will have a more significant impact on students’ recovery from a stressful experience than a barren or no window view condition.
Chapter 2: Method

Participants and Sites

In this study, we recruited 94 participants (53 females and 41 males) from five high schools in central Illinois (Urbana High School, Centennial High School, Unity High School, Heritage High School and Fieldcrest High School). Students’ age range was from 14 to 17 ($M = 15.8$, $SD = 0.9$). Participants included 62 Caucasians, 17 African Americans, 4 Hispanics, 4 Asian Americans or Pacific Islanders and 7 others (see Table 1).

Students were recruited via mailed invitation letters, emails and announcements on their school’s website. Informed consent was obtained from parents or legal guardians and each student signed a consent form prior to participating in the study. All participants were paid $20 for their participation in the study.

Table 1. Summary of participants’ gender, age and race by the 3 window treatments.

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>No window view (N=32)</th>
<th>Barren window view (N=32)</th>
<th>Green window view (N=30)</th>
<th>Total (N=94)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, Female N (%)</td>
<td>18 (56.3)</td>
<td>20 (62.5)</td>
<td>15 (50.0)</td>
<td>53 (56.4)</td>
</tr>
<tr>
<td>Male N (%)</td>
<td>14 (43.7)</td>
<td>12 (37.5)</td>
<td>15 (50.0)</td>
<td>47 (43.6)</td>
</tr>
<tr>
<td>Age, Mean (SD)</td>
<td>15.7 (1.51)</td>
<td>15.7 (0.8)</td>
<td>15.9 (0.90)</td>
<td>15.8 (0.867)</td>
</tr>
<tr>
<td>Race, Caucasian N(%)</td>
<td>19 (59.4)</td>
<td>19 (59.4)</td>
<td>24 (80.0)</td>
<td>62 (66.0)</td>
</tr>
<tr>
<td>African American N(%)</td>
<td>6 (18.8)</td>
<td>8 (25.0)</td>
<td>3 (10.0)</td>
<td>17 (18.1)</td>
</tr>
<tr>
<td>Hispanic N(%)</td>
<td>2 (6.2)</td>
<td>0 (0)</td>
<td>2 (6.7)</td>
<td>4 (4.3)</td>
</tr>
<tr>
<td>Asian or Pacific Islander N(%)</td>
<td>2 (6.2)</td>
<td>2 (6.2)</td>
<td>0 (0)</td>
<td>4 (4.2)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (9.4)</td>
<td>3 (9.4)</td>
<td>1 (3.3)</td>
<td>7 (7.4)</td>
</tr>
</tbody>
</table>

1 This study of high school green window view was conducted by a group of people including: PHD candidate Dongying Li; Master of landscape architecture students Chen Chen and Wenqi Ji; Bachelor of architecture student Rose Schmillen.
Within each school, we selected three classrooms that met the three treatment conditions: 1) no window, 2) barren window view (window that opened on to a built space) and 3) green window view (window that opened on to a green space)(see Figures 1, 2, and 3). All the students participated in the experiments in their own schools.

Figure 1. Images from classrooms in the no window condition.

Figure 2. Images from classrooms in the barren window condition.
Procedure and data collection

The experiment was conducted with one student at a time between 9 am to 5 pm on days without rain in the summer of 2013. The room temperatures were between 65 to 75°F.

When the student arrived at the reception room, each participant was asked to submit the assent and parental consent forms. Then they completed an inclusion criteria questionnaire to make sure they met the study’s mental health requirements. Participants who had drug use or ADD were excluded from participation. A general information questionnaire was administered to collect data about participants’ age, gender, race, year in school, health history, self-reported chronic stress and preference of school landscape.

After the background questionnaire, participants were asked to self-report their baseline stress level on the first Visual Analogy Scale (VAS). Then participants were randomly assigned to classrooms with one of the three window treatments. No matter which window view they had, participants’ seats were in the same position: about five feet from the windows (in classrooms with windows) or five feet from the wall (in classrooms with no windows).
After being seated in the assigned classroom, we put sensors on the participants to measure their finger temperature and skin conductance levels, two physiological measures of stress. Using these measures, we recorded their baseline stress levels. These sensors remained on the participants during the rest of the experiment, and we collected skin conductance and temperature data continuously. Following the short rest, and in order to induce mental fatigue (the analysis of which is not part of this thesis) participants engaged in a 5-minute proofreading task in which they were required to find a certain sequence of letters in lines of random text and be as fast and as accurate as possible.

In order to induce psychological stress, students took a modified Trier Social Stress Test (TSST) that included 3 minutes to prepare a speech, a 5-minute speech, and a 5-minute mental subtraction task (Kirschbaum, Pirke, & Hellhammer, 1993). For the speech task, we asked participants to imagine they were job applicants who were invited for a personal interview with an employer. They were asked to convince the employer that they were the perfect applicant for the position. To increase stress, participants were told that their speeches would be recorded (although no actual video recording was taken). During the subtraction task, we asked each participant to mentally subtract 13 from a series of four-digit numbers for a period of 5 minutes. They were asked to state their answers aloud. Each participant started with 6022, subtracted 13, stated 6009, subtracted 13 again, stated 5996, subtracted 13 again and so forth. When participants got the wrong answer, we asked them to start over at 6022.

After the TSST, students completed the second VAS questionnaire to assess their subjective stress experience. Then they rested for 10 minutes in the same classroom. We asked them to keep their eyes open but gave no instructions to look out of the windows. Finally, they completed a third VAS questionnaire. Afterwards, we removed the skin conductance and temperature sensors. The data collection procedure is illustrated in Figure 4.

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2This thesis is part of a research on high school classroom window view and students’ stress, mental fatigue performance conducted by PHD candidate Dongying Li from University of Illinois at Urbana-Champaign.
Three Methods for Measuring Stress

We used three methods for measuring stress. The first, the Visual Analog Scale (VAS), allows participants to assess their subjective stress experience. The VAS has been used for over 40 years for the clinical assessment of pain and, more recently, stress (Huskisson, 1974; Lesage, Chamoux, & Berjot, 2009). In our experiment, the stress VAS question included a 10-cm horizontal line representing two extreme limits of a participant’s stress level: no stress on the left and severe stress at the far right. Participants were directed to place a mark (X) on each line indicating the degree of stress they felt at
that moment. By measuring the distance from the left end of the scale to the mark, we identified a summary stress value for each participant relative to the particular moment that they answered this question. Figure 5 shows the VAS question we used in experiment.

Figure 5. The VAS question used in the experiment.

**Physiological measures of stress.** We measured participants’ physiological stress using two widely used and respected methods: skin conductance (SC) and temperature (Healey & Picard, 2005; Jacobs et al., 1994; Lin, Yu, Huang, & Chih-Wei, 2011). We used a ProComp5 Infiniti biofeedback system from Thought Technology Ltd to continuously measure skin conductance and skin temperature throughout the experiment (Chang & Chen, 2005). The ProComp5 Infiniti is a 5-channel diagnostic tool that sends information gathered from sensors attached to the participant’s fingers via fiber-optic cable directly to a computer. Skin conductance sensors (Thought Technology: SA9309M) were connected to two of the participants’ fingers.

Skin conductance sensors measure the electrical conductance of the perspiration on a person’s fingers. Higher levels of electrical conductance indicate higher levels of stress. Skin conductance has proven to be a reliable measure in many hundreds of studies assessing stress (Alvarsson, Wiens, & Nilsson, 2010; Lin et al., 2011; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005; R. S. Ulrich et al., 1991).
Finger temperature is another measure widely used for measuring stress (Healey & Picard, 2005; Lin et al., 2011; Vinkers et al., 2013). When a person feels stress, the blood available to their extremities decreases and this results in lower temperatures at a person’s fingertip (Vinkers et al., 2013).

Skin conductance and temperature level was continuously recorded by devices (Figure 6). For each precise time period (before TSST, during TSST, before rest, and after rest), we collected the specific skin conductance and temperature data to analyze in our results.

Figure 6. Skin conductance and temperature sensors were placed on participants’ fingers.
Chapter 3: Results

Results are presented in two sections. In order to test the window views’ impact on stress recovery, we used the TSST to induce stress. In the first section, we explore the extent to which the TSST raised participants’ stress levels. In the second section, we examine the extent to which there is a relationship between classroom window views and stress recovery. Specifically, we want to know whether a natural window view more significantly impacts students’ recovery from the stressful experience. We expect participants in natural window view classrooms to have a better stress recovery than participants in barren or no window view conditions.

Does the TSST induce stress?

To understand whether the Trier Social Stress Test (TSST) successfully induced acute stress in our participants, we compared participants’ stress levels during the rest period before the TSST and in the minutes after the TSST. We conducted t-tests on mean values of VAS, skin conductance (SC), and temperature levels before and after the TSST. Figure 7 shows that the mean value of Visual Analogue Scale (VAS) has been significantly increased by the stressor from 1.63 to 4.93 (t(93) = 14.74, p < 0.001), demonstrating that TSST induced self-reported stress. The physiological measures also show an increase in stress. The higher the SC value, the higher the stress level. Figure 8 shows the mean value of SC has significantly increased from 1.29 to 2.82 by the stressor (t(93) = 8.12, p < 0.001), suggesting that TSST has a significant effect on participants’ SC levels. When a participant feels stressed, his or her skin temperature drops; skin temperature is negatively related to stress. Figure 9 shows that the average participant skin temperature dropped significantly from 29.35°C to 27.73°C after the TSST (t(93) = 6.37, p < 0.001), suggesting the effectiveness of TSST (see table 2).
Table 2. T-tests examining the differences between stress levels measured before and after stressor.

<table>
<thead>
<tr>
<th></th>
<th>Mean Before Stressor</th>
<th>Mean After Stressor</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>1.63</td>
<td>4.93</td>
<td>-14.73</td>
<td>0.0001</td>
</tr>
<tr>
<td>SC</td>
<td>1.29</td>
<td>2.82</td>
<td>-8.12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Temperature</td>
<td>29.35</td>
<td>27.73</td>
<td>6.37</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Figure 7. The self-reported stress levels of participants before and after TSST.
We then computed a summary stress score, using a standardized value for VAS, SC and temperature so we could assess the impact of the TSST on all measures of stress at once. The summary score also shows significant change from before the stressor to after the stressor (t(186)=6.45, p<0.001)
Together, these analyses demonstrate that TSST is effective in inducing both self-reported and physiological stress.

Table 3. T-test summary report showing the stress levels before and after stressor.

<table>
<thead>
<tr>
<th></th>
<th>Mean Before Stressor</th>
<th>Mean After Stressor</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary Stress Score</td>
<td>-0.80</td>
<td>0.80</td>
<td>-6.45</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

**Do window views influence stress recovery?**

Do window views influence stress recovery? Does a natural window view have a better impact on stress recovery than a barren window view or no window view? To answer these questions, we used one-way ANOVA to analyze the stress level changedirectly after the stressor and after the recovery period in the three different window view conditions. We categorized the three measurements into two sections: VAS for self-report measures, and skin conductance and temperature for physiological measures.

**Self-report measurements.** A one-way ANOVA analysis of the VAS measurements does not reveal a statistically significant relationship between the window view conditions and stress recovery. We calculated the mean change between the VAS directly after the stressor and the VAS directly after the rest period.

\[
\text{VAS Mean-change} = \text{VAS after rest period} - \text{VAS after stressor}
\]

Looking at the VAS Mean-change chart, the negative value indicates how much the participants' self-reported stress level decreased after the rest period. Figure 10 shows that, in all window view conditions, participants felt less stressed after the rest period. The natural window view appears to
have a slightly better stress recovery performance than the barren window view or no window view conditions, but the differences between the three conditions are not significant ($F(2, 91) = 1.75, p > 0.05$) (see Table 4).

Figure 10. VAS Mean-change shows participants’ self-reported stress has been reduced after the recovery period, though the effect is not significantly different for the three window view conditions.

![VAS Mean-change](image)

Table 4. One-way ANOVA report of VAS.

<table>
<thead>
<tr>
<th>VAS</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>12.158</td>
<td>2</td>
<td>6.079</td>
<td>1.749</td>
<td>.180</td>
</tr>
<tr>
<td>Within Groups</td>
<td>316.271</td>
<td>91</td>
<td>3.476</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>328.428</td>
<td>93</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Physiological measurements.** To what extent did the window condition impact physiological measures of stress? To address this question, we followed a similar procedure as above. We compared the physiological measures (skin conductance and skin temperature) and the summary measure (the
summary score of the two physiological measures) at two times: immediately after the TSST and after the 10-minute rest. We found that a one-way ANOVA does not reveal a statistically significant relationship between the window view conditions and stress recovery for skin conductance \( F(2, 89) = 2.07, p > 0.05 \) (see Table 5). The same result held for our measures of skin temperature – a one-way ANOVA resulted in a non-significant finding: \( F(2, 87) = 2.28, p > 0.05 \) (see Table 6).

Table 5. One-way ANOVA examining the impact of window view on change of skin conductance after the TSST and after the rest period.

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>4.619</td>
<td>2</td>
<td>2.309</td>
<td>2.073</td>
</tr>
<tr>
<td>Within Groups</td>
<td>99.148</td>
<td>89</td>
<td>1.114</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>103.767</td>
<td>91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. One-way ANOVA examining the impact of window view on change of skin temperature after the TSST and after the rest period.

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>30.021</td>
<td>2</td>
<td>15.010</td>
<td>2.284</td>
</tr>
<tr>
<td>Within Groups</td>
<td>571.826</td>
<td>87</td>
<td>6.573</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>601.846</td>
<td>89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We then converted SC and temperature standard scores into one z-score – what we call the Summary score for stress. A One-way ANOVA shows that there is a significant relationship between window condition and stress recovery \( F(2, 86) = 8.00, p < 0.01 \) (see Table 7). This finding indicates that stress recovery, measured with a combination of skin conductance and skin temperature, is significantly greater in the natural window view condition than in the barren window or no window condition.
Table 7. One-way ANOVA summary report of SC and temperature.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>20.519</td>
<td>2</td>
<td>10.259</td>
<td>8.003</td>
<td>.001</td>
</tr>
<tr>
<td>Within Groups</td>
<td>110.242</td>
<td>86</td>
<td>1.282</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>130.761</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Grand Summary.** In order to see the overall result of both the self-report and physiological measurements, we converted the standard scores of VAS, SC and temperature into one z-score and ran another one-way ANOVA. Here, we asked does the window condition influence stress recovery when all measures of stress are considered at once. As can be seen in Table 8, the answer is that window condition does impact stress recovery (F(2,86)=7.61, p<0.01). Green classrooms help students recover from stress significantly faster than classrooms with barren window views or classrooms with no windows at all.

Table 8. One-way ANOVA summary report of VAS SC and temperature.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>39.132</td>
<td>2</td>
<td>19.566</td>
<td>7.613</td>
<td>.001</td>
</tr>
<tr>
<td>Within Groups</td>
<td>221.030</td>
<td>86</td>
<td>2.570</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>260.163</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 4: Discussion

This study tested the relationship between classroom window view and students’ stress recovery. Analyses revealed that classroom window view has a significant influence on students’ stress recovery. Even though the participants’ self-reports do not show a statistically significant relationship between the window view conditions and stress recovery, the two physiological measurements revealed a significant relationship between window views and stress recovery. The physiological measurements indicated that a natural window view has the most positive impact on participants’ stress recovery. Compared to the barren window view and the no window view conditions, the natural window view impact on stress recovery is nearly two times greater. However, there is no significant difference of stress recovery between barren window view and no window view conditions. This implies that natural daylight might not be the factor for the stress recovery benefits. It is a view to nature that matters more to the process of stress recovery.

The findings contribute to our understanding of the relationship between natural window views and stress recovery and suggest opportunities for intervention and future research.
Chapter 5: Contribution to the literature

By proving a positive link between natural window views and students’ stress recovery, this work contributes to the research on the benefits of contact with nature.

First, the results underscore the potential importance of views to nature. Previous research has shown that a variety of positive outcomes are associated with views of nature in a variety of settings. In residential settings, view of nature have been linked to residential satisfaction, enhanced well-being and effectiveness in coping with day-to-day life problems (R. Kaplan, 1985, 2001; Tennessen & Cimprich, 1995). In the workplace, views of nature have been linked to job satisfaction and well-being (R. Kaplan, 1993; Leather et al., 1998); in prisons, views of nature decrease the demand for health care service (Moore, 1981); and in hospitals, patients recover faster from surgery when they have a window view of nature (Raanaas et al., 2012; R. S. Ulrich, 1984). The findings here suggest that high school classroom settings with natural window views have a positive impact on stress recovery. These findings add to a growing body of evidence on the importance of natural window views.

Second, this work contributes to our understanding of the importance of campus landscapes. Previous studies have assessed the impact of campus window views on student performance. Two studies investigated the effects of viewing natural landscape features from campus building windows. Of these, one focused on dormitories at a university and found that the greener the view from the dormitory window, the better the students performed on attentional tasks (Tennessen & Cimprich, 1995). The other examined the impact of views from classrooms in elementary schools and found that greater levels of vegetation in the view were linked to better academic achievement (Heschong Mahone Group, 2003). A more recent study evaluated landscape characteristics and student academic performance at 101 high schools in southeast Michigan. Views with greater quantities of natural
features (e.g., trees, shrubs) from classroom as well as cafeteria windows were associated with higher standardized test scores, graduation rates, and percentages of students planning to attend college, and lower occurrences of criminal behavior (Matsuoka, 2010). Our study extends the previous research on the relationship between window views of campus landscape and stress recovery. Our findings indicate that students will have a better stress recovery in a classroom with a natural window view.

Overall, this study underscores the potential relationship between window views and stress recovery, extending the research to specific subjects and settings: high school students and classrooms. The findings have a number of implications for campus landscape practice.
Our findings help to reinforce the importance of natural window views in classrooms. The findings here demonstrate that simply putting windows in classrooms is not enough; those windows need to overlook nature in order for them to have a positive effect on students’ stress recovery. Because of assignments and examinations, students spend most of their time at school in classrooms and are often both psychologically and physiologically stressed. Given that, a natural view from a classroom window offers an important contact with nature. These findings support and extend the understanding of the positive role of natural window view on students’ stress recovery. If a classroom has a window view to nature, it can provide more opportunities for contact with nature and help improve stress recovery.

This research also suggests that school administrators, teachers and campus landscape designers should work together to make sure students have an effective exposure to nature. School administrators should pay attention to the importance of campus landscape investigations and encourage landscape designers to increase the amount of nature seen from classroom window views. Teachers should offer students opportunities to view nature, positioning students where they will be able to look out a window. Landscape designers can apply the following criteria when designing classroom landscapes: 1) The views from classroom and cafeteria windows should be filled with natural features such as trees and shrubs. 2) Classroom and cafeteria window views of large expanses of lawns, parking lots, and athletic fields lacking in natural features (e.g., shrubs, trees) should be minimized. 3) Large lawn areas can be improved through the use of flowerbeds, groundcovers, and shrubs in lieu of mowed grass. 4) Every portion of high school landscapes should include vegetation – and this includes large parking lots and athletic fields. Parking lots should be surrounded by trees and can even have rows of trees placed between rows of cars. Athletic fields should also be bordered by trees.
Chapter 7: Future research

Future studies can build upon our research in a number of ways. First, we did our research in the summer when vegetation was at its most dense. In addition, we did not distinguish between various kinds and levels of vegetation. Natural window views could include one or two trees or many trees. It could include best-practices landscaping with native species or traditional plantings of non-native species. Other factors, such as season, weather, biodiversity and tree cover density may make a difference on the stress recovery effects of high school window views. Future research could investigate the relationship between natural window view and stress recovery in a variety of situations. Does season influence the stress recovery effect? What will be the stress recovery effect when trees are bald in the winter as compared to when the trees’ leaves are colorful in the fall? Will a few trees be enough to elicit a positive stress recovery response, or are many trees needed? We are also very interested in the interference of sound. In this study, we tried our best to minimize the impact of noise, but we actually are very interested in the relationship between sound and stress recovery. In a noisy classroom, will window views still elicit a positive stress recovery response? Should teachers open classroom windows to allow nature sounds into the classroom to enhance the stress recovery experience? Although our findings establish that a window view of nature enhances recovery from stressful events, the shape of the dose-response curve for length of exposure is entirely unclear. We do not know if exposure for a certain short time is enough to reduce stress, or if the relationship between time exposure to nature and stress recovery is linear. We strongly suggest that future research should explore these questions.
Chapter 8: Conclusion

This study examined the impact of natural window views on high school students’ stress recovery. We found that natural window views significantly influence students’ recovery from a stressful experience, as shown through physiological measurements of stress. Even though students themselves may not be able to recognize and report the effect, the physiological indicators show that the effect is significant.

In general, this finding corresponds to previous research on the psychological benefits of nature (Kaplan & Kaplan, 1989; Ulrich et al., 1983). A classroom with a natural window view can help students cope with stress. Because stress can lead to a variety of negative outcomes, including physical illness, anxiety, depression, decreased academic performance, social withdrawal and drug or alcohol experimentation. If something as simple as a natural window view can significantly improve students’ stress recovery, it is imperative for administrators, teachers and landscape designers to work together to give students access to natural window views. By improving the campus landscape in this way, educational goals might be more easily reached.
References


