The Benefits of Using Biophilic Design in Post-Secondary Design Studio Classrooms

by

Dima Eltourk

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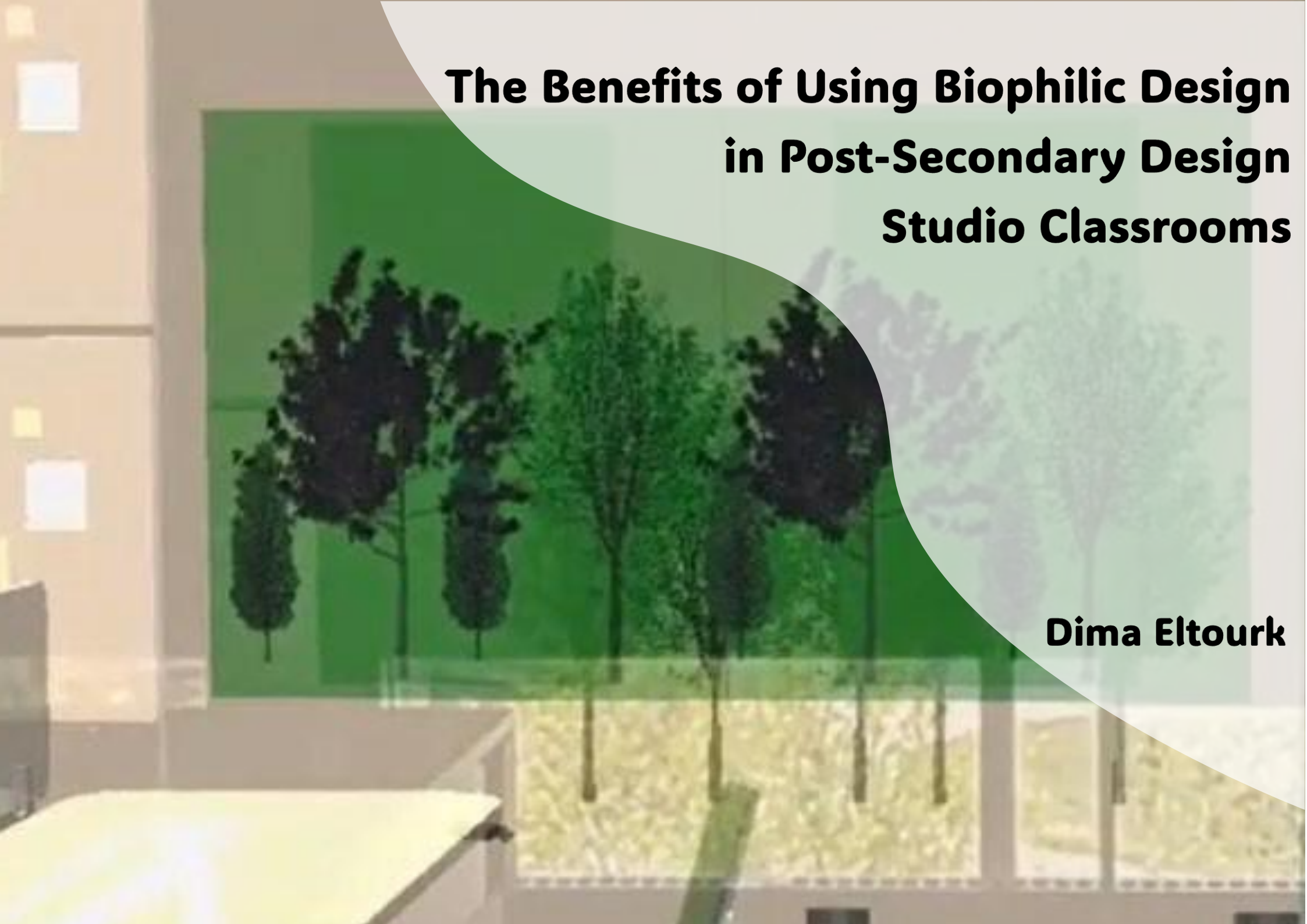

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Dima Eltourk

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ABSTRACT

Post-secondary design students spend a significant portion of their professional education engaging in creative project work in design studio classrooms. This Master of Interior Design (MID) thesis examines the impact of incorporating biophilic elements into the interior design of a studio classroom to create a more supportive, less stressful learning environment for design students. Additionally, this thesis study examines the needs and preferences of design students within studio settings. Biophilic design is supported by prior research demonstrating positive health outcomes among office workers, hospital patients, and middle school students (Mahrous et al., 2024). However, given the limited research on the effects of biophilic design on students in design studio classroom settings, this study helps bridge the gap between past and current research. A unique mixed-methods approach, including augmented reality (AR), was employed. AR enabled interior design students (n = 20) to experience an overlay of biophilic design within their current studio environment, permitting them to walk around and perform typical tasks through a cognitive walkthrough. After experiencing the biophilic studio classroom, semi-structured interviews gathered participants' perceptions of the virtual biophilic environment compared to their current space. An online follow-up survey was also conducted to assess stress levels by comparing experiences in the current studio classroom with those in the AR-viewed biophilic environment. This thesis study highlights the advantages of utilizing augmented reality (AR) technology in environmental and behavioural (EB) research, and its findings support incorporating biophilic design elements into post-secondary studio classrooms to improve comfort and reduce stress.

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DEFINITION OF KEY TERMS

TERM	DEFINITION
***AUGMENTED REALITY* (AR)**	An interactive experience accessed through specialized headsets enables users to view the real world and a computer-generated object or space simultaneously.
BIOPHILIA	The human affinity to connect with nature (Wilson, 1984).
BIOPHILIC DESIGN	A design concept that emphasizes designing spaces that increase user connection to natural environments (Kellert, 2008).
COGNITIVE WALKTHROUGH	A cost-effective assessment employed in evidence-based design to evaluate the practicality of specific features or strategies for target users within a designated spatial context. Users are asked specific questions about the tasks they perform, as well as their opinions and preferences in a particular location and environment, which are used to determine the necessary actions to enhance the space (Lyon et al., 2021).
DESIGN STUDIO CLASSROOM	A classroom used by architecture, interior design, landscape architecture, and urban planning students that features desks or drafting tables, along with projection screens for presentations and lectures. It also incorporates bulletin boards designated for displaying posters and student projects.
ECOTHERAPY	A psychology practice that involves therapeutic approaches incorporating direct interaction with natural environments and species to improve individuals' well-being (Windhorst & Williams, 2015).

***POSITIVE AND NEGATIVE AFFECT SCHEDULE* (PANAS)**	Positive and Negative Affect Schedule (PANAS): A tool used to measure the balance of positive and negative emotions, providing insights into individual emotional states (Leslie Riopel, 2025).
SALUTOGENESIS	Originated by Aaron Antonovsky(1996), a theory that explores one's well-being by examining stress levels along a health spectrum and emphasizes maintaining and improving well-being to avoid harmful health consequences.

Chapter 1: Introduction

1

1.1 Stress in Post-Secondary Institutions

Post-secondary students are required to fulfill both their educational and social obligations simultaneously. This situation can be particularly challenging, especially during their first year, when many students gain greater independence and are expected to manage their daily tasks alongside academic responsibilities to succeed. It is therefore unsurprising to find that researchers have reported that post-secondary students are more susceptible to suffering from high stress and anxiety than high school students (Lisnyj et al., 2021). Moreover, the National College Health Assessment (NCHA II) reported that Canadian post-secondary students' stress levels increased by 3.3% between 2013 and 2019 (Lisnyj et al., 2022). When we look at where university students spend their time, it is primarily indoors, in classroom environments. According to Peters & D'Penna (2020) and Pourbagher et al. (2021), the interior design of the classroom can influence students' comfort and stress levels.

This Master of Interior Design (MID) thesis explores the impact of studio classroom interior design on students' well-being. One of the most challenging and demanding fields of post-secondary education is the study of architecture. It demands mastery of extensive technical and theoretical knowledge, combined with engagement in time-consuming, project-based tasks (Arshard et al., 2023). Given that coursework is predominantly project-oriented, design students usually dedicate over eight hours daily, consistently, week after week, to intellectually and creatively demanding tasks (Arshard et al., 2023). Students specializing in architectural studies spend most of their time in studio classrooms. Within this setting, students participate in lectures and presentations and undertake various academic projects, including sketching, planning, presenting, and model construction. While studio-based learning environments are widely recognized as highly collaborative and engaging places for fostering creativity, they can also foster feelings of solitude and disconnection from peers and the outdoor environment, particularly when students undertake independent work on individual projects. Consequently, these prolonged periods of indoor activity may negatively affect their concentration and attention span, potentially leading to mental fatigue and reduced stress recovery (Felsten, 2009).

1.2 Research Questions & Methodology

This thesis builds on previous research by Edward O. Wilson (1984), Aaron Antonovsky (1996), Kaplan & Kaplan (1989), Kellert (2018), Watchman et al. (2020), Mahrous et al. (2024), and other scholars on the potential of biophilia and salutogenesis to improve the well-being of design students in studio classrooms. Specifically, to determine if design students experience lower stress levels in a biophilic design studio than in a non-biophilic studio classroom. The primary research questions guiding this investigation are as follows:

1. What biophilic interior design features are effective in reducing stress in students?
2. What biophilic interior design features can be readily integrated into interior design studio classrooms?
3. Can such biophilic features assist in reducing stress among interior design students?
4. Do demographic differences affect the students' stress levels when using a biophilic design studio classroom?

The literature review (Chapter 2) provides the theoretical foundation for this research. The main topics covered in the literature review are biophilic design theory, its applications, and its effects on users. A mixed-methods approach was developed, incorporating Augmented Reality (AR), interviews and surveys (Chapter 3) to compare the impact of a non-biophilic design studio classroom versus a biophilic design studio classroom on student well-being and stress. All the participants in the study were post-secondary interior design students at the University of Manitoba. Based on the findings of my investigation (Chapter 4), I identify specific biophilic design strategies to help students feel calmer, more comfortable, and less stressed in their design studio classroom setting (Chapter 4).

1.3 Researcher Positionality / Bias

As a design student who has used the design studio classroom and experienced various academic and social pressures for many years, I was aware that the interior environment potentially was impacting my learning experience and well-being. Now that I am a trained interior designer, I am further motivated to explore evidence-based

approaches to improve learning environments. I recognize that my experience of the studio environment may differ from that of other students, including my preference for biophilic features. Therefore, I had to take steps to minimize bias in my research (see Chapter 3).

1.4 Chapter Summary

The paper encompasses the following information:

The **Literature Review** in Chapter 2 provides a critical examination of the existing evidence on biophilic and salutogenic design for enhancing students' well-being. This analysis reveals a gap in current understanding concerning the benefits of its implementation in design studio settings. The chapter also covers the evolution of traditional and contemporary post-secondary design studio configurations, along with their benefits and challenges.

The **Methodology** detailed in Chapter 3 explains the specific investigative methods, tools, and procedures employed in the research, including interviews and online surveys, as well as the augmented reality (AR) approach. The selection criteria and recruitment strategy for participants are outlined.

The **Findings** of the study are provided in Chapter 4, resulting from an extensive analysis of the collected data. Therein is revealed the impact of biophilic studio classroom design on participants' satisfaction and perceptions of well-being.

Finally, the **Discussion** in Chapter 5 reflects on the research's limitations and strengths and proposes recommendations for future investigations.

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Chapter 2: Literature Review and Analysis

2

2.1 Introduction

The following chapter begins with a brief history of traditional and modern design studio classrooms, outlining current opportunities and challenges. This is followed by an overview of biophilic and salutogenic design theory and its applications, drawn from the existing literature. The impacts of salutogenic and biophilic design on well-being are highlighted, based on studies of non-educational and educational settings. The biophilic design applications used in the proposed design are based on scholarly literature previously applied in classrooms and are shown in Table 1. The applications from earlier studies have helped develop the experimental biophilic studio classroom, which is described later in this study (see Chapter 3).

The literature review draws on peer-reviewed articles and books from the University of Manitoba's digital library database, with a focus on research conducted between 1975 and 2025. Keywords include "post-secondary institutions," "post-secondary students," "stress," "biophilia," "biophilic design," "design studio," "classroom," "salutogenic design," "well-being," "biophilic design challenges," and others. The primary scholarly sources cited in this paper include Wilson (1984), Antonovsky (1996), Kaplan and Kaplan (1989), Kellert (2018), and Browning & Ryan (2020), among others.

Table 1

Summary of Key Biophilic Applications in Classrooms

Biophilic Applications	Source	Year
Adequate natural daylight	Dye et al.	2021
	Mahrous et al.	2024
Natural plants and greenery	Dye et al.	2021
	Mahrous et al.	2024
Landscape views, natural images, and murals	Dye et al.	2021
	Determan et al.	2019
High-colour temperature lighting	Zoubi et al.	2024
Neutral and cool colours	Yıldırım et al.	2019
Use of natural finishes and textures	Watchman et al.	2020
Use of curved shapes in furniture and structures	Kopec & Szenasy	2018

2.2 Traditional and Modern Post-Secondary Design Studio Classroom Layout

The layout of design studio classrooms has been continuously evolving to meet the changing needs of students who use these spaces for various learning activities. The design studio classroom requires a flexible and adaptable concept to meet current and future user needs (Jiwane & Khan, 2018). In the past, design studio classrooms were primarily used for lectures, presentations, and manually crafted projects. This necessitated a classroom design with a fixed setup, typically in a grid layout, equipped with boards, fixed desks, and stools. Such layouts were standard because students were expected to receive information from the instructor and work individually, without sharing ideas or collaborating with classmates (Karsli, 2016). Over time, this has shifted as students and faculty have

adopted a more digital approach to presenting, designing, reviewing, and producing hands-on work at various stages of the design process.

Today, students require advanced digital equipment and tools to complete their academic work and achieve their educational goals. Equipping design studio classrooms with the necessary technology encourages students to spend more time in the studio after hours, working on their projects (Demirbas & Demirkan, 2000). Additionally, when design studio classrooms are designed openly and flexibly, students can easily reconfigure the space to suit their daily tasks. This increased sense of control and comfort enhances students' engagement with their learning environment (Karsli, 2016). Furthermore, it has the potential to foster a sense of control over their workspace and enhance their familiarity and sense of belonging within the environment.

In a 2016 study, Karsli identified specific spatial and technical features necessary in design studio classrooms to enhance students' learning and well-being. Appropriate spatial arrangements include creating a flexible environment with both open and private workspaces and using acoustical desk partitions. As illustrated in the floor plan in Figure 1, this configuration enables students to alternate between independent work (Figure 2) and collaborative group activities (Figure 3). Providing spacious, adaptable design studio classrooms fosters connections among students and faculty from different programs across campus, enabling them to collaborate more easily on projects and tasks. This approach promotes awareness and broadens students' perspectives on non-design topics and issues (Galan & Kotze, 2022). Furthermore, Karsli (2016) highlighted technical features that can be integrated into the design studio classroom, such as ensuring adequate daylight, thermal comfort, and optimal acoustics. Additional design strategies suited for classroom environments may be derived from earlier research, including studies by Determan et al. (2019), You et al. (2023), and Mahrous et al. (2024), which underscore the importance of utilizing natural materials and providing sufficient ventilation.

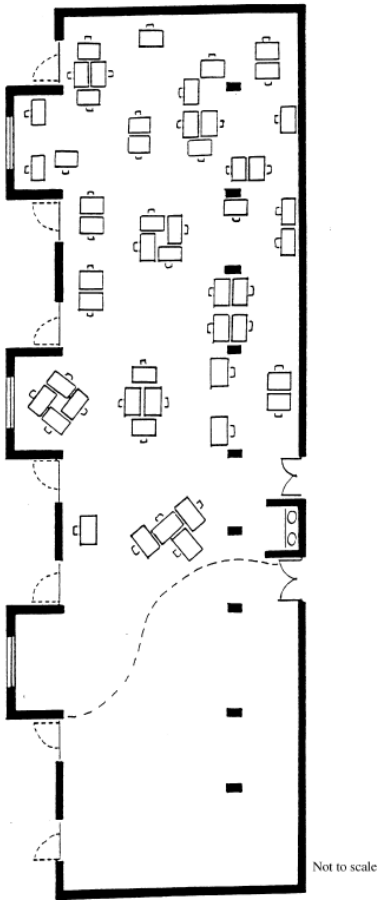

Figure 1

Open Studio Design with Private Sections

Note: Reprinted from Demirbas, O. O., & Demirkan, H. (2000) with permission from Elsevier.

Figure 2

Image from a Traditional Studio Used in a Case Study

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Figure 3

Image from A Traditional Studio Used in A Case Study

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Moreover, Mazzi (2020) advocates enhancing familiarity in the classroom environment through clear wayfinding with obvious entry and exit points and fostering a sense of safety and belonging by minimizing fixtures, colours, and patterns to reduce overstimulation in indoor spaces.

When designing a studio classroom, architects and designers must deliberately consider students' needs. This strategy facilitates the development of learning environments tailored to students' educational needs. Additionally, it can help alleviate any negative perceptions they may have when using such spaces, which may arise from factors related to comfort, flexibility, and accessibility, or from external influences such as personal responsibilities and academic pressures. A user-centred design approach that prioritizes students' academic needs benefits both current and future design students by creating workspaces tailored to their specific workload and demands, thereby enabling greater creativity, improved concentration, and reduced stress.

2.3 Post-Secondary Student Challenges and Stress Triggers

One of the essential reasons the current study is important is to highlight the needs and stress triggers of post-secondary students who regularly use their institution's facilities and classrooms. A 2017 study conducted by Brit et al. on post-secondary students concluded that “13.2 percent had been diagnosed or treated for depression or anxiety” (DeLauer et al., 2022). Mahrous et al. (2024) found that post-secondary students report higher stress levels, anxiety, and depression than secondary students while enrolled in a school program due to various social and academic responsibilities and pressures associated with the heavy workload and tight deadlines. Social challenges stem from the pressure students feel to demonstrate their success and progress to parents, friends, and peers. Furthermore, adapting to independence following their separation from their parents’ household involves managing financial responsibilities and daily tasks. Finally, adjusting to and integrating within the university environment, including its systems and any changes in their enrolled programs, can be both challenging and stressful. Other factors include academic difficulties, such as mastering new learning techniques and strategies necessary for success in their programs, as well as coping with competition among classmates to attain preferred rankings. Classroom design is also regarded as a critical factor that influences students’ stress levels. It shapes their experiences within the educational environment, whether positively or negatively, especially when students spend extended hours at their designated desks (Pourbagher et al., 2021).

2.4 Biophilic and Salutogenic Design

2.4.1 Biophilic Design

The fundamental theory examined in my MID thesis is biophilia. Recent research has demonstrated the significance and necessity of maintaining a strong, consistent connection with nature, whether through engaging with outdoor natural landscapes or experiencing natural elements and features in frequently used indoor environments. Researchers such as Kellert (2018), Browning & Ryan (2020), Yin et al. (2020), Shuda et al. (2020), and Ghaziani et al. (2021) have indicated that connecting with nature enhances both physical and mental health. This research is founded upon the biophilia theory, initially introduced by Erich Fromm in 1964. The concept gained

widespread recognition in 1984 when Edward O. Wilson published a book elaborating on the term, defining it as “an innate need for people to connect with nature.” Kaplan and Kaplan, along with other scholars, suggest that the health benefits stem from the ease with which humans perceive natural environments, thereby resulting in enhanced concentration and “attention restorative effects” (Kaplan & Kaplan, 1989; Ohly et al., 2016).

2.4.2 Salutogenic Design

Salutogenic theory was introduced by the sociologist Aaron Antonovsky (1996), who characterized salutogenesis as an individual’s need to maintain or enhance their health. Antonovsky emphasizes the importance of focusing on the preservation and improvement of everyone's health, regardless of current condition, by reducing health risks that could compromise well-being (Antonovsky, 1996). He highlighted that neglecting stress and allowing it to develop over time in challenging situations could substantially affect an individual's health. Although the salutogenic approach is often used in healthcare settings, it can also be applied to interior design by emphasizing design elements that foster and sustain individuals' health (Dilani, 2017).

2.5 Biophilic Design - Applicable Theories

The following section provides an overview of key nature-based design theories. Within the literature, I have focused on identifying features that potentially can enhance students' concentration and comfort, thereby reducing distractions and stress. A summary of theories and applicable features for design studio classroom design is provided at the end of the section in Table 2.

One of the most cited sources on biophilic design, Kellert (2018), highlights several considerations for developing productive biophilic environments that ensure users derive benefits. According to Kellert (2018), optimal biophilic design requires consideration of three categories: direct natural experiences, indirect representations, and spatial experiences generated by nature within interior spaces. Direct natural experiences involve engaging directly with essential natural elements such as light, water, animals, plants, and landscape vistas. Conversely, indirect

experiences are conveyed through images or illustrations of nature and nature-inspired patterns. Finally, spatial experiences are communicated through the design of secure, practical, meaningful, and diverse interiors, as well as through the establishment of connections and seamless transitions between indoor and outdoor environments (Kellert, 2018).

Dye et al. address the significance of applying nature-inspired elements and fostering connections with nature specifically for post-secondary students in "*Mindful Strategies for Helping College Students Manage Stress*." The book emphasizes the importance of human-nature connections and the influence of nature on post-secondary students (Dye et al., 2021). The authors emphasize the importance of promoting natural light to enhance students' moods and productivity, as well as providing indoor plants in learning spaces to create a sense of relaxation and comfort. Similarly, providing access to outdoor landscapes encourages students to immerse themselves in natural environments, helping reduce their stress levels. Moreover, they address the influence of colours and shapes, which can promote various meanings in the space and affect the user's feelings. For example, they highlight how the presence of images, murals, and paintings, and their influence on eliciting particular emotions, correlates with the utilization of specific colours and patterns. When exposed to the colours blue and green, individuals generally experience a more relaxed state. Additionally, they examine the impact of furniture arrangement on the flow and functionality of the space, thereby influencing user comfort and productivity (Dye et al., 2021). Ultimately, such characteristics can positively or negatively affect students' well-being, depending on their applications and characteristics. The above-mentioned patterns can be used collectively to encourage post-secondary students to engage with and connect to nature.

2.5.1 Attention Restoration Theory

Post-secondary students must pay attention during lectures, while working on individual or group projects and assignments, giving presentations, and participating in discussions. Over time, this affects students' performance and concentration, leading to mental fatigue, feelings of overwhelm, and stress (Peters & D'Penna, 2020). The Attention Restoration Theory (ART) states that attention recovery can be achieved through connecting with nature

(Ohly et al., 2016). Regarding biophilia, ART offers students recognized techniques proven to enhance concentration and reduce stress levels. It suggests that spending time in calm places and engaging in slow-paced activities can help individuals relax, restore their attention, and improve focus. ART claims that being in nature is the most effective way to restore one's attention (Ohly et al., 2016). In the current study, providing direct access to outdoor natural landscapes, nature-inspired indoor environments, and private spaces, such as personal desk space and quiet rooms, can help students unwind and reflect.

2.5.2 Stress Recovery Theory

Furthermore, studies conducted by Ulrich (1979) and Honeyman (1990) have demonstrated that students experiencing academic stress tend to feel safer and more content when surrounded by nature, natural landscapes, and greenery, and consequently feel calmer and less stressed. However, because urban areas lack natural environments, people have been experiencing increasing stress levels, which has affected their physical and psychological well-being (Ulrich et al., 1991). Therefore, there has been a recent focus on applying natural features in indoor environments, such as greenery and water features. Additionally, maintaining outdoor landscapes and evergreen trees provides a consistent landscape year-round, particularly in North America, where most trees shed their leaves before winter. The Stress Recovery Theory (SRT) suggests that when an individual experiences stress, nature can aid recovery from the stressors they face (Watchman et al., 2020; Yin et al., 2020). Thus, being around natural surroundings or viewing natural images and murals can help students detach from pressures by focusing on a calming environment that provides their minds with tranquillity through natural sounds, aromas, colours, textures, and patterns.

2.5.3 Prospect-Refuge Theory

Designers are responsible for creating well-balanced interiors that incorporate functional, durable, ergonomic, and aesthetically pleasing elements to foster inclusive spaces. Providing students with classrooms equipped with all the necessary tools and features has been proven to enhance their learning experience and well-

being, where they can develop a strong connection that fosters a sense of security and safety. Prospect-refuge theory, where prospect signifies outlook or viewing outward and refuge signifies safety and security, illustrates the importance of evoking positive feelings in public spaces by incorporating features that help users feel comfortable and safe (Cushing & Miller, 2020). Prospect and refuge are closely connected to landscape and interior design, promoting natural environments and interiors with views of outdoor vistas (Dosen & Ostwald, 2016). The prospect-refuge theory can be seamlessly integrated into studio environments by offering direct views of outdoor landscapes through windows overlooking natural settings. In cases where such an option is unfeasible due to the building's location or structural limitations, and particularly during winter in North America when vegetation is sparse, digital walls composed of screens may be utilized to display green landscapes, along with artificial windows that depict circadian rhythms, thereby mimicking a similar effect for users.

Table 2

Summary of Key Theories Potentially Helpful for Biophilic Design of Studio Classrooms

Theory	Theorist	Year	Summary	Research Impact
Attention Restoration	Kaplan	1989	Attention recovery can be achieved when connecting with nature.	Implementing biophilic design elements to help restore students' concentration in design studio classrooms, thereby reducing their stress.
Stress Recovery	Ulrich	1991	Promoting nature within and around urban environments to help reduce users' stress.	Incorporating nature connections to help students disconnect from their pressures, thus enhancing their well-being and reducing their stress.
Prospect-Refuge	Appleton	1975	Creating a connection between natural landscapes and interior settings by providing direct views of nature, where users can appreciate natural scenery while feeling safe within their familiar environment.	Providing direct views of outdoor landscapes, where students can enjoy the natural scenery while remaining in their classroom or desk space.

2.6 The Effects of Biophilic and Salutogenic Design on the Students' Well-Being

Both salutogenic and biophilic designs have nature-based approaches that could be applied to studio classrooms to help reduce stress among post-secondary design students. Additionally, the theories mentioned in Table 2 above can be incorporated into these design concepts since they advocate for the interaction with people and nature in both indoor and outdoor spaces to help enhance the user's well-being. Although designers cannot

influence individuals' stress levels upon entering a space, they can adopt strategies empirically shown to ease stress and enhance well-being. According to salutogenic design expert Angela Mazzi (2020), integrating design strategies that foster feelings of safety, comfort, relaxation, and a sense of belonging can help lower stress levels.

2.7 Previous Biophilic Design Applications

Today, biophilia has received much attention in interior applications, driven by numerous studies demonstrating direct health benefits associated with exposure to nature and natural characteristics (Felsten, 2009). Consequently, research conducted in office environments, healthcare facilities, and elementary schools has established that integrating natural elements into interior spaces positively affects users' physical and mental well-being (Peters & D'Penna, 2020). Research indicates that university campuses adopting biophilic design principles provide interior environments with adequate natural light, indoor plants and greenery, the use of natural materials, and views of outdoor landscapes, fostering greater comfort, relaxation, and stress reduction (Peters & D'Penna, 2020). Depending on the desired outcomes, designers may incorporate various natural elements, both direct and indirect, into spaces to enhance the user's experience, guided by Kellert's biophilic theories. Accordingly, evidence demonstrates that educational environments require specific biophilic attributes in classrooms and communal areas to support student well-being and foster a healthier connection to and mindfulness of nature (Beatley, 2018). Drawing on previous research to inform design choices and applications will enhance users' awareness of their surroundings and the importance of preserving natural environments, thereby promoting adherence to sustainable practices (Beatley, 2018).

2.7.1 Biophilic Applications in Non-Educational Settings

To study the effects of biophilic attributes on stress levels, concentration, and the psychological and physical well-being of individuals, researchers explored the following variables: access to natural exterior surroundings, providing sufficient daylight exposure, incorporating organic sounds and aromas, natural elements and patterns, and indoor plants (Determan et al., 2019). A meta-analysis conducted by Gaekwad et al. (2022) explored the effects of natural environments on individuals. They concluded that exposure to nature increases positive emotions and

reduces negative feelings compared to living in urban areas. To measure the positive and negative effects on participants, researchers used the Positive and Negative Affect Schedule (PANAS), a self-evaluation scale that uses a five-point rating to rate a 20-word list of emotions describing pleasant or unpleasant feelings (Watson et al., 1988; Nisbet et al., 2010). Using this scale helped them understand participants' stress levels across different situations.

Similarly, one of the earlier studies performed by Roger Ulrich focused on biophilia's connection with the user's health in clinical settings (Determan et al., 2019). The study involved providing patients with rooms that overlook an exterior natural view. These patients recovered faster and used less medication to ease their pain, compared to patients without natural views (Determan et al., 2019). Another method employed in the study involved presenting natural or blank images to patients before heart surgery; patients in the experimental group showed decreased blood pressure and heart rate, and accelerated recovery after viewing natural images (Determan et al., 2019).

Furthermore, Peter Kahn and colleagues observed lower blood pressure and heart rate among staff working in a windowless office when natural images were projected onto television screens (Kahn et al., 2009). In addition to reducing stress levels, biophilia has been associated with intellectual performance, as it has been proven that the brain functions differently when exposed to nature. Experiencing nature enhances the brain's capacity and, therefore, increases the user's cognitive abilities (Abdelaal & Soebarto, 2018; Determan et al., 2019).

Another example of a unique precedent is Andyrahman, an architectural firm that designed its biophilic office in Sidoarjo, East Java, Indonesia. As Andyrahman mentioned, they incorporated biophilic elements to create a distinct office space that provides employees with an enriched working experience, helping improve their creativity, productivity, and comfort levels, and reducing stress (Abdel, 2022). The office building consists of two floors and a rooftop. The studio incorporates biophilic attributes recognized by Kellert (2018), including direct natural experiences, indirect natural experiences, and spatial experiences presented throughout the building's exterior (Figure 4) and its interior setting.

The first floor features a courtyard, as shown in Figure 5, centred on a pond filled with fish and surrounded by local trees and plants. The offices and amenities on the ground floor are conveniently located near the pond and plants provided. Other biophilic design attributes are represented in the use of natural materials and textures, such as wood, bamboo, and brick.

Figure 4

Andyrahman's Office: Exterior Façade

Figure 5

Andyrahman's Office: Courtyard

Note: Hasan, M. (2021). *Biophilic Office / Andyrahman Architect.*ArchDaily, with permission from Andyrahman Architect.

Additionally, the fully operable windows in the offices and meeting room on the second floor are made from locally harvested, woven bamboo. They can be fully opened to provide direct access to the natural landscapes surrounding the building and to maximize natural light, as shown in Figure 6. The rooftop in Figure 7 offers employees and guests a relaxing spot to unwind from daily work pressures and connect with nature, featuring natural vegetation and an exterior patio (Abdel, 2022). The office space exemplifies the use of sustainable, locally sourced, and renewable materials, thereby reducing the carbon footprint. It also presents a timeless and contemporary aesthetic, characterized by the selection of natural materials and elements that harmonize with the surrounding environment. Furthermore, it takes into account users' needs and essentials to facilitate effective work completion during office

hours, as well as the functionality and practicality of the facilities and various spaces within the building to meet the company's operational requirements. The biophilic features incorporated into the design have been shown to foster a supportive, healthy work environment, thereby enhancing occupants' well-being and reducing stress levels (Tahoun, 2019).

Figure 6

Andyrahman's Office: Meeting Room

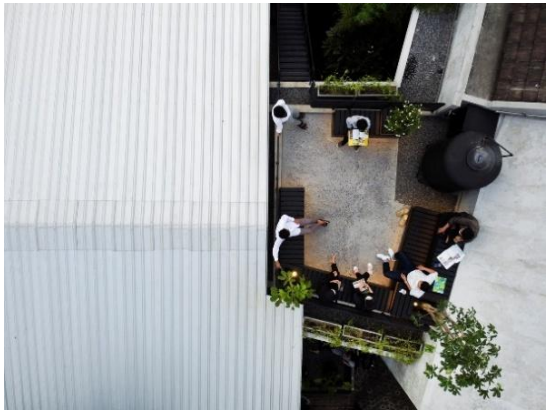

Figure 7

Andyrahman's Office: Rooftop

Note: Hasan, M. (2021). *Biophilic Office / Andyrahman Architect,* with permission from Andyrahman Architect.

2.7.2 Biophilic Applications in Educational Settings

Several studies have investigated the impact of biophilia in educational settings. A study involving elementary students in Spain showed promising results when children were exposed to a biophilic environment. The biophilic interior featured plants, organic patterns, and views of nature. This environment significantly reduced their blood pressure and sweating during stress and improved their short-term memory (Determan et al., 2019). Another case study by Mahrous et al. presented design proposals to post-secondary students that incorporated natural surroundings, as natural visual connections have been shown to impact students' academic progress significantly (Mahrous et al., 2022). Using this method allowed the researchers to conclude that natural scenes have assisted in

reducing the students' stress, anxiety, and depression. The presentation of natural materials and nature-inspired colours has also helped increase participants' feelings of relaxation, thereby improving their cognitive and concentration levels (Mahrous et al., 2024). Additionally, incorporating natural materials such as wood and stone into interior spaces has been shown to reduce anxiety levels and promote recovery from mental exhaustion (Watchman et al., 2020).

These studies provide evidence that representations of biophilic applications in educational spaces should incorporate both visual and non-visual connections with nature (Browning & Ryan, 2020). This involves using paintings and images of natural landscapes to promote outdoor greenery and adding indoor plants, green walls, and water features. Another element that can be introduced is to allow air circulation that mimics natural environments, and to create multiple natural and artificial light sources through windows, skylights, and dynamic light fixtures. Additionally, organic patterns, shapes, textures, and materials can be applied to classroom furniture and fixtures (Browning & Ryan, 2020). Additionally, the studies provide strong evidence supporting the benefits of biophilia on students' psychological and physical health. Therefore, emphasizes the importance of incorporating biophilic patterns and elements in post-secondary classrooms. The previous studies served as a foundation for the current research, which further explores the effects of specific biophilic elements and patterns implemented in the proposed design studio classroom presented to interior design students through augmented reality.

2.8 The Physical, Psychological, and Cognitive Impacts of Biophilia in Classroom Environments

Today's advanced technology and the availability of various software products and applications have led students to rely on digital devices like computers and laptops to complete their coursework. As a result, students often spend most of their daytime hours indoors during the school year to finish their assignments. Excessive time spent indoors can lead to a lack of natural connections, which has been proven to harm students' physical and psychological health (Watchman et al., 2020). Given that biophilia emphasizes the importance of communities engaging with nature to enhance their physical and mental health (Windhorst & Williams, 2015), research has demonstrated that interaction with nature within educational settings can improve users' well-being (Watchman et

al., 2020). This concept has been incorporated into the present study and examined within the design studio classroom. This inclusion is particularly significant owing to the limited empirical evidence regarding its effects in such educational settings.

A study by Determan et al. (2019) found that middle school students who used a biophilic classroom during the 2018-2019 academic year experienced lower stress levels than their counterparts in traditional classrooms. Furthermore, students' academic performance and grade scores in biophilic environments were three times higher than in non-biophilic settings, due to the strong natural connection between outdoor landscapes and classroom interiors (Determan et al., 2019). Additionally, ecotherapy, an emerging therapeutic approach, can be effectively implemented with students to foster a healthy human-nature connection through exposure to natural environments (Windhorst & Williams, 2015).

Furthermore, biophilic design patterns have been shown to yield numerous positive physical and psychological effects on students when applied within educational classroom environments (Browning & Ryan, 2020). The physical outcomes include lowered blood pressure and heart rate, increased visual comfort, physical relaxation, and a sense of safety, since biophilic design promotes a calming atmosphere by emphasizing the importance of incorporating natural elements into interior settings. Research suggests that other psychological outcomes in a biophilic setting include enhanced brain functioning, as evidenced by higher levels of concentration, creativity, productivity, and performance, as well as reduced stress levels and improved stress recovery (Browning & Ryan, 2020). As a result, improvements in physical and psychological health indicate a positive overall attitude, satisfaction, and appreciation for nature, as well as reduced stress and depression (Browning & Ryan, 2020). Such physical and psychological enhancements should be considered within post-secondary institutions to reduce student stress, given the steady increase in its prevalence over recent years.

Previous research has shown support for the benefits of biophilic design applications for individuals. However, there is limited research describing the application of biophilic design in post-secondary design studio classrooms (Mahrous et al., 2024). This is despite the fact that design students spend extensive hours in indoor

settings, performing various tasks to fulfill their program requirements, which particularly affects their well-being (Al-Jokhadar et al., 2023). The motivation for this study is, therefore, to provide evidence on whether biophilic design can provide similar benefits to design students.

Given the limited implementation of biophilic principles and the limited investigation of their effects on post-secondary students in educational settings, the present study examines the influence of biophilic design on design students who frequently use the design studio classroom. This study thereby contributes additional data about a specific sample group and location that have not been extensively researched.

2.9 Chapter Summary

This Chapter highlights the use and design of post-secondary design studio classrooms over time and the potential stress triggers they contain. The theoretical foundation of this study is a biophilic and salutogenic design, which includes attention restoration theory, stress recovery theory, and prospect-refuge theory. An examination of the scholarly literature on biophilic and salutogenic design applications in non-educational and educational environments reveals potential benefits for occupant well-being. Based on this analysis, key biophilic features that can help reduce fatigue and improve comfort in design studio classrooms are identified. These features include providing sufficient natural light, incorporating natural plants and greenery, offering access to outdoor views, and utilizing natural materials, textures, and patterns in interior design (Determan et al., 2019; Browning & Ryan, 2020).

Chapter 3: Research Design and Methods

3

3.1 Introduction: Aims, Objectives and Questions

To provide evidence for designers and researchers on the impact of biophilic interiors in design studio classrooms on student stress and well-being, this research employs a mixed-methods simulation-observation approach that combines interviews, surveys, and augmented reality (AR). The following research questions guide the investigation:

1. What biophilic interior design features are effective in reducing stress in students?
2. What biophilic interior design features can be readily integrated into interior design studio classrooms?
3. Can such biophilic features assist in reducing stress among interior design students?
4. Do demographic differences affect the students' stress levels when using a biophilic design studio classroom?

The following subsections provide a detailed description of the research design.

3.2 Experimental Location Selection, Sampling Strategy, and Participant Recruitment

The in-person portion of the experiment took place in the design studio classroom on the third floor of the Faculty of Architecture (J. A. Russell) building at the University of Manitoba in Winnipeg, Canada. The space is located at the north end of the building's atrium, which provides direct access to natural light and views of outdoor greenery, mainly during the summertime (See Figures 8 and 9 – plan and photo). The location was selected because it is familiar and readily accessible to potential participants. Additionally, it lacks enough biophilic features that could positively influence the students' learning experience. The research focused on undergraduate and graduate students pursuing post-secondary education in interior design who were currently using the design studio classroom. The sampling procedure employed a purposive non-probability sampling approach (Hassan, 2024). This has been achieved by limiting the sample to all registered interior design students who use the same section of the design studio classroom and would have similar experiences and interactions there.

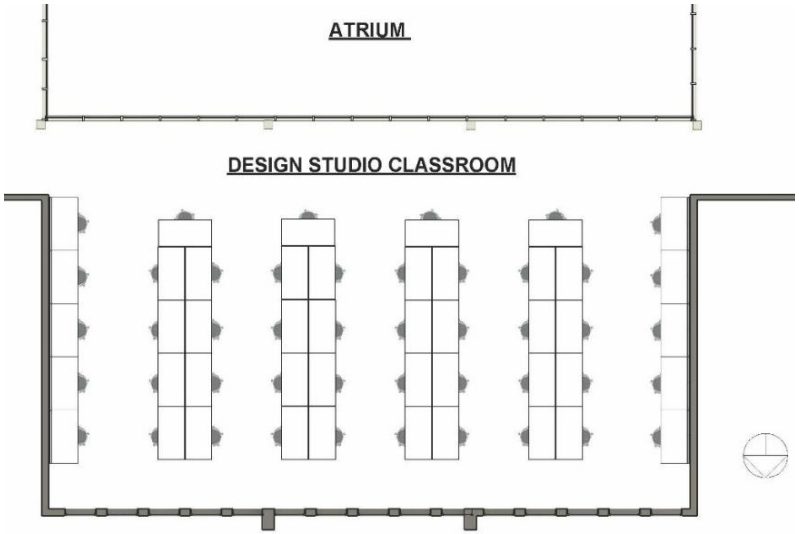

Figure 8
Studio Classroom Plan View

Figure 9
Studio Classroom South View (Atrium)

Invitations to participate were sent via email to all registered interior design students through the UM Faculty of Architecture graduate student advisor to protect the participants' privacy and ensure voluntary participation in the study. The initial email informed students about the study, which involved an Augmented Reality (AR) experience followed by a semi-structured interview (Appendix D). Subsequent emails invited them to complete the online surveys (Appendices E and F). To qualify for the AR experience and interview, students must not have a history of epilepsy, seizures, or motion sickness, as using AR technology, especially with an AR headset, may trigger these conditions. Additionally, to be eligible for the interview and survey, students must have used the interior design studio classrooms at the J. A. Russell building for at least one month.

3.3 Research Design: Approach, Hypothesis and Methods

The current study hypothesizes that students will experience less stress when using biophilic design studio classrooms. It involves independent and dependent variables, with the design studio classroom as the independent variable and students' stress levels as the dependent variable. A simulation design approach was employed to compare students' experiences in the existing design studio classroom and the biophilic design studio classroom experienced through AR. The in-person AR session was combined with a semi-structured interview (Appendix A), followed by a follow-up online survey (Appendix B). Additionally, a separate online survey (Appendix C) was distributed to all registered interior design students at the University of Manitoba. A thematic analysis of the interview data was conducted to gain a deeper understanding of students' opinions, needs in the design studio classroom, and the impact of biophilic features on their well-being and stress levels.

The AR Experience required the creation of a three-dimensional (3D) model of the existing design studio classroom at the J.A. Russell building at the University of Manitoba using Autodesk Revit, a building information modelling software. The space was redesigned by applying biophilic attributes identified explicitly in previous studies to evoke positive health outcomes in classroom settings, as shown in Table 3 below (Almusaed et al., 2022; Peters & D'Penna, 2020; Watchman et al., 2020). The Revit model was then converted to an FBX (Filmbox) file format using the BIM Holoview plug-in for Revit, to be accessible and viewable in AR, specifically the Microsoft HoloLens 2 device.

Table 3

Application of Biophilic Attributes in the Biophilic Design Studio Classroom

Biophilic Attributes Applied	**Type of Application**
Plants	Natural plants and green wall
Natural Materials	Use of wood furniture and fixtures
Landscape views	Application of large windows to provide direct access to outdoor views
Botanical motifs	Nature-inspired patterns on workspace partitions
Curves and arches	Curves are applied to the flooring design and the desk corners
Access to natural light	Increased number and size of windows
Warm light	Use of artificial light that resembles natural light
Spatial variety	Versatile and flexible layout
Prospect and refuge	Providing a safe indoor space with direct views of outdoor landscapes
Curiosity and enticement	A versatile digital wall is suitable for a range of applications, including displaying natural scenery

AR has been used in other studies to examine and identify the health effects and body responses that biophilia has on users when implemented in interiors, while also exploring the diverse restorative effects that users experience when viewing specific biophilic attributes in virtual interior spaces (Chan & Huang, 2024). In this case, the AR device enabled participants to view a projection of the biophilic version over their existing design studio classroom. The initial data collection involved participants viewing a virtual biophilic design proposal of their classroom, overlaid onto their actual design studio classroom using an AR headset. This AR experience allowed participants to walk around the design and observe the biophilic environment, as shown in Figures 10, 11, 12, and 13.

Figure 10

A participant uses an AR Headset

Figure 11

A participant uses an AR Headset

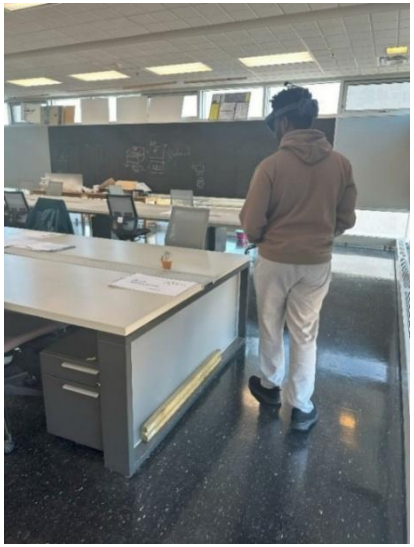

Figure 12

A participant uses an AR Headset

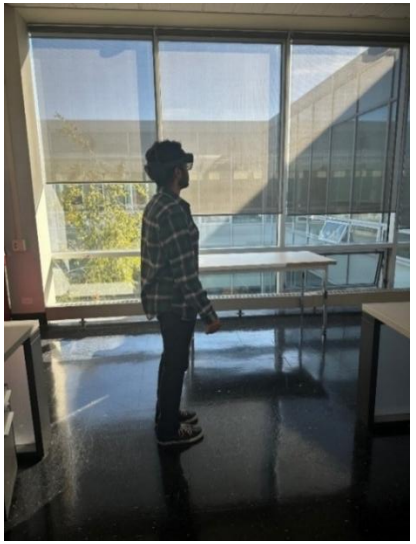

Figure 13

A participant uses an AR Headset

Some participants chose to sit and perform tasks like sketching and writing, as shown in Figures 14 and 15. The augmented reality (AR) approach enabled students to visualize potential biophilic applications within the studio environment and comprehend how these applications can influence their experience therein. Each session lasted approximately 10 minutes and was recorded.

Figure 14
A participant uses an AR Headset while sketching

Figure 15
A participant uses an AR Headset while sketching

An **Interview** was conducted after the participants had viewed the AR biophilic design studio classroom. An interview script (Appendix A) was used to collect basic demographic information, and each participant's perceptions of the current design studio classroom and the biophilic design studio classroom were recorded. The AR experience allowed participants to perform cognitive walkthroughs of everyday studio tasks they typically perform. The cognitive walkthrough is an affordable assessment that evaluates how potential features might affect user interaction and the perception of the space by posing questions to identify optimal modifications prior to their physical implementation (Lyon et al., 2021). The interview questions aimed to gather detailed information about the participants' current studio experience and their perceptions of how they would feel and perform if the studio incorporated biophilic features. The participants' responses helped identify their preferences and opinions on biophilic applications and linked them to existing evidence on biophilic interiors. It also enabled me to understand the significance of biophilic design in fostering a sense of comfort and security among students, which may help reduce stress levels. Each interview was scheduled to occur immediately after the AR session. Participants received a $20 Tim Hortons gift card as a token of appreciation. The interviews were recorded using the Voice Memos app on a password-protected iPhone, with each participant's consent. There were 20 participants in total, and each session lasted around 45 minutes. An **online follow-up survey** (Appendix B) was distributed to participants via their UM email to further explore their stress levels in a biophilic design studio classroom compared to the current studio environment, as well as their opinions on contributing a portion of their tuition fees to support biophilic applications in their design studio classroom.

Finally, all registered interior design students were invited to complete an **online survey** independently. The survey aimed to gather supportive data on their current experience in the design studio classroom within the J. A. Russell building at the University of Manitoba. The survey questions, found in (Appendix C), were designed with closed-ended and open-ended prompts. In addition to demographic data, students' preferences, opinions, and perceptions of having a biophilic design studio classroom were collected. The survey results were coded and anonymized since participants were directly identifiable due to the small sample size and the inclusion of open-ended questions. Participants could also provide their UM email address separately to receive a study report.

Altogether, the AR experience, interview, follow-up survey, and online survey were a practical, cost-effective means for capturing the learning environment needs of interior design students and assessing the effects of the nature-based features on their stress levels (see also Chapter 4).

3.4 Creating the Biophilic Studio

In the current study, the use of the biophilic attributes and elements listed initially by Kellert in "*Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life"* (2008), and the Biophilic Interior Design Matrix by McGee et al., (2019), have helped develop a complete understanding of the current biophilic features and their uses in interior design, specifically when applied to learning environments. The *Biophilic Interior Design Matrix* shown in Figure 16 by McGee and Park, N (2022), is a refined version of the original *Biophilic Design Matrix* developed by McGee and Marshall-Baker (2015), which was created based on Kellert's biophilic attributes and elements. It excludes some landscape and architecture applications that did not work for interior spaces.

Element #1 **Actual natural features**—actual (not images) of natural characteristics in the interior
1 Air
2 Water
3 Plants
4 Animals
5 Natural materials
6 Views and vistas
7 Habitats
8 Fire

Element #2 **Natural shapes and forms**—representations of nature and simulations
9 Botanical motifs
10 Animal-like
11 Shells and spirals
12 Curves and arches
13 Fluid forms
14 Abstraction of nature
15 Inside-outside

Element #3 **Natural shapes and forms**—properties derived from natural features and processes
16 Sensory richness
17 Age, change, and the patina of time
18 Area of emphasis
19 Patterned wholes
20 Bounded spaces
21 Linked series and chains
22 Integration of parts to wholes
23 Complementary contrasts
24 Dynamic balance and tension
25 Natural ratios and scales

Element #4 **Colour and light**—colour, light and material qualities, and space relationships to nature
26 Composition
27 Communication
28 Preference
29 Engagement
30 Pragmatics
31 Natural light
32 Filtered light
33 Reflected light
34 Light pools
35 Warm light
36 Light as shape and form
37 Spaciousness
38 Spatial variety
39 Space as shape and form
40 Spatial harmony

Element #5 **Place-based relationships**—culture together with ecology, rooted in geography
41 Geographic connection to place
42 Historic connection to place
43 Ecological connection to place
44 Cultural connection to place
45 Integration of culture and ecology
46 Spirit of place

Element #6 **Human-nature relationships**—paired biological needs of the human relationship to nature
47 Prospect/refuge
48 Order/complexity
49 Curiousity/enticement
50 Mastery/control
51 Attraction/attachment
52 Exploration/discovery
53 Fear/awe
54 Reverence/spirituality

Figure 16

Biophilic Interior Design Matrix Table

Note. Reprinted from McGee, B., & Park, N.-K. (2022), used under CC BY-NC 4.0.

3.4.1 Biophilic Interior Design Matrix Uses

The Biophilic Interior Design Matrix has been created to help designers better understand different biophilic design attributes and elements. This tool can expand their knowledge by showing various ways to incorporate these features into spaces for effective biophilic interiors. It emphasizes the importance of applying biophilic attributes based on the user's needs and the type of space (McGee et al., 2019). The matrix is organized into six biophilic elements identified by Kellert, with additional attributes linked to each element. The organization and clarity of the Matrix enable designers to easily access and use it when planning a space, as a checklist for proposing new designs or redesigning existing ones, as demonstrated in the biophilic interior design matrix table in Figure 16. The Matrix has been developed to help designers quickly identify biophilic attributes and incorporate them into their design concepts based on confirmed results and effects, as shown in multiple preschool projects illustrated in Figure 17. Furthermore, the Matrix encourages designers to recognize and understand the importance of incorporating biophilic attributes into interior spaces, given their potential benefits for users' well-being and for the preservation of natural environments.

	Biophilic Interior Design Matrix	Shang Preschool	Daveen Preschool	Avrociiy Preschool	Zaryland Preschool	Kapir Preschool	Cihman Preschool	Total Scores	Average
	(1) Environmental features								
1	Color	9	9	13	10	9	9	59	
2	Water	2	1	12	1	1	1	18	
3	Air	9	9	13	8	9	9	57	
4	Sunlight	9	9	13	8	9	9	57	
5	Plants	1	0	0	0	1	0	2	
6	Animals	0	0	0	0	0	0	0	
7	Natural material	0	0	0	0	2	0	2	
8	Views and vistas	9	9	12	8	9	9	56	
9	Fire	0	0	0	0	0	0	0	
	Subscores	39	37	63	35	40	37	251	4.25
	(2) Natural shapes and forms								
10	Botanical motifs	8	8	13	7	7	8	51	
11	Tree and columnar supports	0	1	0	0	0	1	2	
12	Animal	2	9	11	4	5	6	37	
13	Shells and spirals (invertebrates)	6	0	0	3	0	2	11	
14	Egg, oval, and tubular forms	0	1	0	0	0	1	2	
15	Arches, vaults, domes	0	0	9	0	0	0	9	
16	Shapes resisting straight lines	0	0	9	0	0	0	9	
17	Simulation of natural features/biomorphy	0	0	0	0	0	0	0	
18	Geomorphology	0	0	0	0	0	0	0	
19	Biomimicry	0	0	0	0	0	0	0	
	Subscores	16	19	42	14	12	18	121	2.05
	(3) Natural patterns and processes								
20	Sensory variability/information richness	9	9	13	10	9	9	59	
21	Age, change, the patina of time	0	0	0	0	0	0	0	
22	Central focal point	1	1	1	0	1	1	5	
23	Patterned wholes	0	0	0	0	0	0	0	
24	Bounded spaces	9	7	13	10	9	7	55	
25	Transitional spaces	1	1	0	1	1	1	5	
26	Linked series and chains	1	2	1	1	1	2	8	
27	Integrations of parts to wholes	9	9	13	10	9	9	59	
28	Complementary contrasts	0	0	11	0	0	0	11	
29	Dynamic balance and tension	0	0	0	0	0	0	0	

Figure 17

Example of Biophilic Interior Design Matrix Table

Note. Reprinted from Mohammed , I., Onur , Z., & Ça ˘gnan, Ç. (2023), used under CC BY 4.0.

3.4.2 Evidence-Based Design Applications Utilized

To design the biophilic design studio classroom for this study, various tools were used, and biophilic considerations were applied to ensure an effective and robust design solution. The biophilic elements incorporated in the proposed biophilic space were designed and selected according to McGee and Park's (2022) biophilic interior design matrix (BID-M), supplemented by Browning, Ryan, and Clancy's (2014) table that illustrates the "Biophilic design patterns & Biological Responses" (Browning et al., 2014). McGee and Park (2022) suggest that specific design elements can be incorporated to create an effective biophilic environment. Figure 18 references the Biophilic Interior Design Matrix (BID-M) elements used in the study to apply biophilic attributes in the proposed studio classroom design.

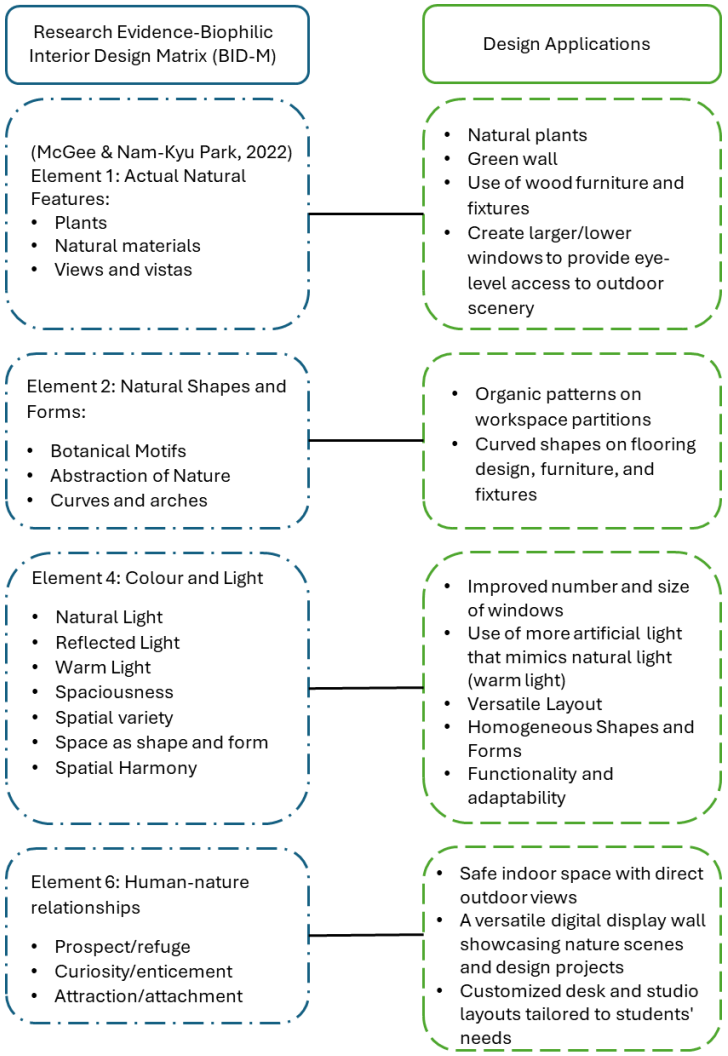

Figure 18
Biophilic Design Applications referencing the Biophilic Interior Design Matrix (BID-M) elements

The specific patterns included in the proposed design studio classroom, presented in Figure 19, address the representation of the three main elements identified by Kellert (2018) that present “Nature in the Space” through visual connections to nature and dynamic, diffused light. “Natural Analogues” through the presence of biomorphic forms and patterns, and a material connection with nature. Finally, “Nature of the Space” through the presence of prospect and refuge (Browning et al., 2014).

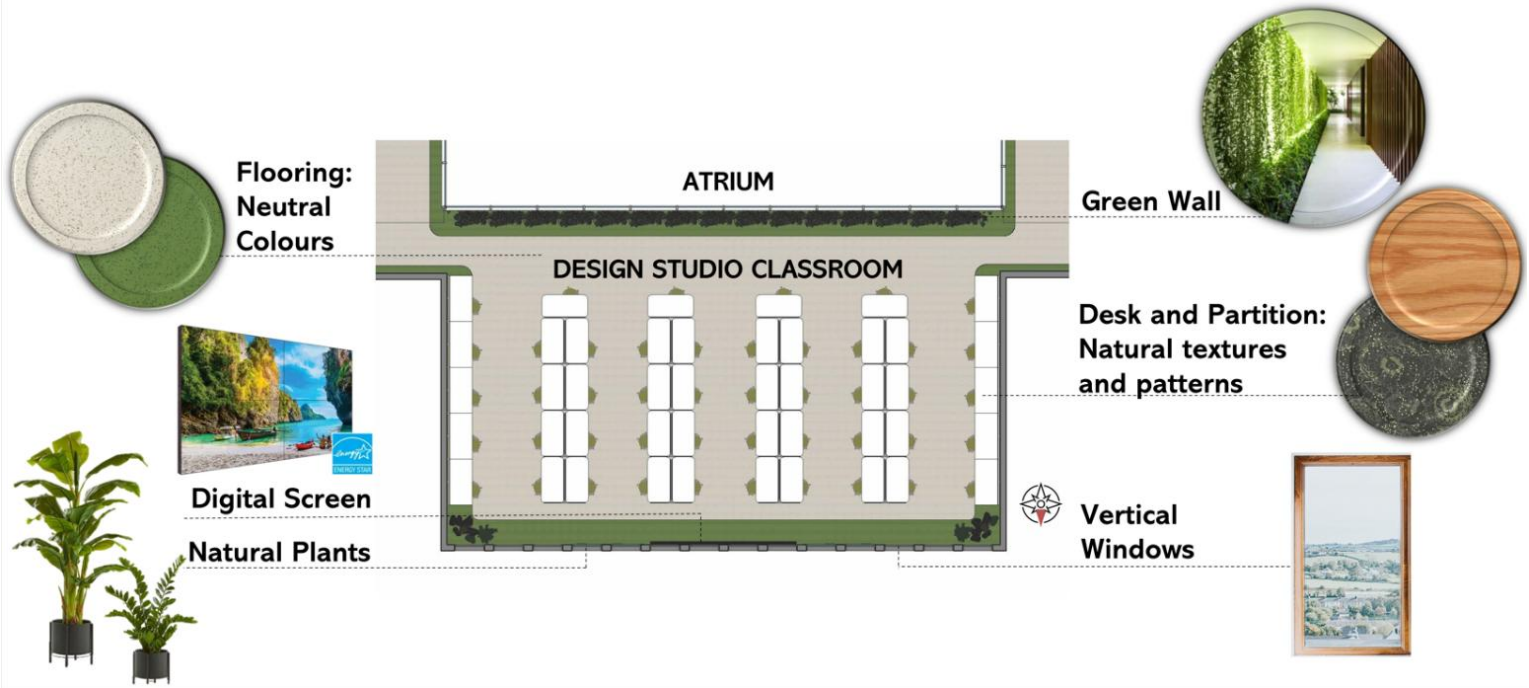

Figure 19

Biophilic Design Implementations for Studio Classroom Design Proposal

The biophilic patterns incorporated into the augmented reality design studio classroom include representing the “Nature in the Space” element by incorporating real natural features, such as plants, green walls, and natural finishes, and by creating larger windows that provide eye-level views of outdoor scenery. The space maximizes access to natural light and provides adequate artificial lighting that mimics it, to enhance students' productivity and concentration (Almusaed et al., 2022). Virtual windows, mainly used in windowless spaces, offer direct views of outdoor landscapes or scenery that mimic real outdoor views (Lassonde et al., 2012). The windows in the design studio classroom provide “Prospect” by offering a large frame through which students can enjoy the natural scenery while remaining in their safe and familiar classroom setting. “Refuge” is created when students are within the boundaries of their enclosed, secure classroom space and their working unit, separated from others by acoustic desk partitions (Browning et al., 2014). Moreover, the use of natural shapes and forms, such as botanical motifs applied on the desk partitions, the incorporation of curved desk corners and flooring design, and the application of neutral and cool colours that mimic nature such as blue, green, yellow, and beige, to create spaciousness and spatial harmony within the space and represents the “Natural Analogues” element. Both colour and light are essential in making the design studio feel more spacious and inviting (Yildirim et al., 2019), thereby helping students feel relaxed in their learning environment and reducing fatigue and stress levels (Almusaed et al., 2022).

The spatial layout of the AR design studio classroom is based on the existing, with functional and nature-based changes intended to enhance the students' learning experience and help reduce their stress levels. The desk layout is identical to the existing design studio classroom layout, which presents a clustered arrangement with a spacious five-foot circulation space between each cluster, as shown in Figure 20.

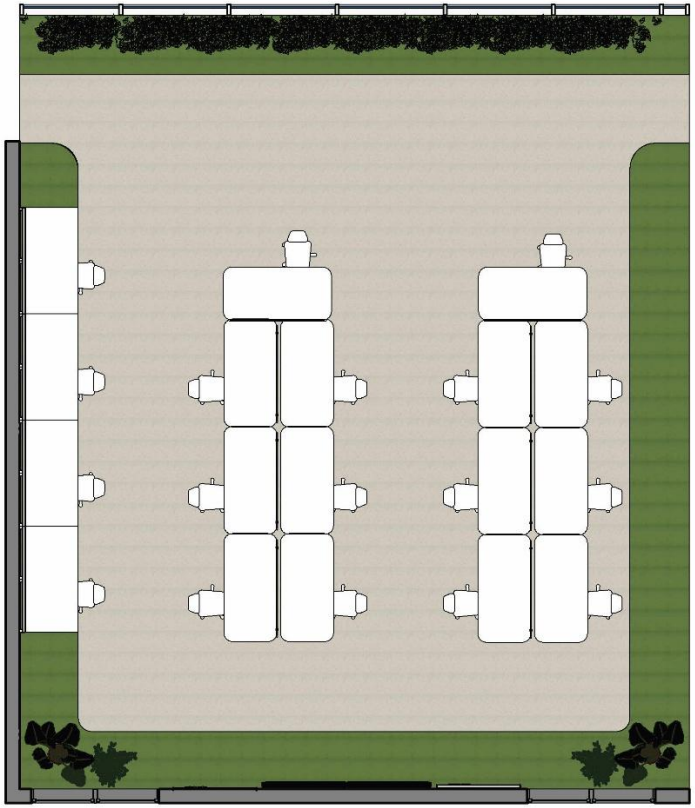

Figure 20

Modified Design Studio Classroom Layout for AR

The spaciousness allows students to arrange themselves flexibly according to their tasks. Students can rearrange the desks if they need to work individually in their personal space or to gather in groups. Minor modifications are incorporated into each desk area, featuring acoustical desk screens with natural shapes and patterns that provide students with adequate privacy when needed. Adjustable desks and task chairs allow students to work in both seated and standing positions. Bulletin boards offer students space to showcase hard copies of their work directly, alongside innovative technology provided by a digital wall with screens. These screens can display any digital content based on user needs, including natural scenery images, presentations and videos, showcasing projects and floor plans during critique sessions, and delivering formal lectures, as shown in Figure 21.

Figure 21
3D View of Modified Design Studio Classroom (North View)

Figure 22 shows a rendering of the green wall, which provides the space with diffused natural light, a direct connection to nature, and improved air quality. Furthermore, a major modification proposed in biophilic studio design includes the incorporation of full-height windows to afford eye-level views of the outdoor scenery and the implementation of simulated windows (skylights) that depict views corresponding to the current time of day and weather conditions.

Figure 22

3D View of Modified Design Studio Classroom (South View)

3.4.3 Representing Biophilic Design using Augmented Reality

Augmented reality (AR) was used in the study to enable participants to see the new biophilic features overlaid on their existing studio. Augmented reality was first introduced in the 1990s and was initially used in the military. Recently, it has gained popularity in the architectural and interior design fields for creating realistic virtual renderings of proposed interior settings (Sandu & Scarlat, 2018). This technique allows users involved in studies or projects to have a real-time, full-size visualization of proposed designs overlaid on familiar spaces, enabling precise comparisons of both environments. Additionally, augmented reality has been effectively employed to reduce time, effort, and costs in architecture and interior design by replacing physical full-size mock-ups and small-scale models. A study by Yin et al. (2020) found that viewing biophilic interiors virtually produces quick results, as participants show an immediate positive physical response, recorded within the first four minutes of exposure to the virtual biophilic space. Similarly, researchers have found that virtual reality can serve as a stress-recovery tool, demonstrating positive restorative effects on hospital patients experiencing stress and anxiety (You et al., 2023). Given the supporting evidence from previous studies on virtual reality and biophilia, I used similar methods, specifically AR, to explore the effects of virtual biophilic spaces on students' stress levels in design studio classrooms.

To further expand on existing studies demonstrating biophilia's positive effects on users' well-being, researchers have incorporated biophilic attributes into virtual classroom environments. For example, a presentation of biophilic features in virtual settings included plants and natural images (Chan & Huang, 2024). In another study, researchers used virtual reality to assess and better understand biophilia's impact on participants' cognition and stress levels. They concluded that virtual environments could produce effects on students' attention restoration similar to those of real biophilic settings, and that they have been shown to lower blood pressure, enhance short-term memory, and reduce stress (Yin et al., 2018). Accordingly, AR can be used as a cost-effective and beneficial tool in classroom design research. Potentially, students, faculty, and staff may benefit from using augmented reality headsets to view biophilic interiors or natural settings when renovations are not feasible or cost-prohibitive. Nonetheless, it is important to note that AR use excludes some users, as it is unsuitable for those who experience motion sickness or seizures. Additionally, when using the AR headset as a research tool, it is recommended to limit participant use to no more than 30 minutes, as prolonged use can feel physically heavy and strain the eyes and brain

(Sharrow, 2025). To address this issue, the current study used the AR device for up to 10 minutes per session to reduce discomfort or stress during headset use.

3.5 Data Collection Equipment

3.5.1 Augmented Reality Device

The AR tool used in the study, the Microsoft HoloLens 2, helped to overlay a design solution onto the existing design studio classroom by presenting biophilic features in the virtual design proposal. The process used a 3D Revit model, which was converted to the Filmbox (FBX) format and then uploaded to the Building Information Modelling (BIM) Holoview account. BIM Holoview is an application supported by the Microsoft HoloLens 2 headset. It requires a monthly academic subscription, with a 200 MB file size limit for HoloLens and 15 monthly conversions. After uploading the 3D model to the Holoview account, it was easily positioned within the existing design studio classroom using reference points placed earlier in the Revit model below the digital screen. This helped accurately position and align the virtual space's structure with the physical studio classroom's layout.

The 3D model was accessed on the AR HoloLens 2 device via the Holoview application to project the model, as shown in Figure 23. Next, using the Holoview application, the uploaded file was retrieved from a personal account created earlier. The model was then positioned in the existing design studio classroom, using the reference points shown in Figure 24 from the Holoview menu and the Studio elevation view in Figure 25, which displays reference points A and B.

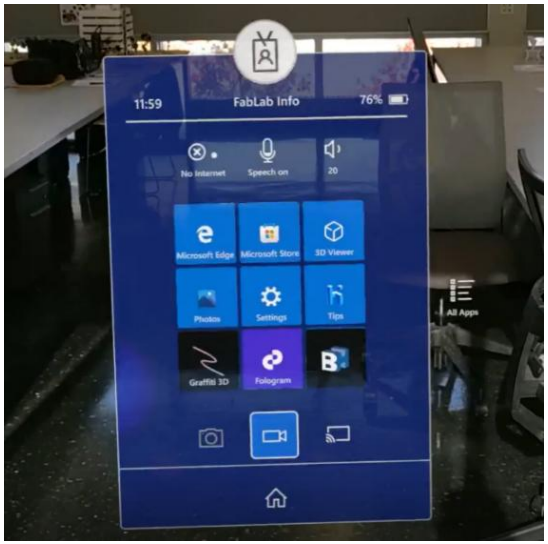

Figure 23

Microsoft HoloLens 2 Main Menu

Figure 24

BIM Holoview Menu

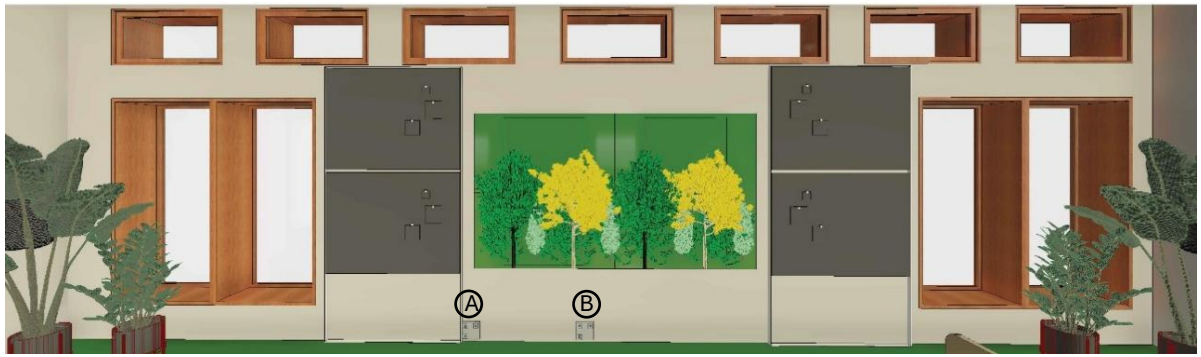

Figure 25

Design Studio with Reference Points

3.5.2 Augmented Reality and Interview Sessions

The existing design studio space acted as the control variable for the study, while the simulation setting was the experimental variable. The study began with an augmented reality experience that lasted approximately 10 minutes. The AR experience consisted of briefly explaining the study's purpose to each participant and describing the displayed scene they would view through the AR headset. Sharing information was necessary before the participants used the AR headset, assuming they were unfamiliar with it. The proposed design illustrates a small section of the existing design studio classroom, utilizing the same layout as shown earlier in Figure 20. This is to stay within the 200 MB file size limit for rendering and uploading via the AR application (BIM Holoview) on the Microsoft HoloLens 2. Also, because the Holoview does not display textures, patterns, or images, participants viewed 3D renderings, as shown earlier in Figures 21 and 22, to create the intended experience by showcasing the specific biophilic elements included in the studio classroom design proposal.

Participants were informed that the AR headset and the device application provide an overlay of the 3D model, displaying only colours that match the applied textures and patterns. This assisted the participants in understanding and visualizing the various biophilic applications through AR, even when represented differently. Also, because the AR headset's capacity and graphics, along with the application used to display the 3D model, are limited, it was challenging to illustrate a digital wall with display screens. The digital screens are designed to present natural scenery or to display design work, presentations and posters. Therefore, it was necessary to explain to the participants that an alternative solution was considered using 3D tree models and greenery to represent a natural scenery, as shown in Figure 26 and the video link.

Figure 26

Augmented Reality Biophilic Studio Classroom Demonstration

Note. Eltourk, D. (2025). https://youtu.be/oxEKvt0tnhs

Communicating information about the AR device helped participants understand the reasons behind choosing AR in the current study. The AR technology helped create an overlay on the existing design studio classroom, enabling prompt comparisons. Additionally, sharing information and 3D images of the proposed design was helpful, as it created awareness and familiarity with the proposed space and the purpose of the biophilic design solutions presented.

During the AR session, participants could move around easily because the AR headset allowed them to view both the existing and proposed biophilic studio simultaneously. This made participants feel as if they were walking, sitting, and working in a biophilic studio classroom. I also asked interested individuals to draw something on paper while wearing the AR headset, which helped them feel more engaged and present in the biophilic environment.

Following the AR session, a semi-structured interview was conducted in the current design studio classroom, with each session lasting approximately 20 minutes. The interview was recorded using the audio recording application Voice Memos on a password-protected iPhone. Voice recordings were obtained with the participant's permission and were later used to transcribe the interview script through Microsoft Word's transcription feature.

Once completed, both procedures allowed participants to experience a biophilic design studio classroom after using their existing design studio classroom, which offers limited biophilic elements, and to share their current design studio classroom experience while comparing it to the biophilic setting experience through AR.

3.5.3 Follow-up Survey

An online follow-up survey was sent to all (n=20) students who participated in the interview and AR sessions, resulting in 13 responses. The survey was sent after the participants had completed the AR session and interviews. It aimed to gather more information about participants' stress levels by comparing their experiences in the current design studio classroom with those in the biophilic design studio classroom viewed through AR. Additionally, it sought to understand their perspective on contributing a portion of their tuition fees to incorporate biophilic elements into the design studio classrooms. The data was analyzed thematically to identify significant themes. The survey was created using Microsoft Forms to ensure participants' security and privacy, and to allow them to access the survey link and complete it at their convenience. Participants could enter their university email address to receive a copy of the survey report. All identifying information (e.g., email) was recorded in a code book on an Excel sheet with its corresponding pseudonym (e.g., Participant's email address Participant 1 = P1).

3.5.4 Online Survey

An online survey was distributed to all registered interior design students at the University of Manitoba. The survey was created due to the limited capacity to accommodate all participants in the AR experience. Additionally, to survey a larger population about their studio experiences, and to gather data on their preferences for biophilic design in design studio classrooms. The online survey questions, detailed in Appendix C, include demographic data, current design studio experiences and satisfaction levels, as well as opinions and preferences regarding the inclusion of

biophilic elements within their studio. The survey was created on Microsoft Forms to ensure the security and privacy of participants' information. Additionally, it gave participants the flexibility and convenience to complete the form at their preferred time. All identifying information (e.g., email) was recorded in a code book on an Excel sheet along with its corresponding pseudonym (e.g., Participant's email address Participant 1 = P1). This process was applied because the survey included open-ended questions and offered participants the option to enter their university email address to receive a copy of the survey report. After collecting the survey data, I coded the responses using thematic analysis to identify major themes. Each theme and subsequent sub-theme were used to extract and analyze the results, as discussed in Chapters 4 and 5.

3.6 Ethical Considerations

The study complies with the requirements of the Human Research Ethics Board at the University of Manitoba, Fort Garry campus, for research involving human participants. Protocol approval was obtained before initiating any research involving human subjects, including the AR session, semi-structured interviews, and online surveys. Consent forms (Appendix G) were sent to participants via their UM email addresses, signed, and returned to the principal investigator prior to conducting the AR sessions and interviews. Furthermore, consent forms were reviewed with each participant on the day of the scheduled meeting, prior to the study commencing. For the online surveys, consent (Appendices H and I) appeared as part of the survey, requiring participants to read the form before agreeing and proceeding to the survey questions.

3.7 Chapter Summary

The study aims to expand existing evidence on the positive effects of biophilia in enhancing user well-being. Since there is limited evidence regarding biophilia's impact on post-secondary design students, this study focuses on applying and understanding the effects of biophilic design in design studio classrooms. The research used a mixed-method approach to collect the necessary data to achieve its objectives and ensure reliability for future

research. Both qualitative and quantitative methods were employed to address the research questions effectively. These included an AR session, semi-structured interviews, and online surveys to collectively explore and provide evidence on the importance of incorporating biophilic design elements in post-secondary design studios while capturing participants' biophilic preferences in these settings. The study also examined participants' feelings and stress levels within a biophilic studio classroom environment and considered whether demographic factors could influence students' stress levels when using such spaces. Participants experienced an AR view of a biophilic studio classroom design proposal through the Microsoft HoloLens 2 headset, allowing them to compare both environments simultaneously, understand the purpose of biophilia, and consider potential applications for studio classrooms. Implementing AR in this study was crucial to provide a versatile tool that is less commonly used in design-based qualitative research. Additionally, the surveys and interviews collected data about participants' demographics, their current studio experiences, stress levels, their design preferences for studio environments, and whether they would be willing to contribute part of their tuition fees to support the integration of biophilic design. Overall, the study offers researchers valuable insights and tools to inform future research involving post-secondary students and biophilic design applications in educational settings.

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Chapter 4: Results

4

4.1 Interview and Survey Data Analysis Method

The qualitative data collected from the interviews and surveys were analyzed using thematic analysis. This method was employed due to its flexibility and accessibility in coding the data, identifying various themes, and ultimately establishing a detailed report (Nowell et al., 2017). Nowell et al.'s step-by-step guide directed the thematic analysis for this study. The interview data analysis included transcribing the recordings, which were sent to each participant for verification. After each participant reviewed and approved their transcript, I started recognizing the general topics that came up from the interview transcripts, then created initial codes, generated themes from the coded data, checked whether the themes aligned with the codes, established a definitive list of themes and finally produced the report as detailed in Chapter 4 referring it to the literature review and addressed research questions. The themes and subthemes extracted from the coded data acquired from the interviews and surveys are described in Table 4. The themes include students' direct experiences; a detailed description of their current design studio classroom and its utilization; their satisfaction with the studio classroom's design and layout; and their emotional responses during classroom use. Additionally, the analysis includes their average stress levels while using the existing studio classroom and a biophilic studio classroom. Other themes included essential biophilic design applications in design studio classrooms, and whether participants would be willing to contribute some of their tuition fees to incorporate biophilic elements in their studio classrooms. Finally, demographics were examined to see if participants' social and academic statuses influenced their stress levels.

Table 4

Themes and Subthemes Extracted from Data

Theme	**Subtheme**	**Theme**	**Subtheme**
Studio Classroom Description	Overall Features	**Stress Levels in Existing Studio Classroom with Limited Biophilic Features**	Comfort
	Likes and dislikes		
		Stress Levels in A Biophilic Studio Classroom (Viewed Through AR)	Comfort
Studio Classroom Use	Years		
	Days per week	**Satisfaction With Studio Classroom Design and Layout**	Features
	Hours per day		Aesthetics
	Activities performed		
	Required tasks	**Required Design Features**	Furniture and fixtures
			Materials and finishes
Studio Classroom Functionality	Accessibility		Quiet spaces
	Ergonomics		Collaborative features
	Technology		
	Practical	**Biophilic Design Features**	Direct applications
	Accommodates various user needs		In-direct applications
Feelings	Encouraged	**Willingness To Financially Contribute to Having Biophilic Features Applied in Their Studio Classroom**	Responsibility
	Satisfied		
	Inspired	**Demographics**	Gender
			Age
			Student Enrolment status and level
			Employment Status

4.2 Results: Online ID General Survey

An online survey (Appendix C) was sent to all registered interior design students (N=103) currently enrolled in the program. Of those, five completed the survey (n=5). The low response rate (4.8%) limits the generalizability of the findings. While some aspects of my population sample are representative of larger population samples, it should be noted that the findings of the general survey reported in the following sections (4.2.2 and 4.2.3) are only indicative of what interior design students are likely to say about their studio experience.

4.2.1 General Survey Participants

The respondents who completed the online survey (n=5) were full-time, female students aged 22-29 years. According to Lindner (2025), in US schools, the majority of Interior Design students are female (58%). Sixty percent were undergraduate students, while 40% were pursuing graduate studies. All participants had used the studio classroom environment for at least 1 year. All were employed, with 80% working part-time and 20% working full-time. The majority (60%) utilized the studio twice weekly, 20% three times weekly, and the remaining 20% more than three times weekly. Additionally, 80% used the studio classroom for more than 3 hours each day, a finding consistent with that of Al-Jokhadar et al. (2023).

4.2.2 Existing Studio Experience

All online survey participants (n=5) have spent at least 1 year working in the current studio classroom. Eighty percent reported feeling encouraged to use the space, while the remaining 20% felt “neutral.” On a 5-point scale, participants rated their satisfaction with the current studio classroom layout at 3.2 (“neutral – moderate satisfaction”), while their satisfaction with the studio classroom design averaged 2.8. Additionally, 60% of participants said the studio classroom is welcoming and accessible to all users, whereas 20% disagreed and 20% responded “maybe.” Regarding working in the studio classroom and receiving design inspiration, 60% found it neutral, 20% found it inspiring, and 20% disagreed. Notably, 80% stated that the studio cannot be used to unwind

and reflect, while only 20% agreed that it can help them relax. Finally, participants rated their stress level on a five-point scale, with an average of 2.8, where one indicates "highly stressed" and five indicates "remarkably calm."

The open-ended questions asked participants what they liked and disliked about their studio classroom to better understand how to improve the design. Participants responded with comments such as: *"I like the open layout that encourages communication and collaboration," "Spacious space with a big opening facing the yard," "Mostly the community aspect and that my friends are there and that I have my own personal space in a larger space," "The clerestory windows and that studio is one large shared space," "Individual spaces (desks) for students,"*. Conversely, their dislikes included: *"Sun glare (needed to put up poster boards to block out windows), lack of diverse seating and textures," "High window creating barrier," "It is noisy, often the temperature is too hot or cold, can be overstimulating with the amount of people, can bring up stress with the relation of studio and studying to the space," "The chairs and desks are a stationary height,"* and *"Windows obscured by bulletin boards, but windows above the MID-2 (masters) area blind users around 2-3 pm in the fall semester."*

4.2.3 Biophilic Design Studio Experience

When asked about incorporating biophilic elements into their studio classroom, 80% agreed that they would like to introduce biophilic features, and 20% expressed neutrality. Additionally, all participants agreed that biophilic elements can be incorporated into their existing studio classrooms, with 60% strongly agreeing and 40% agreeing. All participants desired greenery in their studio classroom; 80% chose natural materials and finishes, while 60% preferred organic shapes in materials and finishes, as well as outdoor landscape views. Conversely, 40% wanted more windows. Meanwhile, only 20% wished for skylights, natural sounds, and scents.

4.3 Results: ID Student AR Experience and Interviews

Participants in the AR experience and interviews provide primary data for my study to analyze and understand the impact of biophilic design on students in studio classrooms. Twenty students (n=20) participated in the AR experience study, which included interviews and a follow-up online survey. This group of participants represents 19% of the total number of students currently enrolled in the interior design program at the University of Manitoba's Faculty of Architecture (N=103).

4.3.1 AR Experience and Interview Participants

The majority of participants (85%) in the study's AR and Interview sessions were female. Most are under 29 (75%), have used the studio for at least 1 year (75%), and were full-time students who also worked part-time (65%). A summary of the demographic characteristics of the interior design students who participated in the study (n = 20) is presented in Table 5.

Table 5

Demographic Characteristics of Participants

Variables	Values	Count	Percentage
Student Status	Full-time Part-time	20	100%
Gender	Female Male	17 3	85% 15%
Age	<21 22-29 30-39 >40	2 15 2 1	10% 75% 10% 5%
Grade Level	Undergraduate Graduate	9 11	45% 55%
Studio Use (In years)	1-2 years >3 years	15 5	75% 25%
Employment	Part-time Full-time Not Employed	13 1 6	65% 5% 30%

Note. n=20 (Total number of AR and interview participants)

4.3.2 AR Experience

During the 5–10-minute period in which participants walked through the biophilic design studio classroom using the AR headset, they were asked to visualize or simulate a common studio task (e.g., sketching). Participants identified and recognized the biophilic elements within the environment and articulated their preferences for their studio classroom. Once they completed the AR experience, interviews were used to capture participant perspectives on the existing and biophilic studio classrooms in more detail.

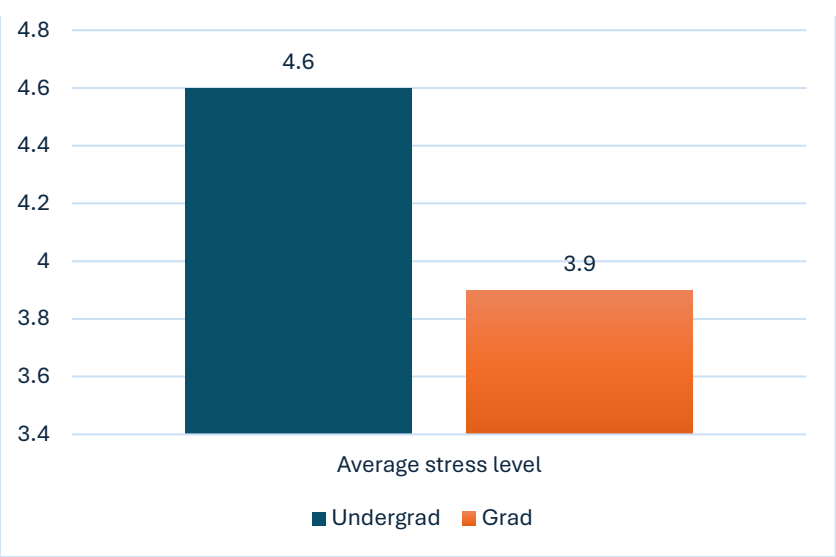
4.3.3 Interviews - Existing Studio Classroom Experience

Based on the interview responses, undergraduate interior design students reported higher average stress levels than graduate design students in the existing studio classroom setting.

Undergraduate students (n=9) reported an average of 4.6 out of 10 stress level compared to 3.9 out of 10 for graduate students (n=11), where 10 is “extremely stressed” (see Table 6). This finding is consistent with a study by Lisnyj et al. (2021), which found that undergraduate students tend to experience higher stress levels due to limited experience managing workloads and balancing personal and academic commitments.

Table 6

Average Stress Level of Undergrad vs. Grad Students in the Existing Studio

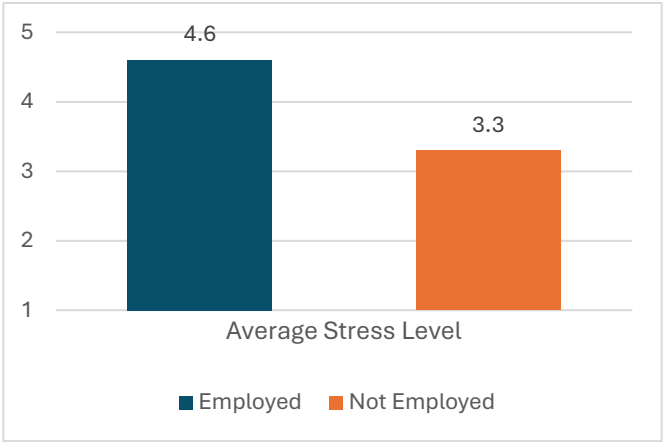


Note. n=20 (Total number of AR and interview participants)

When looking at stress levels in relation to employment status in the existing studio setting, employed students tended to have higher stress levels than students who were not employed. Employed students (n=14) averaged 4.6 out of 10 compared to not employed students (n=6) who reported an average of 3.3 out of 10, where 10 is "extremely stressed" (Table 7). These findings are consistent with a study by Lisnyj et al. (2021), which revealed that students who work to meet their financial obligations while at school experience elevated stress.

Table 7

Average Stress Level of Employed vs. Non-employed Students in the Studio



Note. n=20 (Total number of AR and interview participants)

The physical design of the existing design studio classroom is described in the interviews as an "*office space*" with very dull finishes and colours. Notably, students identified workload and course expectations as the primary sources of stress, not the space. However, the studio's aesthetics and functionality do not help ease students' anxiety or stress. When asked about their satisfaction with the design and layout of their current studio, on average, participants rated it 6.2 ("moderately satisfied") out of 10, with 10 representing complete satisfaction.

A significant concern raised by many is the large open space in the design studio, which is used by over 100 undergraduate and graduate design students. The studio's openness, combined with the lack of acoustic features and partitions, makes it loud, distracting, and uncomfortable. Participant (P15) stated: *"I would also add in more acoustic treatments, I think, because the ceiling is not doing everything that it needs to, and I also think that these*

boards that are covering the view are at the level of where you are seated, which is also an obstruction that could be dealt with better. And then bringing in natural materials, natural tones, and warmer tones to make it more inviting."

Additionally, thermal and visual comfort, along with the ergonomics and flexibility of furnishings, appear to be problematic. Many participants noted that the studio is excessively warm or cold, depending on the season and time of year. Furthermore, students noted that the brightness of the direct artificial lighting in the studio is distracting and uncomfortable for their eyes, especially since they tend to spend long periods in the space during each session. While the studio provides sufficient access to natural light, the window placement does not provide direct outdoor views, and the treatments are insufficient to block excess heat or sun glare on computer screens. This results in an uncomfortable learning environment. Students also mentioned that the studio classroom's layout is "*practical*" and "*appropriate*"; however, the inflexible furniture restricts their ability to connect and collaborate with classmates. Additionally, students are unable to transition from sitting to standing, which makes them feel limited, as most of their tasks are done at their designated desks. The many issues mentioned above have led most students to avoid using the design studio, except when they need to attend their studio classes.

4.3.4 Interviews - Biophilic Studio Classroom

The post-AR interview descriptions of students' design preferences and solutions suggest that biophilic characteristics can help make the design studio classroom more inviting and comfortable. Many of the students' proposed solutions to improve their existing studio included biophilic elements. For example, when asked about redesigning their studio, students mentioned that they prefer direct outdoor views over full-height bulletin boards that block their sightlines. Participant (P2) mentioned, *"I would appreciate it if there were more openings, like on our side, the openings are very small and we barely get to see sunlight, which is depressing. I would definitely appreciate it if there were more openings and more space."* Other preferences included natural materials and finishes, acoustical partitions, thermal comfort, soft seating, and collaborative spaces.

Participants shared their biophilic preferences, believing these would help enhance their comfort and motivation in the studio classroom and reduce their stress. Such preferences include the use of natural materials, finishes, and patterns; direct access to outdoor views and landscape scenery; sufficient daylight; and displays of real plants and greenery within the studio classroom. 50% of participants favoured the natural finish and the wooden desk pattern, and 25% preferred the patterned partitions. Comments included *"The addition of real plants might help create a calmer atmosphere, improve focus, reduce noise, and make the studio feel more private and visually soothing," "The nature elements like plants make the classroom feel more homey and comfortable," "The presence of plants in a room always makes me feel calmer, so that would help with stress," "Having natural materials and plants would lower my stress levels, by creating an environment that is naturally more relatable to humans," "The visual sightlines to greenery create a calm natural atmosphere. It feels pleasant to the eye,"* and *"biophilic features provide a calming presence, freeing some strain from academic work and the feeling of a sterile environment."*

The green wall located by the atrium curtain wall in the AR biophilic studio classroom, as shown in Figure 27, was a particularly desirable feature. Students explained that the green wall can make the studio classroom more comfortable by reducing sun glare, bringing in diffused light, and improving indoor air quality. They also believed it could help boost their motivation and creativity. The mentioned features can provide students with quick visual breaks from their computer screens, making them feel less stressed while working on demanding assignments and projects.

Figure 27

AR Display for Biophilic Studio Classroom's Atrium (South View)

Note. Eltourk, D. (2025). https://youtu.be/oxEKvt0tnhs

Moreover, some students noted that they appreciated the digital screen shown in Figure 28, as it is versatile and can display natural scenery or their design work, thereby increasing student interactions. Comparing the existing studio classroom with the biophilic studio classroom, Participant (P15) mentioned, *"I think it would be more of a calming experience, even with the stress of whatever project not changing. I think the environment being more centred on biophilia would increase the calming and relaxing atmosphere of it"*.

Others suggested adding interactive walls where various materials and textures can be mounted on the bulletin board for projects, serving as an interactive and inspiring element within the studio classroom. Participant (P12) mentioned*, "I think that more interactive elements would be nice aspects that make us get up from our desks, things that contribute to making in the studio, because I think a lot of the time, we spend on our computers sitting at*

the desk. So, it would be really nice if there were elements in the studio that you could pull some textures off the wall or maybe integrate the materials lab with the studio so that you feel like you are drawing inspiration from your surroundings, rather than just sitting at your desk and expecting to look at the gray walls and feel inspired."

Figure 28

AR Display for Biophilic Studio Classroom's North Side

Note. Eltourk, D. (2025). https://youtu.be/oxEKvt0tnhs

Based on the earlier interview findings and participants' feedback about the biophilic studio classroom, Table 8 summarizes the most preferred biophilic elements.

Table 8

Most Preferred Biophilic Elements in the Studio Classroom

	Most Preferred Biophilic Elements in the Studio Classroom
1	Natural materials, finishes, and patterns
2	Direct access to outdoor views and landscape scenery
3	Sufficient daylight
4	Real plants and greenery
5	Acoustics

The students' preferences for a variety of biophilic elements align with Kellert's (2018) three design categories for effective biophilic applications. This includes providing *direct* natural experiences through ample natural light and outdoor views, *indirect* natural experiences through natural materials and colours, and *spatial experiences* through approaches such as acoustical partitions and break areas with soft furnishings to give students a sense of security, while also offering a variety of furnishings to enhance flexibility.

Overall, the impact of the biophilic studio classroom on the participants was positive. Participants reported feeling more motivated to use a biophilic design studio classroom, with an average rating of 8.4 out of 10 (10 indicating high motivation), describing the AR biophilic studio as *"more comfortable," "warm," "inviting," "calm," "relaxing,"* and *"less stressful,"* due to the inclusion of greenery, natural materials, textures, colours, and direct views of outdoor scenery.

4.4 Results: AR Participants Follow-up Survey

A follow-up online survey (see Appendix B) was distributed to all 20 AR experience participants to assess their stress levels using a 10-point rating scale and to compare their experiences in their current studio and the AR biophilic studio classroom. Participants were also asked whether they would be willing to contribute part of their tuition to support biophilic applications in the studio classroom.

4.4.1 Follow-up Survey – Biophilic Studio Classroom

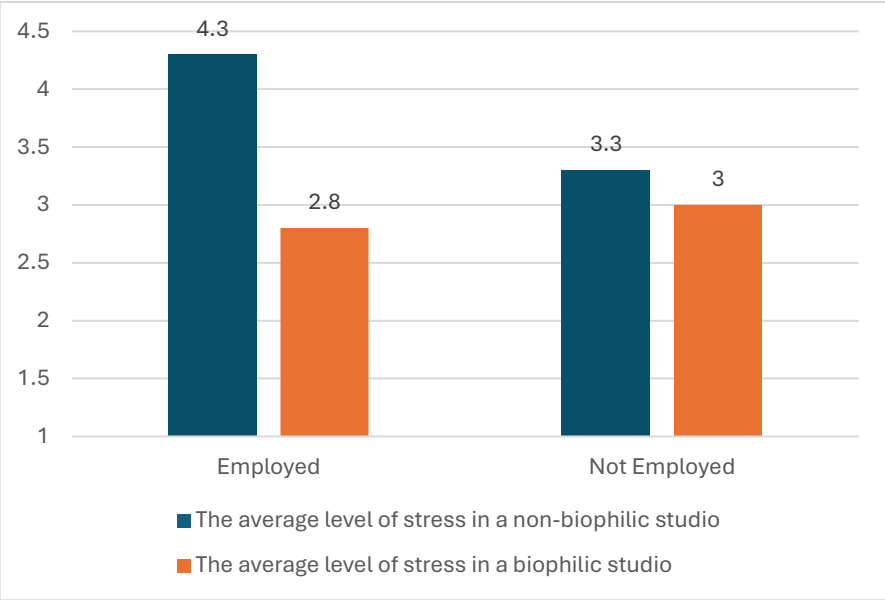
A total of 13 responses were received from participants (65% response rate). The results show that participants' stress levels in a biophilic studio classroom, such as the one they viewed through AR, are 3.08, compared to an average of 4.2 in their current studio classroom. The rating was on a 10-point scale, where 10 indicates the highest level of stress. Additionally, 85% of participants reported that the biophilic studio classroom would be less stressful to work in, while 15% said it would be the same or neutral.

In the follow-up survey (n=6), employed students reported a greater reduction in stress in the biophilic studio compared to the non-biophilic studio. Employed students (n=4) reported an average stress level of 4.3 in the non-biophilic studio and 2.8 in the biophilic studio (where 1 is “least stressed” and 10 is “most stressed”). In contrast, not employed students (n=2) on average, reported hardly any change (3.3 non-biophilic and 3 biophilic). See Table 9. Overall, in both groups, students' average stress levels were lower in biophilic studio classrooms than in non-biophilic studio classrooms. These findings are consistent with a study by Determan et al. (2019) that found lower stress among students in a biophilic studio classroom.

It should be noted that, in the follow-up survey, the employment status of only a subset of participants (n=6 of 13) could be identified through their UM email addresses and cross-referenced with their interview responses. This represents a response rate of 30% of the original AR experience participants (n=20).

Table 9

Average Stress Level of Employed Vs. Not Employed Students in a Non-Biophilic vs. a Biophilic Studio Classroom



Note. n=6

Furthermore, while biophilic applications generally yield positive effects on users, it is imperative to recognize certain limitations, such as the awareness of the significance of biophilic design among designers and users, as well as the initial and ongoing costs associated with incorporating biophilic elements (Sadick et al., 2023; Sholanke et al., 2024). These constraints frequently lead many organizations and individuals to refrain from integrating biophilic design into various projects. As evidenced by participants' responses to the inquiry about their willingness to contribute a portion of their tuition fees toward the inclusion of biophilic features in their studio, 69% disagreed, citing that tuition fees are already high and that it is the university's responsibility to provide biophilic features within the studio classroom. They argue that the current studio classroom environment needs improvement to better support students' educational needs by enhancing its functionality, accessibility, and aesthetics. Additionally, the university could benefit from biophilic applications that might enhance its reputation and recognition among international organizations.

4.5 Summary

The findings from the online general survey, AR experience, interviews, and online follow-up survey provide data on the effects of biophilic design on the stress levels of interior design students within design studio classrooms. Based on participant responses, there is a general sense of satisfaction with the layout and design of the current studio classroom. After exposure to the AR biophilic design studio, participants indicated a preference for certain nature-based features to be included in their studio, including: natural elements and textures, greenery and plants, natural and neutral colours, and direct views of outdoor landscapes. Compared to their existing studio, the AR biophilic studio classroom was perceived as more motivating, inviting, and warmer in atmosphere. Despite the perceived benefits, students expressed reluctance to pay higher tuition to have these features implemented in their existing studio.

An important part of my study was to explore the impact of biophilic studio classrooms on student stress. The analysis revealed that undergraduate interior design students exhibited higher stress levels than their graduate counterparts. Furthermore, employed students demonstrated higher stress levels than those who are not employed. Interestingly, the follow-up survey of AR participants revealed that, while all students experienced a reduction in

stress when exposed to the AR biophilic studio classroom, employed students experienced the greatest reduction in stress.

Overall, the findings of my study are consistent with a previous study by Mahrous et al. (2024), who used virtual reality to showcase biophilic elements in design proposals for their existing studio classroom. Exposing students to natural connections facilitated increased cognitive restoration and satisfaction, thereby supporting improved concentration on their academic pursuits and contributing to stress reduction (Mahrous et al., 2024; Mahrous et al., 2022). Additionally, incorporating features such as windows with direct views of outdoor scenery, ample natural lighting, indoor plants, and natural finishes and patterns in post-secondary institutions helps improve students' well-being by increasing their satisfaction and comfort, while also reducing their stress (Mahrous et al., 2022). Thus, biophilic elements have been shown to influence students' stress levels positively.

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Chapter 5: Discussion

5

5.1 Discussion

The current study provides evidence-based support for researchers interested in exploring how biophilia influences stress levels among post-secondary students. Since the study focuses on interior design students in design studio classrooms, it can serve as a foundation for the research methods used. It can be expanded to investigate other biophilic features. Researchers can also examine different classroom environments within post-secondary institutions or replicate the study using various devices, such as different augmented reality or virtual reality headsets.

Although using Revit as the 3D modelling software and the Microsoft HoloLens 2 AR device for the study has provided the required data, other software and devices might be more accessible and convenient for design-related research. Working with previously tested devices or those offering online resources can reduce trial-and-error testing and shorten the duration of future studies.

5.2 Limitations

The choice of the AR device, the HoloLens 2, and its applications was based on its availability at our faculty and my familiarity with the specific programs required for the technical process, such as Autodesk Revit and SketchUp. Although I was able to cover the monthly subscription costs for using the BIM Holoview program on the HoloLens 2, with additional financial support and time, I would have considered using alternative devices or software that could achieve the intended results of the virtual overlay. Some device recommendations are outlined in Table 10 below (Section 5.4).

Additional limitations include the discontinuation of the Microsoft HoloLens 2 device in October 2024, with all software updates concluding by December 31, 2027 (Warren, 2024); consequently, alternative devices are necessary for future research involving augmented reality design. Furthermore, given the considerable time and financial investment required to acquire proficiency in developing 3D models with new software, I would need additional time to improve my skills in creating and rendering 3D models using alternative programs such as Unity, Autodesk 3ds

Max, and Blender. Additionally, I would need funds to access supporting plug-in subscriptions for the Augmented Reality device.

Given the limited resources available for building modelling software on the Microsoft HoloLens 2, it was challenging to identify effective troubleshooting techniques. Therefore, finding the right software to convert the 3D model into a compatible format for the AR device required multiple trials and extensive hours of work. Additionally, because Visual Live, which supports displaying textures and patterns of 3D models on HoloLens 2, was unavailable, the AR application BIM Holoview was restricted to displaying the converted 3D model in colour only, without textures or patterns. Textures and patterns on the HoloLens 2 can be created by developing models in programs such as Unity, Autodesk 3ds Max, and Blender, which require practice and expertise. After many attempts, I was unable to obtain a Revit file that was compatible with the HoloLens 2 in terms of file size and format; therefore, I continued using Holoview software to create the proposed biophilic studio classroom setting in AR. Ultimately, through continuous testing, I reduced the file size and converted the Revit model to display the proposed biophilic studio classroom on the HoloLens 2. To compensate for the absence of textures and patterns, I showed 3D visual renderings of the proposed biophilic design to participants before they experienced the space in AR, helping them better understand the intended biophilic effect.

Moreover, recruiting participants from the target sample required sending ongoing email reminders to reach the required number. This process took longer than initially expected. Fortunately, with the support of the faculty's academic advisors and professors, I recruited 20 participants for the study. Additionally, I set aside extra time to collect and analyze interview data, which helped me complete the key tasks on schedule. Unfortunately, the number of responses to the online survey was insufficient to provide a statistically significant dataset where I could identify patterns and trends within the sample; therefore, they were combined with the interview results and are included in the study only as a foundation for future research.

Furthermore, it is important to note that challenges arise when implementing biophilic elements in interior spaces that may not have been immediately evident from the experimental setup used in this study. There is a general lack of awareness among designers about the advantages of biophilic design and how to incorporate these

elements effectively to elevate user experience and well-being. Instead, the tendency is to prioritize the incorporation of digital technology. Also, the initial costs of incorporating biophilic elements into an existing space, along with the ongoing maintenance costs for natural plants and green walls, may exceed project budgets. Other challenges include limited strategies for applying biophilic design in cold climates, space constraints, and project location (Sadick et al., 2023; Sholanke et al., 2024). However, designers, clients, and corporations need to understand and embrace the health benefits of biophilic design and explore ways to adapt it to user needs and project budgets. Thorough planning, including detailed design and construction followed by post-occupancy evaluations, can provide valuable data on the impacts of biophilic elements, both positive and negative, that can guide future projects (Sholanke et al., 2024).

5.3 Strengths

One of the study's strengths is the use of AR to test the effects of biophilic elements in an individual setting, specifically a design studio classroom. The benefit of using a simulation design approach is that it allows participants to visualize a design proposal in augmented reality, enabling them to experience a virtual space without physically implementing the design concept in the real world (Robinson, 2023). The use of AR technology in the study is innovative. It has allowed students to easily view and compare the existing and virtual spaces simultaneously, reducing the time, resources, and costs required for project development. In addition to interviews and surveys, the research design provided valuable insights into each individual’s personal experiences and perspectives on the influence of nature-based features in their studio.

Although recruitment posed challenges, the characteristics of the participant sample group are representative of larger populations of interior design students who utilize studio classrooms. Consequently, it is reasonable to anticipate that the findings of this study could be generalized to a broader population of students engaging with design studio environments. Furthermore, despite the limited size of the sample group, the outcomes of this research align with similar findings from prior studies conducted within middle school classrooms, such as the investigation by Determan et al. (2019), which concluded that the presence of natural or organic patterns and textures, along with direct access to natural scenery, has reduced their stress levels and enhanced their short-term

memory. Additionally, Mahrous and colleagues (2024) conducted a study using virtual reality to present biophilic elements in a studio classroom. They found that incorporating natural materials and nature-inspired colours into post-secondary studio classrooms reduced students' stress levels.

5.4 Future Recommendations

Given the limited research on the impact of biophilic design in post-secondary classrooms and their effects on students (Mahrous et al., 2024), future research can expand on the current study by incorporating similar tools and software used here to develop further studies and experiments. Additionally, new insights can be gained from the current study's findings by focusing on students' needs and preferences in a design studio classroom and integrating biophilia as a design solution to enhance the learning experience and well-being of post-secondary students in such environments. More research with larger sample sizes is needed to establish the generalizability of biophilic design and its impact on stress levels among post-secondary students in design studio classrooms.

Additionally, since the Microsoft HoloLens 2 device was discontinued in October 2024 and all associated software updates will end by December 31, 2027 (Warren, 2024), further research into the technological resources available to interior designers is necessary to enhance the technical resources and AR applications within the field. Such research will benefit designers and researchers by providing access to essential research tools and by reducing the time and costs associated with exploring various biophilic design solutions. Recommendations for devices suitable for future AR-based design investigations are summarized in Table 10. The devices listed offer mixed reality capabilities that support augmented reality integration and walkthroughs, enabling users to select preferred software and file formats and work with them accordingly. Users can use familiar programs to convert 3D models to compatible file formats and upload them to the headset via wired or wireless connections.

Table 10

Technical Requirements Table

	Device	Type	Software Compatibility	Compatible File Formats	Connection between the Computer and the Headset	Steps to Install the 3D Model into the Headset
1	Vive XR Elite	Mixed Reality (VR/XR)	CAD, Unity, Blender, Maya, 3ds Max	STL, OBJ, FBX, glTF, GLB, DWG, MAX, BLEND	Wired and wireless (USB and Wi-Fi)	1. Prepare the file in a compatible format 2. Import into Unity 3. Use OpenXR/Vive XR Suite to deploy or stream to the device
2	Varjo XR-4	Mixed Reality (MR)	Unreal Engine, Unity, NVIDIA Omniverse, Autodesk VRED, PREPAR3D	FBX, OBJ, USD/USDA/USDC	Install Varjo Base software, connect power to the headset adapter using the power cable, connect the headset adapter (LB-5) to the back of your computer, connect the headset's data cable to the headset adapter, and connect the headset's display cable to the graphics card of the computer	1. Prepare the file in a compatible format 2. Import to KeyShot, Unity, Unreal Engine, or Autodesk VRED 3. Install Varjo Base on your Computer 4. Connect the headset to the computer to upload the file
3	Varjo XR-4 Focal Edition		Unity, Unreal Engine AR, OpenXR 1.0, Autodesk VRED, NVIDIA Omniverse AR workflows	FBX, OBJ, USD/USDA/USDC, GLTF/GLB		1. Install the latest Varjo Base driver software 2. Use the Varjo Unity or Unreal SDK 3. Prepare and optimize the file in a compatible format 4. Import 3D Model into Unity or Unreal 5. Install to Varjo XR-4 using USB connection

4	Meta Quest Pro	Mixed Reality (AR/VR)	SketchUp, SketchUp Viewer, Revit, Rhino, Navisworks, Prospect, Unity via OpenXR, Meta OpenXR and Oculus XR plugins	FBX, OBJ, IFC	Wired and wireless (USB and Air Link)	1. Prepare and optimize the file in a compatible format 2. Install Unity Hub 3. Install Oculus Integration SDK 4. Import the file from Unity to the headset 5. Install the Oculus XR Plugin 6. Enable Oculus for Android to run on Meta Quest
5	Meta Quest 3	Mixed Reality (AR/VR)	SketchUp Viewer, Ariko (works with Revit, Rhino, Unity, SketchUp)	FBX, OBJ, 3DS, C4D, MA, BLEND, GLTF, STL, and CAD-compatible formats (STEP, CATPART, SAT)	Wired and wireless (USB and Air Link)	1. Prepare and optimize the file in a compatible format 2. Use Model Viewer by SideQuest to view the model on the headset 3. Transfer the model to the device using SideQuest via the Model Viewer app or Blender via the SideQuest ModelViewer Blender addon

Chapter 6: Conclusion

6

6.1 Conclusion

Given that post-secondary students are more susceptible to stress and anxiety and often spend considerable time indoors during their studies (Lisnyj et al., 2021; Arshard et al., 2023), it is imperative to incorporate biophilic design elements into post-secondary classrooms. Existing research indicates that integrating specific biophilic features within indoor environments can substantially enhance users' well-being (Peters & D'Penna, 2020). Therefore, it is essential to foster connections with nature in educational settings, as this has been shown to improve students' cognitive functioning and satisfaction (Watchman et al., 2020). Additionally, a study involving middle school students revealed increased engagement and productivity in classrooms designed with biophilic elements (Watchman et al., 2021). Such findings endorse the use of nature-inspired materials, finishes, and forms, enhancing natural light exposure and greenery, and integrating operable windows with direct nature views within classrooms to elevate students' comfort levels.

The present study hypothesized that implementing biophilic design in studio classrooms would yield comparable beneficial effects on the well-being of post-secondary students as documented in prior research on hospitals, offices, and middle schools. The research questions investigated the importance and efficacy of incorporating biophilic design elements into post-secondary interior design studio classrooms, identified practical and efficient biophilic components suitable for these environments, explored how biophilic attributes can help lower stress among post-secondary design students, and evaluated the influence of demographic variables on students' stress levels within a biophilic-design-infused studio classroom.

The study employed a mixed-method approach, involving interior design students who participated in an augmented reality (AR) walkthrough of their existing studio classroom. Using the Microsoft HoloLens 2 AR headset to project the biophilic design proposal onto the current studio, participants (n=20) were asked to walk around the studio classroom and complete some of their daily tasks. Following their experience in the biophilic studio classroom, semi-structured interviews were conducted to explore each participant's perception of the virtual biophilic studio classroom in comparison to their existing studio classroom, which contains limited biophilic elements. A cognitive walkthrough was used to assess the practicality of specific features or strategies for target

users within a spatial context, where users are asked specific questions about their experiences and opinions in a particular location and setting (Lyon et al., 2021). Subsequently, an online follow-up survey was administered and completed by thirteen participants who also participated in the AR session and in-person interview. The follow-up survey was used to further assess their stress levels. The survey assessed stress levels on a 10-point scale, using both the current studio classroom and the biophilic studio classroom visualized through augmented reality (AR). Furthermore, participants were asked for their perspectives on allocating a portion of their tuition fees to support the integration of biophilic elements into their existing design studio classroom. Additionally, a secondary online survey was distributed to all registered interior design students at the University of Manitoba, with five participants completing it. This survey was utilized to collect additional demographic data and to assess how the current studio classroom configuration affects their comfort and stress levels in relation to a biophilic studio classroom environment.

The results from interviews and surveys were synthesized to analyze the effect of biophilic design on stress levels among interior design students who regularly use the design studio classroom. The participants' demographic characteristics were representative of typical interior design students who use studio classrooms. All were full-time students, predominantly female, aged 22 to 29, with most having used the studio for at least one year and the majority working part-time. According to interview responses, students who are not employed tended to experience lower stress levels than their counterparts who worked part-time. This difference is attributed to the additional social responsibilities faced by part-time working students and to the reduced time available for their academic tasks. Additionally, undergraduate interior design students reported higher stress levels than their graduate counterparts. The follow-up survey showed that both employed and not employed students reported lower average stress levels in the biophilic studio classroom than in the non-biophilic studio classrooms. Interestingly, employed students experienced a larger decrease in stress within the biophilic studio.

Participants expressed increased motivation to use a biophilic design studio classroom, with a mean rating of 8.4 out of 10 (n = 20), indicating a high level of motivation. Overall, individuals from various backgrounds agreed that engaging in a biophilic design studio environment can foster feelings of increased relaxation and reduced stress.

Their stress level evaluations on a 10-point scale showed that their average stress was lower in a biophilic studio classroom than in their existing studio classroom.

Furthermore, participants articulated their biophilic preferences, stating that these would enhance their comfort and reduce stress. Their preferences encompass the use of natural materials, finishes, and patterns; direct access to outdoor views and landscape; an abundance of daylight; and the display of real plants and greenery within the studio classroom environment. Participants agreed that these features could facilitate quick visual breaks from computer screens, thereby helping to reduce stress during the completion of demanding assignments and projects. Numerous studies support integrating features such as windows with direct outdoor views, ample natural light, indoor plants, and natural finishes and patterns in post-secondary educational institutions, as these elements have been shown to promote student well-being by increasing comfort and decreasing stress (Mahrous et al., 2022). The findings of this study align with those of Mahrous et al. (2022) and Watchman et al. (2020) in classroom settings, providing valuable guidance for designers seeking to develop effective biophilic post-secondary studio classrooms, while considering students' feedback and preferences concerning practical biophilic applications.

While the findings of beneficial impacts of biophilic design in studio classrooms align with previous research, several limitations of the current study must be recognized. These limitations include technical constraints such as limited resources for employing augmented reality (AR) within research frameworks, recently discontinued programs such as Visual Live and SketchUp Viewer on the Microsoft HoloLens 2 device, the availability of AR devices and research funding for different software subscriptions, as well as the extensive learning curve associated with developing and constructing software. The process is also notably time-consuming. Prolonged recruitment periods and a low response rate to online surveys limit the broader applicability of the data.

It is interesting to note that, despite students responding positively to the AR biophilic studio, they were reluctant to financially support it. In the study's follow-up survey, 69% of participants (n=13) expressed reluctance to allocate a portion of their tuition fees towards biophilic implementations. This reflects a general lack of awareness among designers and users regarding the significant benefits of biophilic design relative to the initial and ongoing costs of integrating natural elements (Sadick et al., 2023; Sholanke et al., 2024). These limitations often lead to

hesitation among organizations and individuals when considering adopting biophilic design across settings. Students consider tuition fees substantial and believe that the university should incorporate biophilic features within the studio classroom. They argue that the existing studio classroom environment requires enhancements to better cater to students' educational needs, focusing on functionality, accessibility, and aesthetics. Additionally, the university could benefit from biophilic applications, which may help it attain greater recognition and prominence from international organizations.

The present study emphasizes the impact of biophilic elements on post-secondary students, an area with limited scholarly exploration. Furthermore, it incorporates augmented reality (AR) technology, a methodology uncommon in design-based research, to explore innovative and cost-effective strategies for integrating biophilic elements into post-secondary educational settings and assessing their effects prior to implementation. The findings presented are preliminary and indicate that applying biophilic design in post-secondary studio classrooms is essential for enhancing students' learning experiences and overall well-being. Additional research is necessary due to the limited sample size employed in this study. Therefore, recruiting larger sample sizes in future investigations will enable the collection of more generalizable data concerning the impact of biophilic design on stress reduction among post-secondary students in design studio classrooms. Moreover, further research is essential to identify the most suitable AR technologies for design-based research.

Finally, it is crucial to emphasize that integrating biophilic design principles with innovative sustainable techniques is essential in post-secondary educational environments. The current study's findings indicate that such measures are both practical and beneficial for post-secondary interior design students, as they can significantly enhance their well-being.

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APPENDIX A: Interview Questions

Demographic Questions

1. What is your gender?
2. What is your age (in years)?
3. What level design student are you? (undergraduate or graduate)
4. How many years have you used a studio classroom as a student?
5. Are you currently employed?
6. If so, are you a full-time or part-time employee?
7. Are you a full-time or part-time student?

Body

Existing Studio Experience

8. How would you describe your current design studio classroom?
9. What brings you to use the design studio classroom?
10. How many days a week do you use the design studio classroom?
11. What activities or tasks do you usually do in the design studio classroom?
12. Where do you usually sit in the existing design studio classroom to work on the mentioned tasks?
13. How do you perform the mentioned tasks?
14. Do you feel motivated to work when you are in the current design studio classroom?
15. Can you relax in the current design studio classroom?
16. Do you feel anxious about coming to work in the design studio classroom?
17. If yes, on a scale of 1 to 10, 10 being the extremely stressed, how stressed do you feel working in the current design studio classroom?
18. Why do you think you feel this way?
19. How well do you think the classroom is organized?

20. On a scale of 1 to 10, 10 being the most satisfied, how satisfied are you with the current design studio classroom design/layout?
21. Why did you choose this rating?
22. How would you change the current classroom layout if you had a chance to redesign the classroom?
23. On a scale of 1 to 10, 10 being extremely motivated, how motivated would you feel to use a design studio classroom like the one experienced in the AR layout with biophilic characteristics?
24. Why did you choose this rating?

Biophilic Studio Experience

25. Where would you sit in the biophilic classroom to work on the mentioned tasks?
26. The biophilic design studio has several nature-based features. Imagine you were doing some of the tasks you mentioned before. In what way, if any, would any of the features impact the different tasks?
27. How different would working in the existing classroom be from the biophilic classroom you viewed in the AR?
28. Can you name one design characteristic that resonated with you from the design studio classroom AR experience?
29. From the AR experience, what biophilic features, whether similar or different from the ones presented, do you hope to have available in the design studio classroom you regularly use?
30. How do you think including more biophilic features in studio would affect your learning experience?

General

31. What would motivate you to work outside of the scheduled studio hours in the design studio classroom?
32. In your opinion, how can we, as designers, improve the learning experience of interior design students who regularly use design studio classrooms?

APPENDIX B: Online Follow-up Survey Questions

1. **On a scale of 1 to 10, how stressed would you feel in a biophilic studio classroom like the one you have previously viewed in the AR session? (1 being least stressed and 10 being most stressed)**

    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8
    - 9
    - 10

2. **The biophilic environment is (_____) to work in than the non-biophilic environment.**

    - **More stressful**
    - **Neutral/the same**
    - **Less stressful**

3. **If more stressful, then "why?" and "What features of the biophilic studio would contribute to your heightened stress?"**

4. **If neutral or the same, then "why?" and "What features of the biophilic studio would contribute to reducing your stress?"**

5. **If less stressful, then "why?" and "What features of the biophilic features would contribute to your lowered stress?"**

6. **Would you be open to paying fees as part of your tuition for biophilic elements shown in the AR simulation to be implemented in your current studio classroom?**

    - **Yes**
    - **No**

7. **If yes, then why?**

8. **If no, then why?**

APPENDIX C: Online ID General Survey Questions

1. **What is your gender?**
    - Male
    - Female
    - Non-binary
    - Prefer not to say
    - Prefer to self-identify as_____

2. **How old are you?**
    - Younger than 21
    - 22-29
    - 30-39
    - over 40
    - Prefer not to say

3. **What level design student are you?**
    - Undergraduate
    - Graduate

4. **How many years have you used a studio classroom as a student? (Specify the number of years)**

5. **Are you currently employed?**
    - Yes
    - No
    - Prefer not to say

6. **Are you a full-time or part-time employee?**

- Full-time employed (11-20 hours per week)
- Part-time employed (5-10 hrs per week)
- Prefer not to say
- Other

7. **Are you a full-time or part-time student?**
   - Full-time student
   - Part-time student
   - Prefer not to say

8. **How many days a week do you use the design studio classroom at the J. A. Russell building?**
   - Once
   - Twice
   - Three times
   - More than three times a week

9. **How many hours a day (on average) do you spend in the J. A. Russell design studio classroom?**
   - Less than one hour
   - One hour
   - Two hours
   - Three hours
   - More than three hours

10. **Do you feel encouraged to use the J. A. Russell design studio classroom?**
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

11. **On a scale of 1 to 5, how would you rate your satisfaction with the design studio classroom layout? (1 being extremely unsatisfied and 5 being extremely satisfied)**
    - 1 (extremely unsatisfied)
    - 2 (somewhat unsatisfied)
    - 3 (Neutral)
    - 4 (somewhat satisfied)
    - 5 (extremely satisfied)

12. **On a scale of 1 to 5, how would you rate your satisfaction with the design studio classroom design? (1 being extremely unsatisfied and 5 being extremely satisfied)**
    - 1 (extremely unsatisfied)
    - 2 (somewhat unsatisfied)
    - 3 (Neutral)
    - 4 (somewhat satisfied)
    - 5 (extremely satisfied)

13. **Do you find the design studio classrooms at the J. A. Russell building welcoming and open to all users?**
    - Yes
    - No
    - Maybe
    - No Opinion
    - I don’t know

14. **Do you think the design studio classroom at the J. A. Russell building inspires students when working on design projects?**
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

15. **Do you think the design studio classroom at the J. A. Russell building can be used to unwind and reflect?**
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

16. **On a scale of 1 to 5, how do you feel when working in the J. A. Russell building design studio classroom? (1 being extremely stressed and 5 being extremely calm)**
    - 1 (extremely stressed)
    - 2 (somewhat stressed)
    - 3 (Neutral)
    - 4 (somewhat calm)
    - 5 (extremely calm)

17. **Do you hope to have biophilic design features in the J. A. Russell design studio classroom?**
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

18. **Do you think biophilic design characteristics can be implemented in the existing J. A. Russell design studio classroom?**
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

19. **What biophilic design features do you hope to find at the J. A. Russell design studio classroom? (select all that apply)**
    - More windows
    - Skylights
    - Greenery
    - Organic geometry on materials and finishes
    - Natural materials (such as wood and bamboo)
    - Natural sounds
    - Natural scents
    - Outdoor views

20. **What do you like the most about the J. A. Russell design studio classroom? (open-ended)**

21. **What do you mostly dislike about the J. A. Russell design studio classroom? (open-ended)**

22. **If you wish to receive a summary of the study report, please provide your U of M email address below:**

APPENDIX D: Recruitment Email for AR Session and Interview

Email Subject: Recruiting Current Interior Design Students to Participate in an Augmented Reality Experience and Interview.

To all interior design students,

Hello, my name is Dima Eltourk. I'm a Master of Interior Design Student, supervised by Dr. Shauna Mallory-Hill (Associate Dean (Research). I am looking for participants in my study on the effects of biophilic studio design on the well-being of interior design students.

Participation in this study includes an augmented reality (AR) experience that will display a redesigned biophilic setting of the existing design studio classroom at the J. A. Russell building at the University of Manitoba, followed by a semi-structured interview. Each session takes approximately 60-90 minutes. Sessions can be scheduled at a mutually agreeable time, and all sessions must be completed by the end of October 2024. Participants will receive a $20 gift card.

To participate you must be a student enrolled in the Interior Environment Option (IEO-ED) or Master of Interior Design program, have used the design studio classes in the JAR building for at least a month, and be able to read and write in English. You may not participate in this study if you have a history of epilepsy, seizures, or motion sickness due to the use of an augmented reality headset which may cause the participant motion sickness or seizures.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus, and all data will be kept confidential by the research team.

If you wish to participate in this research or would like more information, please contact me through my UM email at eltourkd@myumanitoba.ca

Thank you for considering my request. I sincerely hope you will assist in taking part in this study.

Sincerely,

Dima Eltourk

Master of Interior Design Student (MID)

Follow-up information for participants who contact:

Thank you for your interest in participating in my study.

A consent form will be sent to your provided UM email address for signature. After I have received the signed consent form, a ~90-minute meeting will be scheduled between us based on our availability to perform the study at the J. A. Russell building.

Upon your permission and agreement in the consent form, during the augmented reality experience, I will be taking photographs of you while you are using the augmented reality headset without directly identifying you. Photographs will be used in my final thesis document. After completing the augmented reality experience, which will take approximately 10 minutes, I will conduct an interview with you which will take approximately 60 minutes right after the augmented reality experience, which will be recorded using a digital voice recorder application called Voice Memos on a password-protected iPhone upon your permission. Should you disagree, handwritten notes will be taken upon your consent instead.

The interview will include demographic questions, your opinion on the design characteristics experienced in the augmented reality headset, and your current personal experience, preferences, and expectations when using the design studio classrooms in the J. A. Russell building at the University of Manitoba.

Suppose you choose to participate in the augmented reality experience and interview. In that case, both activities must be completed on the same day through a pre-scheduled meeting by October 2024.

You will receive a $20 gift card from Tim Hortons on the same day of the pre-scheduled meeting, before starting with the augmented reality experience or participating in the interview and after signing the consent form. Whether you decide to continue or withdraw from the study, you will still receive the compensation mentioned above.

You may only participate once in the study.

APPENDIX E: Recruitment Email for Online Survey

Email Subject: Recruiting Current Interior Design Students to Participate in a Survey

To all interior design students,

Hello, my name is Dima Eltourk. I'm a Master of Interior Design Student, supervised by Dr. Shauna Mallory-Hill (Associate Dean (Research). I am looking for participants in my study on the effects of biophilic studio design on the well-being of interior design students.

To participate in the survey, you must be a student enrolled in the Interior Environment Option (IEO-ED) or Master of Interior Design program, have used the interior design studio classrooms at the J. A. Russell building for at least a month and be able to read and write in English.

The survey consists of completing a 10-minute online survey created on Microsoft Forms to ensure the security and privacy of your information. I will record all your identifying information (e.g. email) in a code book on an Excel sheet with its corresponding pseudonym (e.g. Participant's email address= Participant 1 =P1). This process will be applied due to the inclusion of open-ended questions, and the option to enter your UM email address if you decide to receive a copy of the survey report.

Before accessing the survey questions, a consent form must be agreed upon on the online survey link.

The questions will include demographic questions and your current experience and preferences in using the design studio classrooms in the J. A. Russell building at the University of Manitoba.

If you choose to participate in the online survey, it must be completed by November 2024.

You may only complete the online survey once.

The risks involved in this study will not be greater than what one might experience in the normal conduct of one's everyday life.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus, and all data will be kept confidential by the research team.

If you wish to participate in this research or would like more information, please contact me through my UM email at eltourkd@myumanitoba.ca

Thank you for considering my request. I sincerely hope you will assist in taking part in this study.

Sincerely,

Dima Eltourk

Master of Interior Design Student (MID)

APPENDIX F: Recruitment Email for Follow-up Survey

Email Subject: Invitation to Participate in a Follow-up Survey

Dear Participant,

I am inviting you to complete this follow-up online survey that is part of my thesis research project, supervised by Dr. Shauna Mallory-Hill (Associate Dean (Research). The project studies the effects of biophilic design studio classrooms on the stress levels of interior design students at the University of Manitoba. The research questions addressed are: Why is it important to include biophilic design attributes in post-secondary interior design studio classrooms? What biophilic design attributes are essential in interior design studio classrooms? How can biophilic attributes assist in reducing stress among post-secondary design students? Would demographic differences affect the students' stress levels when using a biophilic design studio classroom?

The survey consists of completing a 10-minute online survey created on Microsoft Forms to ensure the security and privacy of your information. I will record all your identifying information (e.g. email) in a code book on an Excel sheet with its corresponding pseudonym (e.g. Participant's email address; Participant 1 =P1). This process will be applied due to the inclusion of open-ended questions and the option to enter your UM email address if you decide to receive a copy of the survey report.

Before accessing the survey questions, a consent form must be agreed upon on the online survey link.

The questions will include questions about your stress levels when using a biophilic design studio classroom as the one previously viewed in the AR session.

If you choose to participate in the online survey, it must be completed by June 16, 2025, through the following link https://forms.office.com/r/A5y7bf5Au2?origin=lprLink.

You may only complete the online survey once.

The risks involved in this study will not be greater than what one might experience in the normal conduct of one's everyday life.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus, and all data will be kept confidential by the research team.

If you wish to participate in this research or would like more information, please contact me through my UM email at eltourkd@myumanitoba.ca

Thank you for considering my request. I sincerely hope you will assist in taking part in this study.

Sincerely,

Dima Eltourk

Master of Interior Design Student (MID)

APPENDIX G: Consent Form for AR Session and Interview

Project Title: Creating Biophilic Environments in Post-Secondary Design Studio Classrooms

Principal Investigator: Dima Eltourk, Master of Interior Design Student, eltourkd@myumanitoba.ca

Research Supervisor: Dr. Shauna Mallory-Hill, Associate Dean, Research, s.mallory-hill@umanitoba.ca

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The study seeks to examine the effects biophilic characteristics will have on the stress levels of post-secondary interior design students regularly using design studio classrooms at the University of Manitoba and recognize their preferences and needs in post-secondary design studio classrooms.

To participate you must be a student enrolled in the Interior Environment Option (IEO-ED) or Master of Interior Design program, have used the design studio classes in the JAR building for at least a month, and be able to read and write in English. You may not participate in this study if you have a history of epilepsy, seizures, or motion sickness due to the use of an augmented reality headset which may cause the participant motion sickness or seizures.

The maximum number of participants will be 20 participants. Eligible students will be selected on a first come first serve basis. Once the principal investigator receives the required number of participants from eligible students, the principal investigator will inform the remaining students who are still interested in participating, that they have received enough participants for the study.

Participation in this study includes an augmented reality experience that will display a redesigned biophilic setting of the existing design studio classroom at the J. A. Russell building at the University of Manitoba, followed by a semi-structured interview. Each session takes approximately 60-90 minutes.

The study will begin with the augmented reality experience which will take approximately 10 minutes. After completing the augmented reality experience, the principal investigator will conduct an interview which will take approximately 60 minutes right after the augmented reality experience, which will be recorded using a digital voice recorder application called Voice Memos on a password-protected iPhone upon your permission. Recording will begin once the principal investigator and participant are ready to begin with the interview questions. When the principal investigator asks all interview questions, the recording will stop. The audio recording will be used so that a transcript of the participant's answers can be produced through Microsoft 365 (word) to convert the interview audio to text using the transcribe function. The audio recordings will be shared from the audio recorder application to the principal investigator's UM email address, then saved on the UM-approved Teams cloud, and immediately deleted from the voice recording application after being saved. Later, the transcriptions will be coded to ensure participants' confidentiality.

Where participants choose not to be recorded, handwritten notes will be taken upon the participant's permission. Handwritten notes will be coded, and the pseudonym list will be transferred to a digital version on an Excel sheet and saved on a UM-approved Teams cloud. After the notes are transferred, hard copies will be safely shredded.

During the augmented reality experience, the principal investigator will photograph participants while they are using the augmented reality headset without directly identifying them. Photographs will be used in the final thesis document. Please select one of the options at the bottom of the form to indicate whether you agree or not to be photographed.

The principal investigator will be using Microsoft 365 (word) to convert the interview audio to text by uploading the audio file using the transcribe feature.

The risks involved in this study will not be greater than what one might experience in the normal conduct of one's everyday life. Participants with a history of epilepsy, seizures, or motion sickness are not eligible to participate due to the use of an augmented reality headset during the study, which may cause the participant to experience motion sickness or seizures.

Since motion sickness or seizures can be a potential risk to some participants, the augmented reality experience is short and will not exceed 10 minutes. Also, the experience will be stopped if the participant indicates they are feeling unwell.

Indirect benefits from this study will contribute to design knowledge and may result in considerations of new approaches to be addressed when designing post-secondary design studio classrooms.

Direct benefits may include the opportunity for participants to share their perspectives on the existing design studio classrooms they are currently using and allow them to share their ideas and preferences to enhance their learning experience in such learning environments.

The gathered data will be anonymized using codes to pertain to the privacy of the participants.

The principal investigator will record all participants' identifying information (e.g. name, email) in a code book on an Excel sheet with its corresponding pseudonym (e.g. John Doe = Participant 1 =P1) and save it on a UM-approved Teams cloud storage for the remainder of the research process which will continue till December 2025.

The principal investigator will be using direct quotes from the participants' responses during the interview process in the thesis document and future conferences and publications while keeping the participant's confidentiality using the pseudonym applied to each participant. While quotes will be directly taken from the interview transcript, the principal investigator will not be using any description, details, or identifying information that might expose specific individuals. Pseudonyms will be used in all subsequent reports, publications, or presentations of the study. The principal investigator will also be thematically coding the transcripts; as such, general statements about themes found in the interview data will be shared. For example, "all participants indicated that.....".

Each participant will receive a $20 gift card from Tim Hortons on the day of the experiment before starting with the augmented reality experience and participating in the interview and after signing the consent form. Whether the participant decides to continue or withdraw from the study, they will still receive the compensation mentioned above.

Participants can withdraw during or after the interview has been completed, by informing the principal investigator through the UM email address provided, that they wish to withdraw from the study. The deadline to withdraw is

February 2025. The principal investigator will erase/destroy all materials relating to that participant. Any analysis of the data will be reviewed to ensure that the participant's data is removed.

Once the augmented reality experience and interview are completed and transcripts are transferred to a document, the principal investigator will send the transcript to the participant for review and approval. They will be given 14 days from the day the document is shared through the UM email address to reply with comments or approval. The principal investigator will send a reminder email to the participant after 7 days, whether the participant responds or not, once the 14 days pass, data will be considered approved.

The results of the study will be part of my thesis research project, as part of the Master of Interior Design program completion requirements, that will be published on MSpace and distributed to the Faculty of Architecture, University of Manitoba.

Additionally, the data collected from the study will be published in conferences and publications beyond the completion of my thesis project.

Participants will be given the option to receive a one to two-page summary of the report by August 2025, sent through their UM email address. Please provide your UM email address at the bottom of the form if you are interested in receiving a copy of the study report.

Completed consent forms will be stored in Outlook and SharePoint, the password-protected, dual authentication, cloud storage, that is hosted by the University of Manitoba. The completed consent forms will be deleted by December 2025.

Similarly, all data collected for the study will be in Outlook and SharePoint, the password-protected, dual authentication, cloud storage, that is hosted by the University of Manitoba for the remainder of the research process which will continue to be stored before they are permanently deleted by December 2025.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional

responsibilities. You are free to withdraw from the study by February 2025, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.
The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.
This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Officer at 204-474-7122 or HumanEthics@umanitoba.ca. **A copy of this consent form has been given to you to keep for your records and reference.**

---------- Provide for Signatures as Required: ----------

Participant's Signature: _____ Date: _____

Researcher and/or Delegate's Signature: _____ Date: _____

---------- If interested in receiving a copy of the study report: ----------

Participant's UM email address: _____

Please select one of the options:

- ☐ I agree to be photographed during the study
- ☐ I do not agree to be photographed during the study

APPENDIX H: Consent Form for Online Survey

Project Title: Creating Biophilic Environments in Post-Secondary Design Studio Classrooms

Principal Investigator: Dima Eltourk, Master of Interior Design Student, eltourkd@myumanitoba.ca

Research Supervisor: Dr. Shauna Mallory-Hill, Associate Dean, Research, s.mallory-hill@umanitoba.ca

This consent form is only part of the process of informed consent. It should give you a basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The study seeks to examine the effects biophilic characteristics will have on the stress levels of post-secondary interior design students regularly using design studio classrooms at the University of Manitoba and recognize their preferences and needs in post-secondary design studio classrooms.

To participate you must be a student enrolled in the Interior Environment Option (IEO-ED) or Master of Interior Design program, who have used the design studio classroom at the J. A. Russell building for at least one month and can read and write in English.

The maximum number of participants will be 50 participants. Once the principal investigator receives the required number of responses from eligible students, the principal investigator will deny access to further participation.

The study will involve the participant completing a 10-minute online survey created on Microsoft Forms to ensure the security and privacy of information.

The principal investigator will record all participants' identifying information (e.g. email) in a code book on an Excel sheet with its corresponding pseudonym (e.g. Participant's email address = Participant 1 =P1) due to the inclusion of open-ended questions, and if the UM email address is provided to receive a copy of the survey report, participants will be directly identifiable. The information of the participants will only be shared between the principal investigator

and research supervisor and stored on an Excel sheet on a UM-approved Teams cloud storage for the remainder of the research process which will continue till December 2025.

The risks involved in this study will not be greater than what one might experience in the normal conduct of one's everyday life.

Indirect benefits from this study will contribute to design knowledge and may result in considerations of new approaches to be addressed when designing post-secondary design studio classrooms.

Direct benefits may include the opportunity for participants to share their perspectives on the existing design studio classrooms they are currently using and allow them to share their ideas and preferences to enhance their learning experience in such learning environments.

The data will be stored on Microsoft Forms using a UM account which will be accessible on the UM account folder by the principal investigator and research supervisor only.

Participants can withdraw at any point during the survey by not submitting the survey. If the participant decides to withdraw from the survey after submitting the form and have submitted their UM email address, they can email the principal investigator to ask to withdraw from the study. The withdrawal deadline is June 2025.

The survey results will be part of a thesis research project, as part of the Master of Interior Design program completion requirements, that will be published on MSpace and distributed to the Faculty of Architecture, University of Manitoba.

Additionally, the data collected from the study will be published in conferences and publications beyond the completion of my thesis project.

Participants will be given the option to receive a one to two-page summary of the report by August 2025, sent through their UM email address. Please provide your email address before submitting the survey if you are interested in receiving a copy of the study report.

Completed consent forms and survey results will be stored in Outlook and SharePoint, the password-protected, dual-authentication, cloud storage, that is hosted by the University of Manitoba. The completed consent forms and survey results will be deleted by December 2025.

Clicking "I agree" on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.
The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.
This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Officer at 204-474-7122 or HumanEthics@umanitoba.ca. **A copy of this consent form has been given to you to keep for your records and reference.**

APPENDIX I: Consent Form for Follow-up Survey

Project Title: Creating Biophilic Environments in Post-Secondary Design Studio Classrooms

Principal Investigator: Dima Eltourk, Master of Interior Design Student, eltourkd@myumanitoba.ca

Research Supervisor: Dr. Shauna Mallory-Hill, Associate Dean, Research, s.mallory-hill@umanitoba.ca

This consent form is only part of the process of informed consent. It should give you a basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The study seeks to examine the effects biophilic characteristics will have on the stress levels of post-secondary interior design students regularly using design studio classrooms at the University of Manitoba and recognize their preferences and needs in post-secondary design studio classrooms.

To participate you must be a student enrolled in the Interior Environment Option (IEO-ED) or Master of Interior Design program, who have used the design studio classroom at the J. A. Russell building for at least one month and can read and write in English.

The study will involve the participant completing a 10-minute online survey created on Microsoft Forms to ensure the security and privacy of information.

The principal investigator will record all participants' identifying information (e.g. email) in a code book on an Excel sheet with its corresponding pseudonym (e.g. Participant's email address = Participant 1 =P1) due to the inclusion of open-ended questions, and if the UM email address is provided to receive a copy of the survey report, participants will be directly identifiable. The information of the participants will only be shared between the principal investigator and research supervisor and stored on an Excel sheet on a UM-approved Teams cloud storage for the remainder of the research process which will continue till December 2025.

The risks involved in this study will not be greater than what one might experience in the normal conduct of one's everyday life.

Indirect benefits from this study will contribute to design knowledge and may result in considerations of new approaches to be addressed when designing post-secondary design studio classrooms.

Direct benefits may include the opportunity for participants to share their perspectives on the existing design studio classrooms they are currently using and allow them to share their ideas and preferences to enhance their learning experience in such learning environments.

The data will be stored on Microsoft Forms using a UM account which will be accessible on the UM account folder by the principal investigator and research supervisor only.

Participants can withdraw at any point during the survey by not submitting the survey. If the participant decides to withdraw from the survey after submitting the form and has submitted their UM email address, they can email the principal investigator to ask to withdraw from the study. The withdrawal deadline is June 2025.

The survey results will be part of a thesis research project, as part of the Master of Interior Design program completion requirements, that will be published on MSpace and distributed to the Faculty of Architecture, University of Manitoba.

Additionally, the data collected from the study will be published in conferences and publications beyond the completion of my thesis project.

Participants will be given the option to receive a one to two-page summary of the report by August 2025, sent through their UM email address. Please provide your email address before submitting the survey if you are interested in receiving a copy of the study report.

Completed consent forms and survey results will be stored in Outlook and SharePoint, the password-protected, dual-authentication, cloud storage, that is hosted by the University of Manitoba. The completed consent forms and survey results will be deleted by December 2025.

Clicking "I agree" on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Officer at 204-474-7122 or HumanEthics@umanitoba.ca. **A copy of this consent form has been given to you to keep for your records and reference.**

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