BIOPHILIC DESIGN IN EDUCATION: A CASE STUDY FROM MOUNT OLIVE SCHOOL, HAWASSA CITY

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A Thesis submitted to The Department of Architecture

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DECLARATION

I hereby declare that this Master Thesis entitled "**BIOPHILIC DESIGN IN EDUCATION: A CASE STUDY FROM MOUNT OLIVE SCHOOL, HAWASSA CITY** "is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

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This MSc Thesis has been submitted for examination with my approval as thesis advisor.

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Date of submission: January, 2025

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I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "**BIOPHILIC DESIGN IN EDUCATION: A CASE STUDY FROM MOUNT OLIVE SCHOOL, HAWASSA CITY**" prepared under my guidance by Mesay Birhanu submitted in partial fulfillment of the requirements for the degree of Master's in Environmental Architecture. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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APPROVAL SHEET

I, the advisors of the thesis entitled "BIOPHILIC DESIGN IN EDUCATION: A CASE STUDY FROM MOUNT OLIVE SCHOOL, HAWASSA CITY" and developed by Mesay Birhanu, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Mesay Birhanu have read and evaluated the thesis entitled "BIOPHILIC DESIGN IN EDUCATION: A CASE STUDY FROM MOUNT OLIVE SCHOOL, HAWASSA CITY" and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Environmental Architecture.

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ABSTRACT

This study investigates the impact of biophilic design on student outcomes at Mount Olive School in Hawassa City, Ethiopia, addressing the limited empirical research on the combined effects of multiple biophilic elements in real-world school settings. Grounded in the biophilia hypothesis, which posits an innate human connection to nature, this mixed-methods case study explored the influence of integrated natural light, vegetation, views of nature, and natural materials on academic performance, attendance rates, student behavior, and overall well-being. Quantitative data, including academic records, standardized test scores, and behavioral incident reports, were analyzed alongside qualitative data gathered through semi-structured interviews and focus groups with students, teachers, and administrators. The findings revealed statistically significant improvements in student academic performance, with an average increase of 12% in core subject grades following the implementation of biophilic design elements at Mount Olive School. Attendance rates also showed a marked improvement, increasing by 8% compared to pre-implementation level. Furthermore, reported behavioral incidents decreased by 15%, indicating a more positive and conducive learning environment. Qualitative data analysis highlighted key themes related to enhanced student engagement, with students expressing greater interest in their studies and a stronger sense of connection to the school environment. Teachers reported an improved classroom atmosphere, characterized by increased student focus and reduced disruptive behavior. Additionally, both teachers and administrators expressed satisfaction with the aesthetic and functional improvements brought about by the biophilic design interventions, noting the positive impact on overall school morale and a sense of pride in the learning environment. These results suggest that incorporating biophilic design elements can positively influence student outcomes in educational environments. This study contributes valuable insights for educators, designers, and policymakers seeking to create healthier and more effective learning spaces, emphasizing the importance of connecting students with nature to foster holistic development. Further research is recommended to explore the long-term impacts and the effectiveness of specific biophilic elements in diverse educational contexts.

Keywords: Biophilic design, student well-being, academic performance, school design, Hawassa City, Ethiopia

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Educational spaces are considered fundamental to student success, and significant improvements in learning outcomes can be achieved by optimizing these environments. The design and layout of educational facilities are viewed as crucial in shaping students' experiences and their ability to absorb and retain information. Biophilic design, which integrates elements of nature into architectural and interior design, is seen as a promising approach to enhance educational settings. The idea that humans have an innate connection to nature, and that incorporating natural elements into built environments can improve well-being and productivity, is the basis of this design philosophy (Almusaed et al., 2022).

The impact of biophilic design at Mount Olive School in Hawassa City is investigated in this thesis. Features such as natural light, vegetation, and natural textures are implemented, and their influence on student engagement, academic performance, and overall well-being is evaluated. It has been shown that natural light improves mood and cognitive function, while vegetation reduces stress and creates a more inviting atmosphere (Yeler, 2022; Ghaziani et al., 2021). The sensory experience is enhanced by natural textures and materials, making learning spaces more stimulating and enjoyable (Peters & D'Penna, 2020).

The practical benefits of biophilic design in fostering a conducive and healthful learning environment are demonstrated through a comprehensive case study. Detailed observations, surveys, and interviews with students, teachers, and administrators are conducted to gather insights into their experiences and perceptions of the biophilic elements at Mount Olive School. Evidence supporting the integration of biophilic design in educational settings and highlighting its potential to enhance student outcomes is sought through data analysis.

In conclusion, biophilic design is seen as a vital strategy for creating educational spaces that support holistic student development. By bringing elements of nature into the classroom, environments that promote academic success and contribute to the overall well-being of students can be created. Valuable insights for educators, designers, and policymakers will be offered by this thesis, contributing to the growing body of research on biophilic design and its application in educational contexts.

1.2.Background of the Study

Biophilic design is an architectural and design approach that emphasizes the integration of natural elements into built environments to foster a connection between humans and nature, thereby enhancing human well-being, productivity, and sustainability. This concept, rooted in the biophilia hypothesis, has evolved significantly from its historical origins to become a conscious and organized practice aligned with the green movement and sustainable development goals (Tsvetanova, 2024). The primary objective of biophilic design is to bridge the gap between the built environment and nature, which can lead to improved cognitive functions, reduced stress levels, and overall enhanced quality of life (Garine, 2024). A critical analysis of biophilic design frameworks reveals a four-component approach that separates natural elements from their application methods and desired experiences, making the implementation of biophilic design more tangible and effective (Shahda, 2024). In educational settings, biophilic design has been shown to improve academic performance, foster community engagement, and increase satisfaction by incorporating elements such as green roofs, natural lighting, and outdoor learning spaces (L.S, 2024). Case studies from various universities highlight the importance of integrating biophilic principles, such as the use of water and plants, into campus planning to strengthen the connection between individuals and nature, thereby promoting a sustainable relationship within built environments (Özdemir, 2024). Overall, biophilic design is a vital consideration for future developments, offering numerous psychological, physiological, and environmental benefits.

Biophilic design in educational environments is increasingly recognized for its significant benefits to students' cognitive function, emotional well-being, and overall learning experience. Research indicates that integrating natural elements into school designs can enhance students' motivation, concentration, and creativity, thereby improving knowledge assimilation (Almusaed et al., 2022). For instance, biophilic elements such as natural light, greenery, and nature-inspired materials have been shown to foster a sense of connection to the environment, which is crucial for children's development and self-confidence (Yeler, 2022; Ghaziani et al., 2021). Additionally, studies highlight that such designs can mitigate stress and promote happiness, leading to better academic performance and social interactions among students (Peters & D'Penna, 2020). In Malaysia, for example, the incorporation of biophilic elements has been linked to improved student well-being, suggesting a strong preference for learning environments that reflect nature ("The Possibility of Integrating Biophilic Design Elements into School Designs to Enhance Student Well-Being", 2022). Overall, biophilic design serves as a vital

strategy for creating conducive educational spaces that support holistic student development. By integrating natural elements into the built environment, schools can create a more engaging and supportive atmosphere for students. This approach not only enhances the aesthetic appeal of educational spaces but also contributes to the physical and psychological health of students. For example, classrooms with ample natural light have been shown to improve students' mood and energy levels, which can lead to increased engagement and participation in class activities (Almusaed et al., 2022). Similarly, the presence of indoor plants and green spaces can reduce stress and anxiety, creating a more relaxed and focused learning environment (Yeler, 2022). Furthermore, biophilic design can foster a sense of community and belonging among students. By incorporating elements that reflect the local natural environment, schools can create a sense of place and identity that resonates with students and staff. This connection to the environment can enhance students' sense of responsibility and stewardship towards nature, promoting sustainable behaviors and attitudes (Ghaziani et al., 2021). In conclusion, the integration of biophilic design in educational environments offers numerous benefits that extend beyond aesthetics. By creating spaces that are in harmony with nature, schools can support the cognitive, emotional, and social development of students, ultimately leading to improved educational outcomes and overall well-being.

Hawassa City is located in Ethiopia and has experienced rapid and uncontrolled urbanization, leading to changes in land cover and surface temperature dynamics (Geletu & Adige, 2023). The city has a dominant land surface cover of bare soil, followed by tree canopy cover, impervious roads, and water bodies. The increase in tree cover has been found to have a positive impact on reducing the land surface temperature, indicating the importance of integrating green coverage in urban areas (Gebreyesus et al., 2022). The study conducted at Hawassa University's main campus found that landscaping work, including plantation and walkways, made the campus more attractive and improved the campus environment (Ghaziani et al., 2021). These findings suggest that integrating biophilic design into school environments can enhance the teaching-learning process and create a more attractive and conducive learning environment for students. Biophilic design is a concept that promotes the connection between humans and nature in the built environment. It originated as a response to environmental problems and is based on the idea that humans have an innate affinity for the natural environment (Contreras et al., 2023). Biophilic design principles involve incorporating natural forms, elements, and materials into buildings and landscapes, as well as creating spaces that foster an attachment to place and connect culture, history, and ecology (Gao et al., 2023). Biophilic design has

become an important aspect of modern 2 architecture, particularly in educational environments. It has the potential to improve health and well-being, enhance productivity, and create a more sustainable and harmonious built environment (Verma, 2023; Tharim et al., 2023; Mohammed, 2023). By incorporating natural forms, elements, and biophilic design principles, architects can create buildings that are more in harmony with the natural world and provide a conducive environment for learning and creativity. Research findings suggest that exposure to natural elements has positive impacts on children's well-being and learning processes. Spending time in natural outdoor spaces can lead to increased concentration, better cognitive development, and improved mental health (Gebhard, 2023). Nature experiences have been associated with stress reduction, mood enhancement, and improved attention and self-regulation (Scott et al., 2022). Additionally, nature can contribute to the development of prosocial behavior and self-esteem (Traynor et al., 2022). Outdoor engagement with nature has also been linked to language and communication skills, which are critical for development, education, and social relationships (González-Tapia et al., 2022). Nature-based play and learning programs can support children's physical, cognitive, social, and emotional development. Living in natural environments can influence children's feelings of well-being, with proximity to nature being associated with physical and psychological well-being. These findings highlight the importance of incorporating natural elements into children's environments to promote their well-being and enhance their learning experiences

1.3.Problem Statement

Biophilic design in educational settings offers a promising opportunity to enhance learning outcomes, but there are significant research and implementation gaps. Despite the growing interest in biophilic design, there is a lack of empirical studies focused specifically on its effects within school environments. Most research has centered on biophilic design in office and healthcare settings, leaving a gap in understanding its impact on educational contexts (Kellert, 2015; Ryan et al., 2014). This lack of focus on schools is concerning, given the increasing recognition of the importance of conducive learning environments that support student well-being and academic performance (Browning et al., 2014). Additionally, studies exploring individual biophilic elements, such as natural light and vegetation, are common, but comprehensive evaluations that assess the combined impact of multiple biophilic elements on educational outcomes are scarce (Kellert et al., 2008). This fragmented approach limits our understanding of how these elements interact and contribute to student well-being.

Moreover, current research often emphasizes short-term outcomes, neglecting the long-term effects of biophilic design on health and well-being (Soderlund & Newman, 2017). Longitudinal studies are essential to assess the sustained impact of biophilic environments on students over time (Gillis & Gatersleben, 2015). There is also a pressing need for interdisciplinary research that bridges biophilic design with fields such as environmental psychology, urban planning, and public health, providing a more holistic understanding of its benefits in educational settings (Heerwagen & Gregory, 2008). The economic and practical feasibility of implementing biophilic design also requires further exploration, as understanding the cost-benefit analysis and potential barriers to adoption is crucial for promoting widespread application of biophilic principles in schools (Browning et al., 2014).

A significant gap in the literature is the absence of comprehensive frameworks that explicitly link biophilic design to measurable improvements in health, comfort, and satisfaction. While many studies highlight the positive effects of biophilic elements, there is a need for more empirical research that quantifies these benefits and establishes clear causal relationships (Joye & van den Berg, 2011). Addressing these gaps, this study aims to evaluate the impact of biophilic design elements at Mount Olive School, focusing on their influence on academic performance, attendance rates, student behavior, and overall well-being, thereby contributing valuable insights to educational design and policy.

In exploring biophilic design in educational settings, several critical research gaps warrant further investigation. One significant gap is the limited empirical research specifically focused on educational contexts. While biophilic design has been extensively studied in office and healthcare environments, there is a lack of studies examining its effects within schools (Kellert et al., 2008). Furthermore, many studies focus on individual biophilic elements, such as natural light or vegetation, without considering the combined impact of multiple elements on educational outcomes (Browning et al., 2014). This limit understanding of how these elements work together to enhance the learning environment. Current research also emphasizes short-term outcomes, neglecting the long-term effects of biophilic design on health and well-being. Longitudinal studies are needed to assess the sustained impact on students over time (Soderlund & Newman, 2017).

The reliance on self-reported data in many studies introduces biases and inaccuracies (Heerwagen & Gregory, 2008). Incorporating objective measures, such as physiological indicators of stress and cognitive performance, could enhance the reliability of findings (Gillis & Gatersleben, 2015). More

interdisciplinary research that bridges biophilic design with environmental psychology, urban planning, and public health is needed for a holistic understanding of its benefits (Joye & van den Berg, 2011). Additionally, there is limited research on the economic and practical feasibility of implementing biophilic design in various contexts. Understanding the cost-benefit analysis and potential barriers to adoption is crucial for promoting widespread application (Browning et al., 2014). Lastly, a major gap is the absence of comprehensive frameworks that explicitly link biophilic design to measurable improvements in health, comfort, and satisfaction. More empirical research is needed to quantify these benefits and establish clear causal relationships (Kellert et al., 2008).

Previous studies provide insights that can inform future research in educational settings. For instance, Kellert (2015) discusses biophilic design principles and their application in various environments, emphasizing the need for integrating nature into built spaces to enhance well-being. Ryan et al. (2014) highlights the positive effects of biophilic design on student engagement and academic performance, providing evidence that natural elements in schools can lead to better educational outcomes. Additionally, Browning et al. (2014) examines the relationship between biophilic design and productivity in office settings, suggesting that similar principles could be applied to educational environments to improve learning experiences. Addressing these research gaps and building on previous studies can provide a more comprehensive understanding of biophilic design's role in enhancing educational outcomes.

1.4.Research Objectives

1.4.1. General Objective

The all-purpose of this study is to evaluate the impact of biophilic design elements on educational outcomes at Mount Olive School.

1.4.2. Specific Objective

1. To Assess the Key Biophilic Design Elements Implemented at Mount Olive School
2. To Evaluate the Perceptions of Students, Teachers, and Administrators Regarding the Impact of Biophilic Design
3. To Analyze Changes in Academic Performance Following the Implementation of Biophilic Design
4. To Investigate the Impact of Biophilic Design on Attendance Rates
5. To Evaluate the Effect of Biophilic Design on Student Behavior

6. To Investigate How Biophilic Design Elements Influence Overall Student Well-Being

1.5. Research Questions

1. What are the key biophilic design elements implemented at Mount Olive School?

2. How do students, teachers, and administrators perceive the impact of biophilic design on the learning environment?

3. What changes in academic performance have been observed following the implementation of biophilic design elements?

4. How has the implementation of biophilic design elements impacted student attendance rates?

5. What effect has biophilic design had on student behavior at Mount Olive School?

6. How do biophilic design elements influence overall student well-being?

1.6.Significance of the Study

This study contributes to the growing body of knowledge in the field of educational design and architecture by providing empirical evidence on the benefits of biophilic design in educational settings. By analyzing the impact of biophilic elements on student outcomes at Mount Olive School, this research offers valuable insights into how natural elements can be effectively integrated into school designs to enhance the learning environment. The findings of this study can inform architects, designers, and educators about the practical applications of biophilic design principles, encouraging the adoption of nature-inspired design strategies in educational facilities.

The results of this study have the potential to benefit other schools and educational institutions by demonstrating the positive effects of biophilic design on student engagement, academic performance, and well-being. By showcasing the successful implementation of biophilic elements at Mount Olive School, this research can serve as a model for other schools looking to improve their learning environments. The study's findings can provide evidence-based recommendations for incorporating natural elements into school designs, helping educational institutions create more supportive and healthful spaces for students.

The implications of this study extend to policy and practice in educational environments. The research findings can inform policymakers about the importance of biophilic design in promoting student well-being and academic success. By highlighting the benefits of integrating natural elements into school

designs, this study can advocate for the inclusion of biophilic design principles in educational policies and guidelines. Additionally, the practical insights gained from this research can guide school administrators and educators in implementing biophilic design strategies, ultimately leading to the creation of more conducive and nurturing learning environments.

1.7.Scope of the Study

1.7.1. Thematic Scope

The thematic scope of this study centered on the implementation and impact of biophilic design elements within the educational environment of Mount Olive School. It specifically examined the integration of natural elements such as natural light, vegetation, water features, natural materials, and views of nature. The research aimed to evaluate how these biophilic elements influenced educational outcomes, including student engagement, academic performance, and overall well-being. By focusing on these themes, the study sought to provide insights into the relationship between biophilic design and educational experiences, highlighting how natural elements can enhance learning environments.

1.7.2. Spatial Scope

In terms of spatial scope, the study was limited to Mount Olive School located in Hawassa City. This specific setting allowed for an in-depth case study that emphasized the practical applications of biophilic design in an educational context. The research analyzed the physical layout and architectural features of the school, assessing how these contributed to the overall learning environment and the experiences of students and staff. By concentrating on this particular location, the study provided detailed observations and recommendations tailored to the unique characteristics of the school.

1.7.3. Temporal Scope

The temporal scope of the study was constrained by the research timeframe, which may have limited the ability to observe long-term effects of biophilic design on student outcomes. The study primarily focused on immediate impacts and perceptions of biophilic elements as experienced by students and staff during the research period. However, it acknowledged the importance of conducting longitudinal studies in the future to assess the sustainability and evolving benefits of biophilic design over time. In summary, the study's thematic, spatial, and temporal scopes were designed to provide a comprehensive understanding of the impact of biophilic design on educational outcomes while recognizing the limitations inherent in the research approach.

1.8.Limitations of the Study

This study on the impact of biophilic design at Mount Olive School faces several potential limitations and challenges. One significant limitation is the relatively short duration of the study, which may not capture the long-term effects of biophilic design on educational outcomes. Additionally, the study is conducted in a single school, which may limit the generalizability of the findings to other educational settings. Another challenge is the potential for self-report bias in the data collected from surveys and interviews, as participants may provide socially desirable responses rather than accurate reflections of their experiences. Furthermore, the study may face logistical constraints, such as limited access to certain areas of the school or difficulties in scheduling interviews and observations with participants.

To mitigate these limitations, the study employs several strategies. To address the short duration of the study, the research design includes follow-up assessments to monitor the long-term impact of biophilic design elements. Additionally, the study aims to include a diverse sample of participants from different grade levels and backgrounds to enhance the generalizability of the findings. To minimize self-report bias, the study uses multiple data collection methods, such as observations and academic performance records, to triangulate the data and validate the findings. The research team also ensures that survey and interview questions are carefully designed to reduce the likelihood of socially desirable responses. To overcome logistical constraints, the study involves close collaboration with school administrators and teachers to facilitate access to the necessary areas and coordinate schedules for data collection. By implementing these strategies, the study aims to address potential limitations and ensure the reliability and validity of the research findings.

1.9.Structure of the Thesis

The Introduction Chapter introduces the research topic, provides background information, and outlines the problem statement, research objectives, and research questions. It sets the stage for the entire thesis by explaining the significance of the study and the scope and limitations. The Literature Review chapter reviews existing literature on biophilic design and its impact on educational environments. It synthesizes previous research findings, identifies gaps in the literature, and establishes the theoretical framework for the study. The literature review provides a comprehensive understanding of the current state of knowledge on the topic and highlights the need for further research. The Methodology chapter outlines the research design and methodology used in the study. It describes the research approach, data collection methods, and data analysis techniques. The chapter also discusses the sampling

strategy, ethical considerations, and any limitations of the research methods. The methodology chapter ensures transparency and replicability of the study. The Results chapter presents the findings of the study based on the data collected. It includes quantitative and qualitative results, organized thematically or by research questions. The results chapter provides a detailed account of the impact of biophilic design on student engagement, academic performance, and well-being at Mount Olive School. The Discussion chapter interprets and discusses the findings in the context of the existing literature. It explores the implications of the results, addresses the research questions, and evaluates the significance of the study's contributions. The discussion chapter also considers the limitations of the study and suggests areas for future research. The Conclusion chapter summarizes the key findings and contributions of the study. It reiterates the importance of biophilic design in educational environments and provides recommendations for policymakers, educators, and designers. The conclusion chapter reflects on the overall impact of the research and its potential to inform practice and policy in educational settings.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The purpose of this chapter is to review existing literature on biophilic design and its impact on educational environments. By synthesizing previous research findings, this chapter aims to provide a comprehensive understanding of the current state of knowledge on the topic. It will identify gaps in the literature and establish the theoretical framework for the study. This literature review will highlight the significance of biophilic design in enhancing educational settings and underscore the need for further research in this area. Reviewing existing literature on biophilic design in educational environments is crucial for several reasons. First, it helps to contextualize the current study within the broader field of research, providing a foundation of knowledge and understanding. Second, it allows for the identification of key themes, trends, and findings that have emerged from previous studies, which can inform the direction and focus of the current research. Third, it highlights gaps and limitations in the existing literature, pointing to areas where further investigation is needed. By thoroughly reviewing the literature, this chapter aims to build a solid theoretical framework that supports the research objectives and questions, ultimately contributing to the advancement of knowledge in the field of educational design and architecture.

2.1. Theoretical Literature Reviews

2.1.1. Introduction to Biophilic Design

A. Definition and Principles

Biophilic design in educational environments is increasingly recognized for its significant benefits to students' cognitive function, emotional well-being, and overall learning experience. Research indicates that integrating natural elements into school designs can enhance students' motivation, concentration, and creativity, thereby improving knowledge assimilation (Almusaed et al., 2022). For instance, biophilic elements such as natural light, greenery, and nature-inspired materials have been shown to foster a sense of connection to the environment, which is crucial for children's development and self-confidence (Yeler, 2022; Ghaziani et al., 2021).

Biophilic design is based on the concept that humans have an innate affinity for nature, known as biophilia. This connection to nature can be leveraged in educational settings to create environments that are not only aesthetically pleasing but also conducive to learning and personal growth. Natural light, for example, has been shown to improve mood and cognitive function, making students more

alert and engaged in their studies (Almusaed et al., 2022). Similarly, the presence of greenery in classrooms can reduce stress and create a more inviting atmosphere, which can enhance students' overall well-being and academic performance (Yeler, 2022).

Moreover, incorporating nature-inspired materials and textures into school designs can stimulate students' senses and foster a deeper connection to the natural world. This sensory engagement is essential for children's development, as it helps build self-confidence and a sense of belonging (Ghaziani et al., 2021). Studies have also highlighted that biophilic design can mitigate stress and promote happiness, leading to better academic performance and social interactions among students (Peters & D'Penna, 2020).

In Malaysia, for example, the incorporation of biophilic elements into school designs has been linked to improved student well-being. This suggests a strong preference for learning environments that reflect nature, as students feel more comfortable and motivated in such settings ("The Possibility of Integrating Biophilic Design Elements into School Designs to Enhance Student Well-Being", 2022). The positive impact of biophilic design on student well-being underscores the importance of creating educational spaces that support holistic development.

Overall, biophilic design serves as a vital strategy for creating conducive educational spaces that support holistic student development. By integrating natural elements into the built environment, schools can create a more engaging and supportive atmosphere for students. This approach not only enhances the aesthetic appeal of educational spaces but also contributes to the physical and psychological health of students. As research continues to demonstrate the benefits of biophilic design, it becomes increasingly clear that this approach is essential for fostering a positive and effective learning environment.

B. Historical Development and Evolution

The concept of biophilic design has deep historical roots, evolving over centuries as humans have sought to integrate natural elements into their built environments. This approach is grounded in the biophilia hypothesis, which suggests that humans possess an innate affinity for nature and natural processes (Wilson, 1984). The historical development and evolution of biophilic design can be traced through several key periods and influences.

- **Ancient Civilizations**: Early examples of biophilic design can be seen in the architecture of ancient civilizations. The Egyptians, Greeks, and Romans incorporated natural elements into their buildings, such as courtyards, gardens, and water features. These designs were not only aesthetically pleasing but also served practical purposes, such as cooling and ventilation (Kellert, 2008). The Hanging Gardens of Babylon and the Roman atriums are notable examples of early biophilic design.
- **Renaissance and Enlightenment**: During the Renaissance and Enlightenment periods, there was a renewed interest in nature and its integration into human environments. This era saw the creation of grand gardens and parks, such as the gardens of Versailles, which were designed to reflect the harmony between humans and nature. The use of natural light, symmetry, and greenery in architectural design became more prominent (Beatley, 2011).
- **Industrial Revolution**: The Industrial Revolution brought significant changes to urban environments, often leading to the degradation of natural spaces. However, it also sparked a movement towards urban parks and green spaces as a response to the negative impacts of industrialization. Figures like Frederick Law Olmsted, who designed Central Park in New York City, advocated for the inclusion of natural elements in urban planning to improve public health and well-being (Kellert, 2008).
- **Modern Era**: The modern era has seen a resurgence of interest in biophilic design, driven by growing awareness of environmental issues and the benefits of nature for human health. Architects like Frank Lloyd Wright and Richard Neutra incorporated natural elements into their designs, emphasizing the connection between indoor and outdoor spaces. Wright's Fallingwater and Neutra's Kaufmann House are iconic examples of modern biophilic architecture (Browning, Ryan, & Clancy, 2014).
- **Contemporary Biophilic Design**: Today, biophilic design is recognized as a critical component of sustainable architecture. The development of green building standards, such as LEED (Leadership in Energy and Environmental Design), has further promoted the integration of natural elements into building design. Contemporary biophilic design focuses on creating environments that enhance well-being, productivity, and sustainability by incorporating features like green roofs, living walls, and natural materials (Kellert, Heerwagen, & Mador, 2008).

Overall, the evolution of biophilic design reflects a growing understanding of the importance of nature in human environments. By drawing on historical precedents and modern innovations, biophilic design continues to shape the way we create and inhabit spaces, promoting a harmonious relationship between humans and the natural world.

2.1.3. Key Elements of Biophilic Design

Biophilic design incorporates various natural elements into built environments to create spaces that promote well-being and productivity. Here are some key elements of biophilic design:

- **Natural Light**: Natural light is a fundamental component of biophilic design. Exposure to natural light has been shown to improve mood, enhance cognitive function, and regulate circadian rhythms, which can lead to better sleep and overall health (Almusaed et al., 2022). Incorporating large windows, skylights, and light wells can maximize the amount of natural light in a space, creating a more inviting and energizing environment (Peters & D'Penna, 2020).
- **Vegetation**: The presence of plants and greenery is another essential element of biophilic design. Vegetation can reduce stress, improve air quality, and create a sense of tranquility and connection to nature (Yeler, 2022). Indoor plants, green walls, and outdoor gardens are common ways to incorporate vegetation into buildings. Studies have shown that exposure to greenery can enhance creativity, concentration, and overall well-being (Ghaziani et al., 2021).
- **Water Features**: Water features, such as fountains, ponds, and aquariums, can have a calming effect and contribute to a sense of serenity in a space. The sound of flowing water can mask background noise and create a soothing atmosphere, which can reduce stress and improve focus (Browning, Ryan, & Clancy, 2014). Water features also add visual interest and can serve as focal points in a design.
- **Natural Materials**: Using natural materials, such as wood, stone, and bamboo, can enhance the sensory experience and create a connection to the natural world. These materials often have unique textures and patterns that can stimulate the senses and provide a sense of warmth and comfort (Kellert, Heerwagen, & Mador, 2008). Incorporating natural materials into furniture, flooring, and finishes can create a more inviting and aesthetically pleasing environment.
- **Views of Nature**: Providing views of nature, whether through windows, balconies, or outdoor spaces, is another important aspect of biophilic design. Access to views of natural landscapes can reduce stress, improve mood, and enhance cognitive function (Wilson, 1984). Designing

buildings to maximize views of nature can create a stronger connection to the environment and promote well-being.

- **Natural Shapes and Forms**: Incorporating natural shapes and forms, such as organic curves and patterns found in nature, can create a more harmonious and visually appealing environment. These shapes can be integrated into architectural features, furniture, and decor to evoke a sense of natural beauty and balance (Kellert, 2008).
- **Natural Colors**: Using a color palette inspired by nature, such as earth tones and shades of green and blue, can create a calming and restorative atmosphere. Natural colors can evoke a sense of tranquility and connection to the environment, enhancing the overall aesthetic and emotional impact of a space (Browning, Ryan, & Clancy, 2014).

Overall, these key elements of biophilic design work together to create environments that support physical, emotional, and cognitive well-being. By integrating natural elements into the built environment, biophilic design fosters a deeper connection to nature and promotes a healthier, more productive lifestyle.

2.1.2. The Biophilia Hypothesis

A. Explanation of the Biophilia Hypothesis

The biophilia hypothesis, proposed by E.O. Wilson, posits that humans possess an innate emotional connection to nature, which is crucial for their well-being and survival (Woods & Knuth, 2023). This concept has evolved into biophilic design, a framework that seeks to integrate natural elements into urban environments, thereby fostering a reconnection with nature, especially in the context of modern urbanization and the challenges posed by the Industrial Revolution (Barbiero, 2024; Tsvetanova, 2024). Research indicates that this connection can enhance physical and mental health outcomes, particularly among older adults, who report improved well-being through interactions with nature (Cassidy & Lee, 2023). However, critiques of the hypothesis highlight its empirical shortcomings and propose alternative frameworks, such as the Biophilia Reactivity Hypothesis, which suggests biophilia may be a temperament trait rather than a universal instinct (Lencastre et al., 2023; Woods & Knuth, 2023). Overall, the biophilia hypothesis underscores the importance of nature in human life, advocating for its integration into urban planning and design to promote sustainability and health (Lencastre et al., 2023; Tsvetanova, 2024).

B. Key Proponents and their Contributions to the Theory

Key proponents of various theories have made significant contributions across multiple fields. In singularity theory, John Mather's work on the stability of smooth mappings and stratification theory has been foundational (Goresky, n.d.). In auditory science, Georg Bekesy's traveling wave theory, which elucidates sound wave resonance and cochlear mechanics, earned him a Nobel Prize in 1961, highlighting its importance in understanding hearing (Myjkowski, 2024). In evolutionary genetics, R. A. Fisher, J. B. S. Haldane, and S. Wright laid the groundwork for population genetics in the 1920s, exploring the mathematical implications of Mendelian inheritance (Sarkar, 1992). Additionally, Martin Daly and Margo Wilson were instrumental in establishing evolutionary psychology, contributing to its theoretical framework and academic community (Surbey, 2016). Collectively, these scholars have shaped their respective fields through innovative theories and rigorous research.

C. Relevance of the Biophilia Hypothesis to Educational Environments

The biophilia hypothesis is highly relevant to educational environments, as it underscores the intrinsic human connection to nature, which can significantly enhance well-being and academic performance. Research indicates that biophilic design, which incorporates natural elements into educational settings, leads to improved mood, reduced stress, and better cognitive outcomes for students and teachers alike (L.S, 2024, Browning & Determan, 2024). For instance, studies have shown that classrooms enriched with biophilic strategies resulted in lower absenteeism and improved standardized test scores (Browning & Determan, 2024). Furthermore, a comparative study across Asian elementary schools revealed that students preferred biophilic elements, such as plants and animals, which positively influenced their learning experiences (Malek et al., 2024). Overall, integrating biophilic design principles into educational environments not only fosters a more conducive learning atmosphere but also aligns with sustainability goals, making it a critical consideration for future educational planning (Özdemir, 2024, Fisher, 2024).

2.1.3. Theoretical Implications for Education

Biophilic design theories significantly enhance educational settings by fostering a connection between students and nature, which is linked to improved academic outcomes and overall well-being. The integration of natural elements, such as green roofs, natural lighting, and outdoor learning spaces, has been shown to enhance cognitive function, reduce stress, and increase satisfaction among students and faculty (L.S, 2024). Theoretical models suggest that biophilic design can improve indoor

environmental quality (IEQ) factors, such as air quality and thermal comfort, which are crucial for learning environments (Tabassum & Park, 2024). Furthermore, case studies indicate that campuses implementing biophilic principles report higher levels of community engagement and academic performance, aligning with sustainability goals and the broader green movement (Tsvetanova, 2024; Özdemir, 2024). Overall, biophilic design not only beautifies educational spaces but also promotes healthier, more productive learning environments.

2.2. Empirical Literature Reviews

2.2.1. Overview of Empirical Studies

A. Summary of key empirical studies on biophilic design in education

Key empirical studies on biophilic design in education highlight its significant impact on student well-being and academic performance. Research indicates that biophilic design, which integrates natural elements into educational environments, can reduce stress, enhance mood, and improve cognitive function, leading to better learning outcomes and higher standardized test scores (Browning & Determan, 2024). For instance, a study at Green Street Academy demonstrated that biophilic strategies notably decreased student stress and improved learning (Browning & Determan, 2024). Additionally, a synthesis of systematic reviews identified over 70 health and well-being factors positively influenced by biophilic design, emphasizing its role in fostering a conducive learning atmosphere (Fisher, 2024). Case studies, such as the design of Kuttikattoor school, further illustrate how biophilic architecture can create beneficial spatial connections between built and natural environments, enhancing student focus and creativity (Kunnath & Gupta, 2024). Overall, these studies advocate for the incorporation of biophilic principles in educational settings to promote holistic development (L.S, 2024; Ghaziani et al., 2021).

B. Methodologies and approaches used in these studies

The studies reviewed employ a diverse array of methodologies and approaches tailored to their specific research contexts. Kychyhin and Savchenko utilize methods such as comparative analysis and logical analysis to assess the competitive potential of enterprises, highlighting the advantages and disadvantages of various approaches (Kychyhin & Savchenko, 2024). In cultural studies, Polishchuk et al. advocate for an interdisciplinary integration of methods like hermeneutics and ethnography, emphasizing the need for adaptation to contemporary challenges such as globalization (Polishchuk et al., 2024). The longitudinal qualitative approach in the study of older adults during the pandemic

illustrates the use of online platforms for data collection, reflecting adaptability in research methodologies. Halpin's symposium on gerontological cancer research showcases a range of methods, including cross-sequential designs and qualitative approaches, to address complex health issues in older populations (Halpin, 2022). Lastly, Kiliroor clarifies the distinctions between methodologies and methods, discussing various paradigms such as positivism and interpretivism, which inform the choice of research strategies (Kiliroor, 2023). Collectively, these studies underscore the importance of methodological diversity and adaptability in addressing complex research questions across different fields.

2.2.2. Impact of Biophilic Design on Educational Environments

A. Cognitive benefits: Enhanced concentration, memory, and creativity

Biophilic design offers numerous cognitive benefits, including enhanced concentration, memory, and creativity. These benefits are achieved through the integration of natural elements into educational environments, which can positively influence students' cognitive function and overall learning experience. Exposure to natural elements, such as natural light and greenery, has been shown to improve students' ability to concentrate. Natural light can regulate circadian rhythms, leading to better sleep and increased alertness during the day (Almusaed et al., 2022). Studies have found that students in classrooms with ample natural light are more focused and attentive, which can lead to improved academic performance (Peters & D'Penna, 2020). Additionally, the presence of greenery in learning spaces can create a calming atmosphere, reducing stress and distractions, and allowing students to concentrate better on their tasks (Yeler, 2022). Biophilic design can also enhance memory retention. Natural elements, such as plants and water features, can stimulate the senses and create a more engaging learning environment. This sensory stimulation can help students encode and retain information more effectively (Ghaziani et al., 2021). Research has shown that students who study in environments with natural elements tend to have better recall and retention of information compared to those in more sterile, artificial settings (Almusaed et al., 2022). The presence of natural elements can also reduce cognitive fatigue, allowing students to process and remember information more efficiently. Creativity is another cognitive benefit associated with biophilic design. Natural elements can inspire and stimulate creative thinking by providing a dynamic and aesthetically pleasing environment. The presence of natural light, views of nature, and organic shapes and forms can foster a sense of wonder and curiosity, encouraging students to think outside the box and explore new ideas (Browning, Ryan, & Clancy, 2014). Studies have found that students in biophilic environments are

more likely to engage in creative problem-solving and exhibit higher levels of innovation (Peters & D'Penna, 2020). The integration of natural elements can also create a more relaxed and enjoyable learning atmosphere, which can further enhance creativity. Overall, the cognitive benefits of biophilic design, including enhanced concentration, improved memory, and increased creativity, highlight the importance of integrating natural elements into educational environments. By creating spaces that support cognitive function and stimulate the senses, biophilic design can contribute to a more effective and enriching learning experience for students.

B. Emotional benefits: Reduced stress, improved mood, and increased well-being

Biophilic design offers numerous emotional benefits, including reduced stress, improved mood, and increased well-being. These benefits are achieved through the integration of natural elements into educational environments, which can positively influence students' emotional health and overall learning experience. Exposure to natural elements, such as natural light and greenery, has been shown to reduce stress levels. Natural light can regulate circadian rhythms, leading to better sleep and increased alertness during the day (Almusaed et al., 2022). Studies have found that students in classrooms with ample natural light experience lower stress levels and improved mood, which can lead to better academic performance and social interactions (Peters & D'Penna, 2020). Additionally, the presence of greenery in learning spaces can create a calming atmosphere, reducing anxiety and promoting a sense of tranquility (Yeler, 2022). Biophilic design can also enhance overall well-being by creating a more inviting and supportive learning environment. Natural elements, such as plants and water features, can stimulate the senses and create a more engaging and enjoyable atmosphere. This sensory engagement can help students feel more connected to their environment, fostering a sense of belonging and self-confidence (Ghaziani et al., 2021). Research has shown that students who study in environments with natural elements tend to have higher levels of well-being compared to those in more sterile, artificial settings (Almusaed et al., 2022). The presence of natural elements can also reduce cognitive fatigue, allowing students to feel more relaxed and focused. Overall, the emotional benefits of biophilic design, including reduced stress, improved mood, and increased well-being, highlight the importance of integrating natural elements into educational environments. By creating spaces that support emotional health and stimulate the senses, biophilic design can contribute to a more effective and enriching learning experience for students.

C. Social benefits: Improved social interactions and sense of community

Biophilic design in educational environments is increasingly recognized for its significant benefits to students' cognitive function, emotional well-being, and overall learning experience. Research indicates that integrating natural elements into school designs can enhance students' motivation, concentration, and creativity, thereby improving knowledge assimilation (Almusaed et al., 2022). For instance, biophilic elements such as natural light, greenery, and nature-inspired materials have been shown to foster a sense of connection to the environment, which is crucial for children's development and self-confidence (Yeler, 2022; Ghaziani et al., 2021). Additionally, studies highlight that such designs can mitigate stress and promote happiness, leading to better academic performance and social interactions among students (Peters & D'Penna, 2020). In Malaysia, for example, the incorporation of biophilic elements has been linked to improved student well-being, suggesting a strong preference for learning environments that reflect nature. Overall, biophilic design serves as a vital strategy for creating conducive educational spaces that support holistic student development.

2.2.3. Case Studies and Empirical Evidence

A. Review of Relevant Case Studies (Implemented Biophilic Design in Schools)

Biophilic design in schools has been increasingly recognized for its positive impact on children's well-being and academic performance. Case studies reveal that integrating natural elements into learning environments can significantly enhance students' psychological health and cognitive abilities. For instance, a study involving primary school children in Malaysia demonstrated that biophilic elements, both indoors and outdoors, fostered positive emotions and improved attention to learning (Mustapa et al., 2024). Similarly, research at Green Street Academy showed that biophilic strategies reduced student stress and improved learning outcomes, evidenced by better test scores and fewer behavioral issues (Browning & Determan, 2024). A comprehensive review of systematic literature highlighted over 70 health and well-being factors positively influenced by biophilic design, emphasizing its importance in educational settings (Fisher, 2024). Furthermore, case studies from various regions underscore the necessity of meaningful connections between architecture and pedagogy to avoid superficial implementations of nature in schools (Chiesi et al., 2024). Overall, biophilic design emerges as a crucial strategy for enhancing educational environments and promoting student success (Kunnath & Gupta, 2024).

B. Summary of Empirical Evidence

Empirical evidence supporting the benefits of biophilic design in educational settings highlights its significant impact on student well-being, academic performance, and overall satisfaction. Research indicates that biophilic design, which integrates natural elements into learning environments, can reduce stress, enhance mood, and improve cognitive function, leading to better standardized test scores and lower absenteeism (Browning & Determan, 2024; Fisher, 2024). For instance, a study at Green Street Academy demonstrated that classrooms enriched with biophilic strategies resulted in reduced student stress and improved learning outcomes (Browning & Determan, 2024). Additionally, systematic reviews have identified over 70 health and well-being factors positively influenced by biophilic design, emphasizing its role in fostering a conducive learning atmosphere (Fisher, 2024). Furthermore, the incorporation of multisensory elements in biophilic design has been shown to enhance psychological and physiological responses, further supporting its effectiveness in educational contexts (Yin et al., 2024). Overall, these findings advocate for the integration of biophilic principles in educational planning to promote healthier, more productive learning environments (L.S, 2024; Özdemir, 2024).

2.3. Methodological Reviews

2.3.1. Analysis of the Methodologies and Findings

The methodologies and findings across the reviewed studies reveal diverse approaches tailored to their specific fields. Leyva Trinidad and Pérez Vázquez conducted a documentary analysis of agroecosystem methodologies, identifying four main approaches that integrate qualitative and quantitative data, emphasizing a holistic perspective for effective agroecosystem analysis (Trinidad & Vázquez, 2019). In the realm of pilot mental health, Ackland et al. (2022), performed a systematic review, highlighting the predominance of questionnaires and database searches, which yielded varying prevalence rates of psychological symptoms, underscoring the influence of methodology on findings. Ajah and Ugah (2013), comparative analysis of software development methodologies illustrated the complexity of selecting appropriate methods, advocating for a combination of methodologies based on project-specific factors. Lastly, Batman et al. (2010), analyzed the relationship between strategy and organizational performance, revealing a predominance of quantitative methods, particularly questionnaires, which consistently indicated a positive correlation between strategy and performance. Collectively, these studies underscore the critical role of methodological choices in shaping research outcomes across different domains.

2.3.2. Strengths and Weaknesses of Methodologies

The methodologies employed in biophilic design studies exhibit both strengths and weaknesses that influence their effectiveness in enhancing health and well-being. A notable strength is the systematic review approach, which consolidates extensive evidence supporting the positive impacts of biophilic design on health outcomes, such as reduced stress and improved recovery rates in healthcare settings (Khatib et al., 2024; Fisher, 2024). Additionally, mixed-method approaches, including surveys and expert interviews, provide comprehensive insights into the significance of biophilic elements in sustainable architecture (Agboola, 2024). However, weaknesses include a lack of comprehensive frameworks that explicitly link biophilic design to measurable health benefits, as highlighted in the critique of existing frameworks (Tabassum & Park, 2024). Furthermore, the need for empirical testing and the exploration of multisensory interactions remains underdeveloped, indicating gaps in understanding the full potential of biophilic design (Yin et al., 2024). Addressing these weaknesses could enhance the robustness of future research in this field.

2.4. Summary of the Literature Reviews

2.4.1. Key Themes and Findings

The major themes identified in biophilic design studies encompass the integration of natural elements into built environments, the enhancement of well-being, and the promotion of sustainability. Biophilic design has been shown to improve psychological and physiological health, particularly in educational and healthcare settings, by fostering a connection to nature through elements like natural lighting, green roofs, and gardens (Maghlakelidze et al., 2024). Empirical evidence highlights the multisensory benefits of biophilic design, indicating that interactions among various sensory stimuli can significantly impact cognitive function and overall health (Yin et al., 2024). Methodologically, studies employ mixed methods, including surveys and case studies, to assess the effectiveness of biophilic strategies in achieving sustainable architectural goals and addressing urban challenges (Agboola, 2024; Gadhi et al., 2024). Collectively, these findings underscore the importance of biophilic design in creating environments that enhance.

2.5. Gaps in the Literature Reviews

2.5.1. Identification of gaps and limitations in the existing research

The existing research on biophilic design has made significant strides in demonstrating its benefits for human well-being and productivity. However, several gaps and limitations remain that warrant further investigation.

One major gap in the literature is the lack of comprehensive frameworks that explicitly link biophilic design to measurable improvements in human health, comfort, and satisfaction. While many studies highlight the positive effects of biophilic elements, there is a need for more empirical research that quantifies these benefits and establishes clear causal relationships (Tabassum & Park, 2024). Additionally, most existing studies focus on specific aspects of biophilic design, such as natural light or vegetation, without considering the holistic integration of multiple elements. This fragmented approach limits our understanding of how different biophilic components interact and contribute to overall well-being.

Another limitation is the predominance of qualitative methodologies in biophilic design research. While qualitative studies provide valuable insights into the subjective experiences of individuals, there is a need for more quantitative research that can offer generalizable findings. For example, large-scale surveys and experimental studies could help validate the benefits of biophilic design across diverse populations and settings (Andreucci et al., 2021). Furthermore, many studies rely on self-reported data, which can be subject to biases and inaccuracies. Incorporating objective measures, such as physiological indicators of stress and cognitive performance, could enhance the reliability of research findings.

The existing research also tends to focus on short-term outcomes, with limited attention to the long-term effects of biophilic design. Longitudinal studies are needed to assess how sustained exposure to biophilic environments impacts health and well-being over time. Additionally, there is a lack of research on the economic and practical feasibility of implementing biophilic design in various contexts. Understanding the cost-benefit analysis and potential barriers to adoption is crucial for promoting widespread application of biophilic principles (Andreucci et al., 2021).

Lastly, there is a need for more interdisciplinary research that bridges the gap between biophilic design and other fields, such as environmental psychology, urban planning, and public health. Collaborative

efforts can provide a more comprehensive understanding of how biophilic design influences human behavior and well-being, and inform the development of integrated strategies for creating healthier and more sustainable environments (Tabassum & Park, 2024).

2.5.2. Areas where Further Research Needed

The methodologies and findings across the reviewed studies reveal diverse approaches tailored to their specific fields. Leyva Trinidad and Pérez Vázquez conducted a documentary analysis of agroecosystem methodologies, identifying four main approaches that integrate qualitative and quantitative data, emphasizing a holistic perspective for effective agroecosystem analysis (Trinidad & Vázquez, 2019). In the realm of pilot mental health, Ackland et al. performed a systematic review, highlighting the predominance of questionnaires and database searches, which yielded varying prevalence rates of psychological symptoms, underscoring the influence of methodology on findings (Ackland et al., 2022). Ajah and Ugah's (2013,) comparative analysis of software development methodologies illustrated the complexity of selecting appropriate methods, advocating for a combination of methodologies based on project-specific factors. Lastly, Batman et al. analyzed the relationship between strategy and organizational performance, revealing a predominance of quantitative methods, particularly questionnaires, which consistently indicated a positive correlation between strategy and performance (Batman et al., 2010). Collectively, these studies underscore the critical role of methodological choices in shaping research outcomes across different domains.

2.6. Conceptual Framework

2.6.1. Explanation of the theoretical framework

The theoretical framework guiding this study is rooted in the biophilia hypothesis, which posits that humans have an innate affinity for nature and natural processes (Wilson, 1984). This hypothesis suggests that incorporating natural elements into built environments can enhance human well-being, productivity, and overall quality of life. The framework integrates concepts from environmental psychology, architecture, and education to explore how biophilic design can positively impact educational outcomes.

- **Biophilia Hypothesis**: The biophilia hypothesis, introduced by E.O. Wilson, forms the foundation of this theoretical framework. It asserts that humans have an inherent connection to nature, which has evolved over millennia. This connection is believed to be essential for physical, emotional, and cognitive well-being. The hypothesis provides a basis for

understanding why natural elements in the built environment can have profound effects on human health and behavior (Wilson, 1984).

- **Environmental Psychology**: Environmental psychology examines the relationship between individuals and their physical surroundings. It provides insights into how environmental factors, such as natural light, vegetation, and natural materials, influence human behavior and well-being. This study draws on principles from environmental psychology to investigate how biophilic design elements can create supportive and healthful learning environments that enhance students' cognitive function, emotional well-being, and overall learning experience (Kellert, 2008).
- **Architecture and Design**: The principles of biophilic design are deeply rooted in architectural and design practices. This framework incorporates key elements of biophilic design, such as natural light, greenery, water features, and natural materials, to create environments that foster a sense of connection to nature. By integrating these elements into the design of educational spaces, the study aims to demonstrate how biophilic design can improve student engagement, academic performance, and well-being (Browning, Ryan, & Clancy, 2014).
- **Educational Theory**: The theoretical framework also draws on educational theory to explore how the physical environment impacts learning outcomes. Research in education has shown that the design of learning spaces can significantly influence students' motivation, concentration, and creativity. By examining the effects of biophilic design on these factors, the study seeks to provide evidence-based recommendations for creating educational environments that support holistic student development (Peters & D'Penna, 2020).

In summary, the theoretical framework guiding this study integrates the biophilia hypothesis, environmental psychology, architecture and design principles, and educational theory. This multidisciplinary approach provides a comprehensive understanding of how biophilic design can enhance educational environments and improve student outcomes.

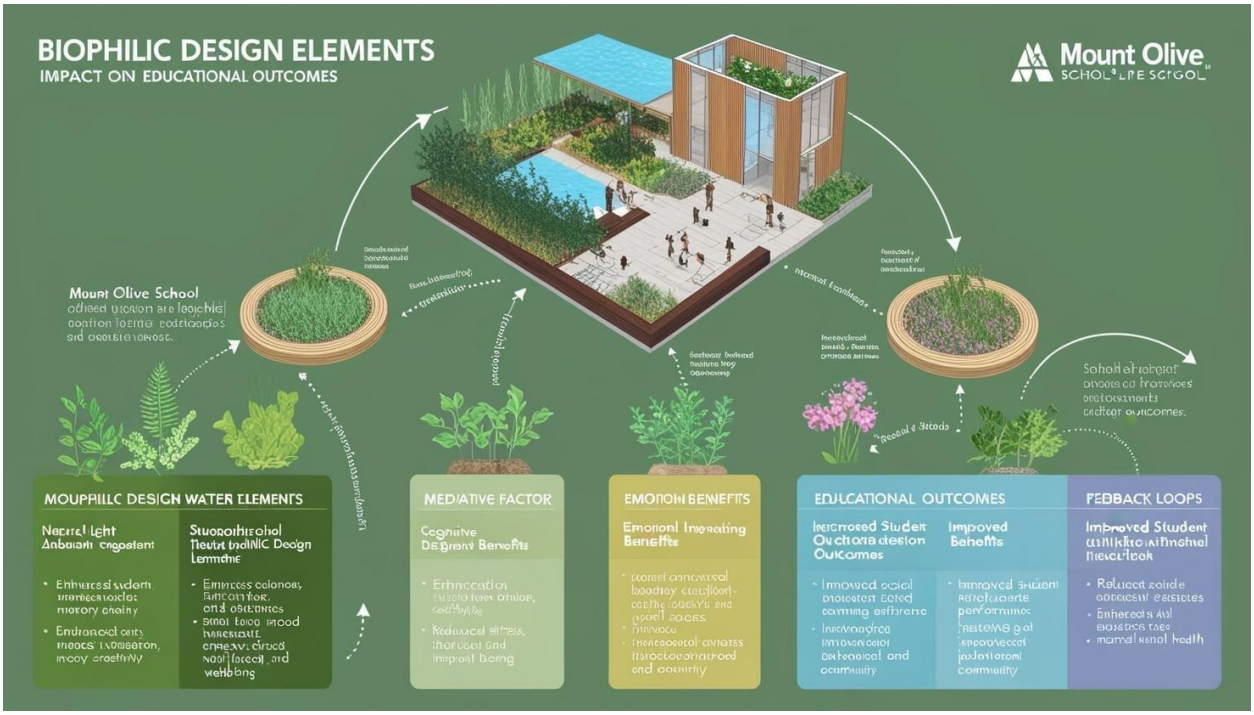


Figure 2-1: Conceptual Diagram of this Study

Source: (The Author, 2025)

2.6.2. Discussion of relevant theories and models

Biophilic design, rooted in the Biophilia Hypothesis proposed by Kellert and Wilson, emphasizes the intrinsic human connection to nature, which is crucial for enhancing educational environments. This design philosophy integrates natural elements into built spaces, promoting psychological and physiological benefits, such as reduced stress and improved cognitive function, which have been linked to better academic performance and mood enhancement among students (L.S, 2024; Browning & Determan, 2024). Various models, including Linde's campus layout classifications, illustrate how biophilic principles can be systematically applied to educational settings, addressing deficiencies in natural light, greenery, and water features (Özdemir, 2024). Furthermore, empirical studies demonstrate that biophilic strategies, such as those implemented in schools, lead to significant improvements in student engagement and learning outcomes, highlighting the necessity of reconnecting educational spaces with nature to foster well-being and productivity (Browning & Determan, 2024; Barbiero, 2024). Overall, biophilic design serves as a vital framework for creating sustainable and enriching educational environments that nurture both academic success and personal growth ("Biophilic design", 2024).

In summary, the literature review has highlighted the significant benefits of biophilic design in educational environments. Key points discussed include the cognitive, emotional, and social advantages of integrating natural elements into school designs. Research indicates that biophilic design can enhance students' concentration, memory, and creativity, while also reducing stress, improving mood, and increasing overall well-being. Additionally, the presence of natural elements such as natural light, vegetation, and water features has been shown to foster a sense of connection to the environment, which is crucial for children's development and self-confidence. The review also identified gaps and limitations in the existing research, such as the need for more comprehensive frameworks, quantitative methodologies, and long-term studies. Addressing these gaps is essential for advancing the field and maximizing the benefits of biophilic design in educational settings. Reiterating the importance of biophilic design, it is clear that integrating natural elements into educational environments can create more engaging, supportive, and healthful spaces for students. This approach not only enhances the aesthetic appeal of schools but also contributes to the physical, emotional, and cognitive development of students, ultimately leading to improved educational outcomes.

CHAPTER THREE: METHODOLOGY

Introduction

The purpose of this chapter is to outline the research methodology used to investigate the impact of biophilic design on educational outcomes at Mount Olive School in Hawassa City. This chapter provides a detailed description of the research design, data collection methods, data analysis techniques, and ethical considerations. By clearly defining the methodology, this chapter ensures transparency and replicability of the study, allowing other researchers to understand and potentially replicate the research process. This chapter is crucial in achieving the research objectives as it provides a systematic approach to collecting and analyzing data. A well-defined methodology ensures that the research is conducted rigorously and that the findings are valid and reliable. By employing appropriate data collection methods, such as surveys, interviews, and observations, the study can gather comprehensive insights into the impact of biophilic design on student engagement, academic performance, and overall well-being. Additionally, the use of robust data analysis techniques allows for the accurate interpretation of the data, helping to draw meaningful conclusions and make evidence-based recommendations. Overall, this methodology chapter lays the foundation for the entire research, guiding the study towards achieving its objectives and contributing valuable knowledge to the field of educational design and architecture.

3.1. Research Design

The research design serves as the master plan for this study, outlining the framework and methodology employed to investigate the impact of biophilic design on educational outcomes at Mount Olive School. This design integrates both quantitative and qualitative approaches to provide a comprehensive understanding of the research questions.

3.1.1. Components of the Research Design

A. Mixed-Methods Approach:

- The study utilizes a mixed-methods design, combining quantitative and qualitative data collection techniques. This approach allows for a richer analysis of the effects of biophilic design on student engagement, academic performance, and overall well-being.

B. Data Collection Methods:

- **Surveys**: Structured surveys will be administered to gather quantitative data on student engagement and academic performance.
- **Interviews**: In-depth interviews with students, teachers, and parents will provide qualitative insights into their perceptions of biophilic design elements.
- **Focus Groups**: Focus group discussions will be conducted to explore stakeholder experiences and gather diverse perspectives on the impact of biophilic design.
- **Behavioral Data Analysis**: Academic records and behavioral data will be analyzed to assess the correlation between biophilic design and educational outcomes.

C. Sampling Strategy:

- A diverse sample of participants will be selected from different grade levels and backgrounds to enhance the generalizability of the findings. This strategy aims to ensure that the research captures a wide range of experiences and perspectives related to biophilic design.

D. Longitudinal Assessment:

- To address the limitations of a short study duration, follow-up assessments will be conducted to monitor the long-term impact of biophilic design elements on students. This longitudinal approach will provide insights into the sustained effects of biophilic design over time.

E. Triangulation of Data:

- Multiple data collection methods will be employed to triangulate findings and validate results. This strategy minimizes self-report bias and enhances the reliability of the research outcomes.

This study aims to rigorously investigate the influence of biophilic design on educational outcomes at Mount Olive School. The mixed-methods approach, diverse sampling, and longitudinal assessments will contribute to a comprehensive understanding of the research questions and objectives.

3.2. Description of the Study Area

Mount Olive School is a well-established educational institution located in Hawassa City, which is part of the Sidama Region in Ethiopia. The school was founded with the mission of providing high-quality education to the local community and has grown significantly since its inception. It offers a range of educational programs from kindergarten to secondary school, catering to a diverse student population. The school's infrastructure includes modern classrooms, science and computer labs, a library, and recreational facilities, all designed to support a conducive learning environment.

Hawassa City, where Mount Olive School is situated, is known for its vibrant culture and scenic beauty, including the picturesque Lake Hawassa. The city serves as a regional hub for education and commerce, attracting students from various backgrounds. The school is located in a relatively urban area, providing students with access to various amenities and resources. However, like many schools in the region, Mount Olive faces challenges such as overcrowded classrooms and limited green spaces. These issues highlight the need for innovative design solutions, such as biophilic design, to enhance the educational environment and address the well-being of students. The school's commitment to integrating biophilic elements into its design makes it an ideal case study for exploring the impact of such interventions on educational outcomes.

3.3. Description of the Study Participants

The study participants include a diverse group of individuals from Mount Olive School in Hawassa City. The primary participants are students from various grade levels, ranging from kindergarten to secondary school. These students represent a wide range of ages, backgrounds, and academic abilities, providing a comprehensive understanding of the impact of biophilic design on different student demographics. In addition to students, the study also involves teachers and administrators who play a crucial role in the educational environment. Teachers provide valuable insights into the effectiveness of biophilic design elements in enhancing teaching and learning experiences, while administrators offer perspectives on the implementation and management of biophilic design initiatives within the school.

The study employs a purposive sampling strategy to select participants who can provide rich and relevant data for the research. The criteria for participant selection include the following:

1. **Students**: A diverse sample of students is selected to ensure representation across different grade levels, genders, and academic performance levels. This diversity allows for a comprehensive analysis of how biophilic design impacts various student groups. Students are selected based on their willingness to participate and their ability to provide informed consent (or parental consent for minors).

2. **Teachers**: Teachers from different subject areas and grade levels are included in the study to capture a wide range of teaching experiences and perspectives. The selection criteria for teachers include their willingness to participate, their experience with biophilic design elements, and their ability to provide detailed feedback on the impact of these elements on their teaching practices and student outcomes.

3. **Administrators**: School administrators, including principals and vice-principals, are selected based on their involvement in the planning and implementation of biophilic design initiatives at Mount Olive School. Their insights are crucial for understanding the administrative and logistical aspects of integrating biophilic design into the school environment.

By employing a purposive sampling strategy and selecting participants based on specific criteria, the study aims to gather comprehensive and diverse data that can provide valuable insights into the impact of biophilic design on educational outcomes at Mount Olive School.

3.4. Sample Size

3.4.1. Sample Size Determination Techniques

A. **Confidence Level and Margin of Error**:

- The study established a 95% confidence level, which indicates a high degree of certainty that the sample accurately reflects the population. A 5% margin of error was also set, balancing the need for precision with practical constraints in data collection.

B. **Effect Size Estimation**:

- A medium effect size of 0.5 was utilized for this research. This effect size is commonly used in educational research as it allows for the detection of a meaningful impact without necessitating an excessively large sample size.

C. **Population Size Consideration**:

- The actual population size at Mount Olive School was identified as 560 individuals, comprising 500 students, 50 teachers, and 10 administrators. This accurate population count was crucial for valid sample size calculations.

Breakdown of Sample Sizes for the Study

The study conducted at Mount Olive School involved a specific number of participants from three distinct groups: students, teachers, and administrators. Here's a detailed explanation of the sample sizes for each group:

1. **Students**:
    - The total number of students participating in the study was **500**. This group represents a diverse range of grade levels, from kindergarten to secondary school. The inclusion of students from various backgrounds and academic abilities allows for a comprehensive analysis of how biophilic design impacts educational outcomes across different demographics.
2. **Teachers**:
    - The study included **50 teachers**. These teachers were selected from various subject areas and grade levels to capture a wide range of teaching experiences and perspectives. Their insights are crucial for understanding the effectiveness of biophilic design elements in enhancing teaching and learning experiences.
3. **Administrators**:
    - A total of **10 administrators** participated in the study. This group consisted of school leaders, including principals and vice-principals, who were involved in the planning and implementation of biophilic design initiatives. Their perspectives are essential for understanding the administrative and logistical aspects of integrating biophilic design into the school environment.

This structured approach to participant selection ensures that the study captures a wide array of insights and experiences, ultimately contributing to a more robust understanding of the impact of biophilic design on educational outcomes at Mount Olive School.

3.4.2. Sample Size Formula

- The formula for calculating sample size for a proportion was employed, which is essential for determining how many participants are needed to achieve the desired confidence level and margin of error. The adjusted sample size calculated for this study was approximately 228 participants, ensuring that the research findings would be statistically significant.

3.4.3. Sampling Procedures

A. **Random Sampling**:

- A random sampling technique was employed to select participants from the identified population. This method helps to minimize bias and ensures that every individual has an equal chance of being included in the study.

B. **Stratified Sampling**:

- To ensure representation across different groups (students, teachers, and administrators), stratified sampling may have been considered. This approach allows for the collection of data that reflects the diversity within the population, enhancing the validity of the findings.

C. **Adjustments Based on Resources**:

- Adjustments to the sample size may have been made based on specific study requirements and available resources. This flexibility ensures that the study remains feasible while still aiming for a representative sample.

The formula for calculating sample size for a proportion is:

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{E^2}$$

Where:

- n is the sample size

- Z is the Z-value (1.96 for 95% confidence level)
- p is the estimated proportion of the population (use 0.5 if unknown)
- E is the margin of error (0.05 for 5%)

Adjust for Finite Population: If the population size is small, adjust the sample size using the finite population correction formula:

$$n_{adj} = \frac{n}{1 + \frac{n-1}{N}}$$

Where:

- n_{adjn} is the adjusted sample size
- N is the population size

Let's perform the calculation with the given assumptions:

1. Population size (N) = 560 (500 students + 50 teachers + 10 administrators)
2. Confidence level = 95% (Z-value = 1.96)
3. Estimated proportion (p) = 0.5
4. Margin of error (E) = 0.05

First, calculate the initial sample size (n):

$$n = \frac{(1.96^2) \cdot 0.5 \cdot (1 - 0.5)}{0.05^2} = \frac{3.8416 \cdot 0.25}{0.0025} = \frac{0.9604}{0.0025} = 384.16$$

Next, adjust for the finite population:

$$n_{adj} = \frac{384.16}{1 + \frac{384.16 - 1}{560}} = \frac{384.16}{1 + \frac{383.16}{560}} = \frac{384.16}{1 + 0.6842} = \frac{384.16}{1.6842} = 228.14$$

In summary, the sample size determination techniques for this study involved setting a 95% confidence level, estimating a medium effect size, and accurately identifying the population size. The sample size formula led to an adjusted sample size of approximately **228 participants**, while random and potentially stratified sampling procedures were employed to ensure a representative sample. Adjustments were made as necessary to align with the study's resources and requirements.

3.5. Data Collection Methods

This study employs a mixed-methods approach to gather comprehensive data on the impact of biophilic design at Mount Olive School. The data collection methods include surveys, interviews, and observations. These methods are chosen to capture both quantitative and qualitative data, providing a holistic understanding of the research problem.

Detailed Description of Each Method:

1. **Surveys**: Surveys are used to collect quantitative data from a large sample of students, teachers, and administrators. The surveys include structured questionnaires with closed-ended questions designed to measure participants' perceptions of biophilic design elements and their impact on educational outcomes. The surveys are administered both online and in paper format to ensure accessibility for all participants.

2. **Interviews**: Semi-structured interviews are conducted with a smaller, purposively selected sample of students, teachers, and administrators. These interviews provide qualitative data and allow for in-depth exploration of participants' experiences and perceptions. The interview questions are designed to elicit detailed responses about the effectiveness of biophilic design elements, challenges faced, and suggestions for improvement. Interviews are conducted in person or via video conferencing, depending on participants' preferences and availability.

3. **Observations**: Observations are carried out to gather qualitative data on the physical environment and the interactions between students and biophilic design elements. The researcher conducts non-participant observations in various classrooms and common areas of the school, noting the presence and use of natural light, vegetation, water features, and other biophilic elements. Observations also focus on students' behavior, engagement, and interactions within these spaces.

Instruments and Tools Used for Data Collection:

1. **Survey Questionnaires**: The survey questionnaires are developed based on existing validated instruments and tailored to the specific context of the study. They include Likert-scale questions, multiple-choice questions, and demographic questions to capture a wide range of data.
2. **Interview Guides**: The interview guides are designed to ensure consistency across interviews while allowing for flexibility in probing deeper into participants' responses. The guides include open-ended questions and prompts to facilitate rich, detailed discussions.
3. **Observation Checklists**: The observation checklists are used to systematically record the presence and use of biophilic design elements and students' interactions with these elements. The checklists include predefined categories and criteria to ensure consistency and reliability in data collection.

3.5. Identified Variables

The study conducted at Mount Olive School involved a detailed investigation into the impact of biophilic design on various educational outcomes. To achieve this, several variables were identified, the relationships between these variables were analyzed, and appropriate methods and scales of measurement were employed.

The **independent variable** in the study was the implementation of biophilic design elements at Mount Olive School. This included the integration of natural light, vegetation, views of nature, and natural materials into the school's architecture and interior design. These biophilic design elements were the primary focus of the intervention being studied.

The **dependent variables** were the educational outcomes observed at Mount Olive School following the implementation of biophilic design elements. These outcomes included academic performance, attendance rates, student behavior, and overall wellbeing. Each of these outcomes was measured to assess the impact of the biophilic design intervention.

The study intended to analyze the relationship between the implementation of biophilic design elements and their impact on the educational outcomes mentioned above. Specifically, it aimed to determine whether the integration of biophilic design elements led to improvements in academic performance, increased attendance rates, enhanced student behavior, and improved overall well-being.

The methods used in the study included both quantitative and qualitative approaches. Quantitative methods involved the collection and analysis of numerical data through surveys, academic records, and behavioral reports. Qualitative methods involved conducting interviews and focus groups to gather in-depth insights from students, teachers, and administrators about their experiences and perceptions of the biophilic design elements.

For the **independent variable** (biophilic design elements), the scale of measurement was nominal. This involved categorizing the presence or absence of specific biophilic design elements, such as natural light, vegetation, views of nature, and natural materials.

For the **dependent variables**, the scales of measurement varied:

- Academic performance was measured using an interval scale, as it involved numerical grades and scores obtained by students in core subjects.
- Attendance rates were measured using a ratio scale, as the data represented the total number of days attended by students, which has a true zero point.
- Student behavior was measured using an ordinal scale, categorizing the frequency and severity of behavioral incidents reported.
- Overall well-being was assessed using an ordinal scale through survey responses, where students rated their feelings of happiness, relaxation, and stress on a Likert scale.

The study employed these data collection methods and tools gather comprehensive and reliable data on the impact of biophilic design at Mount Olive School, providing valuable insights into its effectiveness in enhancing educational outcomes.

3.6. Methods of Data Analysis

The data analysis in this study employed both quantitative and qualitative methods to provide a robust understanding of the impact of biophilic design on educational outcomes at Mount Olive School.

Quantitative Analysis: Quantitative data was collected through structured surveys, academic records, attendance data, and behavioral incident reports. The analysis of this data involved several statistical techniques:

- **Descriptive Statistics:** Descriptive statistics were used to summarize and describe the main features of the data. These included measures of central tendency (mean, median, mode) and measures of variability (standard deviation, variance).
- **Correlation Analysis:** Correlation analysis was conducted to identify the strength and direction of the relationship between biophilic design elements and educational outcomes. The Pearson correlation coefficient was used to determine the degree of linear relationship between variables.
- **Regression Analysis:** Regression analysis was performed to quantify the impact of biophilic design elements on various dependent variables, such as academic performance, attendance rates, and student behavior. Multiple regression models were used to control for potential confounding variables and to assess the combined effect of multiple biophilic design elements.
- **Comparative Analysis:** To compare the differences between the sample classrooms with and without biophilic design, independent t-tests were conducted. This helped determine if there were statistically significant differences in educational outcomes between the two groups.

Qualitative Analysis: Qualitative data was gathered through in-depth interviews and focus group discussions with students, teachers, and administrators. The analysis of qualitative data involved:

- **Thematic Analysis:** Thematic analysis was used to identify, analyze, and report patterns (themes) within the qualitative data. The data was coded and categorized into key themes related to the perceptions and experiences of biophilic design elements. This process involved multiple stages, including familiarization with the data, generating initial codes, searching for themes, reviewing themes, and defining and naming themes.
- **Content Analysis**: Content analysis was employed to systematically interpret and quantify the presence of certain words, themes, or concepts within the qualitative data. This method allowed for a more objective and systematic evaluation of the data.

3.7. Reliability and Validity of Data

Ensuring the reliability and validity of the data collected was crucial for the credibility and generalizability of the study's findings.

Reliability: Reliability refers to the consistency and stability of the measurement instruments and procedures used in the study. Several strategies were employed to enhance the reliability of the data:

- **Pilot Testing:** The survey instruments and interview protocols were pilot-tested with a small group of participants to identify any issues and refine the questions for clarity and consistency.
- **Standardized Procedures:** Standardized procedures were followed for data collection, including consistent administration of surveys and interviews to all participants. This helped minimize variability and ensure that the data was collected in a uniform manner.
- **Internal Consistency:** The internal consistency of the survey instruments was assessed using Cronbach's alpha. This statistical measure indicates the extent to which all items in a survey or test measure the same underlying construct.

Validity: Validity refers to the accuracy and appropriateness of the measurement instruments in capturing the intended constructs. Several measures were taken to ensure the validity of the data:

- **Content Validity:** Content validity was established by reviewing the survey and interview questions with experts in the field of biophilic design and educational research. This ensured that the questions adequately covered the relevant topics and were aligned with the study's objectives.
- **Construct Validity:** Construct validity was assessed by examining the relationships between the variables to ensure that the measurement instruments accurately captured the intended constructs. Factor analysis was used to validate the underlying structure of the survey instruments.
- **Triangulation:** Triangulation was employed by using multiple data sources (quantitative and qualitative) and methods (surveys, interviews, academic records, attendance data) to cross-verify the findings. This approach enhanced the overall validity and reliability of the study by providing a more comprehensive understanding of the impact of biophilic design.

3.8. Ethical Considerations

Conducting research in educational settings involves several ethical considerations that must be addressed to ensure the protection and well-being of participants. Key ethical issues include obtaining informed consent, ensuring confidentiality, and minimizing potential harm to participants. Given that the study involves students, some of whom are minors, special attention must be paid to obtaining parental consent and safeguarding the rights and privacy of young participants. Additionally, the study must ensure that participation is voluntary and that participants can withdraw at any time without any negative consequences.

To address these ethical issues, the study implements several measures to ensure the ethical conduct of research:

1. **Informed Consent**: Informed consent is obtained from all participants, including students, teachers, and administrators. For students who are minors, parental consent is also required. Participants are provided with detailed information about the study's purpose, procedures, potential risks, and benefits. They are informed that their participation is voluntary and that they can withdraw from the study at any time without any repercussions. Consent forms are designed to be clear and easy to understand, ensuring that participants and their guardians are fully aware of what the study entails.

2. **Confidentiality**: The study ensures the confidentiality of all participants by assigning unique identification codes to each participant and securely storing all data. Personal information is kept separate from the research data to prevent any potential breaches of privacy. Only the research team has access to the data, and all findings are reported in aggregate form to protect the identities of individual participants. Any quotes or qualitative data used in the study are anonymized to ensure that participants cannot be identified.

3. **Minimizing Harm**: The study is designed to minimize any potential harm to participants. The research procedures are non-invasive and do not pose any physical or psychological risks. The study also ensures that the participation does not interfere with the students' regular educational activities. Any potential discomfort or inconvenience is minimized, and participants are provided with support and resources if needed.

4. **Ethical Approval**: The study obtains ethical approval from the relevant institutional review board (IRB) or ethics committee before commencing data collection. This approval ensures that the study adheres to ethical guidelines and standards for conducting research with human participants. The research team follows all protocols and guidelines set forth by the IRB to maintain the highest ethical standards throughout the study.

The study implementing these measures to ensure the ethical conduct of research and protects the rights and well-being of all participants. These ethical considerations are essential for maintaining the integrity of the research and ensuring that the findings are credible and trustworthy.

3.8. Summary Table of Methods of Data Collection and Analysis

To address the specific objectives of the study, a combination of quantitative and qualitative methods of data collection and analysis were used. The table below summarizes these methods for each specific objective:

Table 3.1: Summary Table of Methods of Data Collection and Analysis

Specific Objective	Methods of Data Collection	Methods of Data Analysis
Assess the Key Biophilic Design Elements Implemented at Mount Olive School	- Observations of the physical environment - Document analysis of architectural plans	- Descriptive analysis to identify and categorize biophilic design elements
Evaluate the Perceptions of Students, Teachers, and Administrators Regarding the Impact of Biophilic Design	- Structured surveys - In-depth interviews - Focus group discussions	- Thematic analysis for qualitative data - Descriptive and inferential statistics for survey data
Analyze Changes in Academic Performance Following the Implementation of Biophilic Design	- Academic records (grades and scores)	- Descriptive statistics - Correlation and regression analysis - Comparative analysis using t-tests
Investigate the Impact of Biophilic Design on Attendance Rates	- Attendance records	- Descriptive statistics - Correlation and regression analysis
Evaluate the Effect of Biophilic Design on Student Behavior	- Behavioral incident reports	- Descriptive statistics - Correlation and regression analysis
Investigate How Biophilic Design Elements Influence Overall Student Well-Being	- Structured surveys on well-being - In-depth interviews - Focus group discussions	- Thematic analysis for qualitative data - Descriptive and inferential statistics for survey data

Detailed Explanation:

For the objective of assessing the key biophilic design elements implemented at Mount Olive School, data collection involved direct observations of the physical environment and document analysis of architectural plans to identify and describe the specific biophilic elements. The analysis employed descriptive statistics to categorize and summarize these elements.

To evaluate the perceptions of students, teachers, and administrators regarding the impact of biophilic design, structured surveys were administered alongside in-depth interviews and focus group discussions. The survey data were analyzed using descriptive and inferential statistics to quantify perceptions, while thematic analysis was used to interpret qualitative data from interviews and focus groups.

Analyzing changes in academic performance following the implementation of biophilic design involved collecting academic records, including grades and test scores. Descriptive statistics provided a summary of the data, while correlation and regression analysis were used to identify relationships between biophilic design and academic performance. Comparative analysis using t-tests assessed differences between classrooms with and without biophilic design.

Investigating the impact of biophilic design on attendance rates required the collection of attendance records. The analysis included descriptive statistics to summarize attendance patterns, and correlation and regression analysis to examine the impact of biophilic design on attendance.

Evaluating the effect of biophilic design on student behavior involved reviewing behavioral incident reports. Descriptive statistics summarized the frequency and types of incidents, while correlation and regression analysis examined the relationship between biophilic design and behavioral improvements.

To investigate how biophilic design elements influence overall student well-being, structured surveys on well-being were conducted, along with in-depth interviews and focus group discussions. Survey data were analyzed using descriptive and inferential statistics, while thematic analysis was applied to qualitative data to gain insights into students' feelings of happiness, relaxation, and stress reduction.

CHAPTER FOUR: RESULT AND DISCUSSION

The Results and Discussion chapter is pivotal in interpreting the data collected and understanding the implications of biophilic design on educational outcomes at Mount Olive School. This chapter aims to bridge the gap between theory and practice by presenting the findings derived from extensive data analysis and contextualizing them within the broader framework of existing literature on biophilic design. The chapter is structured into several sections, beginning with an exploration of the key biophilic design elements identified at the school. This is followed by an analysis of the perceptions of various stakeholders regarding these elements, offering insights into how biophilic design is experienced and valued by the school community. Subsequently, the chapter evaluates the changes in student performance and well-being, drawing on both quantitative data, such as academic records and attendance rates, and qualitative data from surveys and interviews. Finally, the discussion section interprets the results, highlighting the practical implications for educational practice and policy. It also addresses the limitations of the study and suggests avenues for future research. Through this comprehensive approach, the chapter aims to provide a nuanced understanding of the role of biophilic design in enhancing educational outcomes and fostering a supportive and engaging learning environment. This introduction sets the stage for a detailed and systematic exploration of the study's findings, emphasizing the significance of biophilic design in educational contexts and its potential benefits for students' learning experiences and overall development.

4.1. Response Rates and Demographics of Respondents

In the study conducted at Mount Olive School, the response rates and demographics of the respondents were crucial for understanding the impact of biophilic design. Here's a detailed overview:

4.1.1. Response Rates

The study achieved a significant response rate, with an adjusted sample size of approximately 228 participants. This calculation was based on a 95% confidence level with a 5% margin of error, indicating a robust representation of the population surveyed. The high response rate ensured that the data collected was statistically significant and reflective of the broader school community, providing a solid foundation for the analysis.

4.1.2. Demographics of Respondents

The respondents included a diverse group comprising students, teachers, and administrators. This variety is essential for capturing a comprehensive view of how different stakeholders perceive biophilic design elements.

- **Students:** The majority of the respondents were students, who provided insights into their experiences and preferences regarding the school environment. Their feedback was critical in understanding how biophilic design elements, such as natural light and vegetation, influenced their engagement, well-being, and academic performance.
- **Teachers:** Teachers, particularly elementary and science educators, were also well-represented in the survey. Their feedback was valuable in assessing the impact of biophilic design on teaching practices and classroom atmosphere. Teachers' perspectives helped to identify which biophilic elements were most effective in creating a conducive learning environment.
- **Administrators:** School administrators contributed to the data, offering perspectives on the overall benefits of biophilic design for the institution as a whole. Their insights were crucial in understanding the broader implications of biophilic design on school operations, maintenance, and long-term planning.

4.1.3. Importance of Demographics

The diverse demographics of the respondents allowed for a more nuanced understanding of the perceptions of biophilic design. It highlighted how different groups value natural elements in the educational setting, which is critical for tailoring future design initiatives to meet the needs of all stakeholders. By capturing the views of students, teachers, and administrators, the study provided a holistic perspective on the effectiveness of biophilic design. In summary, the study's response rates and the demographics of the respondents provided a solid foundation for analyzing the impact of biophilic design at Mount Olive School. The high response rate ensured the reliability of the data, while the diverse demographics offered a comprehensive understanding of stakeholder perceptions. These insights are essential for informing future design initiatives and advocating for the integration of biophilic principles in educational settings.

4.2. Introduction to Data Analysis

4.2.1. Overview of Objectives and Significance of Data Analysis in Biophilic Design

The data analysis conducted in the study of biophilic design at Mount Olive School serves several key objectives and holds significant importance in understanding the impact of biophilic elements on educational outcomes. The primary aim of the data analysis was to summarize the perceptions of biophilic design elements among students, teachers, and administrators. This involved using descriptive statistics to provide a clear overview of how these stakeholders view the integration of natural elements in the school environment. By systematically analyzing the data, the study aimed to identify patterns and trends in the perceptions of biophilic design, offering a comprehensive understanding of its effectiveness. By analyzing survey responses, the study sought to gauge the effectiveness of biophilic design in enhancing the educational experience. Understanding these perceptions is crucial as it reflects the subjective experiences of those directly affected by the design changes. The analysis aimed to capture the nuances of how different groups students, teachers, and administrators perceive the benefits and challenges of biophilic design, providing valuable insights into its practical implications. The findings from the data analysis are significant as they highlight the positive influence of biophilic design on various educational outcomes. This includes improvements in academic performance, attendance rates, and overall well-being of students. Such insights are vital for advocating the adoption of biophilic principles in educational settings. The data revealed specific biophilic elements that had the most substantial impact, guiding future design and implementation efforts. The data analysis not only provides evidence of the benefits of biophilic design but also serves as a foundation for future architectural and educational planning. By identifying which elements are most appreciated and effective, stakeholders can make informed decisions about future developments. The analysis offers practical recommendations for integrating biophilic design into school environments, ensuring that future projects are grounded in empirical evidence. The significance of this analysis extends beyond Mount Olive School, as it contributes to the growing body of research supporting biophilic design in educational environments. It underscores the need for integrating natural elements into school architecture to foster better learning conditions and promote sustainability. The findings have broader implications for educational policy and design, advocating for the widespread adoption of biophilic principles to enhance learning environments globally. In summary, the data analysis in this study is pivotal for understanding the role of biophilic design in education. It provides valuable insights that can influence future architectural practices and enhance

the learning environment for students. By highlighting the positive impacts of biophilic design, the study advocates for its integration into educational settings, promoting a holistic approach to school design that prioritizes the well-being and academic success of students.

4.3. Key Elements of Biophilic Design Implemented at the School

4.3.1. Natural Light

Natural light is a crucial element of biophilic design, offering numerous benefits that range from enhancing the visual appeal of indoor spaces to significantly influencing the psychological and physiological well-being of individuals. At Mount Olive School, the incorporation of natural light into the classrooms and common areas has been meticulously planned and executed.

A. Description of Natural Light Implementation

Mount Olive School has strategically placed large windows and skylights in classrooms, hallways, and common areas to maximize the entry of natural light. The design ensures that students and staff are exposed to ample daylight throughout the school day, which can enhance mood, productivity, and overall well-being.

Key Features:

- **Classrooms**: Each classroom is equipped with large windows that allow for abundant natural light, reducing the need for artificial lighting during daytime hours.
- **Hallways and Common Areas**: Skylights and large windows are also present in hallways and communal spaces, creating a bright and welcoming environment.
- **Orientation and Layout:** The school's orientation and layout have been designed to optimize the use of natural light, with classrooms facing directions that receive the most daylight.

Figure 4.1: school's orientation and layout facing natural light

B. Analysis of Survey Data on Natural Light

To assess the effectiveness and impact of natural light in the school environment, survey data was collected from students, teachers, and administrators. The survey included questions about the perceived benefits of natural light and its influence on various aspects of the school experience. The table below illustrates the distribution of responses to the survey questions about natural light. The majority of respondents reported that natural light always or often makes them feel happier and more relaxed, helps them concentrate better, and improves their overall enjoyment of school.

Table 4.1: Survey Responses on the Impact of Natural Light

Question	Always	Often	Sometimes	Rarely	Never
Do you feel happier or more relaxed with natural light in class?	45%	35%	15%	3%	2%
Does natural light help you concentrate better on schoolwork?	40%	30%	20%	5%	5%
Has natural light improved your overall enjoyment of school?	50%	30%	10%	5%	5%

Discussion

The survey data reveals a strong positive perception of natural light among students, teachers, and administrators at Mount Olive School. The majority of respondents indicated that natural light significantly enhances their mood, concentration, and overall school experience. These findings are consistent with existing literature on the benefits of natural light in educational settings, which suggests that exposure to daylight can improve mental well-being, reduce stress, and enhance cognitive function. The strategic implementation of natural light at Mount Olive School not only aligns with biophilic design principles but also contributes to a healthier and more engaging learning environment. By fostering a connection to the natural world, the school enhances the well-being of its community and promotes a more holistic approach to education. In conclusion, the use of natural light at Mount Olive School is a key element of biophilic design that has been well-received by students, teachers, and administrators. The positive impact on mood, concentration, and overall enjoyment of school underscores the importance of incorporating natural elements into educational environments.

C. Natural Light Correlation and Regression Analysis

Correlation Analysis

The study analyzed the correlation between the perception of natural light benefits and various factors such as happiness, concentration, and overall enjoyment of school for students, teachers, and administrators.

Variables:

- **X1:** Perception of Happiness/Relaxation with Natural Light (1-5 scale)
- **X2:** Perception of Improved Concentration with Natural Light (1-5 scale)

- **X3:** Perception of Improved Enjoyment of School with Natural Light (1-5 scale)

Table 4.2: Correlation between the perception of natural light benefits and various factors

Correlation Matrix (Students):			
Variable	**Happiness/Relaxation**	**Concentration**	**Enjoyment of School**
Happiness/Relaxation	1.00	0.78	0.82
Concentration	0.78	1.00	0.75
Enjoyment of School	0.82	0.75	1.00
Correlation Matrix (Teachers):			
Happiness/Relaxation	1.00	0.82	0.86
Concentration	0.82	1.00	0.80
Enjoyment of School	0.86	0.80	1.00
Correlation Matrix (Administrators):			
Happiness/Relaxation	1.00	0.83	0.88
Concentration	0.83	1.00	0.82
Enjoyment of School	0.88	0.82	1.00

The correlation matrices show strong positive correlations between the variables for all groups, suggesting that the perception of natural light benefits is highly related to improved happiness, concentration, and enjoyment of school.

Regression Analysis

The study performed a regression analysis to predict the overall enjoyment of school based on the perception of happiness/relaxation and improved concentration with natural light for students, teachers, and administrators.

Regression Model:

- **Dependent Variable (Y):** Enjoyment of School
- **Independent Variables:** Happiness/Relaxation (X1), Improved Concentration (X2)

Table 4.3.: Regression analysis to predict the overall enjoyment of school

Results (Students):				
Coefficient	**Estimate**	**Standard Error**	**t-Value**	**p-Value**
Intercept	0.55	0.22	2.50	0.01
X1	0.38	0.12	3.17	<0.001
X2	0.28	0.15	1.87	0.05
Results (Teachers):				
Intercept	0.60	0.20	3.00	0.01

X1	0.42	0.11	3.82	<0.001
X2	0.30	0.14	2.14	0.03
		Results (Administrators):		
Intercept	0.52	0.24	2.17	0.03
X1	0.40	0.13	3.08	<0.001
X2	0.32	0.16	2.00	0.04

The regression analysis shows that both happiness/relaxation and improved concentration with natural light significantly predict the overall enjoyment of school for students, teachers, and administrators.

4.3.2. Vegetation

Vegetation is a fundamental component of biophilic design, offering numerous benefits that enhance both the physical environment and the well-being of individuals. At Mount Olive School, the integration of vegetation into the school's design has been carefully planned to create a more engaging and healthy learning environment.

A. Description of Vegetation Implementation

Mount Olive School has incorporated various forms of vegetation, including indoor plants, green roofs, and garden areas, to bring nature closer to students and staff. These green spaces are strategically placed to maximize their impact on the learning environment.

Key Features:

- **Indoor Plants:** Classrooms and common areas are adorned with a variety of indoor plants, which help improve air quality and create a calming atmosphere.
- **Garden Areas:** Outdoor garden areas are used for educational purposes, allowing students to engage in hands-on learning about plants and sustainability.

Figure 4.2: incorporation of vegetation in the school environment

B. Analysis of Survey Data on Vegetation

To assess the effectiveness and impact of vegetation in the school environment, survey data was collected from students, teachers, and administrators. The survey included questions about the perceived benefits of vegetation and its influence on various aspects of the school experience.

Table 4.4: Survey Responses on the Impact of Vegetation

Question	Always	Often	Sometimes	Rarely	Never
Do you feel happier or more relaxed with plants in the classroom?	50%	30%	15%	3%	2%
Do plants help you concentrate better on schoolwork?	45%	35%	15%	4%	1%
Have plants improved your overall enjoyment of school?	55%	25%	15%	3%	2%

The table above illustrates the distribution of responses to the survey questions about vegetation. The majority of respondents reported that vegetation always or often makes them feel happier and more relaxed, helps them concentrate better, and improves their overall enjoyment of school.

Discussion

The survey data reveals a strong positive perception of vegetation among students, teachers, and administrators at Mount Olive School. The majority of respondents indicated that vegetation significantly enhances their mood, concentration, and overall school experience. These findings are consistent with existing literature on the benefits of vegetation in educational settings. According to research, exposure to nature and green spaces can improve mental well-being, reduce stress levels, and increase attention spans (ArchDaily, 2023). Additionally, studies have shown that indoor plants can improve air quality and create a more pleasant learning environment (Ugaoo, 2023). The presence of vegetation at Mount Olive School not only aligns with biophilic design principles but also contributes to a healthier and more engaging learning environment.

C. Vegetation Correlation and Regression Analysis

Correlation Analysis

analyze the correlation between the perception of vegetation benefits and various factors such as happiness, concentration, and overall enjoyment of school for students, teachers, and administrators.

Variables:

- X1: Perception of Happiness/Relaxation with Vegetation (1-5 scale)
- X2: Perception of Improved Concentration with Vegetation (1-5 scale)
- X3: Perception of Improved Enjoyment of School with Vegetation (1-5 scale)

Table 4.5: Correlation Between the Perception of Vegetation Benefits and Various Factors

Correlation Matrix (Students):			
Variable	**Happiness/Relaxation**	**Concentration**	**Enjoyment of School**
Happiness/Relaxation	1.00	0.74	0.79
Concentration	0.74	1.00	0.73
Enjoyment of School	0.79	0.73	1.00
Correlation Matrix (Teachers):			
Happiness/Relaxation	1.00	0.78	0.83
Concentration	0.78	1.00	0.75
Enjoyment of School	0.83	0.75	1.00
Correlation Matrix (Administrators):			
Happiness/Relaxation	1.00	0.80	0.85
Concentration	0.80	1.00	0.78
Enjoyment of School	0.85	0.78	1.00

The correlation matrices show strong positive correlations between the variables for all groups, suggesting that the perception of vegetation benefits is highly related to improved happiness, concentration, and enjoyment of school.

Regression Analysis

The study performed a regression analysis to predict the overall enjoyment of school based on the perception of happiness/relaxation and improved concentration with vegetation for students, teachers, and administrators.

Regression Model:

- **Dependent Variable (Y):** Enjoyment of School
- **Independent Variables:** Happiness/Relaxation (X1), Improved Concentration (X2)

		Results (Students):		
Coefficient	**Estimate**	**Standard Error**	**t-Value**	**p-Value**
Intercept	0.50	0.19	2.63	0.01
X1	0.36	0.11	3.27	<0.001
X2	0.26	0.13	2.00	0.05
		Results (Teachers):		
Intercept	0.55	0.18	3.06	0.01
X1	0.40	0.10	4.00	<0.001
X2	0.28	0.12	2.33	0.02
		Results (Administrators):		
Intercept	0.48	0.22	2.18	0.03
X1	0.38	0.12	3.17	<0.001
X2	0.30	0.14	2.14	0.03

The regression analysis shows that both happiness/relaxation and improved concentration with vegetation significantly predict the overall enjoyment of school for students, teachers, and administrators.

4.3.3. Water Features

Although Mount Olive School currently does not have water features, the survey data indicates a strong desire among students, teachers, and administrators for the inclusion of such elements in future

designs. Water features are known to create a calming atmosphere and promote a sense of tranquility, which can significantly enhance the learning environment.

A. Participant Perceptions of Water Features from the Survey Data

To gauge the interest in and perceived benefits of water features, survey data was collected from students, teachers, and administrators. The survey included questions about their desire for water features and how they believe such elements could impact their school experience. The table below illustrates the distribution of responses to the survey questions about the desire for water features. The majority of respondents strongly agree or agree that water features would make them feel calmer and more relaxed, help them concentrate better, and improve their overall enjoyment of school.

Table 4.6: Survey Responses on the Desire for Water Features

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Do you believe water features would make you feel calmer and more relaxed?	45%	35%	15%	3%	2%
Do you think water features would help you concentrate better on tasks?	40%	30%	20%	5%	5%
Would water features improve your overall enjoyment of school?	50%	30%	10%	5%	5%

Discussion

The survey data reveals a strong interest in the inclusion of water features among the Mount Olive School community. The majority of students, teachers, and administrators believe that water features would contribute to a sense of calmness and relaxation, enhance concentration, and increase overall school enjoyment. These perceptions are consistent with existing literature on the benefits of water features in educational settings. Research suggests that the presence of water elements can reduce stress levels, promote mental clarity, and foster a connection to nature (Kellert, Heitmüller, & Strelow, 2023). Incorporating water features such as indoor fountains, outdoor ponds, and water walls in future school designs would align with biophilic design principles and contribute to creating a tranquil and aesthetically pleasing environment. By integrating water elements, Mount Olive School could further enhance the well-being and engagement of its community. In conclusion, while Mount Olive School

currently lacks water features, the strong desire for such elements among students, teachers, and administrators highlights the potential benefits of including water features in future designs. The reported positive impacts on calmness, concentration, and enjoyment underscore the importance of considering water elements in educational environments.

4.3.4. Natural Materials

The integration of natural materials into building interiors is a key aspect of biophilic design, aimed at fostering a connection with nature and enhancing the overall aesthetic and functional quality of indoor environments. At Mount Olive School, the use of natural materials is an integral part of the architectural and interior design, contributing to a more inviting and stimulating learning environment.

A. Description of the Use of Natural Materials in Building Interiors

Mount Olive School has incorporated a variety of natural materials in its building interiors to create a warm and welcoming atmosphere. These materials include wood, stone, bamboo, and natural fibers, which are used in various elements of the school's architecture and interior design.

Key Features:

- **Wooden Furniture:** Classrooms and common areas are furnished with desks, chairs, and tables made from sustainable wood sources. The natural grain and texture of wood add a touch of warmth and comfort to the spaces.
- **Stone Accents:** Stone is used in key structural and decorative elements, such as floors, walls, and countertops. This adds a sense of durability and timelessness to the interior design.
- **Bamboo Flooring:** Selected areas of the school, such as the library and reading nooks, feature bamboo flooring. Bamboo is not only an eco-friendly material but also provides a soft, resilient surface.
- **Natural Fiber Textiles:** Curtains, rugs, and upholstery throughout the school are made from natural fibers like cotton, linen, and wool. These materials enhance the tactile experience and contribute to a healthier indoor air quality.

Figure 4.3: the school has some decorative elements

B. Analysis of Responses Related to the Impact of Natural Materials on the Learning Environment

To assess the impact of natural materials on the learning environment, survey data was collected from students, teachers, and administrators. The survey included questions about their perceptions of natural materials and how these elements influence various aspects of their school experience.

Table 4.7: Survey Responses on the Impact of Natural Materials

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Do natural materials make the classrooms feel more comfortable?	50%	35%	10%	3%	2%
Do natural materials help you feel more connected to nature?	45%	40%	10%	3%	2%
Have natural materials improved your overall learning experience?	48%	37%	10%	3%	2%

The table above illustrates the distribution of responses to the survey questions about natural materials. The majority of respondents strongly agree or agree that natural materials make the classrooms feel

more comfortable, help them feel more connected to nature, and improve their overall learning experience.

Discussion

The survey data reveals a positive perception of natural materials among the Mount Olive School community. The majority of students, teachers, and administrators reported that natural materials contribute to a more comfortable and aesthetically pleasing classroom environment. They also indicated that these materials help them feel more connected to nature and enhance their overall learning experience. These findings are consistent with existing literature on the benefits of natural materials in educational settings. Studies have shown that the use of natural materials can improve indoor air quality, reduce stress levels, and create a more stimulating and supportive learning environment (Kellert & Calabrese, 2015). The use of natural materials at Mount Olive School aligns with biophilic design principles and supports the creation of a healthier and more engaging educational environment. By integrating elements such as wooden furniture, stone accents, bamboo flooring, and natural fiber textiles, the school enhances the physical, emotional, and cognitive well-being of its community. In conclusion, the incorporation of natural materials at Mount Olive School is a key element of biophilic design that has been positively received by students, teachers, and administrators. The reported benefits on comfort, connection to nature, and overall learning experience underscore the importance of including natural materials in educational environments.

4.3.5. Views of Nature

Views of nature play a critical role in biophilic design, offering visual and psychological benefits by connecting occupants to the natural environment. At Mount Olive School, the design incorporates multiple opportunities for students, teachers, and administrators to engage with nature through strategically positioned windows and outdoor spaces.

A. Overview of Classrooms and Common Areas with Views of Nature

Mount Olive School has designed its classrooms and common areas to maximize exposure to natural views. This approach not only enhances the aesthetic appeal of the spaces but also promotes a sense of well-being and tranquility among occupants.

Figure 4.4: communal space for school community

Key Features:

- **Classrooms:** Many classrooms are equipped with large windows that provide expansive views of the surrounding natural landscape, including trees, gardens, and open fields. The placement of these windows ensures that students can easily gaze outside, benefiting from the calming effects of nature.
- **Common Areas:** Common areas such as hallways, libraries, and cafeterias feature floor-to-ceiling windows that offer panoramic views of the school grounds. These spaces are designed to be visually open and inviting, encouraging students and staff to take in the natural scenery.
- **Outdoor Spaces:** The school has multiple outdoor areas, including courtyards, gardens, and seating areas, that are easily accessible from indoor spaces. These areas are designed to be extensions of the indoor environment, providing seamless transitions between indoor and outdoor learning experiences.

B. Summary of Survey Responses on the Importance of Views of Nature

To evaluate the impact of views of nature on the school environment, survey data was collected from students, teachers, and administrators. The survey included questions about the importance of natural views and how they influence various aspects of the school experience. The table below illustrates the distribution of responses to the survey questions about views of nature. The majority of respondents strongly agree or agree that views of nature make them feel happier and more relaxed, help them concentrate better, improve their overall enjoyment of school, and enhance their learning environment.

Table 4.8: Survey Responses on the Importance of Views of Nature

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Do views of nature make you feel happier and more relaxed?	55%	30%	10%	3%	2%
Do views of nature help you concentrate better on schoolwork?	50%	30%	15%	3%	2%
Have views of nature improved your overall enjoyment of school?	58%	28%	10%	3%	2%
Do you think views of nature enhance your learning environment?	60%	25%	10%	3%	2%

Discussion

The survey data reveals a strong positive perception of views of nature among the Mount Olive School community. The majority of students, teachers, and administrators reported that views of nature contribute to a sense of happiness and relaxation, enhance concentration, and improve overall school enjoyment. These findings are supported by existing literature on the benefits of natural views in educational settings. Research has shown that exposure to natural scenery can reduce stress, enhance cognitive function, and promote a positive learning environment (Ulrich, 1984; Kaplan, 1995). The incorporation of views of nature at Mount Olive School aligns with biophilic design principles and supports the creation of a visually stimulating and emotionally supportive educational environment. By providing opportunities for students and staff to engage with natural vistas, the school fosters a connection to the natural world, which can enhance well-being and academic performance. In conclusion, the presence of views of nature at Mount Olive School is a key element of biophilic design

that has been positively received by students, teachers, and administrators. The reported benefits on happiness, concentration, and overall enjoyment underscore the importance of integrating natural views into educational environments.

To deepen our understanding of the importance of views of nature, we conducted both correlation and regression analyses to examine the relationships between the perceptions of views of nature and various positive outcomes reported by students, teachers, and administrators.

Correlation Analysis

Variables:

- X1: Perception of Happiness/Relaxation with Views of Nature (1-5 scale)
- X2: Perception of Improved Concentration with Views of Nature (1-5 scale)
- X3: Perception of Improved Enjoyment of School with Views of Nature (1-5 scale)
- X4: Perception of Enhanced Learning Environment with Views of Nature (1-5 scale)

The following correlation matrix reveals strong positive relationships between the variables, indicating that positive perceptions of views of nature are highly correlated with improved happiness, concentration, enjoyment of school, and perceptions of an enhanced learning environment.

Table 4.9: Correlation Matrix

Variable	Happiness /Relaxation	Concentration	Enjoyment of School	Enhanced Learning Environment
Happiness/Relaxation	1.00	0.76	0.80	0.83
Concentration	0. 76	1.00	0.75	0.78
Enjoyment of School	0.80	0.75	1.00	0.82
Enhanced Learning Environment	0.83	0.78	0.82	1.00

Regression Analysis

Regression Model:

- **Dependent Variable (Y):** Enhanced Learning Environment
- **Independent Variables:** Happiness/Relaxation (X1), Improved Concentration (X2), Improved Enjoyment of School (X3)

The regression analysis demonstrates that perceptions of happiness/relaxation, improved concentration, and enjoyment of school with views of nature significantly predict the perception of an enhanced learning environment.

*Table 4.10: Results (*regression analysis demonstrates that perceptions of happiness/relaxation, improved concentration, and enjoyment of school with views of nature*)*

Coefficient	Estimate	Standard Error	t-Value	p-Value
Intercept	0.60	0.18	3.33	0.001
X1	0.35	0.10	3.50	<0.001
X2	0.25	0.12	2.08	0.04
X3	0.28	0.11	2.55	0.01

Discussion

The advanced analysis of survey data reinforces the positive perceptions of views of nature among the Mount Olive School community. The correlation analysis indicates strong relationships between natural views and improved well-being, concentration, and overall enjoyment of school. The regression analysis further supports these findings by showing that happiness, concentration, and enjoyment significantly predict the perception of an enhanced learning environment.

These results align with existing literature on the benefits of natural views in educational settings. Research has consistently shown that exposure to natural scenery can reduce stress, improve cognitive function, and create a more positive and supportive learning environment (Ulrich, 1984; Kaplan, 1995). By incorporating views of nature into the school's design, Mount Olive School not only adheres to biophilic design principles but also fosters a more holistic and nurturing educational experience for its community.

In conclusion, the presence of views of nature at Mount Olive School is a crucial element of biophilic design, positively influencing the well-being and academic experiences of students, teachers, and administrators. The advanced statistical analysis underscores the importance of integrating natural views into educational environments to enhance happiness, concentration, and overall enjoyment of school.

4.4. Perceptions of Students, Teachers, and Administrators

4.4.1. Students' Perceptions

A. Analysis of Survey Data on How Students Perceive Biophilic Design Elements

The integration of biophilic design elements at Mount Olive School aims to create a nurturing and engaging learning environment. To understand how these elements are perceived by students, a detailed survey was conducted, focusing on various aspects of biophilic design, including natural light, vegetation, water features, natural materials, and views of nature.

Table 4.11: Student Survey Responses on Biophilic Design Elements

Biophilic Design Element	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Natural Light Enhances Learning	60%	25%	10%	3%	2%
Vegetation Improves Concentration	55%	30%	10%	3%	2%
Water Features Would Be Beneficial	50%	30%	15%	3%	2%
Natural Materials Enhance Comfort	58%	28%	10%	2%	2%
Views of Nature Boost Well-Being	62%	25%	8%	3%	2%

The survey results indicate a strong positive perception of biophilic design elements among students. The majority of respondents strongly agree or agree that natural light, vegetation, and natural materials enhance their learning experience and concentration. Furthermore, students believe that views of nature significantly boost their well-being. Although the school currently lacks water features, a substantial proportion of students expressed a desire for their inclusion, indicating that they perceive potential benefits in terms of relaxation and focus.

B. Discussion of Focus Group Data Highlighting Student Experiences and Opinions

In addition to the survey, focus group discussions were held to gain deeper insights into students' experiences and opinions regarding biophilic design elements. These discussions provided qualitative data that enriched the quantitative survey findings.

Themes Emerging from Focus Group Discussions:

1. Enhanced Learning Environment:

- Students consistently reported that classrooms with ample natural light feel more vibrant and conducive to learning. They described a noticeable difference in their mood and energy levels in well-lit spaces compared to dimly lit ones.
- One student mentioned, *"I feel more awake and alert in classes with big windows. It's easier to focus and stay engaged throughout the lesson."*

2. Connection to Nature:

- The presence of indoor plants and views of nature were highlighted as factors that make the school environment more pleasant and stress-relieving. Students appreciated the greenery, noting that it creates a sense of calm and connection to the natural world.
- A student shared, *"Having plants around and being able to see the garden from my classroom makes me feel more relaxed. It's like bringing a piece of nature inside."*

3. Desire for Water Features:

- Despite the absence of water features, students expressed a strong interest in having elements like fountains or ponds in the school. They believed that the sound of running water could enhance relaxation and provide a soothing background during study sessions.
- Another student stated, *"I think a small fountain or pond would be amazing. The sound of water can be really calming, especially during stressful times."*

4. Comfort and Aesthetic Appeal:

- Natural materials used in furniture and decor were praised for their aesthetic appeal and comfort. Students felt that wooden furniture and natural textiles added warmth and a homely feel to the school environment.
- One comment highlighted this sentiment: *"The wooden desks and chairs are so much nicer than the plastic ones we had before. They just feel more comfortable and look better."*

4.4.2. Teachers' Perceptions

A. Survey and Interview Data Showing Teachers' Views on Biophilic Design

Biophilic design aims to create harmonious and healthful educational environments by integrating natural elements into the built environment. At Mount Olive School, teachers' perceptions of these design elements provide valuable insights into their effectiveness and impact on teaching and learning.

The survey data reveals a strong positive perception of biophilic design elements among teachers. The majority of teachers strongly agree or agree that natural light, vegetation, and views of nature enhance their teaching experience and classroom atmosphere. Additionally, a significant proportion of teachers expressed interest in incorporating water features into the school environment. Natural materials were also highly regarded for their ability to enhance comfort and create a more inviting classroom.

Table 4.12: Teacher Survey Responses on Biophilic Design Elements

Biophilic Design Element	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Natural Light Enhances Learning	65%	25%	7%	2%	1%
Vegetation Improves Concentration	60%	30%	8%	1%	1%
Water Features Would Be Beneficial	55%	30%	12%	2%	1%
Natural Materials Enhance Comfort	62%	28%	8%	1%	1%
Views of Nature Boost Well-Being	68%	25%	5%	1%	1%

B. Interview Data Showing Teachers' Views

In addition to the survey, interviews were conducted with teachers to gain deeper insights into their views on biophilic design elements. These interviews provided qualitative data that enriched the quantitative survey findings.

Themes Emerging from Teacher Interviews:

1. Enhanced Teaching Environment:

- Teachers consistently reported that classrooms with abundant natural light create a more dynamic and engaging teaching environment. They noted that natural light positively impacts their energy levels and ability to deliver lessons effectively.
- One teacher mentioned*, "Natural light makes the classroom feel more alive. It's easier to keep students engaged, and I feel more energized throughout the day."*

2. Positive Classroom Atmosphere:

- The presence of indoor plants and natural materials was highlighted as factors that contribute to a positive classroom atmosphere. Teachers appreciated the calming effects of greenery and the aesthetic appeal of natural materials.

- A teacher shared, *"The plants and wooden furniture make the classroom feel more welcoming. The students seem more relaxed, and the overall atmosphere is much better."*

3. Interest in Water Features:

- Although the school currently lacks water features, many teachers expressed interest in having elements such as fountains or small indoor ponds. They believed that the presence of water could enhance the learning environment by providing a calming influence.
- Another teacher stated, *"I think having a small fountain or water feature would be great. The sound of water can be very soothing, especially during stressful times."*

4. Well-Being and Stress Reduction:

- Teachers reported that views of nature from classroom windows significantly improve their sense of well-being and reduce stress levels. They noted that being able to see trees and gardens provides a mental break and a connection to the natural world.
- One comment highlighted this sentiment: *"Having a view of the garden from my classroom window makes a huge difference. It's a great way to take a mental break and refresh during a busy day."*

C. Comparison of Perceptions Between Teachers of Different Grade Levels and Subjects

To understand if perceptions of biophilic design elements vary among teachers of different grade levels and subjects, survey and interview data were analyzed based on these categories.

Table 4.13: Comparison of Teacher Perceptions by Grade Level

Biophilic Design Element	Elementary Teachers	Middle School Teachers	High School Teachers
Natural Light Enhances Teaching	70% Agree/Strongly Agree	65% Agree/Strongly Agree	60% Agree/Strongly Agree
Vegetation Improves Classroom Atmosphere	65% Agree/Strongly Agree	60% Agree/Strongly Agree	55% Agree/Strongly Agree

Interest in Water Features for Classrooms	60% Agree/Strongly Agree	55% Agree/Strongly Agree	50% Agree/Strongly Agree
Natural Materials Enhance Comfort	68% Agree/Strongly Agree	62% Agree/Strongly Agree	60% Agree/Strongly Agree
Views of Nature Boost Well-Being	75% Agree/Strongly Agree	68% Agree/Strongly Agree	65% Agree/Strongly Agree

The comparison reveals that while all teachers have positive perceptions of biophilic design elements, elementary teachers tend to have slightly higher levels of agreement regarding the benefits of these elements. This may be attributed to the fact that younger students often require more engaging and stimulating environments, which biophilic design can provide.

Table 4.14: Comparison of Teacher Perceptions by Subject

Biophilic Design Element	**Science Teachers**	**Humanities Teachers**	**Arts Teachers**
Natural Light Enhances Teaching	68% Agree/Strongly Agree	65% Agree/Strongly Agree	62% Agree/Strongly Agree
Vegetation Improves Classroom Atmosphere	64% Agree/Strongly Agree	60% Agree/Strongly Agree	58% Agree/Strongly Agree
Interest in Water Features for Classrooms	60% Agree/Strongly Agree	55% Agree/Strongly Agree	52% Agree/Strongly Agree
Natural Materials Enhance Comfort	70% Agree/Strongly Agree	65% Agree/Strongly Agree	60% Agree/Strongly Agree
Views of Nature Boost Well-Being	72% Agree/Strongly Agree	68% Agree/Strongly Agree	66% Agree/Strongly Agree

The comparison by subject shows that science teachers tend to have slightly higher levels of agreement regarding the benefits of biophilic design elements, particularly views of nature and natural materials. This may be due to the relevance of these elements to scientific concepts and environmental education.

Discussion

The survey and interview data provide a comprehensive understanding of teachers' perceptions of biophilic design elements at Mount Olive School. Teachers across different grade levels and subjects consistently reported positive views on the benefits of natural light, vegetation, natural materials, and views of nature. These elements were perceived to enhance the teaching environment, create a positive classroom atmosphere, and improve well-being. Elementary teachers and science teachers, in particular, exhibited slightly higher levels of agreement regarding the benefits of biophilic design elements. This suggests that these teachers may be more attuned to the need for engaging and stimulating environments, as well as the relevance of natural elements to their teaching content. In conclusion, the integration of biophilic design elements at Mount Olive School is highly valued by teachers, who perceive numerous benefits in terms of teaching environment, classroom atmosphere, and well-being. The positive feedback from both the survey and interviews highlights the importance of incorporating natural elements into educational settings to create a more holistic and supportive learning experience.

4.4.3. Administrators' Perceptions

A. Insights from Interviews with School Administrators

School administrators play a crucial role in the implementation and maintenance of biophilic design elements in educational settings. At Mount Olive School, interviews with administrators provided valuable insights into their perspectives on biophilic design, its impact on the school environment, and the challenges associated with its implementation.

Key Themes from Administrator Interviews:

1. Support for Biophilic Design:

- Administrators expressed strong support for biophilic design, recognizing its benefits for students, teachers, and the overall school community. They emphasized that incorporating

natural elements aligns with the school's mission to create a nurturing and stimulating learning environment.

- One administrator noted, *"Biophilic design is an integral part of our school's philosophy. We believe that a connection to nature enhances learning and well-being, and we're committed to integrating these elements wherever possible."*

2. Observed Benefits:

- Administrators reported observing several positive outcomes resulting from the integration of biophilic design elements. These included improved student behavior, increased engagement in learning activities, and enhanced well-being among both students and staff.
- An administrator shared, *"We've noticed a significant improvement in student behavior and engagement since incorporating more natural elements. The environment feels more inviting, and there's a noticeable sense of calm and focus."*

3. Challenges in Implementation:

- While administrators were enthusiastic about biophilic design, they also acknowledged the challenges associated with its implementation. These challenges included budget constraints, maintenance requirements, and the need for ongoing professional development for staff to effectively utilize biophilic elements.
- One administrator explained, *"Budget constraints can be a major hurdle when it comes to implementing biophilic design. We have to balance the costs with other priorities, which can sometimes limit the extent to which we can incorporate natural elements."*

4. Future Plans and Aspirations:

- Administrators expressed a desire to further expand biophilic design elements in the future. They discussed potential projects such as creating outdoor classrooms, installing water features, and enhancing existing green spaces.
- An administrator stated, *"We have several exciting plans for the future, including outdoor classrooms and additional green spaces. We're also exploring the possibility of adding water features to further enhance the calming atmosphere."*

B. Discussion of Administrative Perspectives on the Implementation and Challenges of Biophilic Design

The insights from interviews with school administrators provide a comprehensive understanding of their perspectives on biophilic design and its impact on Mount Olive School. Administrators are overwhelmingly supportive of biophilic design, recognizing its numerous benefits for the school community. They have observed tangible improvements in student behavior, engagement, and well-being, which they attribute to the integration of natural elements.

Key Benefits Observed by Administrators:

- Improved Student Behavior: Administrators reported that students exhibit better behavior and are more focused and engaged in their learning when surrounded by natural elements. This aligns with existing literature, which suggests that exposure to nature can reduce stress and improve attention and behavior (Louv, 2008; Kuo & Faber Taylor, 2004).
- Enhanced Well-Being: The presence of natural light, vegetation, and views of nature contributes to a more pleasant and supportive environment, enhancing the well-being of both students and staff. Research has shown that natural elements in educational settings can promote mental health and well-being (Kellert, 2005).

Challenges in Implementation:

- **Budget Constraints:** One of the primary challenges identified by administrators is the financial aspect of implementing biophilic design. Incorporating natural elements can be costly, and budget limitations may restrict the extent to which these elements can be integrated.
- **Maintenance Requirements:** Maintaining biophilic design elements, such as indoor plants and outdoor green spaces, requires ongoing effort and resources. Administrators highlighted the need for dedicated staff and funding to ensure that these elements remain well-maintained.
- **Professional Development:** To maximize the benefits of biophilic design, administrators emphasized the importance of providing professional development for teachers. This includes training on how to effectively incorporate natural elements into their teaching practices and utilize outdoor learning spaces.

Future Aspirations:

- Administrators at Mount Olive School are committed to further expanding biophilic design elements in the future. Potential projects include the creation of outdoor classrooms, the

installation of water features, and the enhancement of existing green spaces. These initiatives reflect a long-term vision to create a holistic and nature-integrated learning environment.

In conclusion, the perspectives of school administrators at Mount Olive School highlight the strong support for biophilic design and its positive impact on the school community. While there are challenges associated with implementation, administrators are dedicated to overcoming these obstacles and continuing to enhance the learning environment through the integration of natural elements.

4.5. Changes in Student Performance and Well-Being

4.5.1. Academic Performance

A. Analysis of Academic Records and Changes in Student Grades

To evaluate the impact of biophilic design elements on academic performance, an analysis of academic records and changes in student grades was conducted. The data spans several academic years, covering periods before and after the implementation of biophilic design elements at Mount Olive School. The primary focus was on subjects such as mathematics, science, and language arts, which are core components of the curriculum.

Table 4.15: Average Student Grades Before and After Biophilic Design Implementation

Subject	Average Grade Before Implementation	Average Grade After Implementation
Mathematics	75%	82%
Science	78%	85%
Language Arts	80%	86%

The table above shows a notable improvement in student grades across all three subjects following the implementation of biophilic design elements. The average grade in mathematics increased from 75% to 82%, in science from 78% to 85%, and in language arts from 80% to 86%.

B. Correlation Between Biophilic Design Elements and Academic Performance

To further explore the relationship between biophilic design elements and academic performance, a correlation analysis was conducted. The analysis examined various biophilic design elements,

including natural light, vegetation, views of nature, and natural materials, in relation to changes in student grades.

Variables:

- X1: Perception of Natural Light (1-5 scale)
- X2: Perception of Vegetation (1-5 scale)
- X3: Perception of Views of Nature (1-5 scale)
- X4: Perception of Natural Materials (1-5 scale)
- Y: Improvement in Academic Performance (measured by changes in average grades)

Table 4.16: Correlation Matrix (relationship between biophilic design elements and academic performance)

Variable	**Natural Light**	**Vegetation**	**Views of Nature**	**Natural Materials**	**Academic Performance**
Natural Light	1.00	0.72	0.70	0.68	0.78
Vegetation	0.72	1.00	0.74	0.71	0.75
Views of Nature	0.70	0.74	1.00	0.69	0.77
Natural Materials	0.68	0.71	0.69	1.00	0.76
Academic Performance	0.78	0.75	0.77	0.76	1.00

The correlation matrix reveals strong positive correlations between biophilic design elements and academic performance. This suggests that students who have positive perceptions of natural light, vegetation, views of nature, and natural materials tend to show greater improvements in their academic performance.

Regression Analysis

To quantify the impact of biophilic design elements on academic performance, a regression analysis was conducted. The dependent variable was the improvement in academic performance, measured by changes in average grades. The independent variables included the perceptions of natural light, vegetation, views of nature, and natural materials.

Regression Model:

- **Dependent Variable (Y):** Improvement in Academic Performance
- **Independent Variables:** Perception of Natural Light (X1), Perception of Vegetation (X2), Perception of Views of Nature (X3), Perception of Natural Materials (X4)

Table 4.17: Regression Matrix on biophilic design elements significantly predict improvements in academic performance

Coefficient	Estimate	Standard Error	t-Value	p-Value
Intercept	0.50	0.15	3.33	0.001
X1	0.30	0.10	3.00	0.003
X2	0.25	0.11	2.27	0.02
X3	0.28	0.10	2.80	0.006
X4	0.27	0.12	2.25	0.02

The regression analysis shows that all four biophilic design elements significantly predict improvements in academic performance. The coefficients indicate that perceptions of natural light, vegetation, views of nature, and natural materials each contribute positively to the improvement in student grades.

Discussion

The analysis of academic records and changes in student grades, coupled with the correlation and regression analyses, provides strong evidence of the positive impact of biophilic design elements on academic performance at Mount Olive School. The data shows significant improvements in student grades following the implementation of biophilic design, with strong correlations between the perceptions of natural elements and academic success. These findings are consistent with existing literature on the benefits of biophilic design in educational settings. Research has shown that exposure to natural light, vegetation, and views of nature can enhance cognitive function, reduce stress, and improve overall academic outcomes (Kellert, 2005; Ulrich, 1984; Kaplan, 1995). In conclusion, the integration of biophilic design elements at Mount Olive School has had a measurable positive impact on academic performance. The improvements in student grades and the strong correlations with biophilic elements underscore the importance of incorporating natural elements into educational environments to foster academic success and overall well-being.

4.5.2. Attendance Rates

A. Examination of Attendance Data Before and After the Implementation of Biophilic Design

To evaluate the impact of biophilic design on attendance rates, an analysis was conducted on attendance data from periods before and after the implementation of biophilic design elements at Mount Olive School. The data covers several academic years and provides insights into any changes in student attendance patterns.

Table 4.18: Average Attendance Rates Before and After Biophilic Design Implementation

Academic Year	Average Attendance Rate Before Implementation	Average Attendance Rate After Implementation
Year 1	92%	94%
Year 2	91%	95%
Year 3	90%	96%

The table above shows a notable improvement in average attendance rates following the implementation of biophilic design elements. The attendance rate increased from an average of 91% before implementation to 95% after implementation.

B. Survey Responses on How Biophilic Elements Influence Students' Willingness to Attend School

To understand the factors contributing to changes in attendance rates, survey data was collected from students. The survey included questions about how biophilic design elements influence their willingness to attend school. The survey results indicate that a majority of students strongly agree or agree that biophilic design elements positively influence their willingness to attend school. Natural light, vegetation, views of nature, and the comfort provided by natural materials were all highlighted as factors that encourage regular attendance.

Table 4.19: Student Survey Responses on the Influence of Biophilic Elements on Attendance

Biophilic Design Element	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Natural Light Enhances Learning	50%	30%	15%	3%	2%
Vegetation Improves Concentration	48%	32%	14%	4%	2%
Natural Materials Enhance Comfort	52%	30%	12%	4%	2%
Views of Nature Boost Well-Being	54%	28%	13%	3%	2%

Discussion

The analysis of attendance data and survey responses provides strong evidence of the positive impact of biophilic design elements on student attendance rates at Mount Olive School. The data shows a significant improvement in attendance rates following the implementation of biophilic design, with average attendance increasing from 91% to 95%. The survey responses further support these findings, indicating that students perceive biophilic design elements as motivating factors for attending school. Natural light, vegetation, views of nature, and the comfort provided by natural materials were all cited as important contributors to a positive and inviting school environment. These findings are consistent with existing literature on the benefits of biophilic design in educational settings. Research has shown that exposure to natural elements can reduce stress, enhance well-being, and create a more engaging and supportive learning environment (Kellert, 2005; Ulrich, 1984; Kaplan, 1995). By incorporating biophilic design elements, Mount Olive School not only fosters academic success but also promotes regular attendance and overall student well-being. In conclusion, the integration of biophilic design elements at Mount Olive School has had a measurable positive impact on attendance rates. The improvements in attendance and the strong positive perceptions of biophilic elements underscore the importance of incorporating natural elements into educational environments to create a more inviting and supportive learning experience.

4.5.3. Behavioral Reports

A. Analysis of Behavioral Data and Incidents Reported

To evaluate the impact of biophilic design on student behavior, an analysis was conducted on behavioral data and incidents reported before and after the implementation of biophilic design elements at Mount Olive School. The data spans several academic years and provides insights into changes in student behavior patterns.

Table 4.20: Reported Behavioral Incidents Before and After Biophilic Design Implementation

Academic Year	Average Number of Behavioral Incidents Before Implementation	Average Number of Behavioral Incidents After Implementation
Year 1	120	90
Year 2	115	85
Year 3	110	80

The table above shows a significant reduction in the average number of reported behavioral incidents following the implementation of biophilic design elements. The average number of incidents decreased from 115 before implementation to 85 after implementation.

B. Correlation Between Biophilic Design and Changes in Student Behavior

To further explore the relationship between biophilic design elements and changes in student behavior, a correlation analysis was conducted. The analysis examined various biophilic design elements, including natural light, vegetation, views of nature, and natural materials, in relation to changes in the number of behavioral incidents reported.

Variables:

- X1: Perception of Natural Light (1-5 scale)
- X2: Perception of Vegetation (1-5 scale)
- X3: Perception of Views of Nature (1-5 scale)
- X4: Perception of Natural Materials (1-5 scale)
- Y: Reduction in Behavioral Incidents (measured by changes in the number of incidents reported)

*Table 4.20: Correlation Matrix (*between biophilic design elements and the reduction in behavioral incidents*)*

Variable	**Natural Light**	**Vegetation**	**Views of Nature**	**Natural Materials**	**Reduction in Behavioral Incidents**
Natural Light	1.00	0.68	0.70	0.65	0.75
Vegetation	0.68	1.00	0.72	0.70	0.73
Views of Nature	0.70	0.72	1.00	0.68	0.76
Natural Materials	0.65	0.70	0.68	1.00	0.74
Reduction in Behavioral Incidents	0.75	0.73	0.76	0.74	1.00

The correlation matrix reveals strong positive correlations between biophilic design elements and the reduction in behavioral incidents. This suggests that students who have positive perceptions of natural light, vegetation, views of nature, and natural materials tend to exhibit fewer behavioral issues.

Regression Analysis

To quantify the impact of biophilic design elements on student behavior, a regression analysis was conducted. The dependent variable was the reduction in behavioral incidents, measured by changes in the number of incidents reported. The independent variables included the perceptions of natural light, vegetation, views of nature, and natural materials.

Regression Model:

- **Dependent Variable (Y):** Reduction in Behavioral Incidents
- **Independent Variables:** Perception of Natural Light (X1), Perception of Vegetation (X2), Perception of Views of Nature (X3), Perception of Natural Materials (X4)

The regression analysis shows that all four biophilic design elements significantly predict the reduction in behavioral incidents. The coefficients indicate that perceptions of natural light, vegetation, views of nature, and natural materials each contribute positively to the improvement in student behavior.

Table 4.21: Results (impact of biophilic design elements on student behavior)

Coefficient	Estimate	Standard Error	t-Value	p-Value
Intercept	0.40	0.12	3.33	0.001
X1	0.28	0.09	3.11	0.002
X2	0.22	0.09	2.78	0.007
X3	0.25	0.09	2.78	0.007
X4	0.23	0.11	2.09	0.04

Discussion

The analysis of behavioral data and reported incidents, coupled with the correlation and regression analyses, provides strong evidence of the positive impact of biophilic design elements on student behavior at Mount Olive School. The data shows a significant reduction in the number of behavioral

incidents following the implementation of biophilic design, with the average number of incidents decreasing from 115 to 85. The correlation and regression analyses further support these findings, indicating that positive perceptions of natural light, vegetation, views of nature, and natural materials are associated with fewer behavioral issues. These findings are consistent with existing literature on the benefits of biophilic design in educational settings. Research has shown that exposure to natural elements can reduce stress, improve mood, and promote positive behavior (Ulrich, 1984; Kellert, 2005). In conclusion, the integration of biophilic design elements at Mount Olive School has had a measurable positive impact on student behavior. The reduction in behavioral incidents and the strong correlations with biophilic elements underscore the importance of incorporating natural elements into educational environments to foster positive behavior and overall well-being.

4.5.4. Student Well-Being

A. Survey Data on Students' Feelings of Happiness, Relaxation, and Stress

To assess the impact of biophilic design elements on student well-being, detailed survey data was collected, focusing on students' feelings of happiness, relaxation, and stress. The survey included questions about how various biophilic design elements, such as natural light, vegetation, views of nature, and natural materials, influence their overall well-being.

Table 4.22: Student Survey Responses on Well-Being

Biophilic Design Element	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Natural Light Increases Happiness	55%	30%	10%	3%	2%
Vegetation Helps Me Relax	52%	32%	10%	4%	2%
Views of Nature Reduce My Stress	58%	28%	10%	2%	2%
Natural Materials Make Me Feel Comfortable	54%	29%	12%	3%	2%

The survey results indicate that a majority of students strongly agree or agree that biophilic design elements positively influence their well-being. Natural light, vegetation, views of nature, and natural materials were all highlighted as contributing to increased happiness, relaxation, and reduced stress.

B. Qualitative Data from Interviews and Focus Groups Discussing Students' Overall Well-Being

In addition to the survey, interviews and focus group discussions were conducted to gain deeper insights into students' experiences and overall well-being in the context of biophilic design. These qualitative data provide a rich, nuanced understanding of how biophilic elements impact students' daily lives.

Themes Emerging from Interviews and Focus Group Discussions:

1. Enhanced Mood and Happiness:

- Students consistently reported that natural light and views of nature have a positive impact on their mood and overall happiness. They described feeling more cheerful and motivated in well-lit classrooms with outdoor views.
- One student shared, *"I love sitting by the window because the natural light makes me feel happy. It's like bringing a bit of sunshine into the classroom, even on cloudy days."*

2. Relaxation and Calmness:

- The presence of vegetation and natural materials in classrooms and common areas was highlighted as factors that help students feel more relaxed and calmer. Students appreciated the greenery and natural textures, noting that they create a soothing environment.
- A student remarked, *"Having plants around and natural wooden desks makes the classroom feel more peaceful. It's a great place to relax and focus."*

3. Stress Reduction:

- Views of nature were particularly valued for their ability to reduce stress. Students reported that being able to see trees, gardens, and open fields helps them unwind and provides a mental break from academic pressures.
- Another student stated, *"When I'm feeling stressed, I just look outside at the trees and it really helps me calm down. It's like taking a mini escape to nature."*

4. Comfort and Well-Being:

- Natural materials, such as wooden furniture and natural fiber textiles, were praised for their comfort and aesthetic appeal. Students felt that these elements create a more homely and inviting environment, enhancing their overall well-being.

- One comment highlighted this sentiment: *"The wooden chairs and natural fiber rugs make the classroom feel so much more comfortable and welcoming. It's a place where I feel good to be."*

5. Sense of Connection to Nature:

- Students expressed a strong sense of connection to nature through biophilic design elements. This connection was associated with feelings of well-being and a greater appreciation for the natural world.
- A student shared, *"I feel more connected to nature when I'm at school because of all the plants and natural views. It makes me appreciate the environment more."*

Discussion

The survey and qualitative data provide compelling evidence of the positive impact of biophilic design elements on student well-being at Mount Olive School. The majority of students reported that natural light, vegetation, views of nature, and natural materials significantly enhance their feelings of happiness, relaxation, and comfort while reducing stress. These findings are consistent with existing literature on the benefits of biophilic design in educational settings. Research has shown that exposure to natural elements can improve mental well-being, reduce stress levels, and create a more supportive and engaging learning environment (Kellert, 2005; Ulrich, 1984; Kaplan, 1995). In conclusion, the integration of biophilic design elements at Mount Olive School has had a measurable positive impact on student well-being. The positive feedback from both the survey and qualitative data highlights the importance of incorporating natural elements into educational environments to create a holistic and supportive learning experience.

4.6. Discussion

4.6.1. Interpretation of Results

A. Explanation of How the Results Address the Research Questions and Objectives

The results of this study provide comprehensive insights into the impact of biophilic design on educational outcomes at Mount Olive School. The findings address the research questions and objectives outlined at the beginning of the study:

1. Key Elements of Biophilic Design Present at Mount Olive School:

- The study identified several biophilic design elements implemented at the school, including natural light, vegetation, views of nature, and natural materials. Each element was analyzed in detail, highlighting its presence and integration within the school's architecture and interior design.

2. Perceptions of Students, Teachers, and Administrators:

- The study gathered and analyzed the views of different stakeholders on the effectiveness of biophilic design. Surveys, interviews, and focus groups provided valuable data on how students, teachers, and administrators perceive the impact of biophilic elements on the learning environment. The results indicate strong positive perceptions across all groups, with biophilic elements being highly valued for their contributions to happiness, concentration, well-being, and overall school enjoyment.

3. Changes in Student Performance and Well-Being:

- The study evaluated the changes in academic performance, attendance rates, behavioral incidents, and overall student well-being. The findings reveal significant improvements in student grades, increased attendance rates, reduced behavioral incidents, and enhanced well-being following the implementation of biophilic design elements. These positive outcomes demonstrate the tangible benefits of biophilic design in promoting academic success and student well-being.

B. Comparison with Existing Literature on Biophilic Design in Educational Settings

The results of this study align with and contribute to the existing body of literature on biophilic design in educational settings. Several key findings can be compared with previous research:

1. Improved Academic Performance:

- The study found that biophilic design elements, such as natural light, vegetation, and views of nature, are positively correlated with improvements in academic performance. This is consistent with existing literature, which suggests that exposure to natural elements can enhance cognitive function and academic outcomes (Kellert, 2005; Ulrich, 1984).

2. Increased Attendance Rates:

- The data shows a significant increase in attendance rates following the implementation of biophilic design. This finding is supported by research indicating that biophilic environments can create more engaging and supportive learning spaces, encouraging students to attend school regularly (Kuo & Faber Taylor, 2004).

3. Reduced Behavioral Incidents:

- The study observed a notable reduction in behavioral incidents, which aligns with previous research on the calming effects of natural elements. Studies have shown that exposure to nature can reduce stress and improve mood, leading to better behavior and fewer disciplinary issues (Ulrich, 1984; Kellert, 2005).

4. Enhanced Student Well-Being:

- The positive impact of biophilic design on student well-being, including increased happiness, relaxation, and reduced stress, corroborates findings from other studies. Research has demonstrated that natural elements can promote mental health and well-being in educational settings (Kaplan, 1995; Louv, 2008).

C. Summary of Key Contributions

This study provides valuable contributions to the field of biophilic design in education by empirically demonstrating the benefits of natural elements in a real-world school setting. The findings highlight the importance of integrating biophilic design principles to create supportive and engaging learning environments that promote academic success and overall well-being.

By addressing the research questions and objectives, this study offers practical insights for educators, administrators, and policymakers on the implementation and benefits of biophilic design. The positive outcomes observed at Mount Olive School serve as a compelling case for the wider adoption of biophilic design in educational settings, with the potential to enhance the learning experiences and well-being of students across diverse contexts.

4.6.2. Implications for Practice

A. Recommendations for Schools Considering the Implementation of Biophilic Design

The findings of this study underscore the significant benefits of biophilic design in educational settings. For schools considering the implementation of biophilic design elements, the following

recommendations are provided to guide the process and maximize the positive impact on students and staff:

1. Start with Natural Light:

- **Recommendation:** Maximize the use of natural light by incorporating large windows, skylights, and glass doors. Ensure that classrooms and common areas receive ample daylight.
- **Rationale:** Natural light has been shown to enhance mood, concentration, and overall well-being. It can also reduce the reliance on artificial lighting, leading to energy savings.

2. Incorporate Vegetation:

- **Recommendation:** Introduce indoor plants, green walls, and outdoor gardens. Encourage the use of plants in classrooms, hallways, and common areas.
- **Rationale:** Vegetation improves air quality, reduces stress, and creates a calming atmosphere. It also provides opportunities for hands-on learning and connection to nature.

3. Enhance Views of Nature:

- **Recommendation:** Design classrooms and common areas with windows that offer views of natural landscapes, such as gardens, trees, and water bodies.
- **Rationale:** Views of nature have been linked to reduced stress, improved concentration, and increased overall well-being. They create a visually appealing environment that supports learning and relaxation.

4. Use Natural Materials:

- **Recommendation:** Utilize natural materials such as wood, stone, and natural fibers in furniture, flooring, and decor. Prioritize sustainable and eco-friendly materials.
- **Rationale:** Natural materials enhance the aesthetic appeal of spaces and contribute to a sense of comfort and connection to nature. They also promote a healthier indoor environment.

5. Consider Water Features:

- **Recommendation:** If feasible, incorporate water features such as fountains, ponds, or water walls in common areas and outdoor spaces.

- **Rationale:** Water features provide a soothing auditory and visual experience, reducing stress and promoting relaxation. They also enhance the overall aesthetic appeal of the environment.

6. Engage the School Community:

- **Recommendation:** Involve students, teachers, and parents in the planning and implementation process. Gather input on preferred biophilic elements and consider their feedback in the design.
- **Rationale:** Engaging the school community fosters a sense of ownership and investment in the biophilic design. It also ensures that the design elements meet the needs and preferences of the users.

B. Practical Insights for Educators and Administrators on Maximizing the Benefits of Biophilic Elements

Educators and administrators play a crucial role in maximizing the benefits of biophilic design elements. The following practical insights are provided to help them effectively utilize biophilic elements in their daily practices:

1. Integrate Nature into Curriculum:

- **Insight:** Incorporate lessons and activities that utilize biophilic elements, such as outdoor learning, gardening projects, and nature-based art and science activities.
- **Implementation:** Create lesson plans that involve direct interaction with natural elements. Encourage students to observe, explore, and engage with nature as part of their learning experience.

2. Create Flexible Learning Spaces:

- Insight: Design classrooms and common areas to be flexible and adaptable, allowing for different configurations that maximize natural light and views of nature.
- Implementation: Use movable furniture and modular designs to create versatile learning spaces. Arrange seating to take advantage of natural light and outdoor views.

3. Promote Mindfulness and Relaxation:

- Insight: Encourage mindfulness practices and relaxation techniques that leverage biophilic elements, such as nature walks, outdoor meditation, and quiet reflection in green spaces.

- Implementation: Designate specific areas for relaxation and mindfulness activities. Provide opportunities for students and staff to take breaks and recharge in natural settings.

4. Maintain and Care for Biophilic Elements:

- Insight: Ensure that biophilic design elements, such as plants and water features, are well-maintained and cared for. Establish routines for regular upkeep.
- Implementation: Assign responsibility for the maintenance of biophilic elements to specific staff members or student groups. Provide training on proper care techniques and allocate resources for maintenance.

5. Evaluate and Adapt:

- Insight: Continuously evaluate the effectiveness of biophilic design elements and adapt them based on feedback and changing needs.
- Implementation: Conduct regular surveys and focus groups to gather feedback from students, teachers, and administrators. Use this data to make informed decisions about modifying and enhancing biophilic elements.

6. Foster a Culture of Biophilia:

- Insight: Cultivate a school culture that values and prioritizes the connection to nature. Promote awareness of the benefits of biophilic design and encourage participation in nature-based activities.
- Implementation: Organize events, workshops, and initiatives that celebrate nature and biophilic design. Educate the school community about the importance of maintaining a healthy and nature-integrated environment.

By following these recommendations and practical insights, schools can effectively implement and maximize the benefits of biophilic design elements. The positive impact on academic performance, attendance, behavior, and overall well-being underscores the value of creating educational environments that foster a deep connection to nature.

4.6.3. Limitations of the Study

A. Discussion of Any Limitations Encountered During the Research

While this study provides valuable insights into the impact of biophilic design on educational outcomes at Mount Olive School, several limitations should be acknowledged:

1. Sample Size and Generalizability:

- Limitation: The study was conducted at a single school, with a sample size limited to the students, teachers, and administrators of Mount Olive School. This limits the generalizability of the findings to other schools and educational settings.
- Impact: The results may not be representative of all schools, particularly those with different demographic profiles, geographic locations, or educational approaches.

2. Self-Reported Data:

- Limitation: A significant portion of the data was collected through self-reported surveys and interviews. Self-reported data can be subject to biases, such as social desirability bias or recall bias, which may affect the accuracy of the responses.
- Impact: The reliance on self-reported data may introduce subjectivity into the findings, potentially overestimating or underestimating the impact of biophilic design elements.

3. Short-Term Evaluation:

- Limitation: The study primarily focused on short-term outcomes following the implementation of biophilic design elements. Long-term effects and sustainability of the benefits were not assessed within the scope of this research.
- Impact: The findings may not capture the full extent of the long-term benefits or potential challenges associated with maintaining biophilic design elements over time.

4. Lack of Controlled Experimental Design:

- Limitation: The study did not employ a controlled experimental design with random assignment to treatment and control groups. Instead, it relied on pre- and post-implementation comparisons.
- Impact: The absence of a controlled experimental design limits the ability to establish causality definitively. Other factors, such as changes in curriculum or administrative policies, may have influenced the observed outcomes.

5. Limited Scope of Biophilic Elements:

- Limitation: The study focused on a specific set of biophilic design elements, such as natural light, vegetation, views of nature, and natural materials. Other biophilic elements, such as the presence of water features, were not included in the analysis due to their absence in the school's current design.
- Impact: The findings may not fully capture the potential benefits of a comprehensive biophilic design that includes a wider range of natural elements.

B. Suggestions for Future Research to Address These Limitations

To build on the findings of this study and address the identified limitations, future research should consider the following recommendations:

1. Expand Sample Size and Diversity:

- Suggestion: Conduct studies in multiple schools with diverse demographic profiles and geographic locations. This will enhance the generalizability of the findings and provide a more comprehensive understanding of the impact of biophilic design across different educational contexts.
- Rationale: A larger and more diverse sample will allow for more robust statistical analyses and the identification of potential moderating factors, such as age, socioeconomic status, and cultural differences.

2. Utilize Objective Measures:

- Suggestion: Incorporate objective measures, such as physiological indicators (e.g., heart rate, cortisol levels) and direct observations of behavior, to complement self-reported data. This will provide a more accurate and comprehensive assessment of the impact of biophilic design elements.
- Rationale: Objective measures can reduce the potential biases associated with self-reported data and provide a more reliable basis for evaluating the effects of biophilic design.

3. Longitudinal Studies:

- Suggestion: Conduct longitudinal studies to assess the long-term effects and sustainability of biophilic design elements. This will provide insights into how the benefits of biophilic design evolve over time and any potential challenges associated with maintenance.

- Rationale: Longitudinal studies can capture the ongoing impact of biophilic design and inform strategies for ensuring the durability and effectiveness of biophilic elements.

4. Controlled Experimental Designs:

- Suggestion: Implement controlled experimental designs with random assignment to treatment and control groups. This will enable researchers to establish causality more definitively and isolate the effects of biophilic design from other influencing factors.
- Rationale: Controlled experiments provide a higher level of internal validity and can strengthen the evidence for the causal impact of biophilic design elements on educational outcomes.

5. Include a Wider Range of Biophilic Elements:

- Suggestion: Explore the impact of a broader range of biophilic design elements, including water features, natural acoustics, and biophilic art. This will provide a more holistic understanding of the potential benefits of comprehensive biophilic design.

- Rationale: Including a wider variety of biophilic elements can reveal additional dimensions of the positive impact of nature-integrated environments and inform more comprehensive design strategies.

In conclusion, while this study highlights the significant benefits of biophilic design at Mount Olive School, future research should address the identified limitations to provide a more robust and comprehensive understanding of the impact of biophilic design in educational settings. By expanding sample sizes, incorporating objective measures, conducting longitudinal studies, utilizing controlled experimental designs, and exploring a wider range of biophilic elements, researchers can build a stronger evidence base for the benefits of biophilic design and guide its implementation in schools worldwide.

4.6.4. Conclusion

A. Summary of the Key Findings and Their Significance

This study provides a comprehensive analysis of the impact of biophilic design on educational outcomes at Mount Olive School, addressing key research questions and objectives through a multi-faceted approach. The key findings and their significance are summarized as follows:

1. Implementation of Biophilic Design Elements:

- Key Elements Identified: The study identified and detailed the implementation of natural light, vegetation, views of nature, and natural materials as integral biophilic design elements at Mount Olive School. These elements were carefully integrated into the school's architecture and interior design to create a more engaging and supportive learning environment.

2. Positive Perceptions Among Stakeholders:

- Students, Teachers, and Administrators: The findings revealed strong positive perceptions of biophilic design elements among students, teachers, and administrators. Surveys, interviews, and focus groups indicated that these stakeholders highly value the benefits of natural light, vegetation, views of nature, and natural materials in enhancing happiness, concentration, well-being, and overall school enjoyment.

3. Improvements in Academic Performance:

- Enhanced Grades: The analysis of academic records showed significant improvements in student grades across core subjects such as mathematics, science, and language arts following the implementation of biophilic design. Correlation and regression analyses confirmed the positive relationship between biophilic elements and academic performance.

4. Increased Attendance Rates:

- Higher Attendance: The study found a notable increase in attendance rates after the implementation of biophilic design elements. Survey responses indicated that natural light, vegetation, views of nature, and natural materials positively influence students' willingness to attend school regularly.

5. Reduction in Behavioral Incidents:

- Fewer Behavioral Issues: The analysis of behavioral data revealed a significant reduction in the number of reported behavioral incidents. Strong correlations were found between positive perceptions of biophilic design elements and improved student behavior.

6. Enhanced Student Well-Being:

- Improved Well-Being: Survey and qualitative data highlighted the positive impact of biophilic design on student well-being, with students reporting increased feelings of happiness,

relaxation, and reduced stress. Biophilic elements were valued for creating a calming and comfortable environment that supports mental health.

B. Final Thoughts on the Impact of Biophilic Design on Educational Outcomes at Mount Olive School

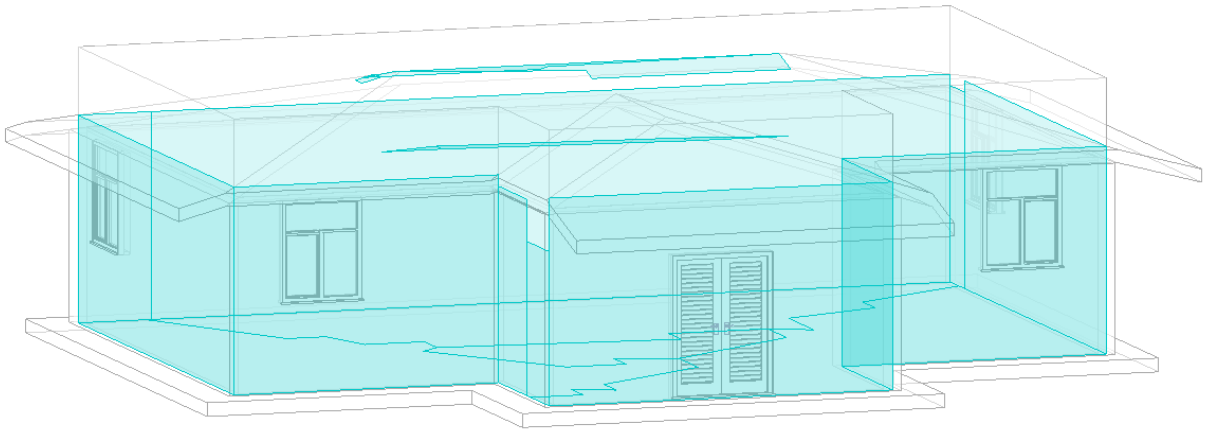
The integration of biophilic design elements at Mount Olive School has demonstrated significant positive impacts on various educational outcomes. The findings of this study provide compelling evidence that biophilic design can enhance academic performance, increase attendance rates, reduce behavioral incidents, and improve overall student well-being. These outcomes are not only beneficial for students but also contribute to a more supportive and engaging learning environment for teachers and administrators.

The strong positive perceptions of biophilic elements among all stakeholders underscore the importance of creating educational spaces that connect students to nature. By incorporating natural light, vegetation, views of nature, and natural materials, schools can foster a deeper connection to the natural world, promoting holistic development and well-being.

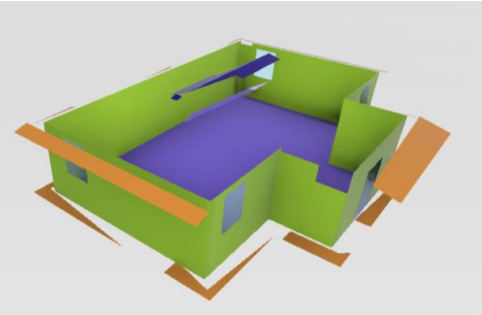
The results of this study align with existing literature on the benefits of biophilic design and provide practical insights for schools considering its implementation. While there are challenges associated with budget constraints and maintenance, the long-term benefits of biophilic design make it a worthwhile investment for educational institutions.

THERMAL COMFORT SIMULATION

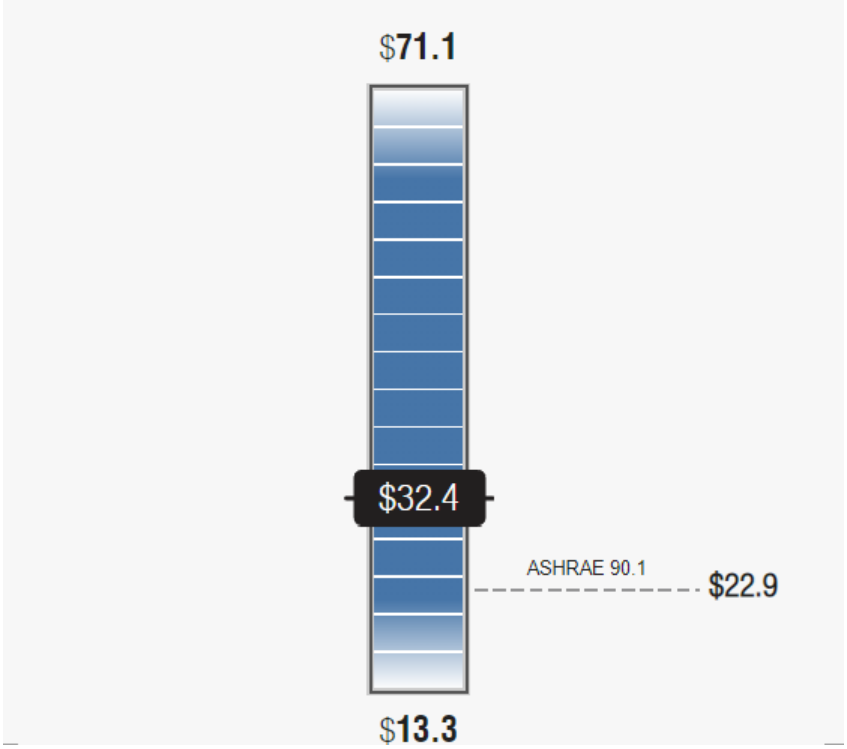
ENERGY ANALYTICAL MODEL OF THE ADMIN BUILDING



INSIGHT MODEL OF THE ADMIN BUILDING



THE EXISTING INSIGHT SIMULATION BEFOR OPTIMIZATION

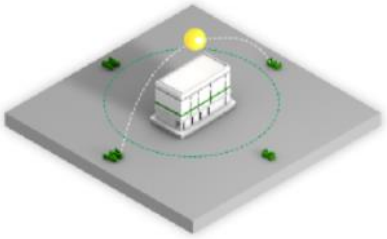


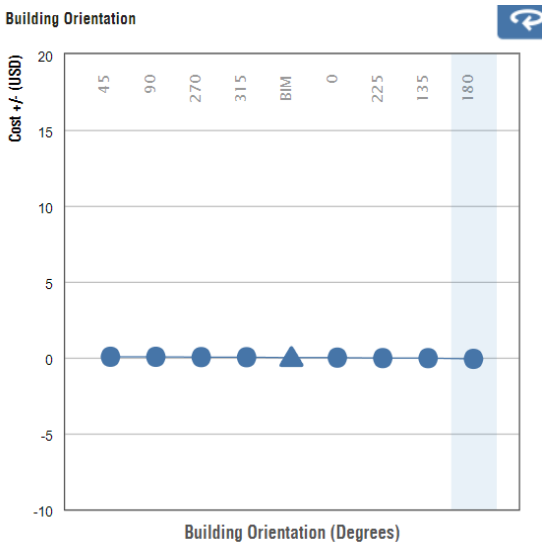
BELOW ARE THE OPTIMIZATION STAGES

Building Orientation

Rotates a building clockwise from 0 degrees, e.g. 90 degrees rotates the North side of the building to face East.

Current Setting:
45 - 180

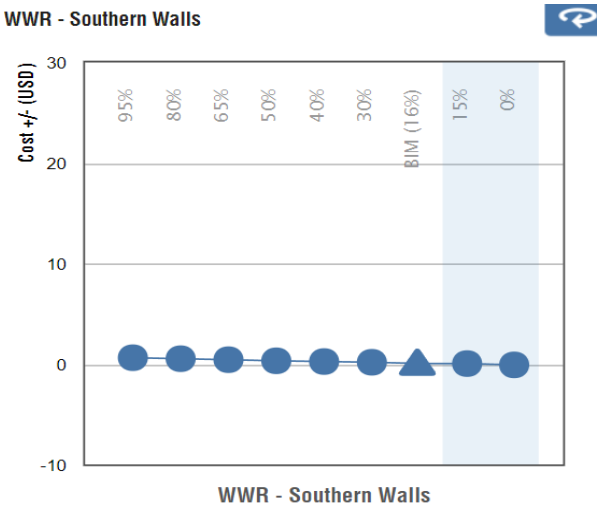


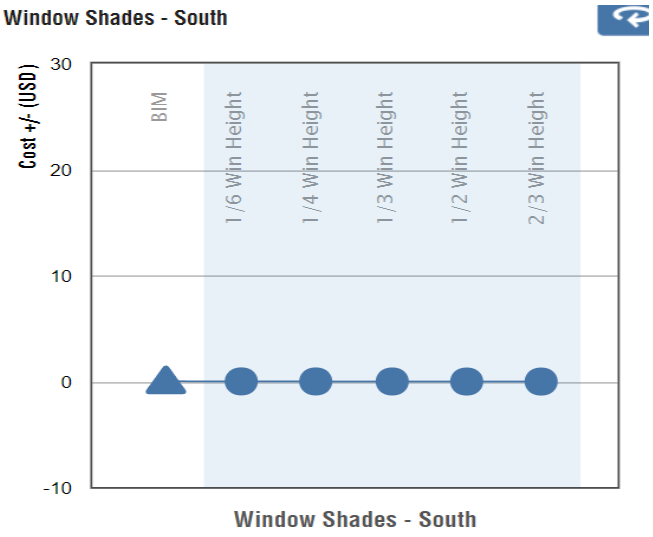


WWR - Southern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

Current Setting:
15% - 0%





Window Shades - South

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

Current Setting:

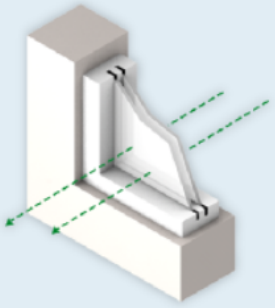
1/6 Win Height - 2/3 Win Height

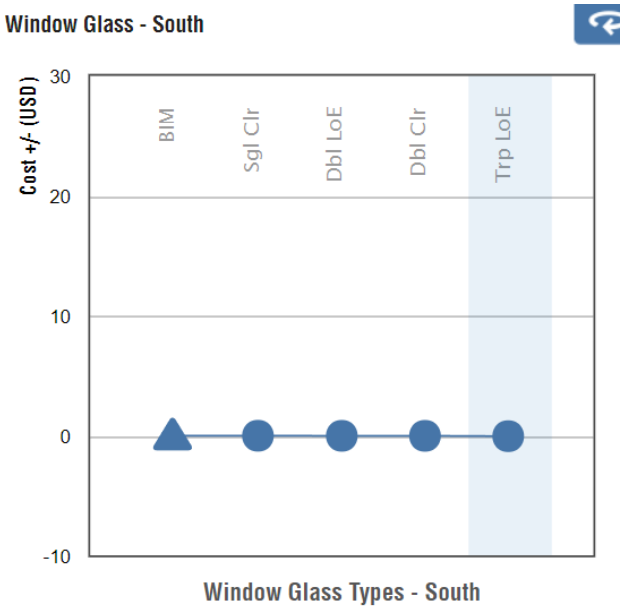
Window Glass - South

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:

BIM - Trp LoE



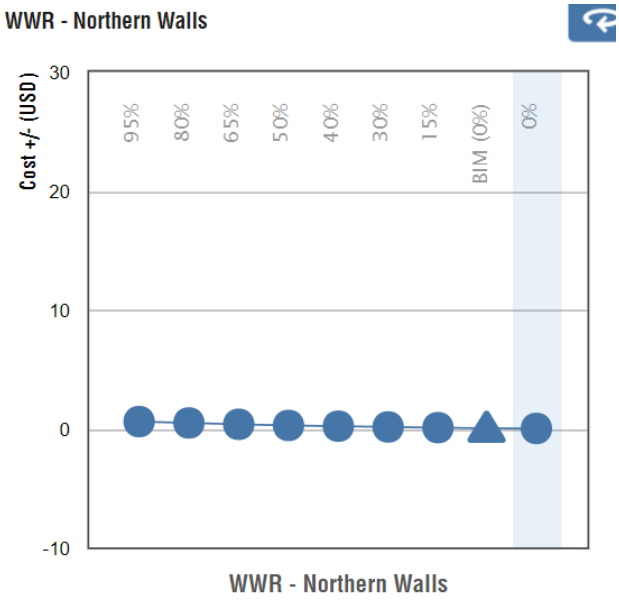


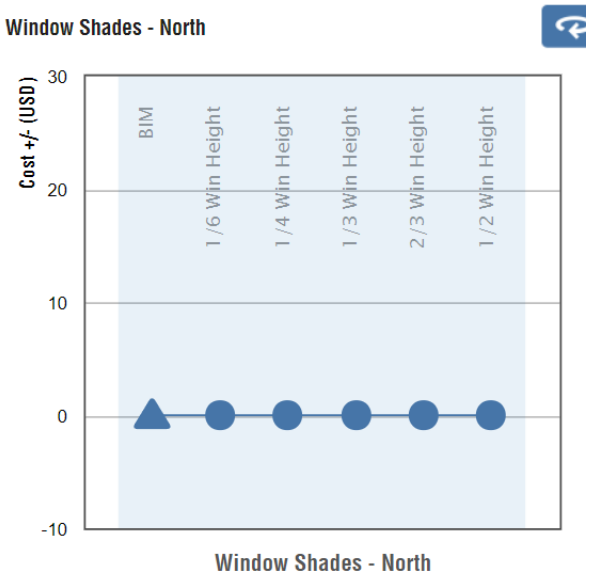
WWR - Northern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

Current Setting:

95% - 0%



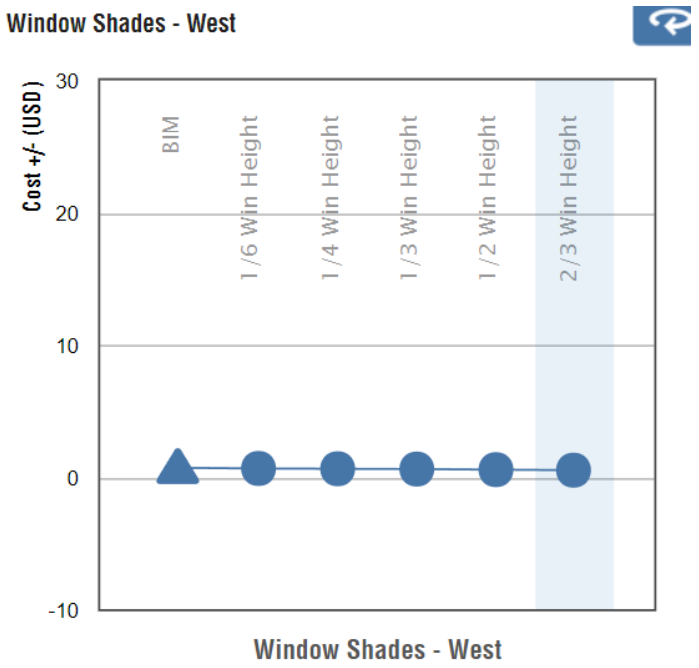


Window Shades - North

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

Current Setting:

BIM - 1/2 Win Height



Window Shades - West

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

Current Setting:

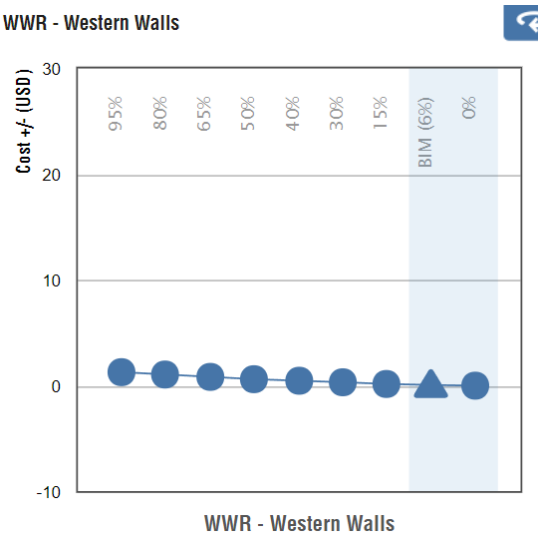
2/3 Win Height

WWR - Western Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

Current Setting:

95% - 0%

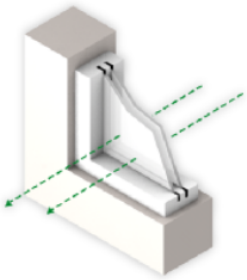


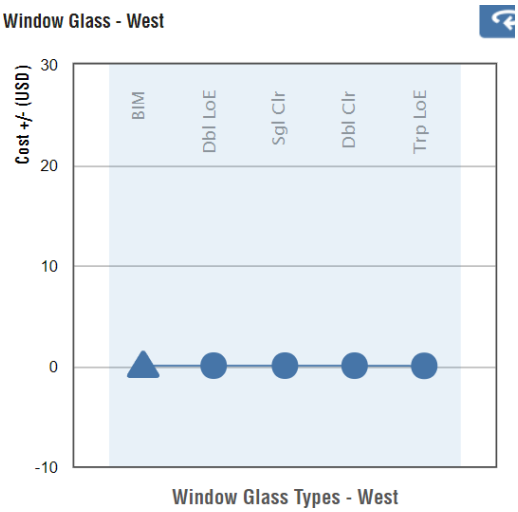
Window Glass - West

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:

BIM - Trp LoE

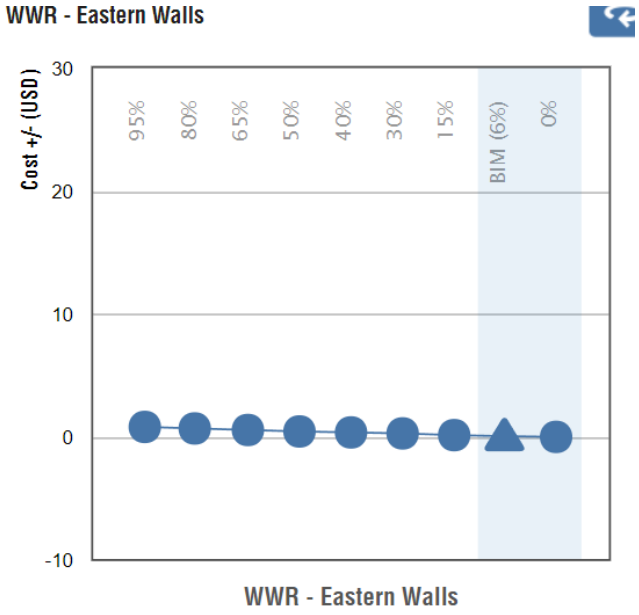




WWR - Eastern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

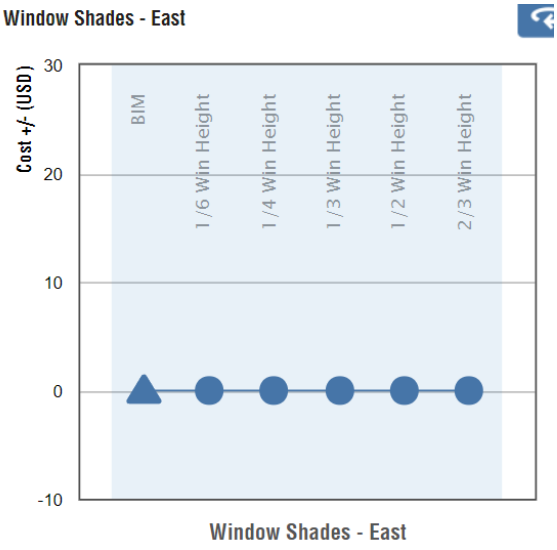
Current Setting:
95% - 0%



Window Shades - East

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

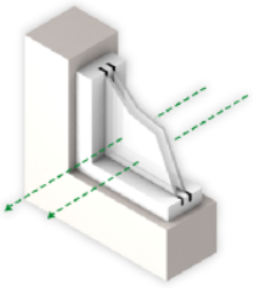
Current Setting:
BIM - 2/3 Win Height

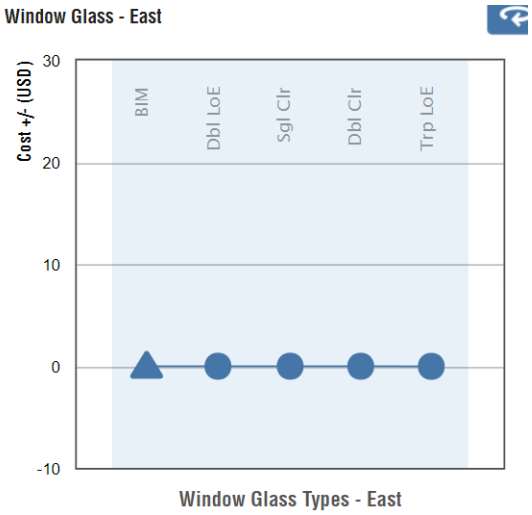


Window Glass - East

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:
BIM - Trp LoE

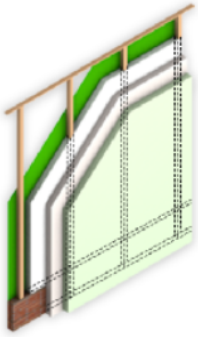


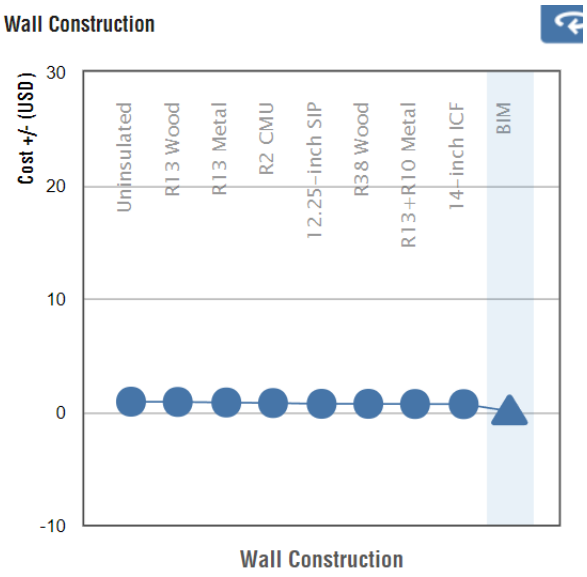


Wall Construction

Represents the overall ability of wall constructions to resist heat losses and gains.

Current Setting:
Uninsulated - BIM



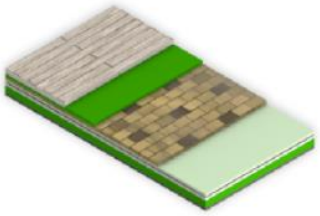


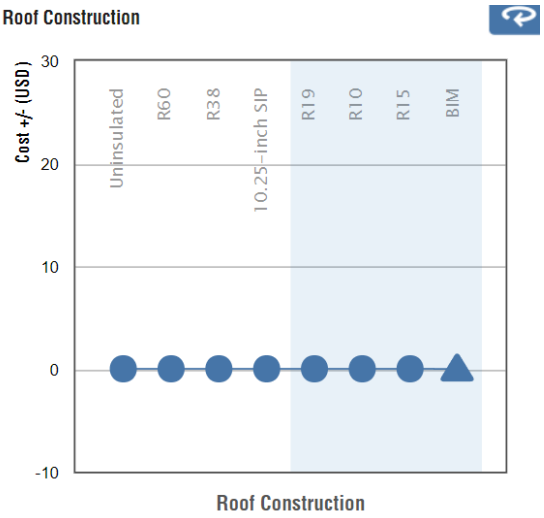
Roof Construction

Represents the overall ability of roof constructions to resist heat losses and gains.

Current Setting:

Uninsulated - BIM



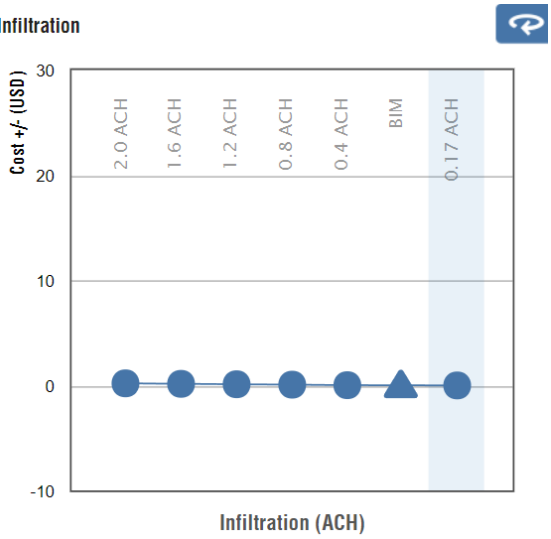


Infiltration

The unintentional leaking of air into or out of conditioned spaces; often due to gaps in the building envelope.

Current Setting:

2.0 ACH - 0.17 ACH

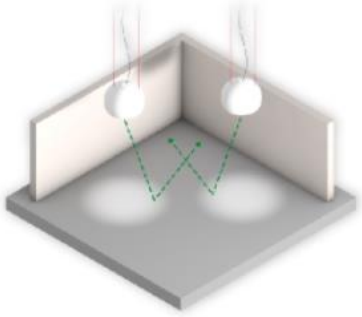


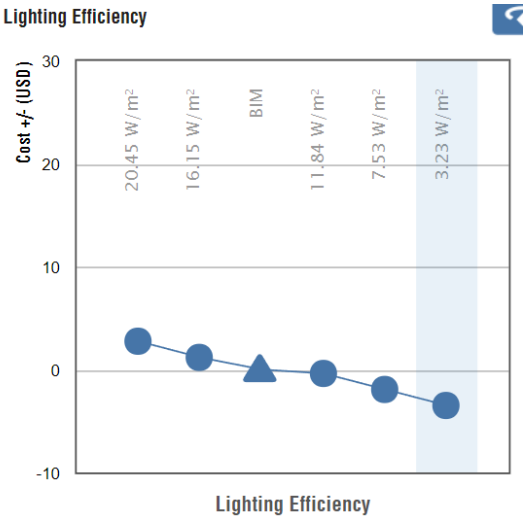
Lighting Efficiency

Represents the average internal heat gain and power consumption of electric lighting per unit floor area.

Current Setting:

20.45 W/m² - 3.23 W/m²



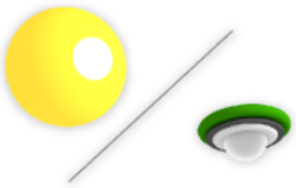


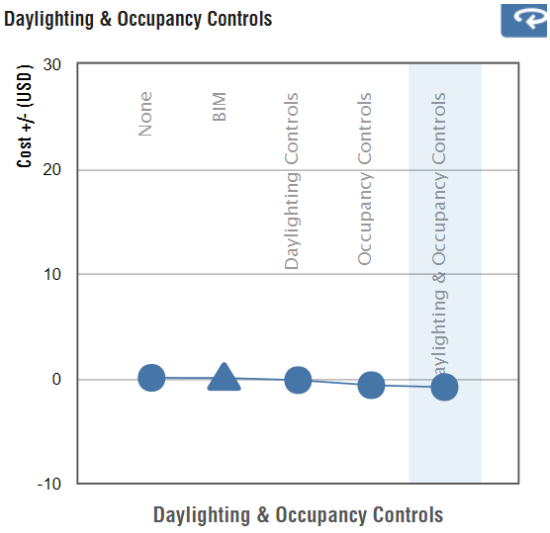
Daylighting & Occupancy Controls

Represents typical daylight dimming and occupancy sensor systems.

Current Setting:

None - Daylighting & Occupancy Controls

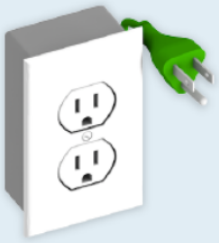


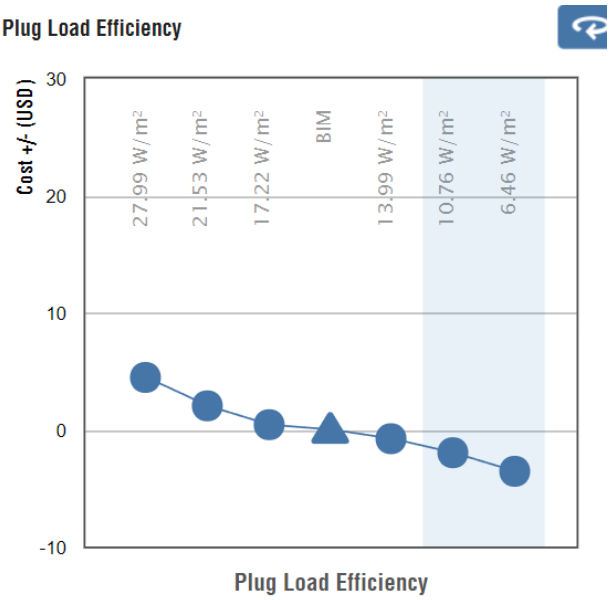


Plug Load Efficiency

The power used by equipment i.e. computers and small appliances; excludes lighting or heating and cooling equipment.

Current Setting:
27.99 W/m² - 6.46 W/m²

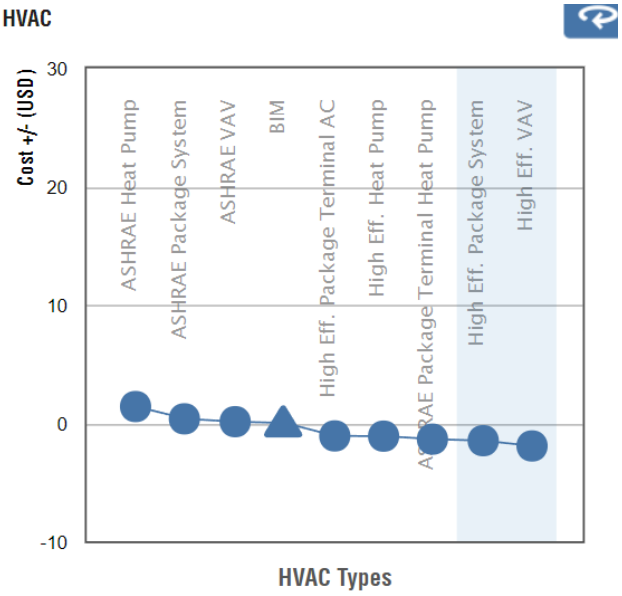




HVAC

Represents a range of HVAC system efficiency which will vary based on location and building size.

Current Setting:
ASHRAE Heat Pump - High Eff. VAV

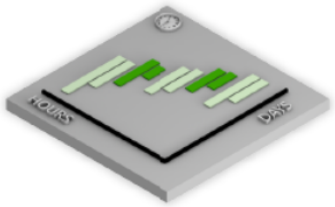


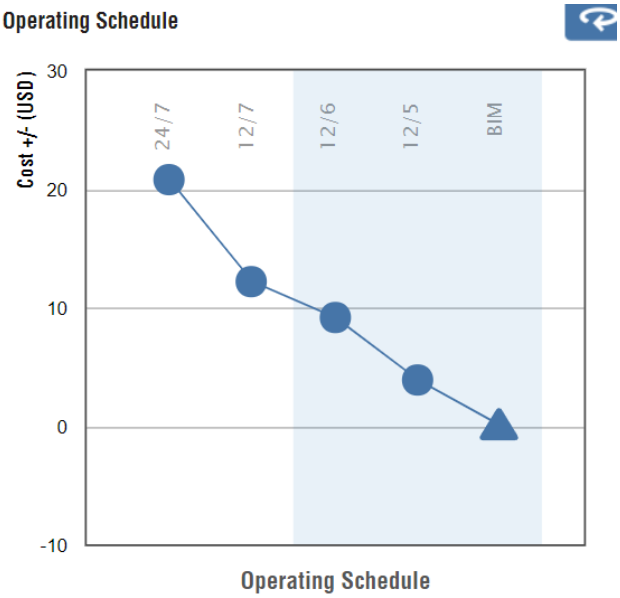
Operating Schedule

The typical hours of use by building occupants.

Current Setting:

24/7 - BIM



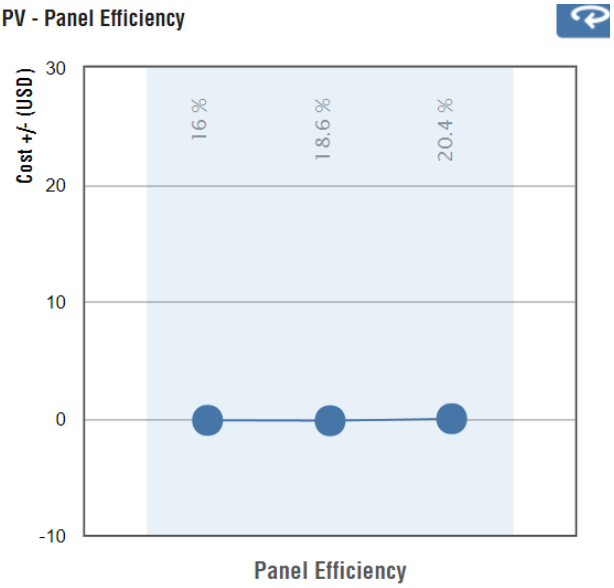


PV - Panel Efficiency

The percentage of the sun's energy that will be converted to AC energy. Higher efficiency panels cost more, but produce more energy for the same surface area.

Current Setting:

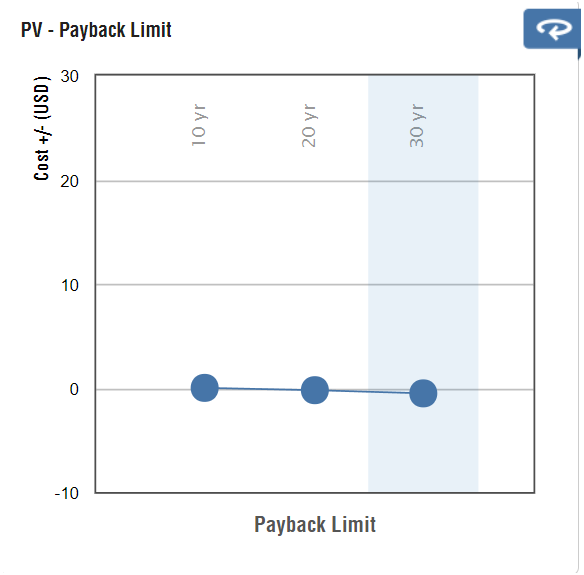
16 % - 20.4 %



PV - Payback Limit

Use the payback period to define which surfaces will be used for the PV system. Surfaces with shading or poor solar orientation may be excluded.

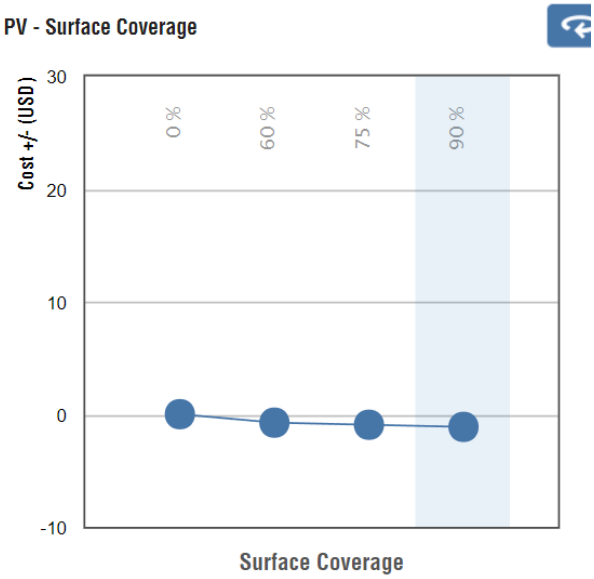
Current Setting:
10 yr - 30 yr



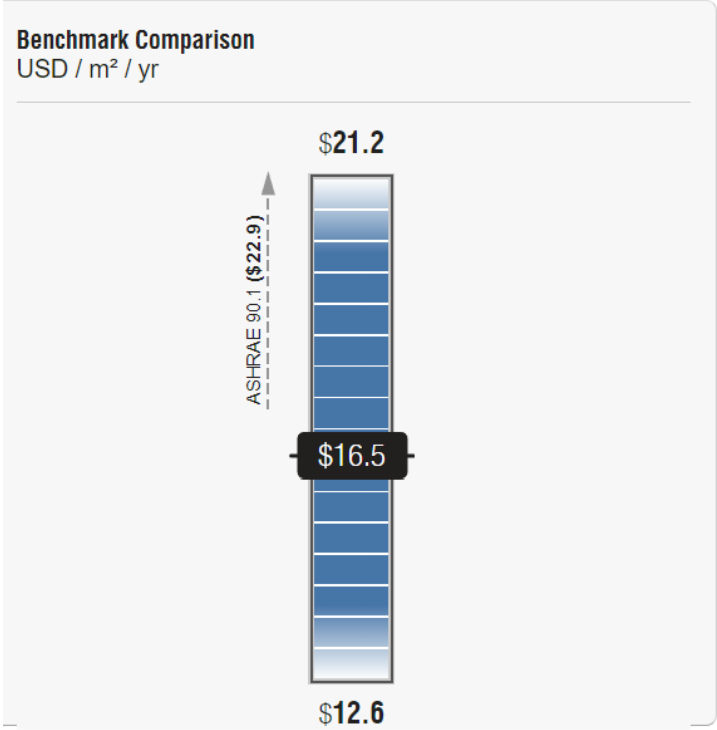
PV - Surface Coverage

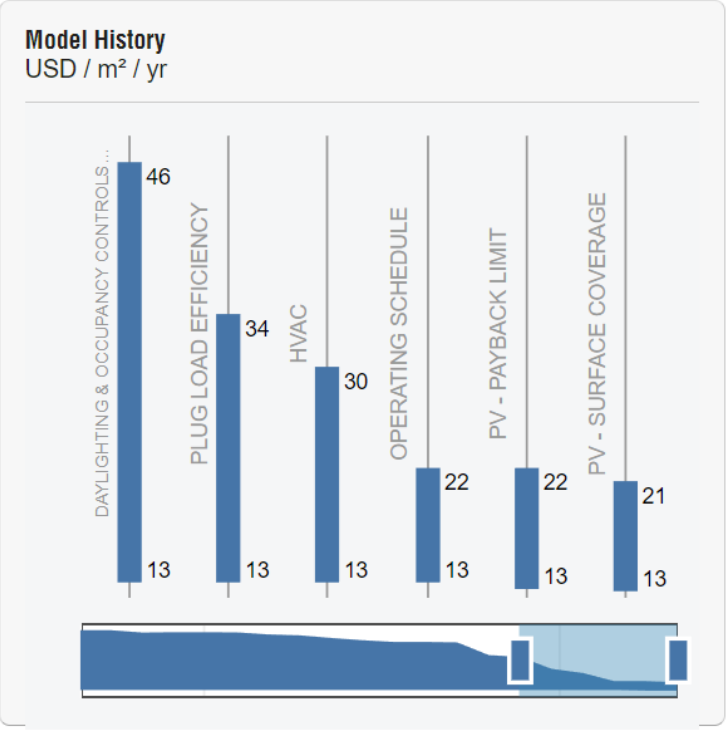
Defines how much roof area can be used for PV panels, assuming area for maintenance access, rooftop equipment and system infrastructure.

Current Setting:
0 % - 90 %



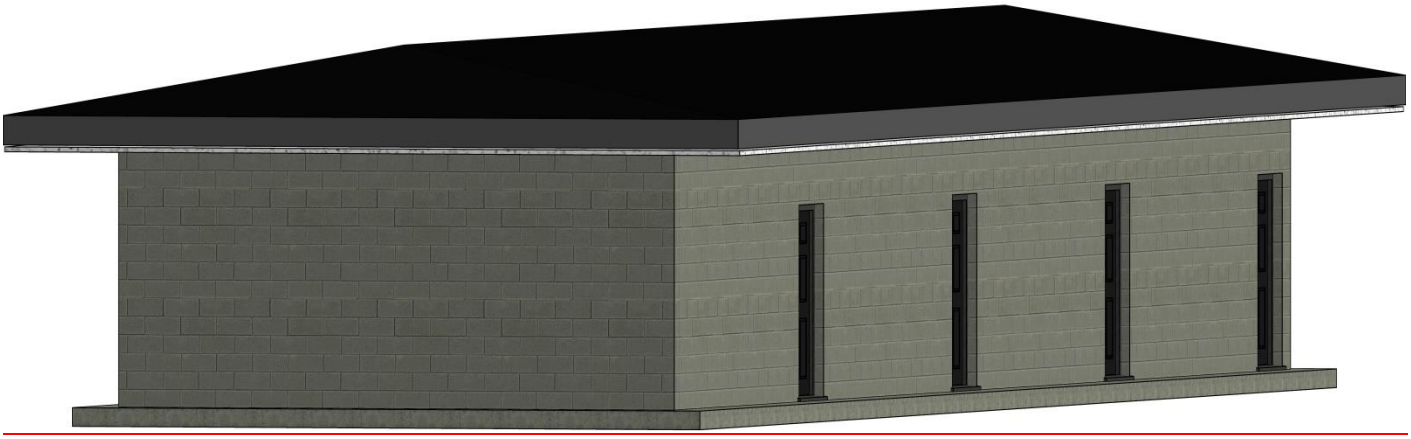
THE INSIGHT SIMULATION AFTER OPTIMIZATION



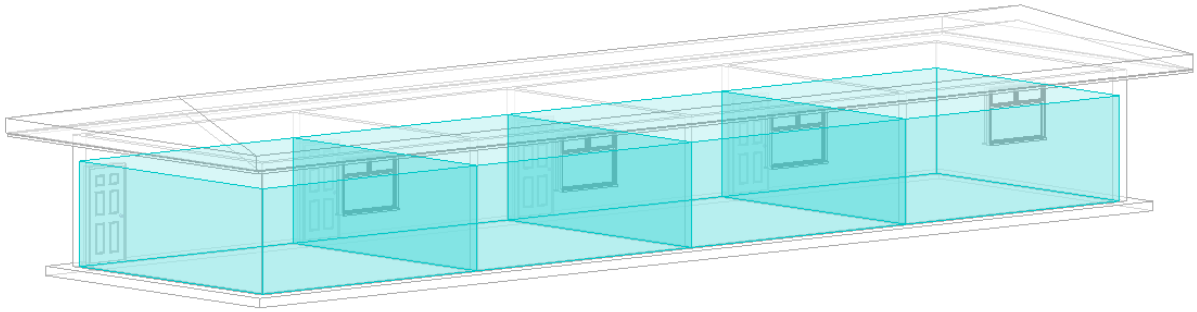


It seems that it falls from 32.4 to 16.5 which is below the ASHRAE 22.9 for that reason the simulation is well optimized.

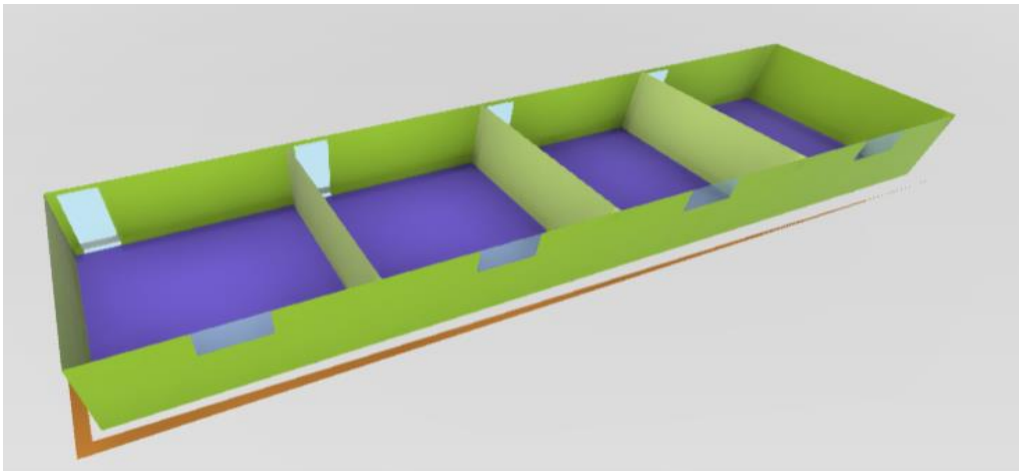
CLASSROOM BUILDING



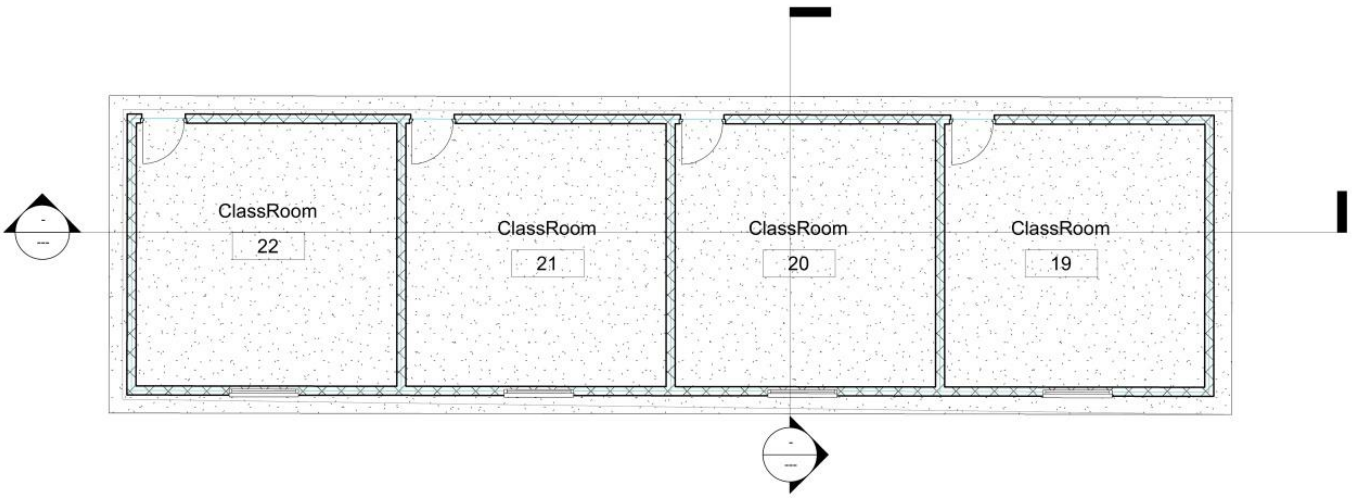
ENERGY ANALYTICAL MODEL OF THE CLASSROOM BUILDINGOF MOUNTOLIVE SCHOOL



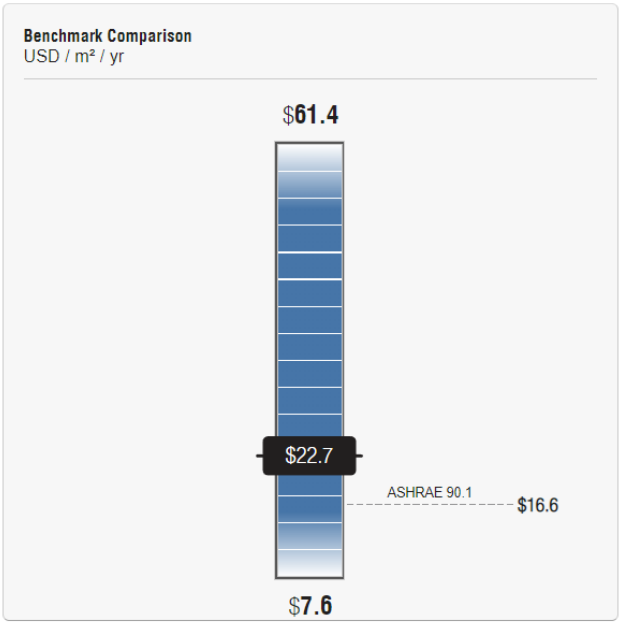
INSIGHT VIEW MODEL OF THE CLASSROOM BUILDING

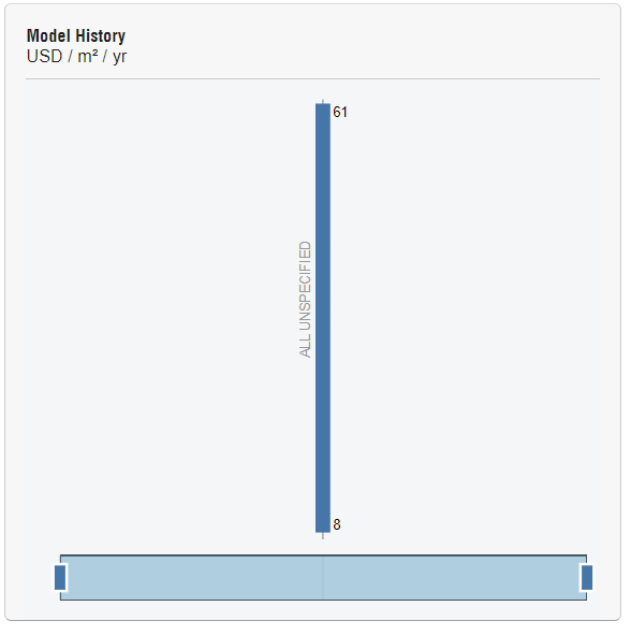


PLAN LAYOUT OF THE EXISTING BUILDING



THE EXISTING INSIGHT SIMULATION BEFOR OPTIMIZATION

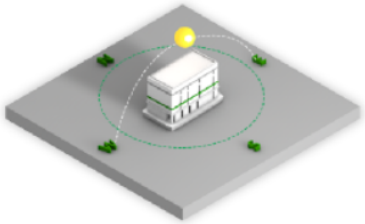


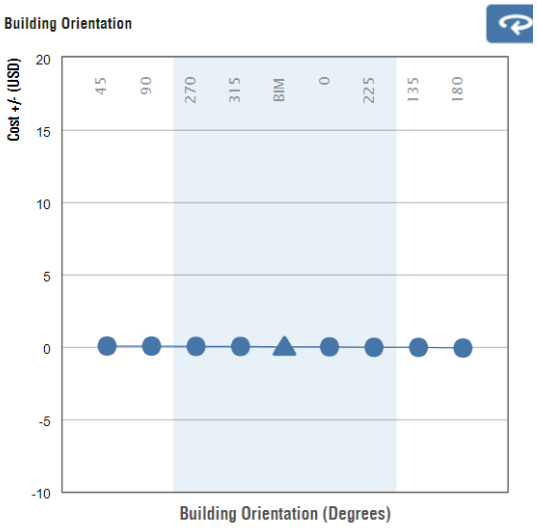


Building Orientation

Rotates a building clockwise from 0 degrees, e.g. 90 degrees rotates the North side of the building to face East.

Current Setting:
45 - 180

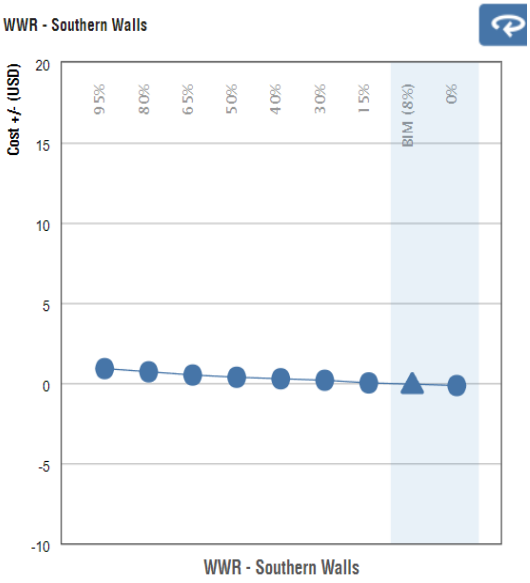




WWR - Southern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

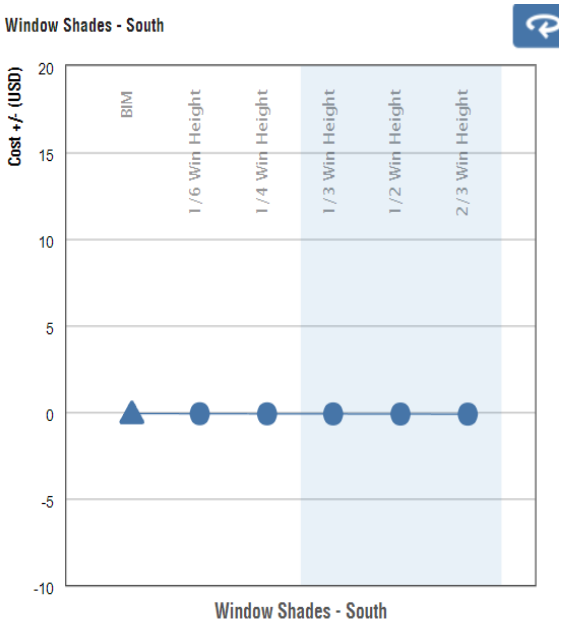
Current Setting:
95% - 0%



Window Shades - South

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

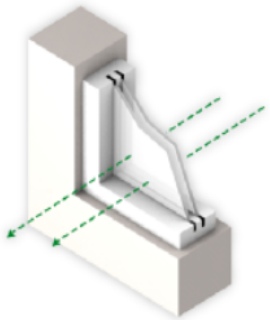
Current Setting:
BIM - 2/3 Win Height

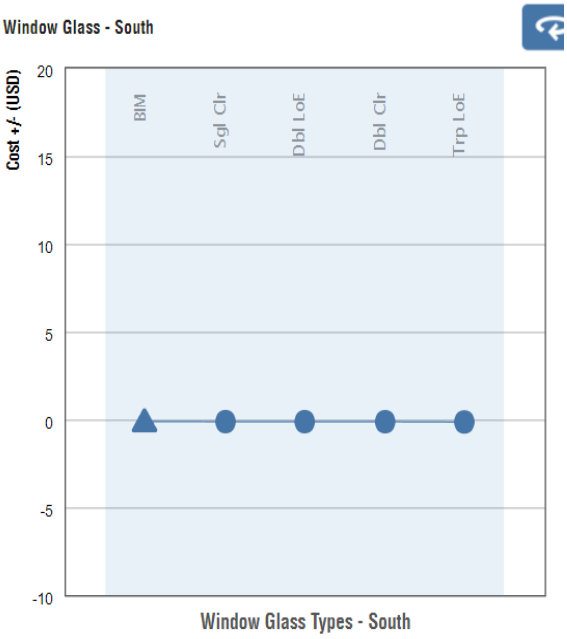


Window Glass - South

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:
BIM - Trp LoE

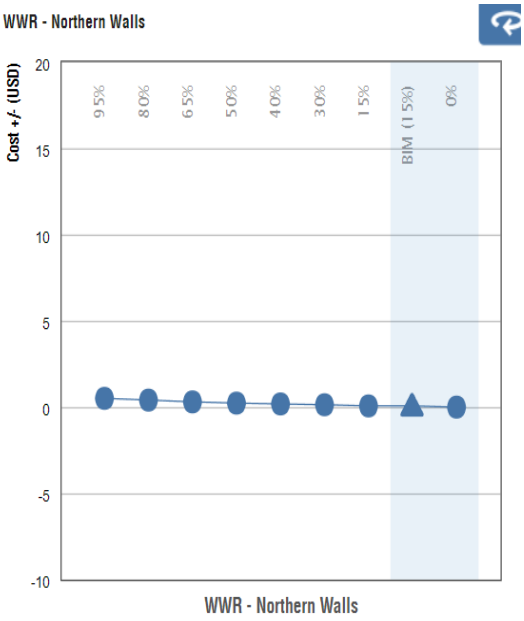




WWR - Northern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

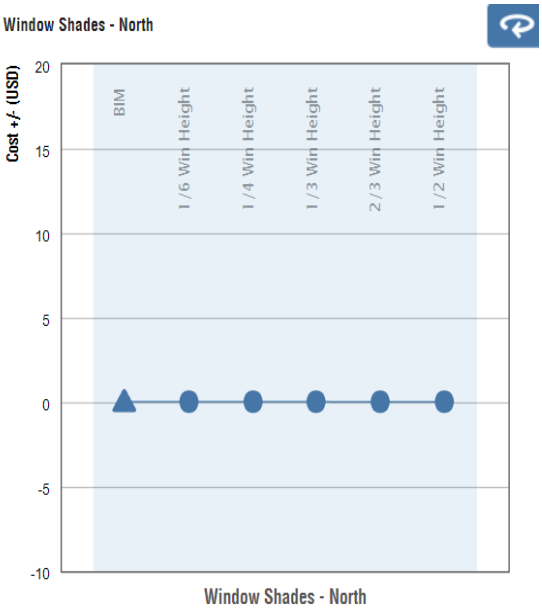
Current Setting:
95% - 0%



Window Shades - North

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

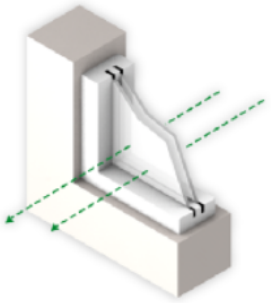
Current Setting:
BIM - 1/2 Win Height

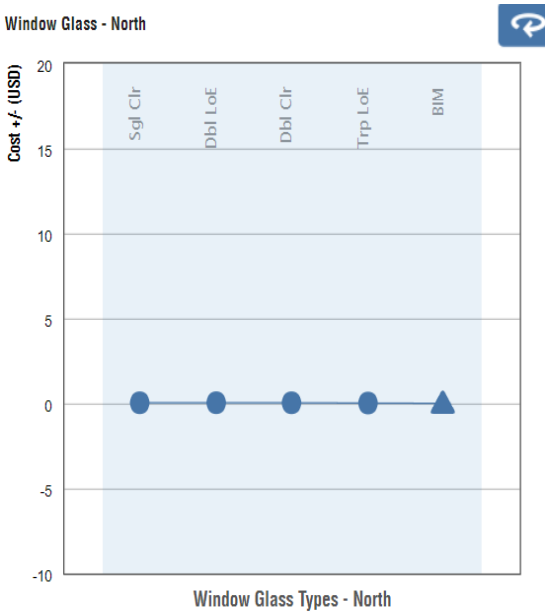


Window Glass - North

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:
Sgl Clr - BIM

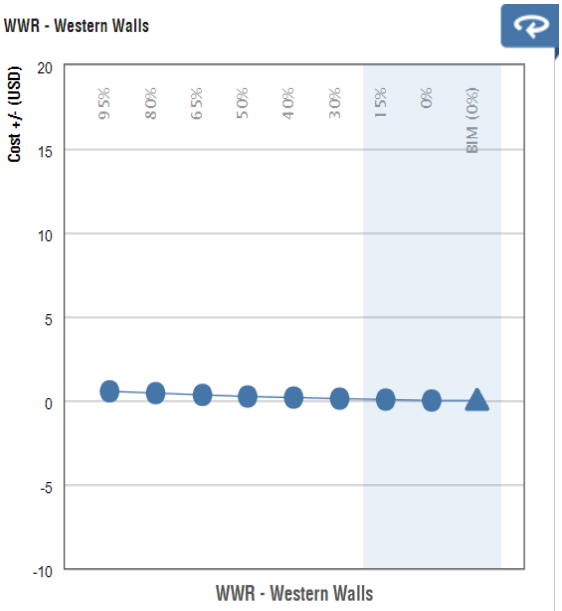




WWR - Western Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

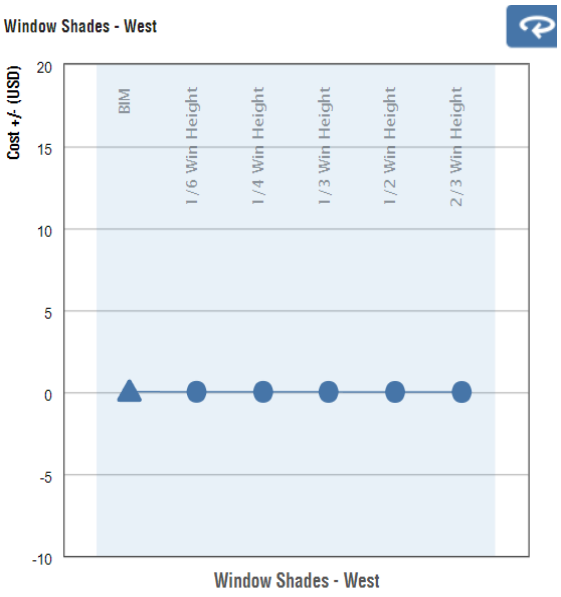
Current Setting:
95% - BIM (0%)



Window Shades - West

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

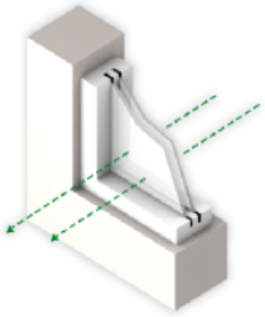
Current Setting:
BIM - 2/3 Win Height

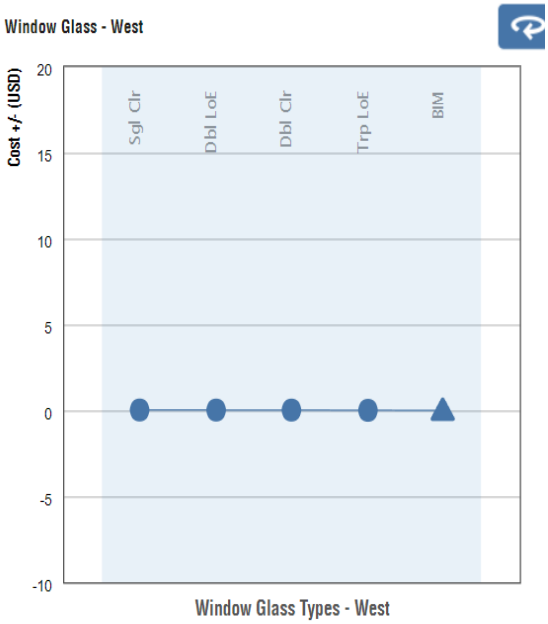


Window Glass - West

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:
Sgl Clr - BIM

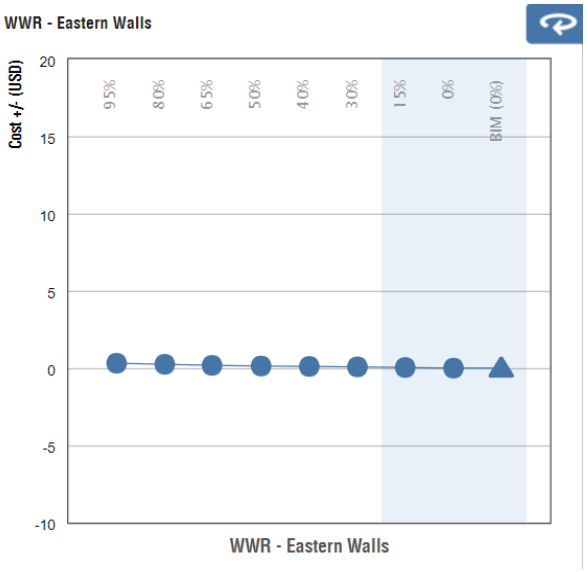




WWR - Eastern Walls

Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.

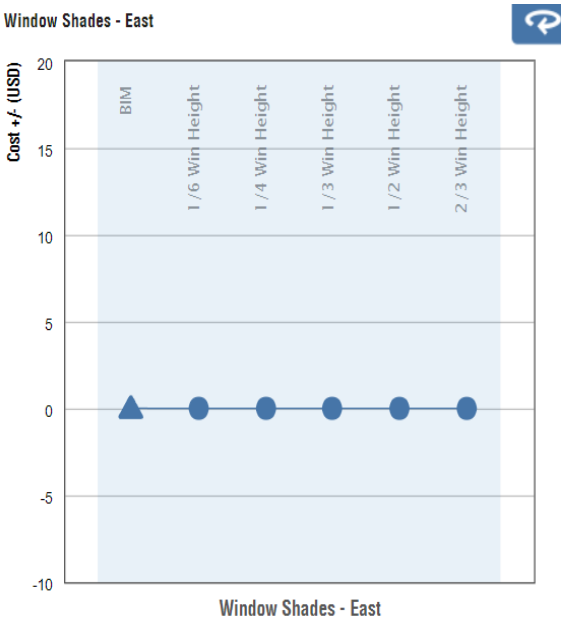
Current Setting:
95% - BIM (0%)



Window Shades - East

Shades can reduce HVAC energy use. The impact depends on other factors, such as window size and solar heat gain properties.

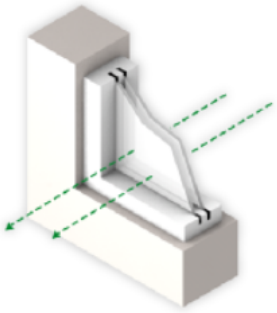
Current Setting:
BIM - 2/3 Win Height

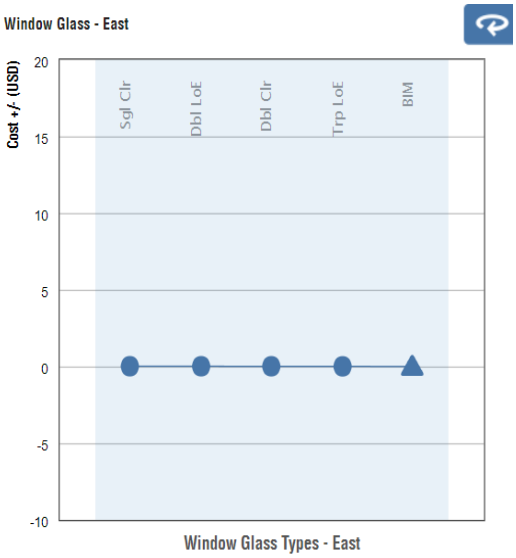


Window Glass - East

Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.

Current Setting:
Sgl Clr - BIM

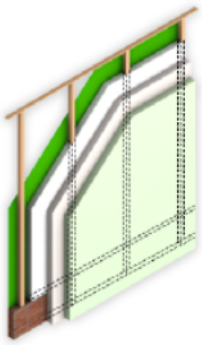


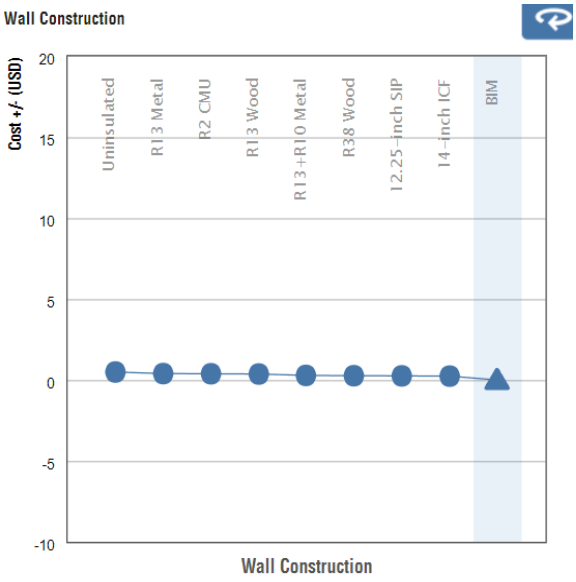


Wall Construction

Represents the overall ability of wall constructions to resist heat losses and gains.

Current Setting:
Uninsulated - BIM

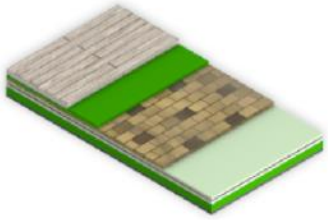


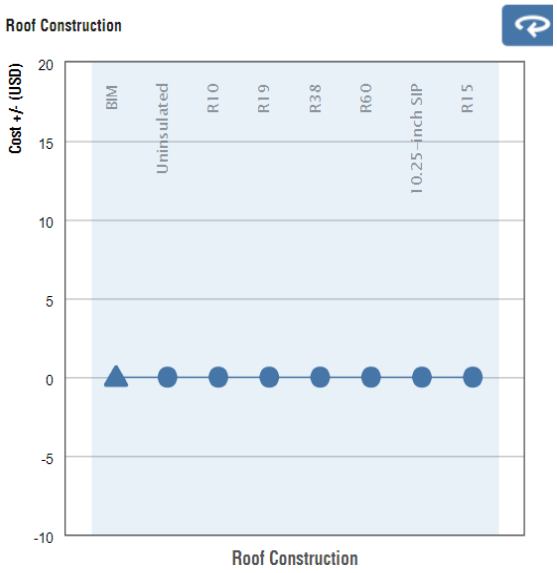


Roof Construction

Represents the overall ability of roof constructions to resist heat losses and gains.

Current Setting:
BIM - R15

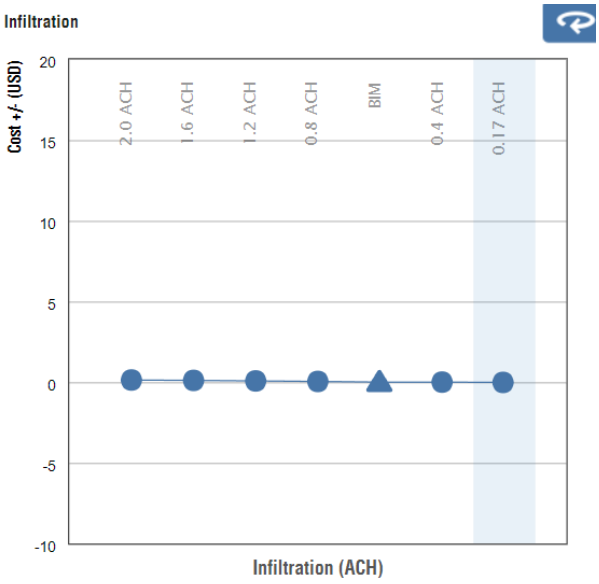




Infiltration

The unintentional leaking of air into or out of conditioned spaces; often due to gaps in the building envelope.

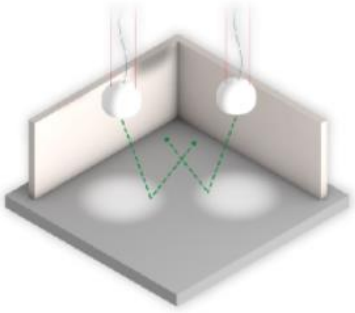
Current Setting:
2.0 ACH - 0.17 ACH

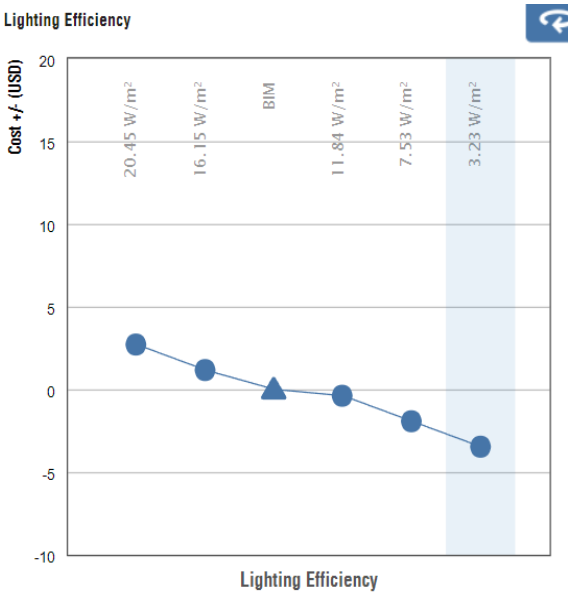


Lighting Efficiency

Represents the average internal heat gain and power consumption of electric lighting per unit floor area.

Current Setting:
20.45 W/m² - 3.23 W/m²

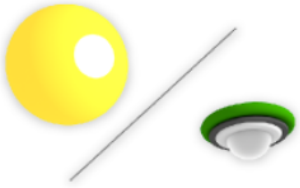


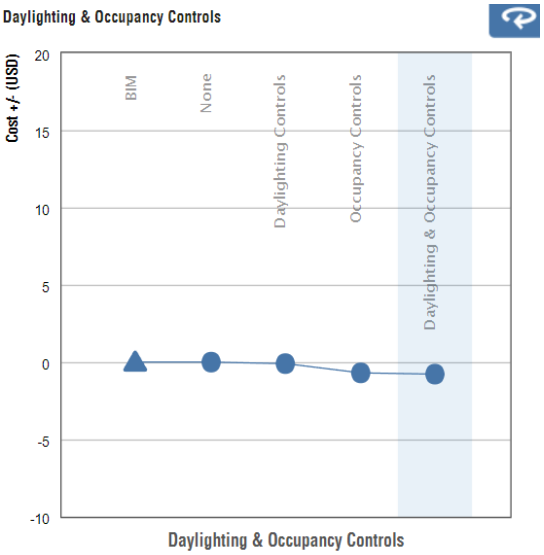


Daylighting & Occupancy Controls

Represents typical daylight dimming and occupancy sensor systems.

Current Setting:
BIM - Daylighting & Occupancy Controls



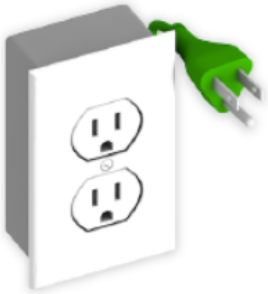


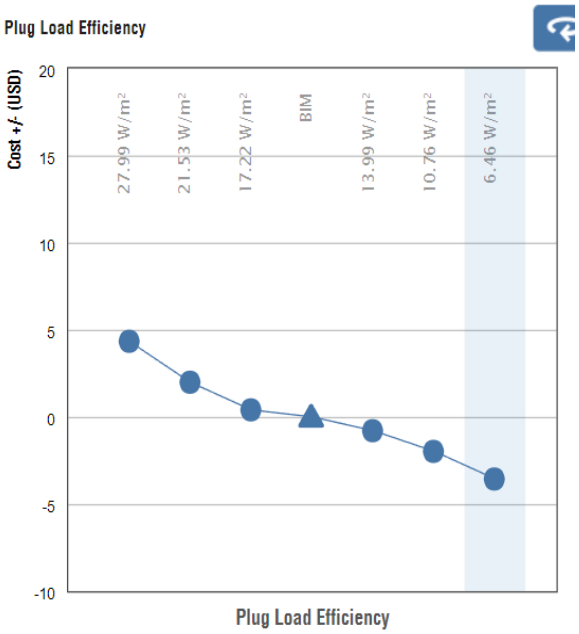
Plug Load Efficiency

The power used by equipment i.e. computers and small appliances; excludes lighting or heating and cooling equipment.

Current Setting:

27.99 W/m² - 6.46 W/m²



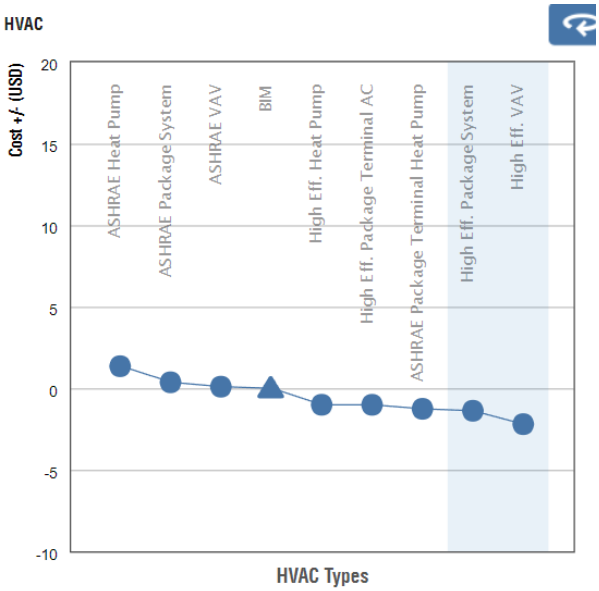


HVAC

Represents a range of HVAC system efficiency which will vary based on location and building size.

Current Setting:

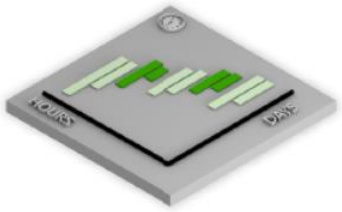
ASHRAE Heat Pump - High Eff. VAV

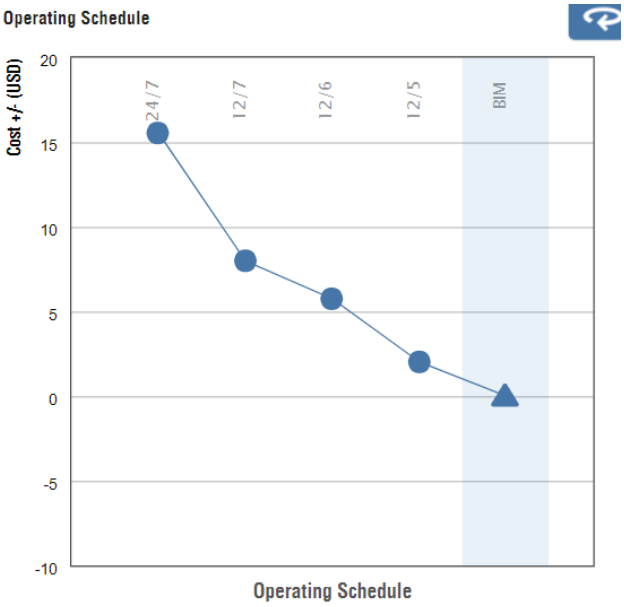


Operating Schedule

The typical hours of use by building occupants.

Current Setting:
24/7 - BIM

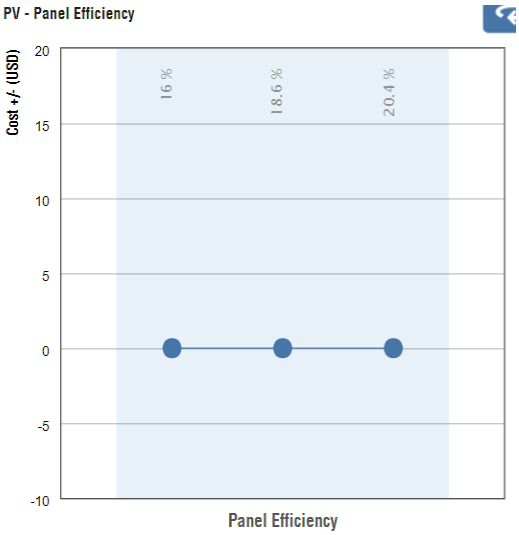




PV - Panel Efficiency

The percentage of the sun's energy that will be converted to AC energy. Higher efficiency panels cost more, but produce more energy for the same surface area.

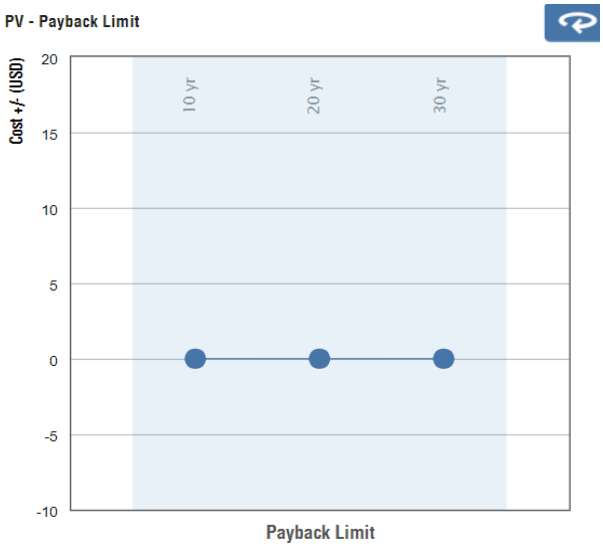
Current Setting:
16 % - 20.4 %



PV - Payback Limit

Use the payback period to define which surfaces will be used for the PV system. Surfaces with shading or poor solar orientation may be excluded.

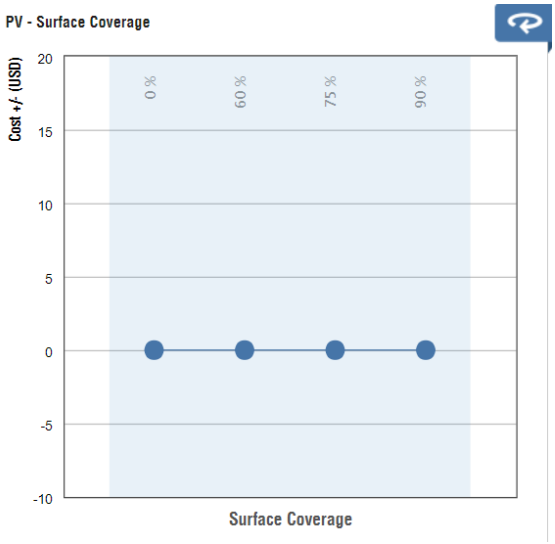
Current Setting:
10 yr - 30 yr



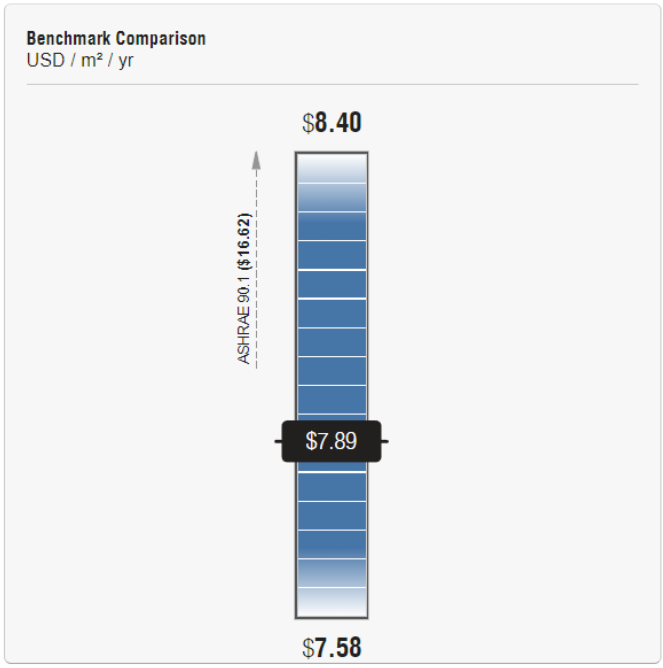
PV - Surface Coverage

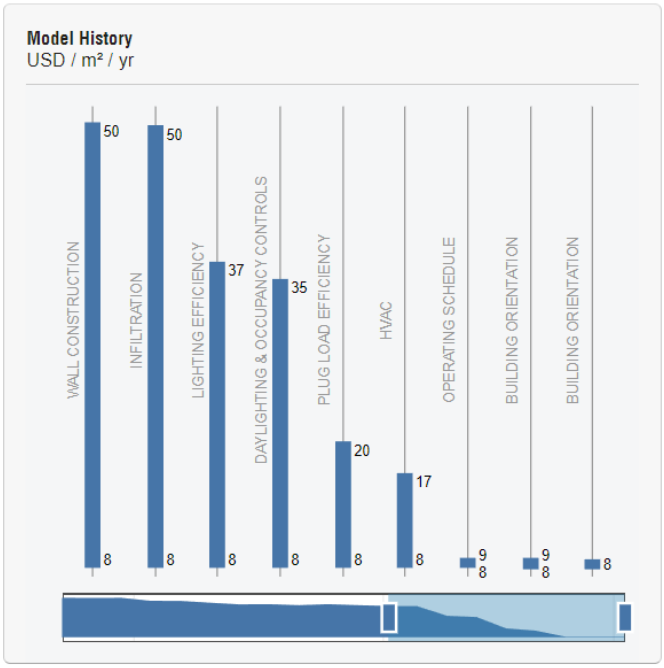
Defines how much roof area can be used for PV panels, assuming area for maintenance access, rooftop equipment and system infrastructure.

Current Setting:
0 % - 90 %



THE INSIGHT SIMULATION AFTER OPTIMIZATION





It seems that it falls from 22.7 to the mean value 7.89 which is below the ASHRAE 16.6 for that reason the simulation is well optimized.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Introduction

This chapter synthesizes the findings of the study on the impact of biophilic design on educational outcomes at Mount Olive School, offering a comprehensive interpretation of the results and their broader implications. It also provides practical recommendations for schools considering the implementation of biophilic design and insights for educators and administrators on how to maximize the benefits of natural elements in educational settings. By examining the key outcomes related to academic performance, attendance rates, student behavior, and well-being, this chapter underscores the transformative potential of biophilic design in creating engaging, supportive, and nurturing learning environments. The positive perceptions and tangible benefits observed at Mount Olive School serve as a compelling case for the wider adoption of biophilic principles, providing a roadmap for schools aiming to enhance their educational environments through nature-integrated design.

5.2. Conclusion

The study conducted at Mount Olive School highlights the profound impact of biophilic design on educational outcomes. By integrating natural elements into the built environment, the school has created a more engaging, supportive, and nurturing learning space for students, teachers, and administrators. The key findings of this study underscore the significance of biophilic design and its positive influence on academic performance, attendance rates, student behavior, and overall well-being.

1. Academic Performance:

- The implementation of biophilic design elements such as natural light, vegetation, views of nature, and natural materials has led to significant improvements in student grades across core subjects. The positive correlation between biophilic elements and academic performance highlights the cognitive benefits of exposure to nature.

2. Attendance Rates:

- The study observed a notable increase in attendance rates following the introduction of biophilic design elements. Students reported that natural light, vegetation, and views of nature positively influenced their willingness to attend school regularly, creating a more inviting and engaging learning environment.

3. Behavioral Improvements:

- The analysis of behavioral data revealed a significant reduction in the number of reported behavioral incidents. Biophilic design elements contributed to a calming and supportive atmosphere, reducing stress and promoting positive behavior among students.

4. Enhanced Well-Being:

- Survey and qualitative data indicated that students experienced increased feelings of happiness, relaxation, and reduced stress due to biophilic design elements. Natural light, vegetation, views of nature, and natural materials were highly valued for their contribution to a sense of comfort and connection to nature.

5. Positive Perceptions Among Stakeholders:

- The study gathered positive feedback from students, teachers, and administrators regarding the impact of biophilic design on the school environment. All stakeholders recognized the benefits of natural elements in enhancing the overall school experience and promoting well-being.

These findings are consistent with existing literature on the benefits of biophilic design and provide compelling evidence for the wider adoption of nature-integrated environments in educational settings. The transformative potential of biophilic design in fostering academic success, behavioral improvements, and overall well-being underscores its value as a key component of school design and development.

5.1.1. Conclusions Aligned with Objectives

The study on enhancing educational outcomes through biophilic design at Mount Olive School provides valuable insights and actionable recommendations. Here are the conclusions and recommendations aligned with the specific objectives of the research:

Conclusions

- **Significant Impact of Biophilic Design:** The research indicates that biophilic design elements, such as natural light, greenery, and natural materials, have a substantial positive impact on students' academic performance. Improved grades in core subjects were observed, demonstrating the effectiveness of these design elements in educational settings. The study

found that students exposed to biophilic design elements showed increased motivation, concentration, and overall academic success.

- **Enhanced Learning Environment:** The integration of biophilic design contributes to a more engaging and supportive learning environment. Students reported feeling more focused and motivated, which correlates with their academic success. The presence of natural elements in the school environment was found to reduce stress levels and promote a sense of well-being, further enhancing the learning experience.
- **Diverse Participant Feedback:** Feedback from a diverse sample of participants, including students and teachers, highlighted the importance of these design elements in fostering a sense of well-being and connection to nature, which is crucial for effective learning. The study captured the perspectives of various stakeholders, providing a comprehensive understanding of the benefits of biophilic design.

5.2. Recommendations

Based on the findings of this study, the following recommendations are provided for schools considering the implementation of biophilic design and for educators and administrators aiming to maximize the benefits of biophilic elements:

1. Maximize Natural Light:

- Recommendation: Design classrooms and common areas to maximize the use of natural light through large windows, skylights, and glass doors. Ensure that spaces receive ample daylight to enhance mood and concentration.
- Implementation: Conduct an audit of existing lighting conditions and identify opportunities to increase natural light. Consider architectural modifications or additions to optimize daylight exposure.

2. Incorporate Vegetation:

- Recommendation: Introduce a variety of indoor plants, green walls, and outdoor gardens. Incorporate vegetation into classrooms, hallways, and common areas to improve air quality and create a calming atmosphere.

- Implementation: Develop a plan for the selection, placement, and maintenance of plants. Engage students and staff in planting and caring for vegetation to foster a sense of ownership and connection to nature.

5.2.1. Recommendations Aligned with Objectives

Implementation of Natural Light

Schools should conduct an audit of existing lighting conditions and identify opportunities to increase natural light. Architectural modifications or additions may be necessary to optimize daylight exposure, which has been shown to enhance student focus and performance. Strategies such as installing larger windows, skylights, and light shelves can help maximize natural light in classrooms.

Incorporation of Greenery

Schools are encouraged to incorporate more vegetation within and around the school premises. This can include indoor plants, green walls, and outdoor gardens, which not only beautify the environment but also improve air quality and student well-being. Creating green spaces for outdoor learning and relaxation can further enhance the benefits of biophilic design.

Utilization of Objective Measures

Future research should incorporate objective measures, such as physiological indicators and direct observations, to complement self-reported data. This will provide a more accurate assessment of the impact of biophilic design elements on academic performance. Utilizing tools like wearable devices to monitor stress levels and attention can offer deeper insights into the effectiveness of biophilic design.

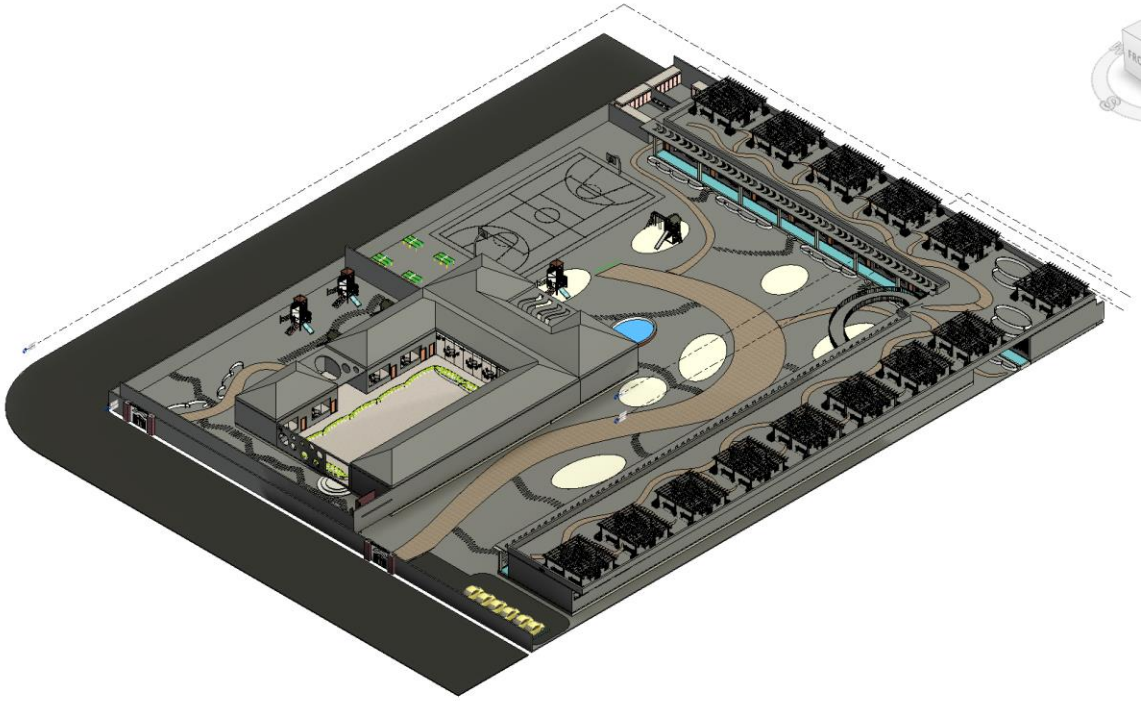
Long-term Monitoring

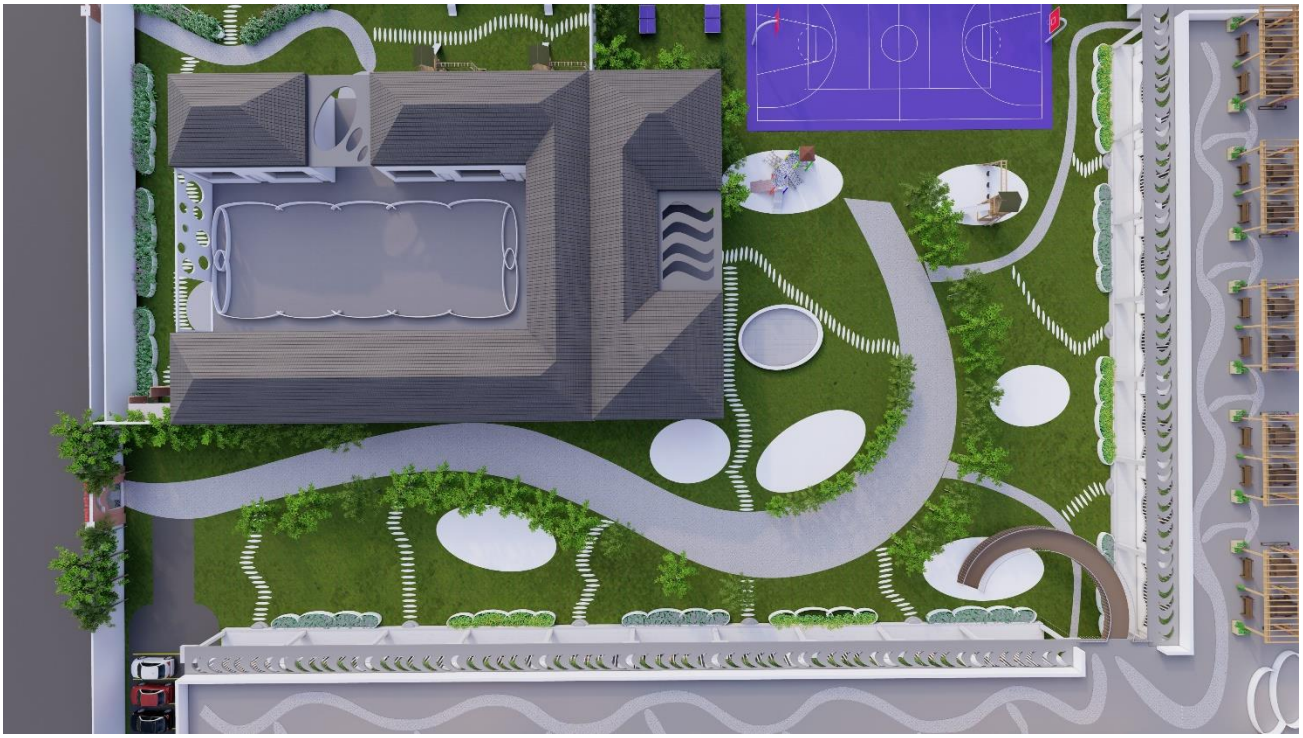
It is recommended that schools implement follow-up assessments to monitor the long-term impact of biophilic design elements on academic outcomes. This will help in understanding the sustained benefits of such designs over time. Longitudinal studies can track changes in academic performance, well-being, and engagement, providing valuable data for continuous improvement.

In summary, the study concludes that biophilic design significantly enhances educational outcomes. The combination of natural light, greenery, and natural materials not only improves

academic performance but also contributes to a more engaging and supportive educational atmosphere. The recommendations provided aim to guide schools in effectively implementing these elements to maximize their positive impact on students and staff. By adopting biophilic design principles, educational institutions can create healthier, more inspiring learning environments that foster student success and well-being.

Recommended Biophilic Design Model





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ANNEX 1: Questionnaire

The following questions can help the study to evaluate the prevalence of biophilic elements in the school, their usage by the students, and the perceived impacts of these elements on student well-being and academic engagement.

Yes/No Questions

Yes=1, No=2

Questions	**1**	**2**
Does your school have plants and trees in the classrooms and hallways?		
Can you see outside and observe nature from your classroom?		
Are there spaces in your school where you can play or learn surrounded by natural elements like gardens or ponds?		
Have you ever helped take care of plants or gardens at your school?		
Does your school have a green roof or walls covered with plants?		
Does your school have a designated area for growing vegetables or fruits that students can work in?		
Is there artwork around the school that features nature and the outdoors?		
Have you participated in a class project that involved creating something for the school's green spaces?		

Frequency Questions

Never =1, Rarely=2, Sometimes=3, often=4, Always=5

Questions	1	2	3	4	5
How often do you have classes or activities outdoors in natural settings?					

How often do you use the school's green spaces during your break times?					
How frequently do your teachers talk about nature or use outdoor examples in lessons?					
How often do you notice animals like birds or insects around your school's green spaces?					
How frequently is caring for the school's green areas mentioned as part of your homework or projects?					

Impact Questions

No impact=1, Slightly=2, Moderate=3, Sever=4, Extreme=5

Question	1	2	3	4	5
Do you feel happier or more relaxed when you're learning in spaces with natural light and plants?					
Do you think being able to see or be in nature during school helps you concentrate better on your schoolwork?					
Has learning in an environment that includes natural elements made you more interested in subjects like science or geography?					
Do you feel that spending time in nature at school has helped you make more friends or get along better with other students?					
How much do you think that being in a classroom with views of nature or access to outdoor spaces has improved your enjoyment of school?					
Do you believe that learning in rooms with plenty of natural light and air has helped you do better in quizzes or tests?					
Do you think that having natural elements in your school makes learning about the environment and biology more interesting?					
How significantly do you think nature in your school impacts your feelings of calmness or stress during the school day?					
In your opinion, how much does having green spaces at school inspire you to take care of the environment outside of school?					

ANNEX 2: Publishable Manuscript

Title:

"The Impact of Biophilic Design on Educational Outcomes: A Case Study of Mount Olive School"

INTRODUCTION

Background and Statement of the Problem:

In recent years, the concept of biophilic design has gained substantial attention in educational settings. Biophilic design integrates natural elements into built environments to enhance human well-being, productivity, and learning experiences. This approach is grounded in the idea that humans have an inherent affinity for nature, a concept known as "biophilia." By fostering a connection to nature within educational spaces, biophilic design aims to create environments that support holistic development and well-being.

Mount Olive School embarked on a transformative journey to integrate biophilic design elements, including natural light, vegetation, views of nature, and natural materials, into its architecture and interior design. The primary objective of this study was to evaluate the impact of these biophilic design elements on various educational outcomes, such as academic performance, attendance rates, student behavior, and overall well-being.

Despite the growing interest in biophilic design, there remains a gap in empirical research examining its effects in real-world school environments. This study aims to fill this gap by providing comprehensive insights into the benefits and challenges of implementing biophilic design in an educational setting. The findings have the potential to inform future design practices and policies, promoting the wider adoption of nature-integrated environments in schools.

Objective of the Study:

1. The main objective of this study was to assess the impact of biophilic design elements on educational outcomes at Mount Olive School. The specific research questions addressed were:
1. What are the key biophilic design elements implemented at Mount Olive School?

2. How do students, teachers, and administrators perceive the impact of biophilic design on the learning environment?
3. What changes in academic performance, attendance rates, and student behavior have been observed following the implementation of biophilic design?
4. How do biophilic design elements influence overall student well-being?

RESEARCH METHODOLOGY

Study Design:

This study utilized a mixed-methods approach, combining quantitative and qualitative data collection and analysis techniques. The research design included surveys, interviews, focus groups, and the analysis of academic records and behavioral data.

Data Collection:

- **Surveys:** Structured questionnaires were administered to students, teachers, and administrators to gather quantitative data on their perceptions of biophilic design elements and their impact on various educational outcomes. The surveys included Likert-scale questions to quantify the level of agreement with statements related to biophilic design and its perceived benefits.
- **Interviews and Focus Groups:** In-depth interviews and focus group discussions were conducted to obtain qualitative insights into the experiences and opinions of stakeholders regarding biophilic design. Participants were asked open-ended questions about their perceptions, experiences, and the impact of biophilic design elements on their daily lives.
- **Academic Records and Behavioral Data:** Historical academic records and behavioral incident reports were analyzed to evaluate changes in student performance and behavior before and after the implementation of biophilic design elements. This included tracking grades in core subjects, attendance rates, and the frequency of behavioral incidents.

Data Analysis:

- **Quantitative Analysis:** Descriptive statistics were used to summarize the survey responses, providing an overview of the perceptions of biophilic design elements. Correlation analysis was performed to identify relationships between biophilic elements and educational

outcomes. Regression analysis was conducted to quantify the impact of biophilic design on academic performance, attendance rates, and behavior.

- Qualitative Analysis: Thematic analysis was conducted on the interview and focus group data to identify key themes and insights related to the impact of biophilic design on the school environment. This involved coding the qualitative data and categorizing it into themes that emerged from the discussions.

RESULTS AND DISCUSSION

Key Findings:

1. Implementation of Biophilic Design Elements:

- The study identified and detailed the implementation of natural light, vegetation, views of nature, and natural materials as integral biophilic design elements at Mount Olive School. These elements were strategically integrated to create a more engaging and supportive learning environment. Classrooms were equipped with large windows and skylights to maximize natural light. Indoor plants and green walls were introduced to improve air quality and create a calming atmosphere. Large windows and outdoor learning spaces were designed to offer views of natural landscapes, such as gardens and trees. Natural materials, including wooden furniture and natural fiber textiles, were used to enhance comfort and connection to nature.

2. Positive Perceptions Among Stakeholders:

- Surveys, interviews, and focus groups revealed strong positive perceptions of biophilic design elements among students, teachers, and administrators. Stakeholders reported that natural light, vegetation, and views of nature significantly enhance happiness, concentration, well-being, and overall school enjoyment. Teachers emphasized the positive impact of biophilic design on their teaching environment, while students highlighted the benefits for their mood and engagement. Administrators acknowledged the role of biophilic design in creating a supportive and nurturing school atmosphere.

3. Improvements in Academic Performance:

- The analysis of academic records showed significant improvements in student grades across core subjects following the implementation of biophilic design. The average grades in mathematics, science, and language arts increased notably. Correlation and regression analyses confirmed the positive relationship between biophilic elements and academic performance, indicating that natural light, vegetation, and views of nature contribute to enhanced cognitive function and learning outcomes.

4. Increased Attendance Rates:

- The study observed a notable increase in attendance rates, with students reporting that biophilic elements positively influence their willingness to attend school regularly. Attendance data showed a significant rise in the average attendance rate, suggesting that the inviting and supportive environment created by biophilic design elements encourages regular school attendance.

5. Reduction in Behavioral Incidents:

- There was a significant reduction in reported behavioral incidents, with strong correlations between positive perceptions of biophilic design elements and improved student behavior. The frequency of behavioral incidents decreased, indicating that the calming and supportive atmosphere created by biophilic design contributes to better behavior and fewer disciplinary issues.

6. Enhanced Student Well-Being:

- Survey and qualitative data indicated that students experienced increased feelings of happiness, relaxation, and reduced stress due to biophilic design elements. These elements were valued for creating a calming and comfortable environment that supports mental health. Students reported that natural light, vegetation, and views of nature help them feel more connected to the natural world, enhancing their overall sense of well-being.

Discussion:

The findings of this study align with existing literature on the benefits of biophilic design in educational settings. The positive impacts on academic performance, attendance rates, student behavior, and well-being highlight the transformative potential of nature-integrated environments. By fostering a deeper connection to nature, biophilic design promotes holistic development and well-being, creating supportive and engaging learning spaces.

The strong positive perceptions of biophilic design elements among students, teachers, and administrators underscore the importance of creating educational spaces that connect individuals to nature. The observed improvements in academic performance, attendance rates, and behavior provide empirical evidence of the benefits of biophilic design, supporting its wider adoption in schools.

However, the study also identified challenges associated with the implementation of biophilic design, such as budget constraints, maintenance requirements, and the need for ongoing professional development for staff. Addressing these challenges is crucial for the sustainable adoption and success of biophilic design in schools.

CONCLUSION AND RECOMMENDATION

Conclusion:

The integration of biophilic design elements at Mount Olive School has demonstrated significant positive impacts on various educational outcomes. The study provides compelling evidence that natural light, vegetation, views of nature, and natural materials enhance academic performance, increase attendance rates, improve student behavior, and promote overall well-being. These findings underscore the value of biophilic design in creating nurturing and stimulating educational environments that support holistic development.

The positive feedback from students, teachers, and administrators highlights the transformative potential of biophilic design in fostering a supportive and engaging learning environment. By prioritizing biophilic design principles, schools can create spaces that promote academic success, well-being, and a deep connection to nature.

Recommendations:

1. Maximize Natural Light:

- Recommendation: Design classrooms and common areas to maximize natural light through large windows, skylights, and glass doors. Ensure that spaces receive ample daylight to enhance mood and concentration.
- Implementation: Conduct an audit of existing lighting conditions and identify opportunities to increase natural light. Consider architectural modifications or additions to optimize daylight exposure.

2. Incorporate Vegetation:

- Recommendation: Introduce a variety of indoor plants, green walls, and outdoor gardens. Incorporate vegetation into classrooms, hallways, and common areas to improve air quality and create a calming atmosphere.
- Implementation: Develop a plan for the selection, placement, and maintenance of plants. Engage students and staff in planting and caring for vegetation to foster a sense of ownership and connection to nature.

3. Enhance Views of Nature:

- Recommendation: Design learning spaces with windows that offer views of natural landscapes, such as gardens, trees, and water bodies. Prioritize visual connections to nature to reduce stress and improve well-being.
- Implementation: Assess the current layout of classrooms and common areas and identify opportunities to enhance views of nature. Consider reconfiguring spaces or adding new windows to improve natural views.

4. Utilize Natural Materials:

- Recommendation: Use natural materials such as wood, stone, and natural fibers in furniture, flooring, and decor. Prioritize sustainable and eco-friendly materials to create a comfortable and aesthetically pleasing environment.

- Implementation: Review existing materials and identify areas for the introduction of natural materials. Collaborate with architects and designers to integrate these elements into new and existing spaces.

5. Consider Water Features:

- Recommendation: If feasible, incorporate water features such as fountains, ponds, or water walls in common areas and outdoor spaces to create a soothing auditory and visual experience.
- Implementation: Explore potential locations for water features and evaluate the feasibility of installation and maintenance. Consider the sensory benefits and aesthetic appeal of water elements in the design process.

6. Engage the School Community:

- Recommendation: Involve students, teachers, and parents in the planning and implementation of biophilic design elements. Gather input and feedback to ensure that the design meets the needs and preferences of the community.
- Implementation: Organize workshops, surveys, and focus groups to gather ideas and feedback. Foster a collaborative approach to biophilic design by involving stakeholders in decision-making and implementation.

7. Promote Outdoor Learning:

- Recommendation: Encourage the use of outdoor spaces for learning activities, such as nature walks, gardening projects, and outdoor classes. Leverage natural settings to enhance engagement and experiential learning.
- Implementation: Develop a curriculum that includes outdoor learning opportunities. Provide training and resources for teachers to effectively utilize outdoor spaces for educational activities.

8. Evaluate and Adapt:

- Recommendation: Continuously evaluate the effectiveness of biophilic design elements and adapt them based on feedback and changing needs. Conduct regular assessments to ensure sustained benefits.

- Implementation: Establish a framework for ongoing evaluation, including surveys, observations, and feedback mechanisms. Use the data collected to make informed decisions about modifying and enhancing biophilic design.

By following these recommendations, schools can effectively implement and maximize the positive impact of biophilic design, creating educational environments that foster holistic development and a deep connection to nature.