ABSTRACT

Title of Thesis: INVESTIGATING THE RELATIONSHIPS BETWEEN BUILT AND NATURAL WINDOW VIEWS, AND STUDENTS PERCEIVED RESTORATION USING VRITUAL REALITY

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This thesis explores the concept of perceived restorativeness in virtual window views, which have significant contributions to the field of landscape architecture and environmental psychology. It begins with a comprehensive literature review to define perceived restorativeness which lies on Attention Restoration Theory(ART). The main emphasis in literature is on the importance of four restorative factors: fascination, being away, extent, and compatibility. All these four factors contribute to an environment's restorative quality.

This study acknowledges the existing gaps regarding the impact of virtual views both built and natural environments on perceived restoration within design studio , because the studio environments are critical in landscape architecture, architecture, and all the fields related to design. This study wants to fill this gap.

In terms of research questions, all the research questions are designed to explore how different virtual window views affect perceived restoration, and whether variation in the natural and built environment affects that restorative quality.

In the methodology chapter, the process of collecting data from participants for data analysis is described.45 participants responded to the perceived restorativeness scale (PRS-16), after displaying virtual window views from the School of Architecture Design Studio. All the responses were analyzed by using paired t-test and ANOVA to measure the restorative quality of different window views. Findings from data analysis indicate that not all virtual window views make the same restorative impact on participants. A significant variation was observed within and between categories of built and nature. Although all the nature views have significant restorative quality, the plaza as a virtual built window view perceived restorative benefit as well. This study makes an important contribution to investigating the restorative quality of virtual views in educational settings.

INVESTIGATING THE RELATIONSHIPS BETWEEN BUILT AND NATURAL WINDOW VIEWS, AND STUDENTS PERCEIVED RESTORATION USING VRITUAL REALITY

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Landscape Architecture
2024

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Acknowledgements

I would like to express my deepest gratitude to my committee chair Dr. Christopher D. Ellis, whose expertise and knowledge was invaluable during this research. My sincere thanks also go to Dr. Byoung-Suk Kweon for her enduring support throughout my thesis journey. Their wise counsel and encouragement have profoundly enriched my work and growth.

I am also deeply thankful to Dr. David Myers, my thesis committee, for his support.

A special thanks to Dr.Reza Mabadi, whose friendship and steady support have been a comforting presence in this endeavor. Lastly, I want to express my gratitude to my family for their constant love and support. This project could not have been accomplished without your help.

Thank you all for your kindness, guidance, and faith in my abilities.

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List of Abbreviations

ANOVA-Analysis of Variance

ART- Attention Restoration Theory

PRS- Perceived Restorative Scale

VR-Virtual Reality

VRSQ-Virtual Reality Sickness Questionnaire

Chapter 1: Introduction

Purpose of study

The purpose of this study is to investigate the relationships between built and nature window views, and student's perceived restoration using virtual reality. Through a perceived restorativeness scale (PRS-16), this investigation aims to find out how different virtual landscapes, both built and natural, contribute to the restorative experience as perceived by individuals. The main goal of this study is to determine whether virtual built environments: parking lots, office building, and plaza have the same restorative effects, and whether all virtual natural window views: woodland, pond, and meadow have a consistent effect on perceived restoration. More importantly, this study aims to determine whether different variations within virtual views of natural and built affect the perception of restorative quality. This research is based on the theoretical framework Attention Restoration Theory(ART) which indicates four restoration factors: fascination, being away, extent, and compatibility, all these factors can facilitate a mental recovery from mental fatigue. The findings of this research not only contribute to our perception of psychological impact of virtual window views both built and natural, but also pave the way for future application of virtual technology in therapeutic design of educational settings

Research questions

- How is perceived restoration affected by virtual window views of built and natural environment?
- Do all virtual built window views affect perceived restoration the same?
-Do all virtual nature window views affect perceived restoration the same?
-To what extent does variation within natural(e.g., woodland, pond, meadow) and built(e.g., parking lot, office building, plaza) virtual window views influence the perceived restoration benefits?

Definition of key terms

Nature: A natural landscape represents the original environment before any human intervention (Humboldt, 1804). The term "natural landscape" originated in the contexts of landscape painting and landscape gardening to distinguish a more organic, nature style from a formal style((Humboldt, 1804).Therefore in this research natural landscapes are areas that have remained undisturbed for an extended period, allowing them to evolve into stable ecosystems such as woodland and pond

Therapeutic Landscape: Therapeutic is defined as something which encourages wellness and healing (Batties, 2015). when an environment conducts and assists the whole process of healing or includes some levels of healing, it can be considered as the exact definition for the word “therapeutic” (Sachs, 2015).

Attention Restoration Theory: Environments with potential for effortless attention and natural elements that offer aesthetic stimuli improve mental capacity and are more restorative. people can concentrate better after either spending time in natural environment or just looking at presentation of nature even by picture or videos (Kaplan, R., Kaplan, S, 1989)

Stress Reduction Theory: The natural environments foster stress recovery better than built spaces (Ulrich R. S., 1991).

Biophilia: based on E.O. Wilson defines biophilia is "the urge to affiliate with other forms of life" (Wilson, 1984)

Views to Garden: Indoor contact with nature can include looking out at nature through a window; viewing nature imagery (still and moving pictures); seeing, touching, and smelling indoor vegetation; and hearing nature 's sounds through an open window or through sound recordings (Sachs, N.A, 2019). nature improves wellbeing in the several ways: providing fresh air, reducing air pollution, adjust humidity, and provide pleasant views (Kim, E., & Mattson, R. H, 2002).

Nature Rx: The Nature Rx refers to the use of nature to directly treat certain mental health problems such as depression, anxiety, or high blood pressure. college students transitioning from adolescence to adulthood and for those who may experience an array of health and well-being issues, the gains from NatureRx are both promising and endless (Roberts, 2021).

Significant of study

The significance of this study lies in several important areas, offering a comprehensive understanding of how virtual window views can restorative quality of students. since in many educational programs, such as landscape architecture, architecture and other design disciplines, students must spend more time in studio classes to design their projects. In this regard, the average time allocated to studio courses at the undergraduate level has been estimated around 22.2 hours per week (Nelson, 2017)
Here's a detailed exploration of its importance:

Improving virtual reality applications: while virtual reality technology becomes common in educational and therapeutic settings. It is important to understand how virtual environments affect users. This study targets two main goals how the design of virtual environments can promote mental health and how virtual reality can contribute to stress reduction and provide restorative benefits for the users.

Extending theoretical contributions to environmental psychology: this study extent the applicability of attention restoration theory(ART) to virtual environment. It is important to know that all the restorative factors are applicable to virtual environments.

Providing a guideline for landscape architect and urban designer: the result can provide a recommendation for landscape architect and urban designer to integrate virtual window view into built environment. Acknowledge of which virtual window views built or nature best support restoration benefits of occupants.

Chapter 2: Literature review

Introduction

To better understand the background of this research, literature review has six specific parts. The first part of the literature reviews the impact of spending time in school on students' well-being and concentration is investigated. Any prolong mental effort leads to direct attention fatigue (StephenKaplan, 1995).In the second part the importance of Virtual Reality is explained. In the third part of the literature review, informed by Stephen Kaplan (1995), focuses on the impact of prolonged mental effort required in educational settings, leading to direct attention fatigue. This condition underlines the importance of perceived restorative environments in mitigating mental exhaustion and facilitating cognitive recovery. In the fourth part the positive impact of attaching green space and landscape to academic environment is explained. For college-age students a dose of 10-20 min in sitting or walking in green space can has a meaningful impact in reducing stress, anger, anxiety, and increasing vigor, comfort, and a sense of feeling refreshed (Genevive R. Meredith, 2020). The importance of campus NatureRX is another part of literature review. Access to nature is an important need on university campuses. Therefore, academic environment should encourage students to take advantages of this valuable sources (Genevive R. Meredith, 2020). The final part of the literature reviews the importance of healing impact of view to garden on occupants has explained.

Stay time in school

Students' well- being encompasses the overall health of students including their emotional, mental, and physical health. The positive impacts of student's well-being are inextricably tied to their academic performance. In this regard, the negative effect of stress and fatigue on student focuses and well-being are mentioned in several studies. Any time someone has worked intensely on a project subsequently finds oneself mentally exhausted. Even though the project is enjoyable that is a typical state of mind of students at the end of semester (StephenKaplan, 1995). It is true that any prolong mental effort leads to direct attention fatigue (StephenKaplan, 1995).

Although during academic life, students make different choices in how they spend their time. Including class attendance, studying, working, leisure and recreation and so on (Nelson, 2017). In many educational programs, such as architecture and other engineering colleges, students must spend more time in studio classes to design their projects. In this regard, the average time allocated to studio courses at the undergraduate level has been estimated around 22.2 hours per week (Nelson, 2017). Based on previous studies, Across the United States of America college age students have already experienced unprecedented levels of depression ,stress , and other severe psychological conditions (Wiliam, Dylan, Leahy, Siobhan, 2017). There are many reasons for this problem ranging from competition for getting higher grades, to technologically isolation, to financial pressures (Eagan, 2014). Alongside counseling and medical treatment and other solutions to address the student's mental problem, several studies have demonstrated the positive effect of spending time in natural sitting to improve students overall well –being. (Maller, 2006); (Van Den Berg, 2007); (Bratman, 2012); (Cox.Daniel T.C., 2017) ; (Hansen, 2017); (Antonelli.Michele, 2019). When feeling stressed and sad, teenagers prefer places surrounded by plants rather than by people (Lückmann, Lagemann, & Menzel, 2013). The appropriate time which can improve mental health was mentioned in different studies. Spending time in nature between 20 and 30 min, three time per week was very efficient (Hunter, 2019). And spending 120 min in nature, per week can lead to significant change in s self-reports of positive health and well-being (White.Mathew P, 2019). For college-age

students a dose of 10– 20 min sitting or walking in a green space can significantly impact in reducing anxiety ,stress, anger, and increasing mood, comfort, and having a sense of feeling refreshed. (Genevive R. Meredith, 2020)

Virtual Reality

Landscape design covers regional planning and architectural space design as well as modifications of buildings and their landscape environment (Hui Xie, 2020). Landscape design deals with the description, understanding and visualization of spaces (open spaces, surfaces, buildings, volumes, vegetation . . .) in the landscape or in urban areas (Motloch, 2000). Within landscape design, landscape architecture can be considered as a professional branch focused on the spatial configuration of land and buildings at different scales (from the interior design of small spaces to the design and planning of large urban areas). Due to its professional nature, landscape architecture needs tools to visualize and evaluate the spatial relationships between the different elements of the landscape (Mei Liu, 2020; Kara, 2013)This is more than 20 years from the time which Virtual Reality was proposed by Jaron Lanier, founder of VPL Research Company in 1989 (Jialu Song, 2018). Virtual reality technology works by creating a computer system with multiple senses of sight, hearing, touch (Jialu Song, 2018).Therefore users are able to Users immerse themselves in the system of virtual environment with various hardware devices and interact with the virtual environment (Jialu Song, 2018). as Wei Youshuang (2014) says virtual reality can create “virtual world” The most important aspect of virtual reality for the ability to stimulate real world as Jialu says Through the use of VR technology designers, decision-makers, engineering construction personnels and the public can watch the effect of landscape design from any angle at any time, as it were, to feel the landscape design and understand the designing idea, and offer timely feedback, which would greatly strengthen the communication among different project teams and improve work efficiency, so as to break through the bottleneck of traditional landscape design method.

Virtual reality is one of the tools that is being used more in landscape architecture (George, 2018), and its use in landscape design teaching can improve teaching efficiency (Zhe Li, 2018). The VR technology provide the opportunity for users to visualize the designed environment and navigate through it interactively (Zheng., 2022).More importantly Virtual reality (VR) facilitates the visualization of spatial relationships among different elements in landscape architecture. VR enables users to experience and easily move through the designed environment. VR technology allows for the exploration of spaces designed for both indoor (within buildings) and outdoor (landscape) environments (Carlos Carbonell-Carrera, 2021). Although Virtual reality is frequently used in the final phases of landscape architecture projects, to visualize their final result, the use of this technology is not common at first steps of design process (Hill, 2019; Benjamin H. George, 2017)it is important to know that virtual reality, helps to understand the spatial concepts of landscape design, can improve the abilities of professionals to find solutions from the early phases of the project (Chamberlain, 2015). As Carbonell claims, the appearance of three-dimensional representation technologies can facilitate the visualization tasks of the landscape environment. Technologies loke virtual reality (VR) can assist landscape design professionals to visualize their projects, therefore the user can see plan , elevation, and geospatial information at same time and user is able to navigate between views . as general virtual reality offers different level of immersion depending on designer preference. VR can be low immersive using a conventional computer with a monitor (desktop VR) or high immersive using virtual reality glasses (head mounted display, HMD VR) (Carlos Carbonell-Carrera, 2021). The degree of realism is another important factor while some people said that it is important to define the appropriate degree of realism since photorealism can become negative (Sébastien Griffon, 2011). Portman (M.E. Portman, 2015)said that real representation is not essential for landscape design. However, the levels of realism can be varied based on stimulation factors, like lighting condition. Although Virtual reality is considered as powerful tools for not only learning but also communication (DEDE, 2019; Tassos A. Mikropoulos, 2011). Many researchers have suggested more study in this field Sayyad mentioned a virtual reality experience with head mounted display (HDM) where natural movement

was compared with physical movements against the possibility of teleporting around the stage. The presence and preference of the user was measured. The results showed that users preferred natural movements and that teleportation, where the user's avatar is instantly translated to the destination (discontinuous translation), induced dizziness. The presence value was higher in natural displacements. Regarding dizziness, this effect can appear when the user navigates in a virtual environment. In this sense, authors in the field of VR highlighted the need to study the impact on the health of the user of VR technology (Kent, 2017).

PRS: Perceived Restoration Scale

Based on Oxford English Dictionary restoration is "the action of restoring a person to health or consciousness; recovery of physical strength" (The Oxford English Dictionary, J. A. H. Murray).Another definition for the restoration according to the Random House Unabridged Dictionary is "a return of something to former, original, or unimpaired condition", and "restitution of something taken away or lost" (House, 1993) when it comes to environmental effect on restoration (T Hartig, 1991; S.Kaplan, 1995)pointing to the restorative influences of environments, particularly natural scenes, on human beings. Natural scenes are typically characterized by the absence of artificial structures, although they may still involve some level of human management, such as in national forests or national parks (John D. Balling, 1982). more importantly (Ulrich R. S., 1991)mentioned that Interacting with natural environments has been proven to enhance positive emotions, physical health, cognitive function, and overall well-being. Research indicates that certain positive emotions can be stimulated, and specific negative feelings can be alleviated through engagement with nature. (Kaplan, R., Kaplan, S, 1989). , (Ulrich R. , 1993) patients who viewed natural images showing open water scenes reported reduced postoperative anxiety, while those who viewed abstract images experienced strong negative emotions. . Also research has discovered that even ordinary natural settings can diminish negative emotions like anger, fear,

aggression, or arousal, while boosting overall positive sensations such as happiness, amiability, or joy. (Ulrich R. S., Visual Landscapes and Psychological Well-Being, 1979; Ulrich.Roger S, 1991; Terry Hartig M. M., 1991). To function efficiently in daily tasks, it is crucial for individuals to have clear mental focus. Without this clarity, one may encounter distressing experiences that can only be mitigated through focused attention. However, the ability to concentrate is finite and can be exhausted through prolonged use. Kaplan's Theory refers to this depletion of focused attention as "mental fatigue.". Mental fatigue adversely affects individuals in several ways, leading to irritability, heightened negative emotions, impatience, and impulsiveness. There's a noticeable decrease in frustration tolerance, sensitivity to social cues, and altruistic actions. Additionally, it results in diminished performance, a higher rate of errors, and a reduced capacity to absorb information. Moreover, it increases the propensity to engage in risky behaviors. directed attention fatigue leads to diminished ability to lower efficiency in performance (T Hartig, 1991; StephenKaplan, 1995). Based on Kaplan and Kaplan Recovering from mental fatigue is marked by the rejuvenation of efficiency or capability, a process encapsulated by the Attention Restoration Theory (ART). This theory defines a decrease in directed attention fatigue as a restorative experience. Environments that facilitate the reduction of mental fatigue are known as restorative environments. These restorative experiences can occur at various times and vary in their intensity. (Terry Hartig M. M., 1991; S.Kaplan, 1995). the restorative environments encompass a wide range of settings from wilderness to indoors and a variety of different scales (S.Kaplan T. , 1983). Kaplan and Kaplan (1989) identified four key attributes of restorative experiences and settings: being away, extent, fascination, and compatibility, relevant to both conceptual and physical domain (S.Kaplan, 1995). They propose that humans, possessing the ability to conceptualize, can envision themselves operating within virtual environments. Thus, restorative environments may exist as either actual or imagined spaces, allowing restorative experiences to occur within illusory, physical, or combination settings. According to Kaplan and Kaplan’s (1989) theory, if an individual spends sufficient time in an environment possessing the four components intensively, humans can experience four progressive levels of restoration. The first level is referred to as “cleaning the head”

that allows random thoughts to wander in the head and gradually fade away (Kaplan, R., Kaplan, S, 1989). The second level of restoration is recharging directed attention capacity. At the third level, one can hear unattended thoughts or matters on one's mind, due to reduced internal noise and enhanced cognitive quiet which are facilitated by soft fascination. The final and the deepest level requires not only an environment possessing the four components of restoration but also a longer time of involvement. It tends to evoke "reflections on one's life, on one's priorities and possibilities, on one's actions and one's goals" (Kaplan, R., Kaplan, S, 1989). Attention Restoration Theory (ART), pivotal within evolutionary psychology, underscores the cognitive enhancements, notably in cognitive performance, gained through nature engagement. Direct attention is a vital mental tool for students, enabling them to accomplish their assignments and attain their academic objectives. ART points out that an individual's preference for landscapes is closely linked to the landscape's ability to restore attention. Preferred environments, especially preferred natural environments, can enhance directed attention (Piret Rennit, 2015). The spaces with the following four environmental characteristics can contribute to attention restoration.

Fascination

Attention Restoration Theory (ART) introduces the idea that our depleted ability to pay attention can be refreshed through engaging activities or elements that captivate our interest effortlessly. This rejuvenation can stem from a variety of sources, including immersive stories, challenges that require problem-solving, or the inherent allure of the natural world encompassing humans, water, fire, animals, and scenic views. Such stimuli effortlessly draw our attention, providing a reprieve from monotony and enabling us to operate without the necessity for focused mental effort, as highlighted by (Rita Berto, 2008). According to (Margherita Pasini R. B., 2009) fascination extends beyond mere functionality to include aspects of attractiveness and intensity, in environments devoid of fascination or other restorative attributes, we find ourselves compelled to apply focused attention to interact with our surroundings.

Being away

Kaplan and Kaplan (1989) identified "Being Away" as encompassing three main aspects: escaping from undesirable or disruptive environments, withdrawing from daily professional duties and their reminders, and ceasing intentional or methodical activities. Urban residents, for instance, might seek refuge in large or secluded urban forests to distance themselves from unwanted disturbances and experience a sense of removal. A restorative environment should align with an individual's preferences and tendencies, considering that the needs and expectations vary among different people (across ages and generations). As such, the restorative qualities perceived in an environment are not fixed (S.Kaplan, 1995). In terms of landscape, Being Away might be signified by features unlike those found in typical settings, such as tall trees or distinctive terrain; aesthetically pleasing elements, including man-made structures like pavilions or planted walls, also contribute. The sensation of fresh air can further enhance the feeling of detachment from everyday life and physical settings like the office. Essentially, Being Away involves transitioning to a different context; without specific restorative attributes, this new setting is less effective in facilitating restoration (Terry Hartig F. G., 1997). Kaplan then introduces "Extent" as a subsequent element (Kaplan, R., Kaplan, S, 1989).

Extent

The concept of a restorative environment closely relates to the harmony between the expanse and configuration of space, ensuring individuals feel oriented and not lost. Extent is characterized by two main aspects: Connectedness and Scope. Scope involves the expansion of the environment across dimensions of space and time, offering individuals the awareness of a welcoming space for their presence (Terry Hartig F. G., 1997).Based on Herzog, "Extent" describes the quality of an environment to captivate one's attention sufficiently, allowing a break for directed attention. Such environments may not be large but are rich in engaging features. For example, Japanese gardens, despite their modest size, possess a wealth of elements and structure that capture the

mind's focus (Thomas R. Herzog, 2003). Additionally, extended environments typically include recognizable features such as trees, shrubs, flowers, and ornamental details, which along with repeated motifs, contribute to a cohesive perception of the space. In the original Swedish study by Kaplan, the term "Coherence" was used in place of "Extent," incorporating both tangible aspects, like size, and intangible feelings of the space's continuity beyond visible limits and time (Kaisa Hauru, 2012). Coherence signifies the initial phase of forming connections (T. Hartig K. K., 1996).

Compatibility

Kaplan (1995) defines Compatibility as the alignment between an individual's preferred activities and the activities facilitated by a particular environment. This alignment significantly influences people's daily choices. According to research, environments that support or enable the activities an individual wishes to engage in exhibit high Compatibility (Terry Hartig F. G., 1997). While restorative experiences can occur with just one element present (e.g., the physical act of being away), Attention Restoration Theory (ART) suggests that restoration is more profound in environments incorporating all four elements: Compatibility, Fascination, Being Away, and Extent (Bagot, 2004) . Research supports this, indicating that environments lacking in areas such as Fascination, Being Away, and Extent cannot achieve high Compatibility (Terry Hartig K. K., 1997).

Many studies employ the Perceived Restorative Scale (PRS) to assess the positive relationship between human well-being and nature, as suggested by Attention Restoration Theory (ART). In environments where both ART and PRS elements are strongly present, individuals can experience a three-stage recovery process: mental decluttering—allowing random thoughts to arise and then dissipate, regaining directed attention, and restoring focus levels (Piret Rennit, 2015).

The first time PRS was applied goes back to 1996 . One of the main goal of this scale is to give the designers a measurement tool that could be used to evaluate the impact of existing and prospective settings on people (Carina Tenngart Ivarsson C. M., 2008).the PRS scale is based on four ART characteristics, which have several variations that have developed over the times (S.Kaplan, 1995; KaleviI Korpela, 1996; Terry Hartig K. K., 1997; Maria Bodin, 2023). PRS has already been applied in many researches, (T. Hartig K. K., 1996; Terry Hartig F. G., 1997; Laumann, 2001; Carina Tenngart Ivarsson C. H., 2008; Berto, 2005). The scale created by (T. Hartig F. K., 1995)with its 26 items to describe the human-environment relations with its four subscales is the best-clarified and most easily accessible scale. however, in this study PRS-16 items were chosen from the initial 26-item instruments developed by (Terry Hartig F. G., 1997; M Pasini, 2009; Margherita Pasini R. B., 2014) a. the four subscales are: Fascination, Being away, Extent, and Compatibility. Each subscale is assessed on a 7-point Likert-type scale that includes: Strongly Disagree, Disagree, Somewhat Disagree, Neither Agree nor Disagree, Somewhat Agree. Agree, Strongly Agree.

Schools garden

During the last three decades, the restorative impacts of natural elements such as gardens and trees on students and faculty members have been studied. That research concludes that viewing garden in educational settings has many health benefits and improves overall well-being of occupants, those positive impacts include but not limited to; mental and physical restoration, create the sense of place attachment, increase concentration, decrease anxiety and stress, improve scores, foster learning, and improve productivity. The theories of restorative effects in environmental psychology discuss the therapeutic impacts of natural elements (Hartig T. , 2004). Those studies argue that natural environments foster stress recovery better than built spaces (Ulrich.Roger S, 1991). Analytical research by Grinde (1996) examines the different and effective aspects of the plants' presence on stress reduction (Grinde.Bjørn, 1996). Attaching elements of nature to living environment has several impact including: improving air quality, adding fragrance and also providing visual impact (Grinde.Bjørn

P. , 2009) A wide variety of theories have been proposed over the time to explain the mechanism by which time spend in nature improves psychological state. Attention-restoration theory (ART) developed by Kaplan and Kaplan in the 1980s, the ART provides a new approach to explain the psychological benefits of nature (Kaplan, R., Kaplan, S, 1989). Based on the Attention Restoration Theory (ART), environments with potentials for effortless attention and natural elements which offer aesthetic stimuli improve mental capacity and are more restorative (Kaplan, R., Kaplan, S, 1989). Attention Restoration Theory(ART) contends that people can concentrate better after either spending time in natural environment or just looking at presentation of nature even by picture or videos (Kaplan, R., Kaplan, S, 1989). Stress-reduction theory, developed by Ulrich et al. in the 1980s another important theory mentions that the visual environment plays a crucial role in stress recovery, with stress reduction occurring more rapidly in natural settings compared to urban environments (Bodin, 2003).

Spending time in nature has been shown to offer relief from stress, depression, and lack of focus (Lau.Stephen S.Y, Yang.Feng, 2009). In addition to this Sachs and Marcus (2013) indicate that connection with nature is beneficial—even vital—for health. Walking through the woods, sitting on a park bench, gardening, and observing nature's colors and movements from indoor environment are ways to engage with nature, both passively and actively. These activities stimulate our senses, promote physical activity and exercise, foster social interactions, decrease stress and depression, and provoke positive physiological and psychological responses (Marcus, C, Sachs, N. A., 2013).
Spending time in natural environments, or simply viewing natural scenes from a window or on a screen, can lead to positive alterations in physiological activity and consequently foster a more positive emotional state (Hartig T. M., 2014). Hartig (1993) also found that stress recovery generally occurs more rapidly, and it is disappearing faster, while recovery from mental fatigue is indeed a slow process and may also be more resistant. All the studies in this domain indicate on rapid recovery from stress, fatigue, and health outcomes after viewing nature scenes, or spending time in a natural

sitting (Kuo & Sullivan, 2001).More specifically, contact with nature and green space have had psychological benefits by improving attention (Kaplan, R., Kaplan, S, 1989), by reducing stress (Bodin, 2003), by having a positive effect on mental restoration (BROWN, 2005) and more importantly by coping with attention deficits (Boakes Elizabeth H., 2010).Taking all these studies into account, it is clear that the interacting with nature can provide positive effect on health and well-being, environment that create a potential for effortless attention and natural elements that offer aesthetic stimuli improve mental capacity and are more restorative (Kaplan, R., Kaplan, S, 1989). Natural settings are preferred places for self- and emotion regulation (Korpela, 2001). Psychological and emotional influences of visual presence of plants and flowers on students' subconscious have been described by Liu, Kim, and Mattson in 2007. They argued that the presence of plants, even in background, can influence the unconscious mechanism of the brain (Liu, 2003). Students prefer open spaces with natural settings to boost their moods when they are stressed, upset, depressed, angry, or confused (Lau.Stephen S.Y, Yang.Feng, 2009). In addition, engagement in nature-related activities may greatly impact one's self-identity as well (Olivos, 2017). Salingaros (2020) acclaims that a campus is mainly a pedestrian environment with multiple internal and external links. The importance of providing green space in university campuses to enhance connectedness are mentioned in several studies on campuses, sociopetal spatial arrangements in green spaces might create connectedness to others by enabling effective breaks on campus which in turn might enhance opportunities to bring people together (Osmond, 1959; Gehl, 1987). Green scenery and a relaxing atmosphere in sociopetal open spaces encourage meetings and conversations, while providing fresh air for stressed people. Supportive campus settings have intimate-scaled spaces, informal spaces, and welcoming spaces for students to mold relationships with others, expand their social network and feel connected to a place (Alves.S, 2022).

NatureRX

In recent decades providing access to nature is an urgent need in university campuses. Higher education institutions should offer programs that promote student engagement with these valuable resources. (Genevive R. Meredith, 2020). Many colleges and universities have launched "Nature Rx" or "Park Prescription" programs, which include dedicated websites, nature prescriptions provided by health clinics, and classes focused on nature experiences. These initiatives aim to encourage all students, regardless of their health status, to explore the natural world (Razani, 2018; Rakow and Eells, 2019). For college students transitioning from adolescence to adulthood and for those who may experience an array of health and well-being issues, the gains from NatureRx@UMD are both promising and endless (Roberts, 2021).

Although University campuses play a crucial role in nurturing and supporting the health and quality of life (QOL) of students.

The health benefits on being in nature might be increased by campus spaces and activities that afford connectedness (Alves.S, 2022). If environmental education interventions providing a sustainable and emotionally significant contact with nature may increase the perception of being connected to the wider natural world among children and adolescents (Barrable and booth,2020)

Students are often unaware of the ecological importance of green spaces on their campuses (Speake, 2013) even though their choice of university critically depends upon perceptions and evaluation of outdoor spaces (Groen and White, 2003). Campuses offer unparalleled place-based learning which can be complemented by the potential for deep connections with, and use of their green spaces. The Biophilic Hypothesis suggests that humans have an innate attraction to certain features of the natural environment and that their well-being is, to some extent, dependent on their interactions with the surrounding natural world. (Wilson,1978; Wilson; 1984; Kellert,1997, Kellert,2002; Ulrich,1993). The Biophilic approaches have been considered to understand how urban sitting can help people with a ‘Daily dose of nature’(Beatley,2010). To develop biophilic design on campuses the view of nature

must be acknowledge with biophilic elements and attributes (Alves.S, 2022). Green campus plays an important role in perceived student restoration and quality of life (Hipp.,2016; Gulwadi,2019). Biophilic design is not just adding trees and vegetation to build sitting-it is an effort to build a positive environment experience (Alves.S, 2022)

View to garden

Over time, gardens and natural elements have shaped human psychological state of mind and physical health(Mabadi,2021). restorative needs can be met through direct (i.e., gardening) and indirect (i.e., view from window) engagement in nature (Soga et al., 2021; Theodorou et al., 2021). According to Sachs and Marcus (2013) Indoor contact with nature can include looking out at nature through a window; viewing nature imagery (still and moving pictures); seeing, touching, and smelling indoor vegetation; and hearing nature 's sounds through an open window or through sound recordings (birds, water, and the like). Greenery and wild life attract and also engage garden users, invite them to stay longer, and keep them coming back (Sachs, N.A, 2019).view to the outside might be important for individual who has unvarying schedules and spend a great deal of time in the same room (Collins.B.L, 1975) . Number of research provides strong evidence that nature positively affects recovery from stress and attention fatigue, and that exposure to nature, both direct and indirect, has health benefits. This includes the positive effects of viewing natural landscapes(Velaard.,2007) viewing a garden had positive impact on health of nursing home residents (Frost.,2012) some studies indicate that all hospital user experience positive health outcomes from access to daylight and landscape views (Nedučin.D, 2010).Ulrich study proved that there was significant difference between recovery in hospital patient who had view of nature from their hospital window and a group with a view of a brick wall. There are every day growing numbers of empirical studies on outdoor environments and health, for example, in 2004 a comprehensive study found out that there is a positive correlation between proximity to nature and health indicators (Health Council of the Netherlands, 2019). Additionally, many other studies conclude that exposure to natural elements reduces stress and

improves concentration (Taylor, Kuo, & Sullivan, 2001). Nature can improve wellbeing in the following ways: providing fresh air, reducing air pollution, adjust humidity, and provide pleasant view s (Kim, E., & Mattson, R. H, 2002). According to the conclusion of Velarde et al (2007) and Grinde (2009), "nature appears to have qualities useful for stress relief, mental restoration, and improved mood simply by being consciously or unconsciously pleasing to eye" (Grinde.Bjørn P. , 2009). Louv (2008) presented evidence from studies that confirm the therapeutic impacts of viewing nature in indoor environments (Louv, 2008). The theory of healing effects of visual contact with greenery is supported by both the empirical data and theoretical studies (Park & Mattson, 2009; Mabadi, 2017). According to recent studies, the psychological benefits of indoor greenery and experiencing nature are also determined by cultural factors (Bringslimark, Hartig, & Patil, 2009; Hartig, 2003). Grinde and Patil (2009) hypothesized that "The positive effects of having view from the window may be related more to the perceived openness that to any particularities of vista" (Grinde.Bjørn P. , 2009), while other study by Velarde et al (2007) also confirmed that a view to green landscaped areas has most positive mental effects (Velarde, Fry, & Tveit, 2007). Additionally, the possible different responses from different genders toward the presence of plants and natural elements have been investigated. As that research conclude, female are more susceptible to show interest and pay attention to plants than male (Pergams & Zaradic, 2006; United States Department of Labor, 2019). In work environment workers were more satisfied and outcomes were significant with views that includes green elements (StephenKaplan, 1995). Shibata& Suzuki found that man is less productive than women in plant-free environment. Visibility is important spatial (Kellert et al.,2008) Restorative needs can be met through direct (Gardening) and indirect (view from window) engagement in nature (Soga et al, 2021; Theodorou et al,.2021). Visual connection to nature is defined as visual access to elements of nature, living systems and natural processes (Browning et al., 2014) By providing large windows to the outdoor landscape which is allowing expansive views (Appleton, 1975/1996) Generally People prefer natural views over built views and derive restoration from mental fatigue and stress after engaging with nature (StephenKaplan, 1995). In study of Tennessen and Cimprich (1995) natural view were associated with

better performance on attentional measures than built views even viewing videotapes of natural environments led to better concentration than viewing built environment (Van den Berg.2003) Introducing plants into a windowless computer lab was found to reduce mental fatigue and enhance attentiveness, compared to environments without any plants(Lohr.1996). In the 20th century, two important studies by Ulrich explained that the views to nature or natural scenes like the outdoor visual environments have positive impacts on patients and have a significant advantage on brick walls (Ulrich, 1983). In addition, in 1984, Kaplan implemented a theoretical analysis and acclaim that the natural settings in cities have strong restorative effects. Furthermore, in 1989, Olds indicated that outdoor spaces with natural elements have positive healing characteristics. This survey research concluded that both the indoor and outdoor natural environments can influence the healing perception of people (Olds, 1989).

In this thesis to better understanding the restorative impacts landscape mentioned the Synopsis of the Recent Studies and Methodologies of Therapeutic Environments in terms of the focus and methodology of those studies (Table1) (Mabadi,2017).

	Authors	Focus	Method
1	Ulrich (1983), Ulrich (1984),	the views to nature or natural scenes,	survey, EBD
2	Kaplan (1984), Kaplan & Kaplan, 1989, Herzog et al., (2003)	restorative effects of natural settings	theoretical analysis
3	Olds (1989)	healing influences of nature	survey
4	Francis & Cooper-Marcus, 1991, 1992	the healing elements of nature and, environmental conditions	qualitative formative research
5	Pretty(2004), Pretty, Peacock, Sellens, & Griffin, (2005), Ward Thompson, (2011)	natural elements to mental and physical health	qualitative and quantitative
6	Kaplan (2001), Kuo, Bacaicoa, & Sullivian (2001)	Human satisfaction, neighborhoods & overall wellbeing.	qualitative
7	Collins (1975)	view through a window may influence recovery	quantitative
8	Wells & Evans (2003), Cimprich (2007), Franklin, (2012), Park & Mattson (2009)	biophilic" environments and attention restoration	qualitative
9	Jiang (2015)	person's nature engagement	Literature review
10	Berman, Jonides, & Kaplan (2008), Nordha, Alalouch, & Hartig (2011), Irvine et al,(2013), Berman et al.	attention-restoration theory and public parks	Survey, quantitative
11	(2008)		

Table 1- Therapeutic Environments (by Mabadi,2017)

Chapter 3: Methodology

Introduction

This thesis investigates the relationships between built and natural window views, and student's perceived restoration using virtual reality.

Research Design

The study aims to investigate the potential restorative benefits of different window views at the School of Architecture building at the University of Maryland, College Park. applying virtual reality, the purpose of this study is to identify the effects of different window views of both the built and natural environment on student perceived restoratives through the lens of Attention Restoration Theory (ART). which indicates four restoration factors: fascination, being away, extent and compatibility, all these factors can facilitate a mental recovery from mental fatigue and crucial for transitioning from a state of voluntary, effortful attention to effortless attention, thereby helping in attentional recovery. The attention restorative theory and therapeutic landscapes constitute a pivotal element of this thesis. This thesis builds upon existing qualitative and quantitative research that has already established the positive effects of such design and planning methods on both humans and the environment. As such, it aims to apply the conclusions found within the literature review as a foundation for this study. Furthermore, by employing perceived restoratvensse scale (PRS) and virtual reality for data collection and analysis, this research seeks to identify the most restorative natural environments (figure1).

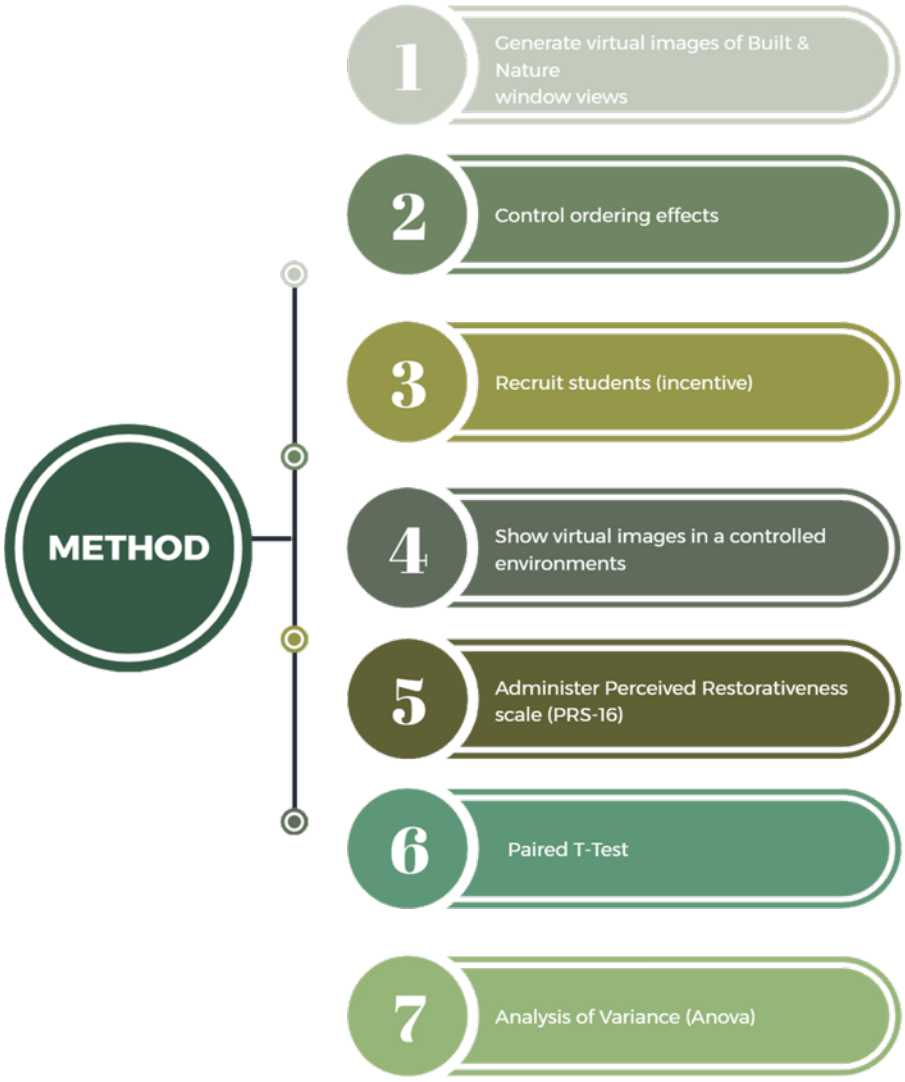

Figure 1-Research Design for thesis (by Author)

Generalization of the hypothesis

Environmental settings have been shown to contribute to restorative outcomes, such as reduced anxiety, improved mood, and recovery from stress. Within this context, ART serves as a pivotal theoretical model, providing the foundation for the restorative properties of different environments. This study aims to investigate the impact of window views on restoration, drawing upon ART's theory. The theory was an important groundwork in environmental psychology for defining Perceived Restorativeness Scale (PRS) and its four principles of a restorative environment: Fascination, being away, extent, and compatibility. Subsequently, it evaluates the research findings to identify the most restorative design viewed through the windows and generalizes the outcomes for broader application in educational settings.

School of Architecture courtyard

For this research, the selection of windows in the Design Studio at the School of Architecture was strategic. The large window chosen for this investigation offers a view of the courtyard, providing a consistent scene across different observation points. Additionally, all the windows share same structural features, including height and width, ensuring that any observed differences in perceived restoration can be attributed to the visual content of the window views rather than variations in physical window characteristics. This uniformity in window design reduces potential confounding variables, allowing for a clearer analysis of how virtual window views of built and natural environments impact perceived restoration. The choice of these particular window supports the research's aim to explore the restorative effects of virtual window views in architectural and educational settings, thereby offering valuable insights into how window design and placement can enhance the well-being and productivity of occupants within educational institutions like the School of Architecture.

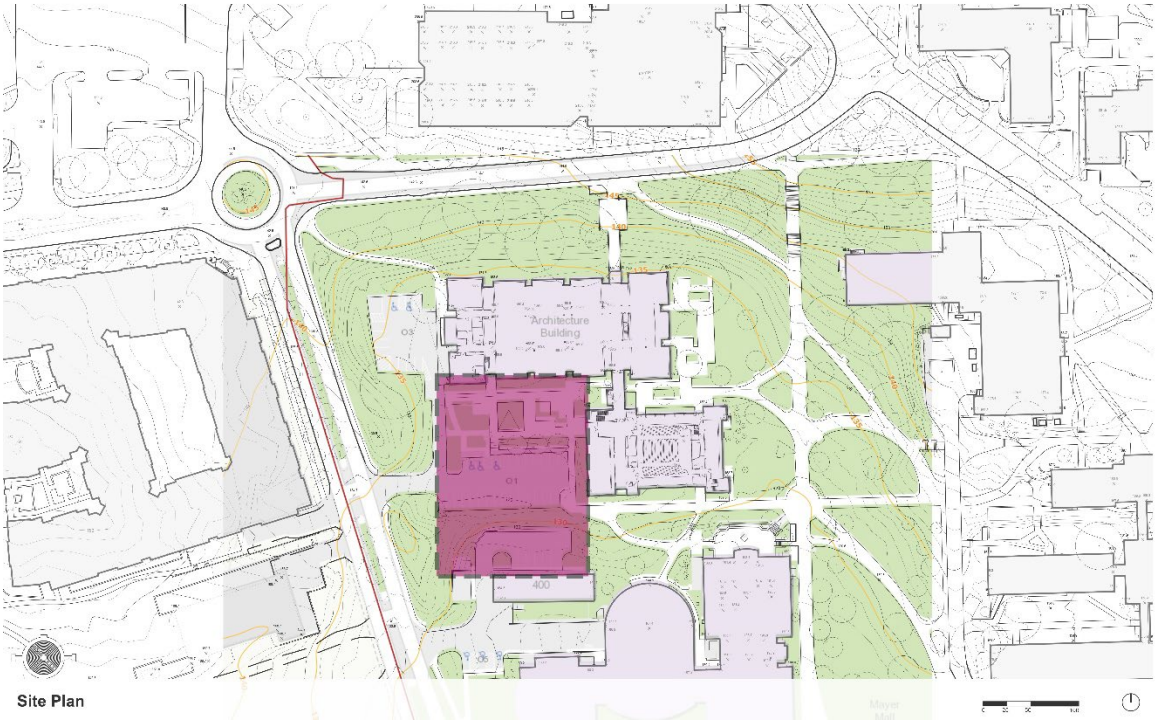

Figure 2-School of Architecture courtyard (by Author)

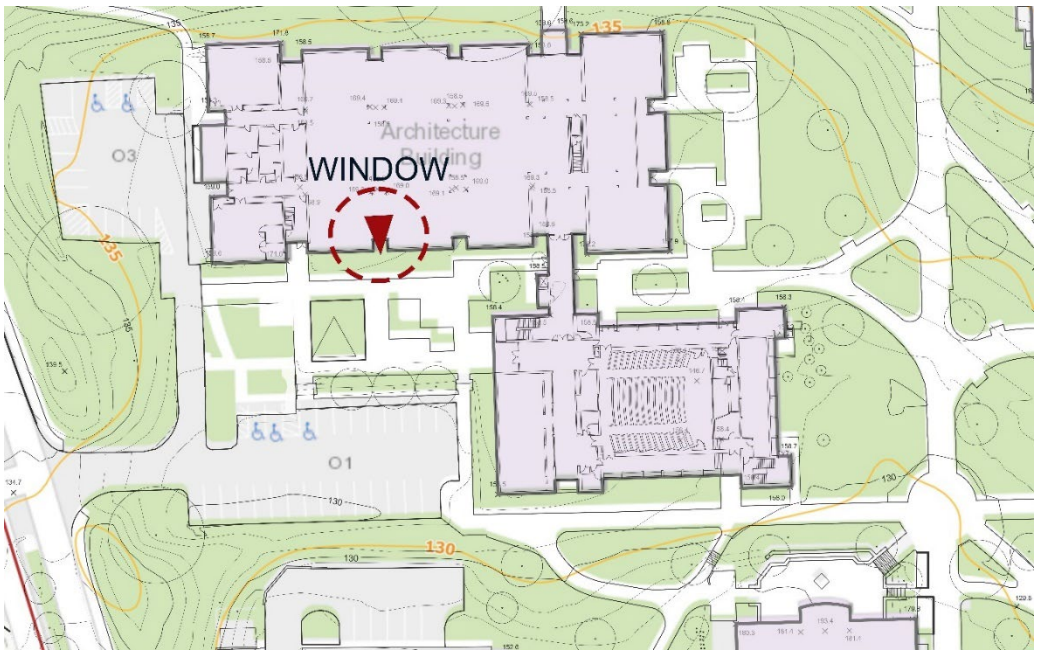

Figure 3-Selected window (by Author)

Figure 4-Existing window view (by Author)

Figure 5-Existing window view (by Author)

Experimental Data Collection

IRB Application

An application for conducting this research was submitted to the Institutional Review Boards on November 16, 2023, and received approval following an exempt review on December 19, 2023.

Participant Recruitment

College age students at the University of Maryland College Park, who have taken at least one design studio course, were invited to participate in this study. The experiment commenced on February 12, 2024, with an initial duration of two weeks. A total of 45 participants were recruited through various methods:

- Distributing flyers throughout the UMD Plant Science Building and the School of Architecture.
- Announcements made in all design studio courses across undergraduate and graduate levels.
- An announcement in LARC160 Introduction to Landscape Architecture and Environmental Design.
- Direct conversations with students and word-of-mouth referrals.

Additionally, signup sheets were left in all undergraduate and graduate studios, filled by interested students over a week, after which they were collected. Participants were scheduled within a two-week window from Monday, February 12, 2024, to Monday, February 26, 2024, though all participants were accommodated within the first ten days.

360 Panorama Stereoscopic Images

For this study, six digital 3D models were constructed using SketchUp Pro 2024, categorized into two design sets: Built vs. Nature. The Built set comprised three fully constructed environments: a Parking Lot, an Office Building, and a Plaza. The Nature set included three fully natural environments: a Woodland, a Pond, and a Meadow with Flowers. These designs were conceptualized for the School of Architecture's courtyard located at the southern part of the building, ensuring all studio windows overlooked these scenes. A specific window was selected from the five available, all of which were uniform in size, height, and design.(figure)

After completing the digital 3D models for both the Built and Nature sets, each was imported into Lumion Pro 12 for rendering. For each condition, a 360-degree panorama stereoscopic view was captured, considering the eye level of students seated in the studio. Since the study did not consider any interior design elements within the studio, simple 3D models of the existing conditions were created for all six environments to minimize the impact of interior features while changing the window view. Figures 6 to 11 illustrate two-dimensional versions of the 360-degree panorama stereoscopic images used in the experimental study.

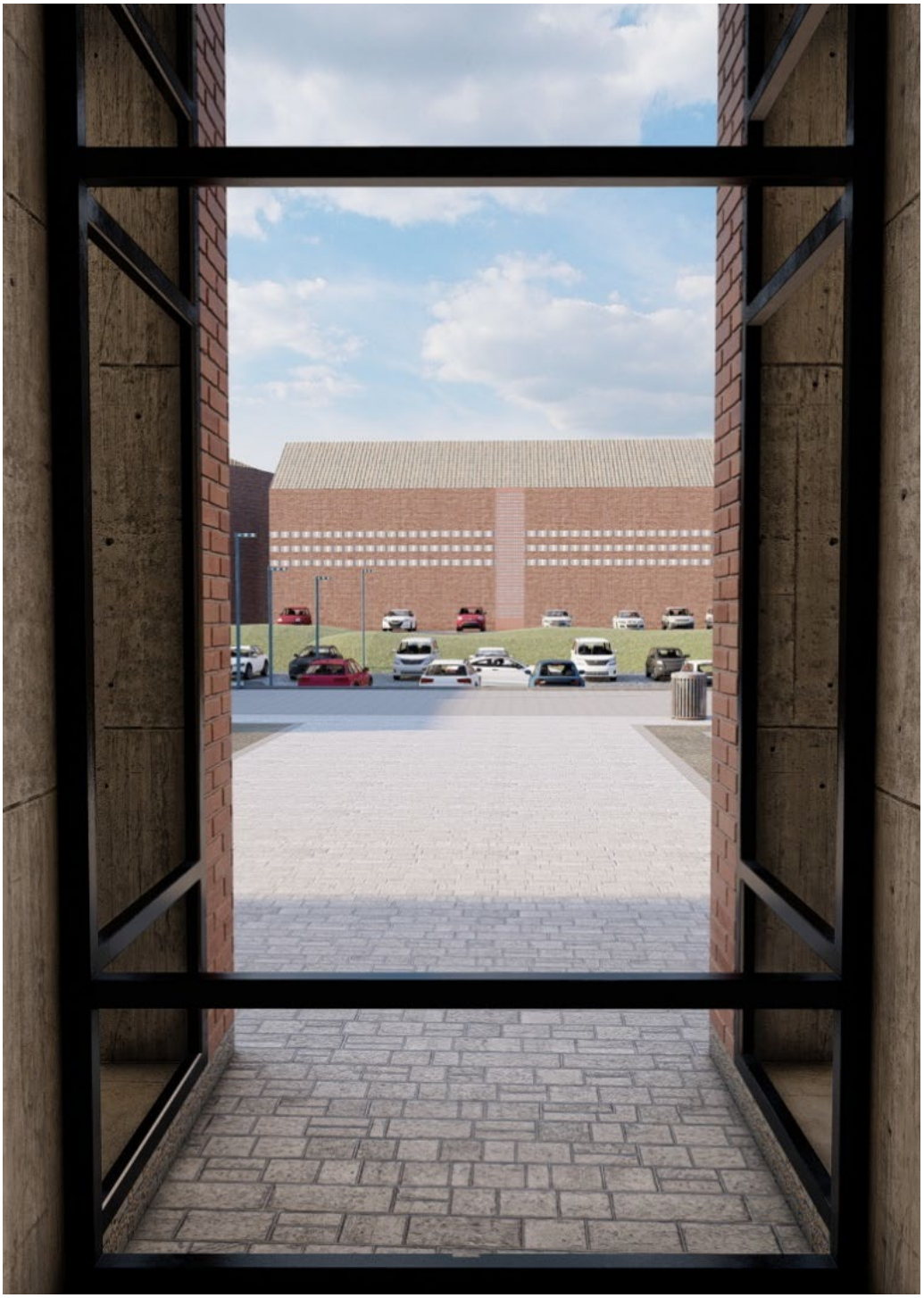

Figure 6-Virtual window view to parking lot (by Author)

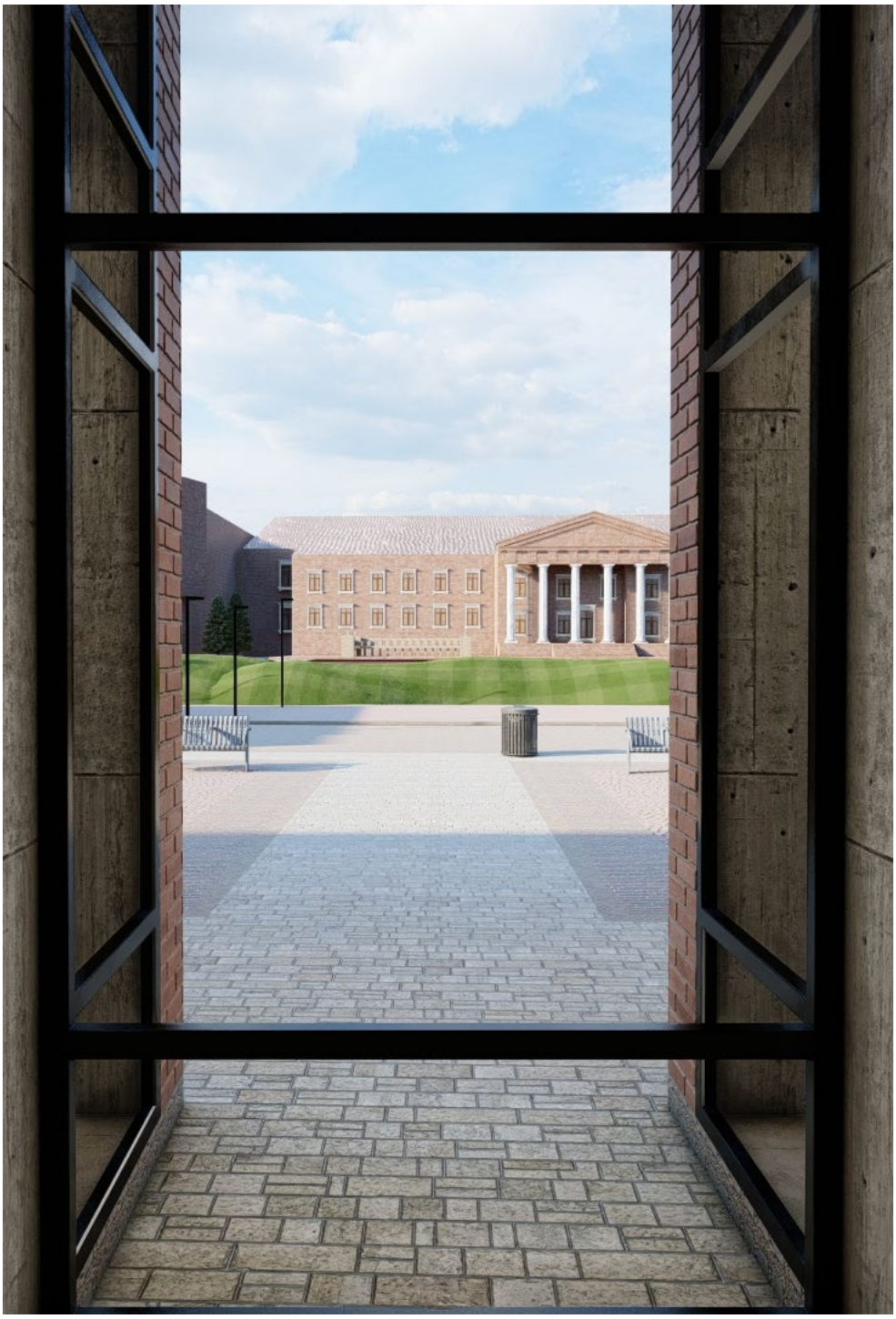

Figure 7-Virtual window view to the office building (by Author)

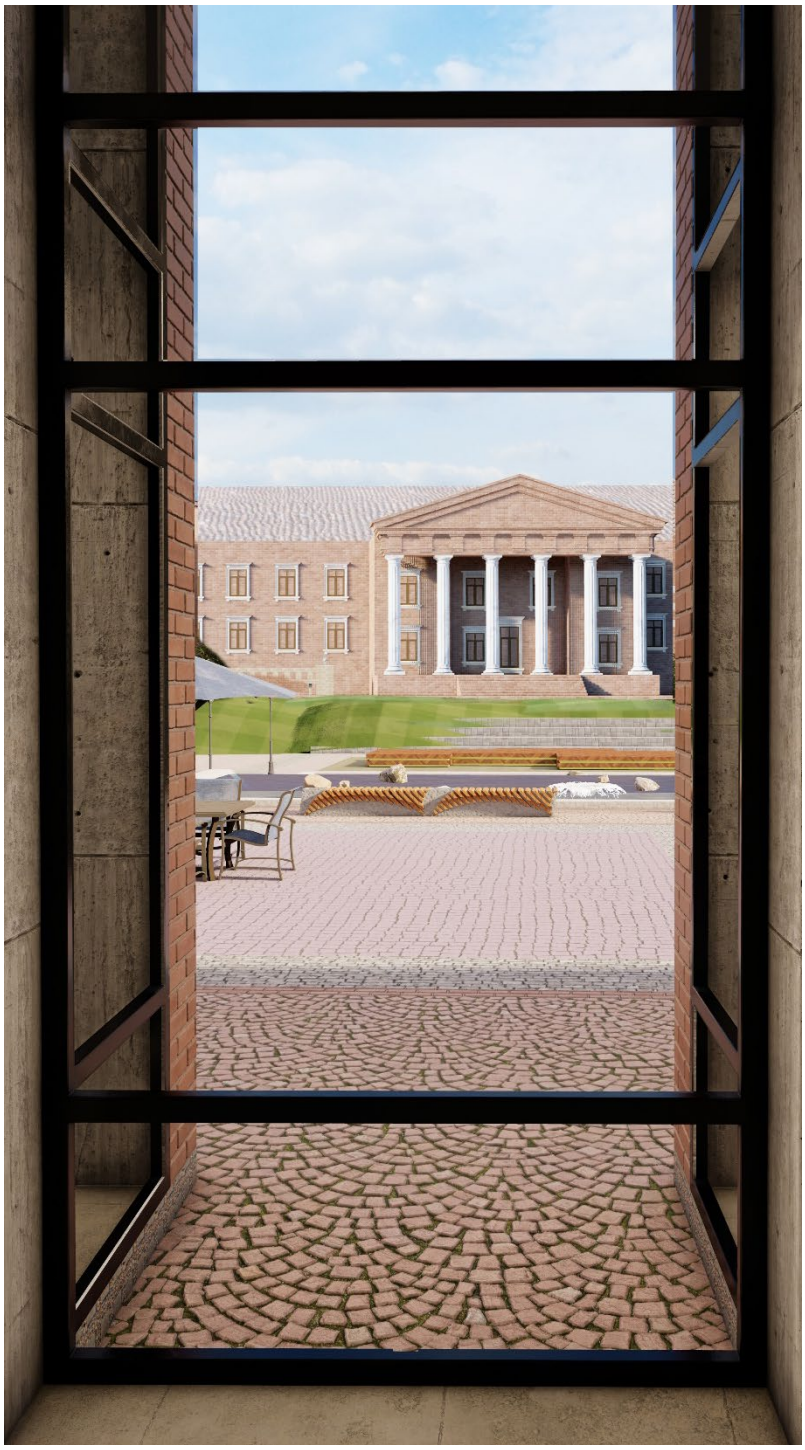

Figure 8-Virtual window view to the plaza (by Author)

Figure 9-Virtual window view to the woodland (by Author)

Figure 10-Virtual window view to the pond (by Author)

Figure 11-Virtual window view to the meadow with flowers (by Author)

Procedure

Measurement instrument

Evaluating Restorative Environments and VR-Induced Discomfort: A Comparative Analysis through the Lens of the Perceived Restrictiveness Scale(PRS-16) and the Virtual Reality Sickness Questionnaire(VRSQ)

The Perceived Restorativeness Scale (PRS) stands as the leading tool for evaluating individuals' subjective perceptions regarding the restorative qualities of an environment, specifically designed to probe the four critical elements of a restorative experience as outlined by Attention Restoration Theory (ART) (Berto, 2014). Originating from the foundational work of Hartig in 1991, After reviewing the relevant literature the PRS has undergone various revisions to accurately capture and assess the elements of fascination, being away, coherence, and compatibility, employing a range of statement types for this purpose. (Berto, 2005; Hartig et al., 1996; Hartig et al., 1997a; Hartig et al., 1997b; Pasini et al., 2014; Purcell et al., 2001).

Running Experiment

This study engaged 45 participants, divided evenly into three distinct groups labeled A, B, and C, to investigate the restorative qualities of various environmental designs. Participants in Group A were exposed to two contrasting views specifically, a parking lot (referred to as Built1) and a woodland scene (Nature1) and subsequently assessed the perceived restrictiveness of each using the Perceived restrictiveness Scale (PRS), a 16-item questionnaire. This process was mirrored for Groups B and C, with Group B evaluating an office building (Built2) and a pond scene (Nature2), and Group C examining a plaza (Built3) and a meadow with flowers (Nature3). After viewing each respective built and natural environment, participants completed the PRS to gauge their restorative impression, marking their responses on a 7-point Likert scale.

The primary objective of this research is to ascertain which category of design Built or Nature possesses greater restorative properties as measured by the PRS. Further, within

each design category, the study aims to identify the specific environment—Lot, Office, and Plaza for the Built category, and Woodland, Pond, and Meadow for the Nature category—that is perceived as most restorative. This nuanced comparison involves assessing Group A's responses to the parking lot versus the woodland scene, Group B's to the office versus the pond, and Group C's to the plaza versus the meadow with flowers, to comprehensively evaluate and contrast the restorative potential of these diverse environmental designs.

In the concluding phase of the study, participants were requested to complete the Virtual Reality Sickness Questionnaire (VRSQ), which was specifically designed to gather information regarding any side effects experienced because of exposure to virtual reality environments. This step was crucial for assessing the incidence and severity of VR-induced discomfort among the study's participants. (figure)

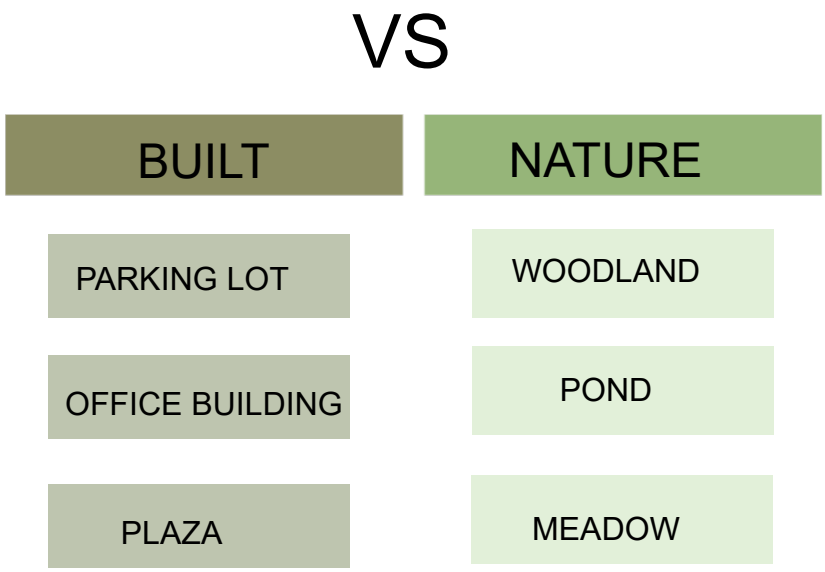

Figure 12-Research Design for thesis

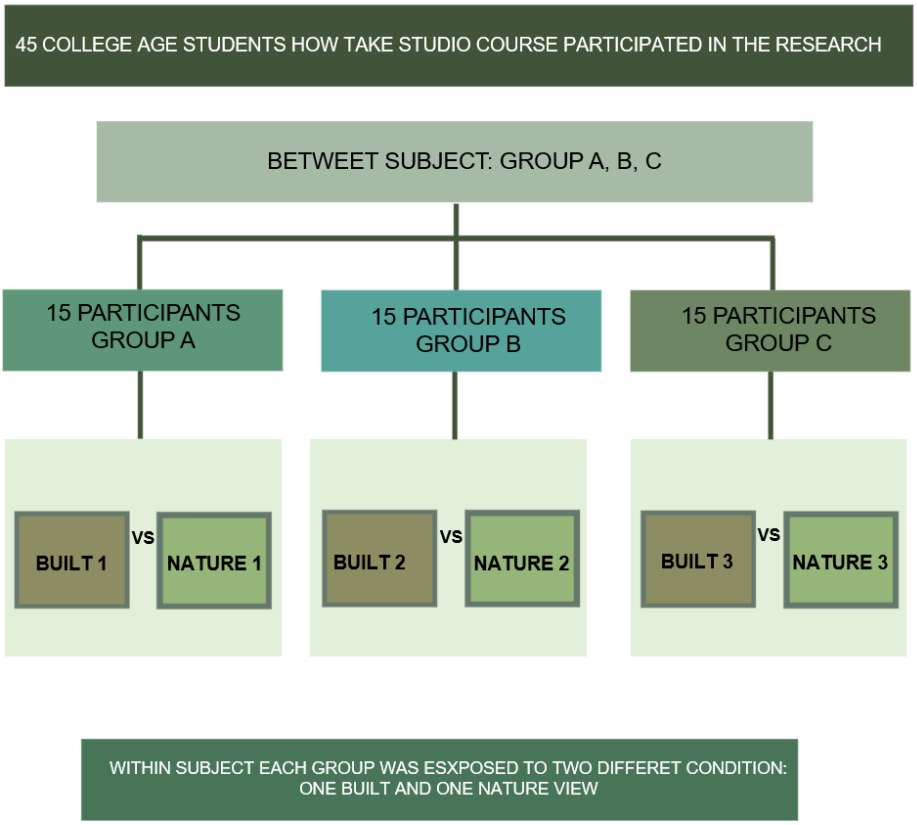

Figure 13-Research Design for thesis

Setting

Data collection took place in seminar room 1144 at the Department of Plant Science and Landscape Architecture. This room, chosen for its quiet and distraction-free environment, hosted the 35-minute study sessions, which included a brief introduction and all procedures. Before participants entered the study room, the group of images was uploaded to an Oculus Quest 2 VR headset via the Pegasus media player. For each participant group (A, B, C), an image matrix was established to ensure a balanced presentation of the two stimulus environments.(table2,3,4)

PARTICIPANT	SEQUENCE OF VIEW
PARTICIPANT 1	B1,N1
PARTICIPANT 2	N1,B1
PARTICIPANT 3	B1,N1
PARTICIPANT 4	N1,B1
PARTICIPANT 5	B1,N1
PARTICIPANT 6	N1,B1
PARTICIPANT 7	B1,N1
PARTICIPANT 8	N1,B1
PARTICIPANT 9	B1,N1
PARTICIPANT 10	N1,B1
PARTICIPANT 11	B1,N1
PARTICIPANT 12	N1,B1
PARTICIPANT 13	B1,N1
PARTICIPANT 14	N1,B1
PARTICIPANT 15	B1,N1

Table 2-Image order (by Author)

PARTICIPANT	SEQUENCE OF VIEW
PARTICIPANT16	B2,N2
PARTICIPANT17	N2,B2
PARTICIPANT18	B2,N2
PARTICIPANT19	N2,B2
PARTICIPANT20	B2,N2
PARTICIPANT21	N2,B2
PARTICIPANT22	B2,N2
PARTICIPANT23	N2,B2
PARTICIPANT24	B2,N2
PARTICIPANT25	N2,B2
PARTICIPANT26	B2,N2
PARTICIPANT27	N2,B2
PARTICIPANT28	B2,N2
PARTICIPANT29	N2,B2
PARTICIPANT30	B2,N2

Table 3-Image order (by Author)

PARTICIPANT	SEQUENCE OF VIEW
PARTICIPANT31	B3,N3
PARTICIPANT32	N3,B3
PARTICIPANT33	B3,N3
PARTICIPANT34	N3,B3
PARTICIPANT35	B3,N3
PARTICIPANT36	N3,B3
PARTICIPANT37	B3,N3
PARTICIPANT38	N3,B3
PARTICIPANT39	B3,N3
PARTICIPANT40	N3,B3
PARTICIPANT41	B3,N3
PARTICIPANT42	N3,B3
PARTICIPANT43	B3,N3
PARTICIPANT44	N3,B3
PARTICIPANT45	B3,N3

Table 4-Image order (by Author)

Upon entering the study room, participants were briefed on the study procedures and had the opportunity to inquire further. After reviewing and signing a consent form and completing a preliminary questionnaire regarding their demographic information and prior VR experience, participants donned the VR headset, which was adjusted for fit. They were given two minutes to acclimate before the experiment began. The researcher could view the same steps and images as the participant through the Meta Quest application on an iPad.

The experimental procedure began with a one-minute preparing participants by displaying blue color image which displaying the text “study will begin shortly.” Participants were asked to confirm their view at each step. Following this, they were exposed to the first window view from the stimulus environment, during which they could look around the studio. Each image was viewed for 90 seconds. After the first view, a message stating “study complete” appeared, and the VR headset was removed for the participant to complete the PRS questionnaire. The process was repeated for the second window view, after which participants filled out the PRS questionnaire for a second time and a VR Sickness Questionnaire (VRSQ) to report any side effects experienced. As compensation for their participation, each participant received a $10 gift card and a copy of the consent form.(figure14)

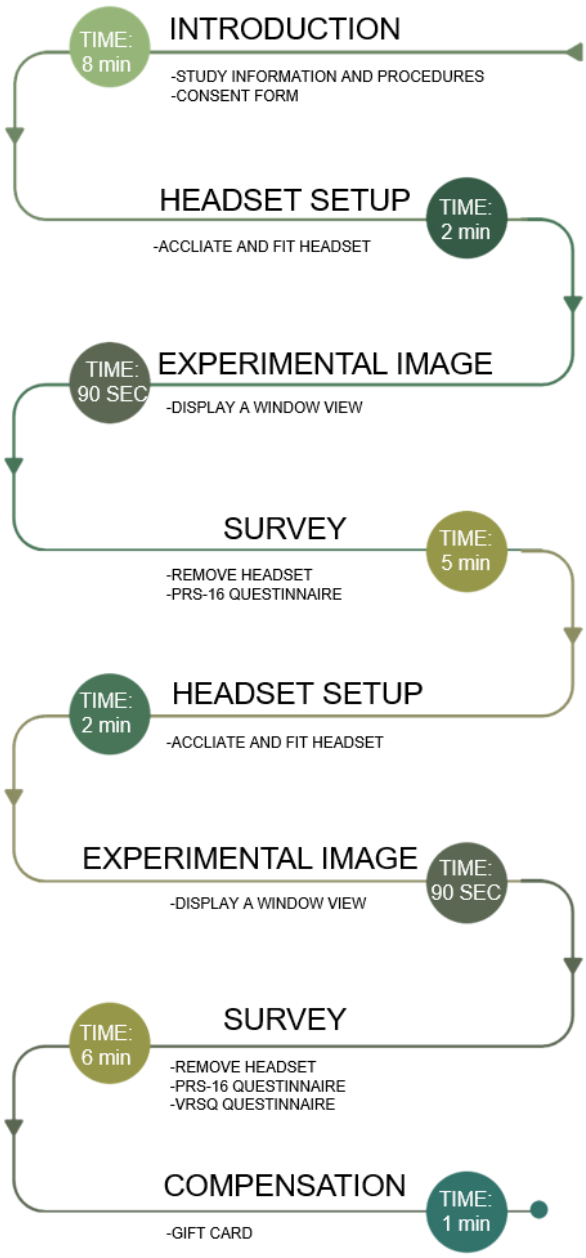

Figure 14-Experimental process

Data Analysis

The data analysis phase of the study begins with the process of importing the responses collected from the questionnaires into Excel. This initial step involves organizing the data in a structured format that facilitates easy analysis.

Once the data is neatly organized in Excel, the next step involves the application of statistical tests to assess the differences in perceived restoration across various virtual window views. To compare the restorative effects between two specific conditions views of natural versus built environments a Paired t-test was conducted. This statistical test was chosen because it was designed to compare the means of two related groups, making it ideal for situations where the same subjects are exposed to two different conditions. The Paired T-test helped to determine if the observed differences in perceived restoration are statistically significant, thus providing insights into the effectiveness of natural versus built views in enhancing psychological well-being.

For a broader comparison that includes multiple groups, different types of natural (woodland, pond, meadow) and built (parking lot, office building, plaza) environments.an Analysis of Variance (ANOVA) was employed. The ANOVA test is particularly useful for comparing the means across more than two groups, allowing us to identify whether there are significant differences in perceived restoration among various virtual window views.

Chapter 4: Results

Introduction

The results chapter of this study presents a comprehensive analysis of the data collected through the PRS questionnaire, aimed at understanding the perceived restorative effects of virtual window views in both built and natural environments. After importing and organizing the responses into Excel, I employed statistical techniques including paired t-tests and Analysis of Variance (ANOVA) to examine perceived restoration among various virtual window views selected from the Design Studio at the School of Architecture. This chapter details the outcomes of these analyses, highlighting significant findings that emerged from comparing the restorative impacts of different types of environments as viewed through the windows. I explore the comparative restorative benefits of natural versus built environments and investigate the extent to which specific variations within these categories influence perceived restoration. Through charts, tables, and descriptive statistics, setting the path for a discussion on the implications of these results for landscape design for studio.

Paired t-test

a Paired t-test was conducted specifically for comparing group A lot versus woodland for the PRS data, then for group B office versus pond and finally for group C plaza versus Meadow with flowers as paired t-test were performed to determine if there were statistically significant different between means by the PRS in the Built versus Nature window view.

Paired t-test group A (Lot vs Woodland)

A paired samples t-test was conducted comparing PRS scores after seeing lot and woodland in group A. Significant differences were found between PRS scores after seeing the lot and woodland views, $t(14) = -9.42$, $p < .001$.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total.PRS.Built	28.9333	15	13.80200	3.56366
	Total.PRS.Nature	69.8000	15	10.26227	2.64971

Table 5-Paired t-test Group A(Lot vs Woodland)

Paired Samples Test

		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Total.PRS.Built - Total.PRS.Nature	-40.86667	16.78803	4.33465	-50.16357	-31.56976	-9.428	14	<.001	<.001

Table 6-Paired t-test Group A(Lot vs Woodland)

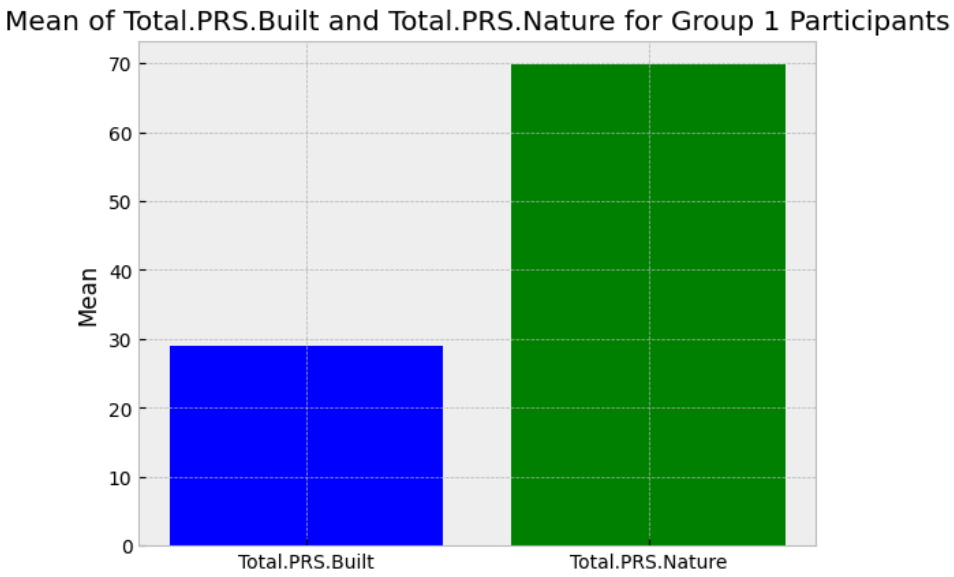

Figure 15-Group A(Lot vs Woodland)

Paired t-test group B (Office vs Pond)

A paired samples t-test was conducted comparing PRS scores after seeing office and pond in group B. Significant differences were found between PRS scores after seeing the office and pond views, t(14) = -6.90, p< .001.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total.PRS.Built	33.3333	15	19.27125	4.97581
	Total.PRS.Nature	74.8000	15	11.88156	3.06781

Table 7-Paired t-test Group B(Office building vs Pond)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Total.PRS.Built - Total.PRS.Nature	-41.46667	23.25900	6.00545	-54.34707	-28.58626	-6.905	14	<.001	<.001

Table 8-Paired t-test Group B(Office building vs Pond)

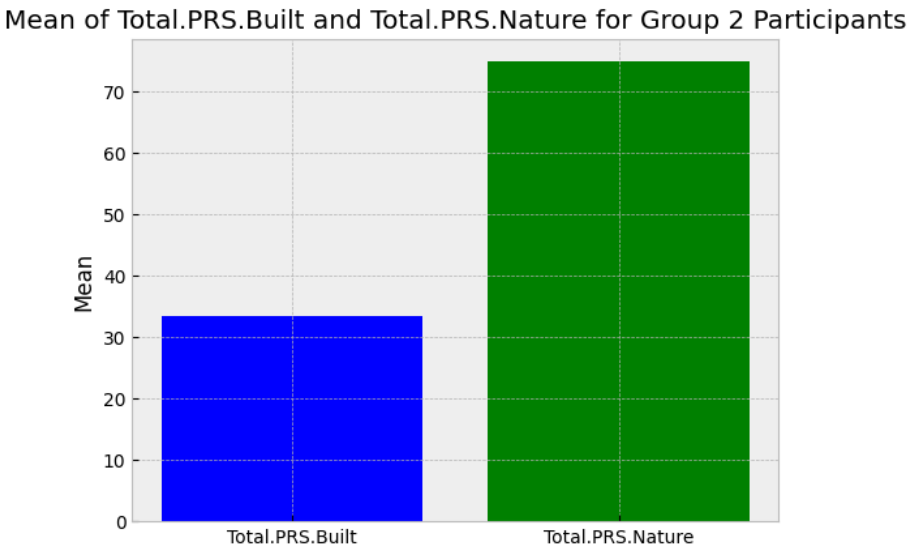

Figure 16-Group B(Office building vs Pond)

Paired t-test group C (Plaza vs Meadow)

A paired samples t-test was conducted comparing PRS scores after seeing plaza and meadow in group C. No significant difference was found between PRS scores after seeing the built and nature views, t(14) = -.57, p> .001.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total.PRS.Built	63.8000	15	22.27170	5.75053
	Total.PRS.Nature	67.6000	15	14.34673	3.70431

Table 9-Paired t-test Group C(Plaza vs Meadow with flowers)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Total.PRS.Built - Total.PRS.Nature	-3.80000	25.40866	6.56049	-17.87085	10.27085	-.579	14	.286	.572

Table 10-Paired t-test Group C(Plaza vs Meadow with flowers)

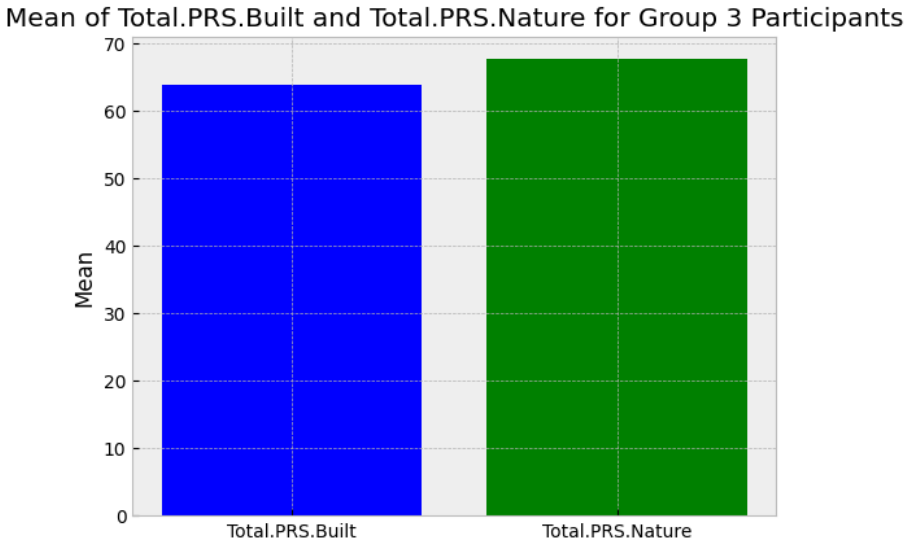

Figure 17-Group C(Plaza vs Meadow with flowers)

Paired t-test Total: Built and Nature (3 groups together)

We conducted paired t-test to find out is there any significant difference in PRS total score among all participants in three groups after seeing nature or built views.

A paired samples t-test was conducted comparing PRS scores after seeing built and nature views in all three groups. Significant differences were found between PRS scores after seeing the built and nature views among all participants, $t(44) = -6.87$, $p < .001$.

Participants in the 3 groups had higher scores after seeing nature than the built views. Based on the paired samples t-test results we can conclude in all three groups nature type are more restorative than built type.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total.PRS.Built	42.0222	45	24.13361	3.59763
	Total.PRS.Nature	70.7333	45	12.37740	1.84511

Table 11-Paired t-test Total(Built vs Nature)

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	Total.PRS.Built - Total.PRS. Nature	-28.71111	28.01105	4.17564	-37.12656	-20.29566	-6.876	44	<.001	<.001

Table 12-Paired t-test Total(Built vs Nature)

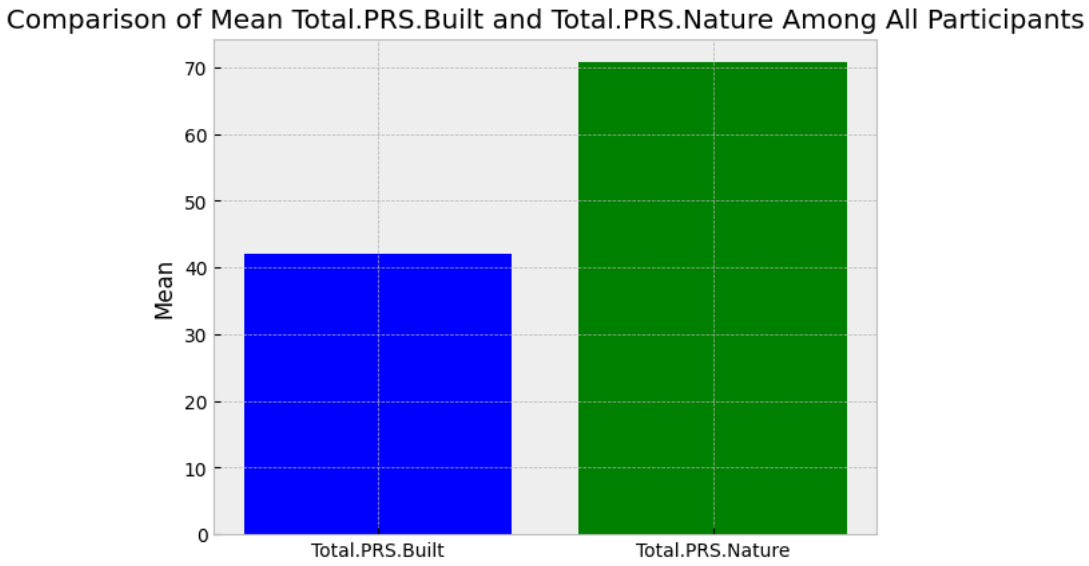

Figure 18-Total(Built vs Nature)

Analysis of Variance ANOVA for Built

We conducted ANOVA (Analysis of Variance) to find out is there any significant difference in PRS total score among all participants in three groups after seeing built views. And which group has the highest score among three built views.

An ANOVA was conducted comparing PRS scores after seeing built views in all three groups. Significant differences were found between PRS scores after seeing the built views among all participants, $F(44) = 15.33$, $p < .001$.

Participants in group c (view to plaza) had the highest score in PRS, then group b (view to office), and finally group a (view to parking lot).

Descriptives

Total.PRS.Built

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	15	28.9333	13.80200	3.56366	21.2900	36.5766	11.00	56.00
2	15	33.3333	19.27125	4.97581	22.6613	44.0054	4.00	70.00
3	15	63.8000	22.27170	5.75053	51.4663	76.1337	13.00	92.00
Total	45	42.0222	24.13361	3.59763	34.7717	49.2728	4.00	92.00

Table 13-Descriptives Total PRS Built

ANOVA

Total.PRS.Built

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10816.311	2	5408.156	15.336	<.001
Within Groups	14810.667	42	352.635		
Total	25626.978	44			

Table 14-ANOVA Total PRS Built

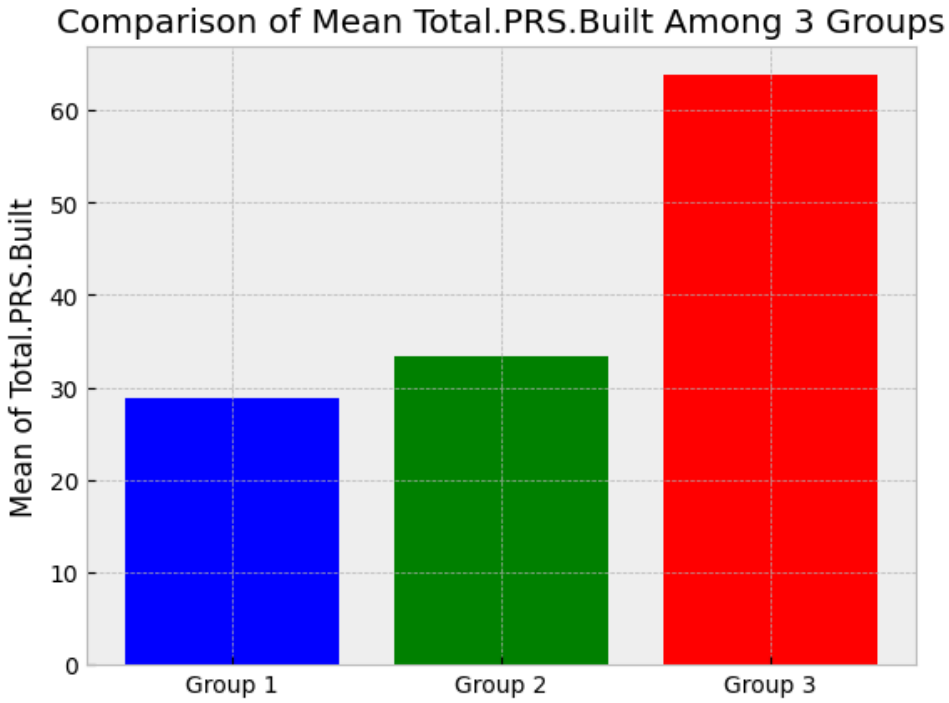

Figure 19-Total PRS Built

Analysis of Variance ANOVA for Nature

We conducted ANOVA (Analysis of Variance) to find out is there any significant difference in PRS total score among all participants in three groups after seeing the nature views. And which group has the highest score among three nature views.

An ANOVA was conducted comparing PRS scores after seeing nature views in all three groups. No significant difference was found between PRS scores after seeing the nature views among all participants, $F(44) = 1.35$, $p > .26$.

Participants in group b(view to pond) had the highest score in PRS, then group a (view to woodland), and finally group c (view to meadow).

Descriptives

Total.PRS.Nature

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	15	69.8000	10.26227	2.64971	64.1169	75.4831	53.00	96.00
2	15	74.8000	11.88156	3.06781	68.2202	81.3798	57.00	87.00
3	15	67.6000	14.34673	3.70431	59.6550	75.5450	40.00	89.00
Total	45	70.7333	12.37740	1.84511	67.0148	74.4519	40.00	96.00

Table 15-Descriptives Total PRS Nature

ANOVA

Total.PRS.Nature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	408.400	2	204.200	1.354	.269
Within Groups	6332.400	42	150.771		
Total	6740.800	44			

Table 16-ANOVA Total PRS Nature

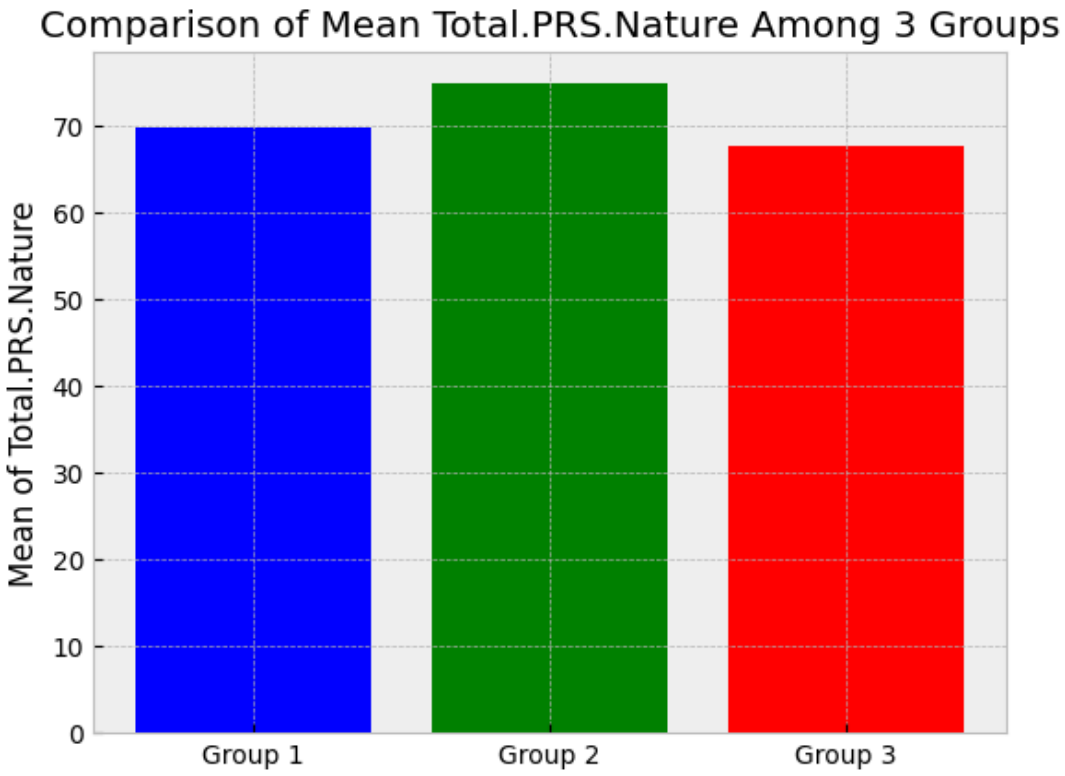

Figure 20-Total PRS Nature

Comprehensive Results

The analytical framework employed in this study, comprising paired t-tests and Analysis of Variance (ANOVA), the three participant groups each participant exposed to a distinct pair of built and natural views—consistently highlighted a preference for natural views in terms of their perceived restorative qualities.

Significant Restorative Advantage of Natural Environments

- Across all participant groups, natural views (woodland, pond, meadow) were consistently rated higher in terms of restorative qualities compared to build views (parking lot, office building, plaza), as measured by the Perceived Restrictiveness Scale (PRS).

Paired t-tests

Paired t-tests conducted for each group illuminated significant differences in Perceived Restrictiveness Scale (PRS) scores when comparing views of built environments to those of natural settings. The results demonstrated a substantial restorative advantage of natural views woodland, pond, and meadow views over their built views parking lot, office building, and plaza. This pattern of preference indicates the significant value of natural landscapes in enhancing psychological well-being and restorative benefits for students in studio.

- Paired t-tests revealed statistically significant preference natural environments over built environments in enhancing participants perceived restorative experience. The results were as follows:
- Group A (Parking Lot vs. Woodland): Demonstrated a significant preference for the woodland view over the parking lot, with a $t(14) = -9.42$, $p < .001$
- Group B (Office Building vs. Pond)): Revealed a marked preference for the pond scene over the office building, with a $t(14) = -6.90$, $p < .001$.

- Group C (Plaza vs. Meadow): Did not show a statistically significant preference between the plaza and meadow views, with a $t(14) = -.57$, $p > .05$.

Overall Preference for Nature

- When considering all groups together, a comprehensive paired t-test indicated a significant overall preference for natural views across the board, with a $t(44) = -6.87$, $p < .001$, underscoring the universal restorative appeal of natural environments.

ANOVA

Anova results further indicate the different impacts of various environments. While significant difference emerged among the restorative perceptions of built views with the plaza view being significantly more restorative than the office and parking lot while the natural views did not exhibit a statistically significant variance in their restorative impact. This outcome suggests a certain uniformity in the beneficial effects of natural environments, although there is not significant preferences for specific types of natural landscapes.

Comparative Analysis of Built and Natural Environments

-Anova for built views: An Analysis of Variance conducted among the three built views showed significant differences in PRS scores, $F(2, 42) = 15.33$, $p < .001$, with the plaza view receiving the highest restorative ratings, followed by the office building and parking lot.

-Anova for natural views: contrarily, the Anova among the natural views did not reveal significant differences in restorative perceptions, $F(2, 42) = 1.35$, $p > .26$, indicating a generalized restorative value attributed to natural environments, despite slight preferences among them

Virtual Reality Sickness Questionnaire (VRSQ) outcomes

Moreover, the result of the Virtual Reality Sickness Questionnaire (VRSQ) as part of the study's methodology was pivotal in assessing potential VR discomfort. The moderate reports of discomfort indicate the viability of VR technology as a reliable tool for simulating environmental exposures in psychological and environmental research.

VR side effects among all participants

Based on the mean scores, the worst side effects of VR among the 45 participants appear to be: Blurred vision (mean score: 2.13), followed by Eye strain (mean score: 1.98), General discomfort (mean score: 1.87), Fullness of the head (mean score: 1.82), Difficulty focusing (mean score: 1.69), Fatigue (mean score: 1.36), Headache (mean score: 1.09), Dizziness with eyes closed (mean score: 0.89), and Vertigo (mean score: 0.84).

Statistics

		General discomfort	Fatigue	Headache	Eye strain	Difficulty focusing	Fullness of the head	Blurred vision	Dizziness with eyes closed	Vertigo
N	Valid	45	45	45	45	45	45	45	45	45
	Missing	1	1	1	1	1	1	1	1	1
Mean		1.87	1.36	1.09	1.98	1.69	1.82	2.13	.89	.84

Table 17-Statistics for VRSQ

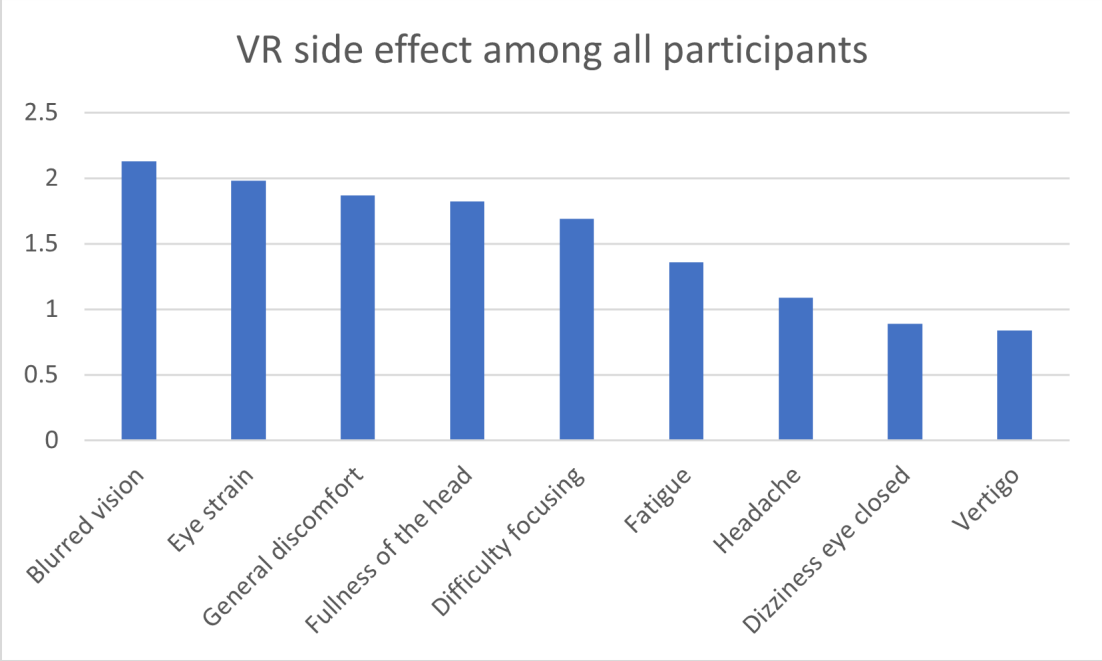

Figure 21-Statistics for VRSQ

Chapter 5: Discussion

Experimental results

This research aims to investigate the relationships between built and nature window views, and students perceived restoration within studio design, using virtual reality (VR) technology. The results of this study indicate that views to nature as opposed to build environments, significantly enhance both the restorative quality and attention recovery for students, which is align with the existing literature and has emphasis on the restorative impact of natural environment within educational settings

The utilization of VR technology offered a unique avenue to simulate the experience of different window views in a controlled setting, allowing for a precise measuring of their impacts. The virtual landscapes were carefully designed to reflect both built and natural environments, offering participants a diverse range of stimuli. The responses collected through the Perceived Restrictiveness Scale (PRS-16) and the Virtual Reality Sickness Questionnaire (VRSQ) measure the perceived restorative qualities of these environments and any discomfort contributed by the VR experience.

Our analysis revealed a marked preference for natural views over built environments in enhancing student attention recovery. Specifically, the nature views woodland, pond, and meadow consistently yielded higher PRS scores compared to their built counterparts parking lot, office building, and plaza. This difference was statistically significant across the board, save for the comparison between plaza views and meadow views, suggesting a overall restorative effect of natural environments on individuals' psychological states.

Furthermore, the research examined the variance in restorative perceptions among the different natural and built environments. While all nature views were more restorative than built views, the pond scene emerged as particularly beneficial, followed by the woodland and meadow scenes. Among the built environments, the plaza view held a higher restorative value than the office and parking lot views. These findings suggest a

hierarchy of restorative potential across the different types of views, with specific natural environments offering more benefits.

Additionally, the use of Virtual Reality (VR) as a methodological tool in this study allowed for an immersive exploration into the effects of simulated window views, providing a new lens through which to understand these dynamics. This technological approach not only ensured a consistent and controlled environment for participants but also highlighted the potential of VR in future research and practical applications within the design field. By simulating various environmental exposures, VR opens up possibilities for testing and implementing design interventions aimed at optimizing learning environments for attention restoration and well-being.

Limitations

The limitations of this study have many aspects, each influencing the interpretation and applicability of the findings. A primary constraint is the limited number of participants, which restricts the generalizability of the results. The small sample size may not accurately represent the broader population. This limitation affects the statistical power of the study, reducing its ability to detect subtle yet significant differences in perceived restorativeness across various virtual window views.

Another significant limitation is the reliance on virtual reality (VR) technology to simulate window views. While VR offers a new and controlled setting for this research, it cannot fully replicate the sensory complexity of real environments. The potential for VR sickness among participants could also impact their perception of the environments' restorativeness, introducing a bias that may not be present in real-world settings.

Lastly, the technological familiarity and accessibility of participants to VR might vary, potentially influencing their experiences and perceptions of the virtual window views.

Addressing these limitations in future research will be crucial for enhancing the solid and applicable finding.

Chapter 6: Conclusion

General Conclusion

The conducted study investigated the relationships between built and natural window views, and student's perceived restoration within studio environments, using virtual reality (VR) technology. The findings offer compelling evidence that views of natural landscapes significantly enhance restorative benefits and attention recovery among students, as opposed to built view.

Key Conclusions Drawn from the Study

Natural Environments as Restorative Spaces:

The research demonstrates an overall preference for natural over built environments in terms of their restorative impact. This preference, statistically significant across various comparative analyses.

VR Technology as a useful Research Tool:

The application of VR technology in simulating different environmental views provided a new and effective approach to study the psychological effects of environmental exposures. The minimal discomfort reported by participants in response to VR simulations further emphasis on the potential of this technology as a useful tool for future research in environmental psychology and related fields.

Implications for Educational Space Design

The findings from this study are important for the design and planning of educational environments. Considering views of natural landscapes or integrating restorative design elements into the architectural planning of educational spaces could serve as therapeutic approach to enhancing student restorative benefits .

Foundation for Future Research:

This study contributes to the growing body of literature on the restorative effects of natural environments and serves as a foundation for future research exploring the psychological benefits of nature in various contexts. Further studies could expand on these findings by exploring the long-term impacts of exposure to restorative environments on academic performance and well-being.

And future study might explore the restorative effect of water in designing both natural and built environment.

Additionally, considering the effect the way architect and landscape architect can apply material for hardscape of built environment.

Concluding Thoughts

In conclusion, this study highlights the importance and beneficial impact of natural environments on human psychological states, specifically within the context of educational settings. The clear preference for natural landscapes over built environments emphasizes the need for thoughtful integration of nature into the design and planning of spaces where learning and creativity are important. By fostering environments that are not only functional but also restorative, educators, designers, and landscape architects can significantly contribute to the well-being and success of students. The innovative use of VR technology in this research opens new avenues for exploring the dynamic relationship between humans and their environments, promising further advancements in our understanding of space and well-being.

Appendices

Appendix :IRB Approval

UNIVERSITY OF MARYLAND
INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	December 19, 2023
TO:	Azadeh Esmaeili, MLA master of landscape architecture
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[2105711-1] Investigating the relationships between different Window views and students' well-being and focus attention in studios using Virtual Reality (Case study School of Architecture, Planning & Preservation at University of Maryland College Park)
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	December 19, 2023
REVIEW CATEGORY:	Exemption category # 45CFR46.104(d)(3i)(A-B)

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Maryland College Park (UMCP) IRB's records.

Appendix: Research Flyer

AppendixI: Consent form

Initials: _____ Date: _____

Institutional Review Board
1204 Marie Mount Hall • 7814 Regents Drive • College Park, MD 20742 • 301-405-4212 • irb@umd.edu

CONSENT TO PARTICIPATE

Project Title	*Investigating the relationships between different window views and students' well-being and focus attention in studios using Virtual Reality (Case study School of Architecture, Planning & Preservation at University of Maryland College Park)*
Purpose of the Study	*This research is being conducted by Azadeh Esmaeili at the University of Maryland, College Park. We are inviting you to participate in this research project because your major is landscape Architecture, therefore you have already taken some studio courses at the University of Maryland College Park. The purpose of this research project is to investigate the impact of different window views on students' overall well-being and their concentration levels .*
Procedures	The procedures are about 16 minutes, the procedures will be begun with 3 minutes going through instruction of wearing VR headset and adjusting VR headset then you will spend 1 minutes on seeing the first window view(3D model image) and taking off VR headset, then you will spend 5 minutes on answering the PRS questionnaire. This procedure will be repeated two times for two different window views and answering the PRS questionnaire. Therefore, you will spend 15 minutes on seeing three different window views , taking off the VR headset and answering the PRS questionnaire for two times, by the end of the experiment after seeing all the window views and answering the PRS questionnaire, we will answer a Virtual Reality sickness Questionnaire VRSQ to measure possible side effect of wearing VR headset(there is no need to wear VR headset again for answering VRSQ). The experiment will take place in a mutually convenient, safe location at Plant Science building seminar room 1144. You will receive a 10$ Chick-fil-A Gift Card for completing the study
Potential Risks and Discomforts	*There may be some risks from participating in this research study, such as possible Headache or dizziness as documented side effects of wearing VR headset. The participants can request 5 minutes break at any time. Their participation in this research is completely voluntary. If they decide not to participate in this study or if they stop participating at any time, they will not be penalized. Also, there would be no identifiable information associated with any data record. record. No participant name will be associated with the data records, we will not store any identifiable data.*

AppendixII: Consent form

Initials: _____ *Date:* _____

	If we write a report or article about this research project their name will not be included.
Potential Benefits	*There are no direct benefits from participating in this research. However, the benefits to you include participation in VR research project as new knowledge. We hope that, in the future, other people might benefit from this study through improved understanding of designing the built environment.*
Confidentiality	*There would be no identifiable information associated with any data record. No participant name will be associated with the data records, we will not store any identifiable data.* *If we write a report or article about this research project their name will not be included. The student's information may be shared with representatives of the University of Maryland, College Park, or governmental authorities if they are in danger or if we are required to do so by law.* .
Medical Treatment	*Not Applicable*
Compensation	*You will receive a 10$ Chick-fil-A Gift Card for completing the study. You will be responsible for any taxes assessed on the compensation.* *If you earn $100 or more as a research participant in this study, you must provide your name, address and SSN to receive compensation.* *If you do not earn over $100 only your name and address will be collected to receive compensation.*
Right to Withdraw and Questions	*Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized. If you need break upon your request, you will have 5 minutes for break at any time of the procedure* *If you decide to stop taking part in the study, if you have questions, concerns, or complaints, or if you need to report an injury related to the research, please contact the investigator:* ***Azadeh Esmaeili*** ***aesmaeil@umd.edu*** ***University of Maryland College Park*** ***Department of Plant Science and Landscape Architecture*** ***room2144*** ***301-405-7782***

AppendixIII: Consent form

Initials: _____ *Date:* _____

Participant Rights	*If you have questions about your rights as a research participant or wish to report a research-related injury, please contact:* University of Maryland College Park Institutional Review Board Office 1204 Marie Mount Hall College Park, Maryland, 20742 E-mail: irb@umd.edu Telephone: 301-405-0678 *For more information regarding participant rights, please visit:* https://research.umd.edu/research-resources/research-compliance/institutional-review-board-irb/research-participants *This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.*	
Statement of Consent	*Your signature indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction and you voluntarily agree to participate in this research study. You will receive a copy of this signed consent form.* *If you agree to participate, please sign your name below.*	
Signature and Date	**NAME OF PARTICIPANT** **[Please Print]**	
	SIGNATURE OF PARTICIPANT	
	DATE	

Appendix IV: PRS-16

We are interested in how you experience this window view. To help us understand your experience, we have provided the following statements for you to respond to. Please read carefully, then ask yourself: "how much do these statements apply to my experience there?". To indicate your answer, circle only one number on the rating scale beside the statement. A sample of the rating scale is given below and at the top of each subsequent page. So, for example, if you are strongly disagreeing with the statement based on your experience of the environment, then you would circle "0" (Strongly Disagree), if you think you are somewhat agreeing with the statement, then you would circle "4" (Somewhat Agree), but if you think you are strongly agree with the statement, then you would circle"6" (Strongly Agree).

Please indicate on the 7-point scale the extent to which the given statement describes your experience in the setting:
(0 = Strongly Disagree; 1= Disagree; 2= Somewhat Disagree; 3= Neither Agree nor Disagree; 4= Somewhat Agree; 5= Agree; 6 = Strongly Agree).

1.Places like that are fascinating

Strongly disagree — Strongly agree

2.In places like this my attention is drawn to many interesting things

Strongly disagree — Strongly agree

3.In places like this it is hard to be bored

Strongly disagree — Strongly agree

4.I want to spend more time looking at the surroundings

Strongly disagree — Strongly agree

5.There is much to explore and discover here

Strongly disagree — Strongly agree

6.Being here is an escape experience

Strongly disagree — Strongly agree

7.Spending time here gives me a break from my day-to-day routine

Strongly disagree — Strongly agree

8.It is a place to get away from it all.

Strongly disagree — Strongly agree

9.Being here helps me to relax my focus on getting things done

Strongly disagree — Strongly agree

Appendix V: PRS-16

10.Coming here helps me to get relief from unwanted demands on my attention

Strongly disagree — Strongly agree

11.There is a clear order in the physical arrangement of places like this

Strongly disagree — Strongly agree

12.In places like this it is easy to see how things are organized

Strongly disagree — Strongly agree

13.There is a great deal of distraction.

Strongly disagree — Strongly agree

14.Being here suits my personality.

Strongly disagree — Strongly agree

15.I can do things I like here.

Strongly disagree — Strongly agree

16.I have a sense that I belong here.

Strongly disagree — Strongly agree

AppendixVI: VRSQ

We are interested in how you experience wearing an Oculus Headset. To help us understand how much each symptom below is affecting you right now, we have provided the following statements for you to respond to. Please read carefully, then ask yourself: "how much do these statements affect my right now?". To indicate your answer, circle only one number on the rating scale beside the statement. A sample of the rating scale is given below and at the top of each subsequent page. So, for example, if you are strongly disagreeing with the statement based on your experience of the wearing VR headset, then you would circle "0" (Strongly Disagree), if you think you are somewhat agreeing with the statement, then you would circle "4" (Somewhat Agree), but if you think you are strongly agree with the statement, then you would circle"6" (Strongly Agree).

Please indicate on the 7-point scale the extent to which the given statement describes your experience in the setting:
(0 = Strongly Disagree; 1= Disagree; 2= Somewhat Disagree; 3= Neither Agree nor Disagree; 4= Somewhat Agree; 5= Agree; 6 = Strongly Agree).

1.General discomfort

Strongly disagree — Strongly agree

2.Fatigue

Strongly disagree — Strongly agree

3.Headache

Strongly disagree — Strongly agree

4.Eye strain

Strongly disagree — Strongly agree

5.Difficulty focusing

Strongly disagree — Strongly agree

6.Fullness of the head

Strongly disagree — Strongly agree

7.Blurred vision

Strongly disagree — Strongly agree

8.Dizziness with eyes closed

Strongly disagree — Strongly agree

9.Vertigo

Strongly disagree — Strongly agree

***** Once again, Thank you for your participation in this study!*****

***Vertigo** is the feeling of spinning, even when you are not moving

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