

## ABSTRACT

Title of Thesis: THE NEXUS: HEALTHY STUDENT LIVING  
AT THE LIBRARY

Brianna Riffle, Master of Architecture and  
Master of Real Estate Development, 2024

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With nearly 80% of students in the United States consistently experiencing moderate to high levels of stress and a significant proportion attributing stress to poor academic performance, there is a clear imperative to explore innovative design solutions. Drawing on the field of neuroarchitecture, this thesis investigates how architectural design can positively influence the physical, psychological, emotional, and social experiences of university users. This thesis addresses the pressing need for university libraries and student housing that better support student well-being and learning capabilities.

Neuroarchitecture, a field that integrates neuroscience, environmental psychology, and architecture, speaks to the psychological effects that a building's design decisions can have on the user's experience of the space. One main contributor to a positive experience within a building includes the use of biophilic design principles. This offers a unique opportunity to study the neurological effects and prominent biophilic principles that create a calming, rejuvenating, inspirational, and focus-inducing space. This thesis will apply strategies derived from neuroarchitecture principles to the design of university libraries.

THE NEXUS  
HEALTHY STUDENT LIVING AT THE LIBRARY

By

Brianna Riffle

Thesis submitted to the Faculty of the Graduate School of the  
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# Introduction

Architecture profoundly influences human experience, cognition, behavior, and well-being. This thesis explores the integration of cutting edge architectural approaches stemming from neuroarchitecture to create holistic human centered environments that promote health, productivity, and overall quality of life.

Neuroarchitecture examines the intersection of neuroscience and architecture, focusing on how built environments impact brain function and behavior. By understanding neuroplasticity, the brain's capacity to adapt and rewire in response to environmental stimuli, neuroarchitecture seeks to optimize spaces for cognitive function, emotional well-being, and social interaction. This thesis delves into the historical roots, principles, and methodologies of neuroarchitecture, highlighting key studies that reveal the intricate relationship between the brain and the built environment. Through neuroimaging techniques, cognitive mapping, and physiological measurements, the research demonstrates how architectural elements like lighting, spatial layout, and color influence mood and spatial navigation.

Biophilic Design emphasizes the innate human connection to nature, integrating natural elements and processes into the built environment to enhance health, well-being, and environmental sustainability. Drawing on the concept of biophilia, biophilic design incorporates direct connections with nature, indirect references to natural forms, and sensory experiences that engage sight, sound, touch, and smell. This thesis traces the historical origins of biophilic design and presents empirical studies that demonstrate its benefits, such as stress reduction, improved cognitive function, and enhanced overall well-being. By creating harmonious spaces that foster a deeper relationship with nature, biophilic design principles aim to transform urban environments into regenerative ecosystems.

Multisensory Design recognizes the importance of engaging multiple senses, visual, auditory, olfactory, tactile, and even gustatory, in the architectural experience. Moving beyond traditional visual aesthetics, multisensory design creates immersive and enriching environments that provoke specific emotions and enhance user satisfaction. By integrating elements such as soundscapes, textured surfaces, natural ventilation, and greenery, architects can craft spaces that stimulate the senses and foster a sense of comfort and connection. This thesis explores synesthetic design principles and empirical research on sensory perception, demonstrating how multisensory engagement influences spatial cognition, mood modulation, and user behavior.

This thesis aims to utilize the design principles derived from these areas of research into a comprehensive architectural framework that prioritizes human well-being and environmental sustainability. By leveraging insights from neuroscience, environmental psychology, and sensory perception, the project proposes innovative design strategies that will be featured in a dual-typology, university library and student housing design. The goal is to create an environment that supports cognitive health, emotional resilience, and social cohesion while addressing contemporary challenges such as academic stress, cognitive overload, and environmental degradation. This design will look to answer two main questions, how can the campus library of the future promote student wellbeing and how can universities discover a financially viable path to creating the library of the future?

# Chapter 1: Student Stress at the University Level

## Introduction

In today's world, the pressure on university students is greater than ever before. From academic demands to financial pressures and social expectations, students face a myriad of stressors that can take a toll on their mental health and overall well-being. In 2022 the American College Health Association performed a study finding that 49.3% of students in the United States felt moderately stressed most of the time with 29.5% experiencing high stress and 19.7% reporting low stress most often. This leaves only 1.5% of students reporting that they are not experiencing stress most days. The association also found that 41.3% of students believe stress is the largest contributor to poor academic performance.<sup>1</sup> This chapter explores the current problem of student stress levels in university settings and examines the contributing factors.

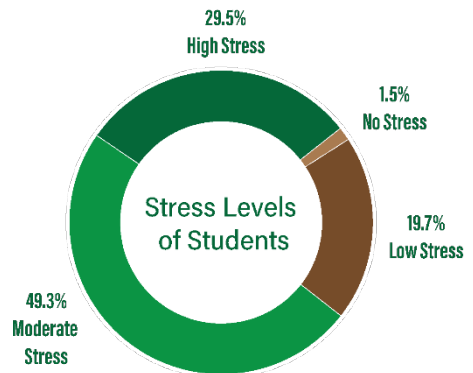


Figure 1: Author's Diagram of American College Health Association Stress Data

## Contributing Factors to Student Stress

The most commonly considered factor that contributes to high levels of stress in university students would be academic pressures including coursework, exams, and deadlines. The increasing competitiveness of the job market adds to these pressures to excel academically, leading students to experience anxiety and fear of failure.

Financial concerns also play a significant role in student stress levels. Many students struggle to afford tuition fees, textbooks, and living expenses, leading to financial stress and

<sup>1</sup> "National College Health Assessment - ACHA." 2024. <https://www.acha.org/>. 2024. <https://www.acha.org/ncha/>.

worries surrounding student loan debt. Additionally, the need to balance part-time work with academic responsibilities further exacerbates stress levels.

Social pressures, such as maintaining relationships, fitting in with peers, and navigating social events, can also contribute to student stress. The transition to university life can be challenging, particularly for first-year students who may feel overwhelmed by the new environment and expectations.



*Figure 2: Google Images of Coursework, Financial Aid, Student Socialization*

The built environment plays a crucial role in shaping the experiences and well-being of university students. From lecture halls to libraries to dormitories, every space within the campus ecosystem exerts its influence on students' daily lives. This chapter explores the ways in which built environments can contribute to stress levels and emphasizes the importance of creating study spaces, including libraries, that promote relaxation and focus.

## The Stressful Nature of the Built Environment

University campuses are often characterized by bustling activity, crowded spaces, and noise pollution, all of which can contribute to students feeling overwhelmed and anxious. Lecture halls filled to capacity or left dramatically bare, cramped dormitories, and noisy common areas offer little respite from the demands of academic life. Moreover, the lack of privacy and personal space in these environments can exacerbate feelings of stress and social pressure.

The design of physical spaces within university settings also plays a significant role in shaping student experiences. Poorly lit areas, uncomfortable seating, and inadequate ventilation can create physical discomfort and hinder students' ability to concentrate. Additionally, the absence of designed quiet zones and study areas further compounds the challenges faced by students seeking a conducive environment for academic work.

## The Need for Stress-Free Study Spaces

Amidst the chaos of campus life students require designated study spaces where they can retreat to focus, unwind, and recharge. Libraries, with their quiet ambiance and abundance of resources, have traditionally served as sanctuaries for students seeking solace from the chaos of campus life. However, the modernization of libraries and the integration of digital technologies have transformed these spaces potentially disrupting their traditional role as havens of tranquility.

As libraries evolve to meet the changing needs of their patrons, it is essential to prioritize the creation of stress-free study spaces that promote concentration and well-being. Comfortable seating, ample natural light, and ergonomic furniture are essential elements of an ideal study environment. Additionally, the incorporation of soundproofing materials and designated quiet zones can help minimize distractions and create a conducive atmosphere for focused study.

Despite the importance of stress-free study spaces, libraries face several changes in designing environments that prioritize student well-being. Limited physical space, budget constraints, and competing demands for resources present significant barriers to the creation of optimal study environments. Moreover, the need to balance traditional library services with innovative technologies further complicates the design process.

In addition to student stress, libraries face their own set of challenges in meeting the evolving needs of their communities. Despite efforts to innovate and adapt to changing technologies, libraries often struggle with limited resources and funding constraints. Initiatives such as digital media labs and library kiosks present promising opportunities for expanding access to resources and services. However, the high costs associated with implementing and maintaining these programs pose significant barriers for many libraries.

Librarians and campus administrators must collaborate to overcome these challenges and prioritize the creation of student-centric spaces within libraries. By soliciting feedback from students and incorporating their input into the design process, libraries can ensure that their spaces meet the unique needs and preferences of their users. Additionally, strategic investments in infrastructure and technology can enhance the functionality and accessibility of library spaces, further supporting student success and well-being.

### Consequences of High Stress Levels

The consequences of high stress levels among university students are far-reaching and have a detrimental impact on their academic performance, mental health, and overall quality of life. Chronic stress can lead to burnout, fatigue, and decreased motivation, making it difficult for students to concentrate on their studies and perform at their best.

Moreover, prolonged stress can increase the risk of developing mental health disorders such as anxiety and depression. Studies have shown a significant rise in the prevalence of mental health issues among university students, highlighting the urgent need for effective interventions and support services.

Beyond academic and mental health consequences, high levels of stress can also impact students' physical health, leading to sleep disturbances, headaches, and weakened immune systems. Furthermore, excessive stress can strain relationships with family and friends, further exacerbating feelings of isolation and loneliness.

## Conclusion

The design of built environments within university settings profoundly influences student stress levels and academic performance. By providing the creation of stress free study spaces, including libraries, campuses can foster environments that promote relaxation, focus, and productivity. Through thoughtful design, strategic investments, and ongoing collaboration, universities can create spaces that empower students to thrive academically and personally, ensuring their holistic well-being in the pursuit of higher education.

The issue of student stress in university settings is multifaceted and requires A nuanced understanding of its underlying causes and consequences. By addressing the complex interplay of academic, financial, and social stressors, academic communities can better support the holistic well-being of their students. Similarly, libraries must confront their own challenges in adapting to the digital age while ensuring equitable access to information and resources for all members of their communities. Through collective efforts and a commitment to innovation, universities can work towards creating environments that foster resilience, empowerment, and academic success for all stakeholders.

## Chapter 2: The Evolving Role of Libraries in Supporting University Students

### Introduction

libraries have long been integral to the academic experience, serving as havens of knowledge, research, and learning for university students. However, as the needs and preferences of students evolve in the digital age, libraries are undergoing significant transformations to remain relevant and supportive of student success. This chapter explores the importance of library typology to university students, examines how libraries support students, and discusses the changes library typologies are experiencing. Furthermore, it speculates on the future of libraries in the context of student well-being and academic achievement.

### The Importance of Library Typology to University Students

libraries serve as more than repositories of books; they are dynamic spaces that facilitate research, collaboration, and intellectual exploration. The typology of libraries influences the ways in which students interact with these spaces and the resources they offer. Whether it's the traditional grandeur of a historic library the modern functionality of a digital learning Commons, each typology shapes the student experience unique ways.

For university students, the libraries offer a sanctuary from the distraction of campus life and provide access to a wealth of academic resources period from quiet study areas to collaborative workspaces, libraries accommodate diverse learning styles and preferences, making them indispensable to student success. Moreover, libraries serve as community hubs, fostering connections between students, faculty, and staff, and promoting a culture of scholarship and inquiry.

## How Libraries Support Students

Libraries play a multifaceted role in supporting students throughout their academic journey. Beyond offering access to books and research materials, libraries provide a range of services and resources designed to enhance student learning and well-being. These include:

1. **Research Assistance:** librarians offer expert guidance and support to students navigating the research process, helping them locate relevant resources and develop effective search strategies.
2. **Study Spaces:** libraries provide quiet study areas, group study rooms, and collaborative workspaces where students can focus, collaborate, and engage in academic pursuits.
3. **Technology Access:** libraries offer access to computers, printers, scanners, and other technology resources, ensuring that students have the tools they need to succeed in an increasingly digital world.
4. **Academic Workshops:** libraries host workshops and training sessions on topics such as information literacy, citation management, and research skills, empowering students to become more effective scholars.
5. **Special Collections:** many libraries house special collections, archives, and rare materials that enrich student academic experiences and provide opportunities for original research and scholarship.

## Impact of Library Architecture on the Learning Environment

The architecture of her library plays a crucial role in shaping the learning environment and influencing the experience of students, faculty, and researchers. Here are some ways in which library architecture can impact the learning environment:

design esthetics: the aesthetic appeal of a library's architecture can contribute to a sense of inspiration, calmness, and focus among users. A well-designed library with pleasing aesthetics, such as ample natural light, comfortable seating areas, and visually appealing interiors, can enhance the overall learning experience and encourage prolonged engagement with scholarly activities.

1. Spatial layout: the spatial layout of a library affects how users navigate and interact with the space. Thoughtful design considerations, such as clear signage, intuitive wayfinding, and strategically placed study areas, can optimize the flow of foot traffic, minimize congestion, and create conducive environments for individual and collaborative learning.
2. Functional zones: libraries often feature distinct functional zones tailored to different learning activities and user preferences. These may include quiet study areas for focused individual work, group study rooms for collaborative projects, multimedia rooms for audio-visual presentations, and designated areas for leisure reading or relaxation. By providing diverse spaces that accommodate several learning styles and needs, library architecture supports a range of academic pursuits and promotes student success.
3. Technology integration: modern libraries incorporate technology seamlessly into their architectural design to facilitate digital learning and research period this may involve the integration of power outlets, Wi-Fi connectivity, computer stations, and multimedia resources throughout the library space. By embracing technology in its architecture, libraries empower us to access and utilize digital resources effectively, enhancing the overall learning experience.
4. Flexibility and adaptability: flexible architecture allows libraries to adapt to changing user needs and pedagogical trends over time. Modern furniture, movable partitions, and

adaptable spaces enable libraries to accommodate different activities and events, from lectures and workshops to exhibitions and social gatherings. By prioritizing flexibility and design, libraries can remain dynamic and responsive to the evolving demands of the academic community.

## Space Requirements for University-Scale Libraries

The space requirements for a university-scale library vary depending on factors such as the size of the student population, the scope of academic programs offered, and the institution's educational mission. However, a comprehensive university library typically requires a significant amount of space to accommodate its diverse functions and services. Here is a breakdown of how space is typically allocated:

1. **Collection Space:** A substantial portion of the library space is dedicated to housing its collections, including books, journals, multimedia material, and archival resources. This may involve shelving units, compact storage systems, and specialized storage areas designed to preserve and organize the library's holdings efficiently.
2. **Reading and Study Areas:** libraries allocate space for reading and study areas to accommodate the academic needs of students, faculty, and researchers. This may include individual carrels, tables, and soft seating arrangements arranged in quiet zones conducive to focus study and research period group study rooms equipped with whiteboards, projectors, and collaborative technology are also essential components of the library's study spaces.
3. **Technology Infrastructure:** given the increasing reliance of digital resources and technology-enabled learning tools, university libraries allocate space for technology infrastructure, including computer labs, multimedia stations, and audio-visual resources.

These spaces provide users with access to computers, printers, scanners, and other digital resources essential for academic research and coursework.

4. **Specialized Facilities:** some university libraries feature specialized facilities to support specific academic disciplines or research activities. These may include laboratories, archives, special collections rooms, and makerspaces equipped with tools for hands-on experimentation and creative projects.
5. **Administrative and Support Spaces:** in addition to user facing areas, university libraries require administrative and support spaces to facilitate day-to-day operations and provide essential services to users. These spaces may include offices for library staff, conference rooms for meetings and consultations, circulation desks for loan services, and information desks for user assistance.

Overall, the allocation of space in a university-scale library is carefully planned to accommodate the diverse needs of its users, promote academic excellence, and foster a supportive learning environment conducive to intellectual inquiry and discovery.

## The Potential of Libraries to Reduce Student Stress

In addition to their academic support services, libraries have the potential to reduce student stress and promote well-being. By providing serene study environments, access to mindful resources, and opportunities for relaxation and rejuvenation, libraries can serve as vital resources for students seeking refuge from the pressures of university life. Moreover, libraries can foster a sense of belonging and community, helping students connect with peers and build supportive networks.

## Changes in Library Typologies

The advent of digital technologies has prompted significant changes in library technologies, challenging traditional notions of what constitutes a library. Digital libraries, learning Commons, and makerspaces are just a few examples of innovative library technologies that have emerged in response to evolving student needs and technological advances. These new typologies reflect a shift towards more interactive, flexible, and technology-enabled library spaces designed to accommodate diverse learning styles and preferences.

## The Future of Libraries

Looking ahead, the future of libraries you're likely to be shaped by ongoing technological innovation, changing pedagogical approaches, and evolving student demographics. Libraries will continue to evolve as dynamic, multifunctional spaces that support teaching, learning, research, and community engagement. Moreover, libraries will play an increasingly important role in promoting suitable being and mental health, providing resources and services that help students manage stress, cultivate resilience, and thrive academically and personally.

## Conclusion

In conclusion, libraries are indispensable to the academic success and well-being of university students. As they adapt to meet the changing needs of students and embrace new technologies and pedagogical approaches, libraries will remain vital institutions that empower students to pursue their intellectual passions, achieve their academic goals, and lead fulfilling lives both inside and outside the classroom.

# Chapter 3: Neuroarchitecture

## Introduction

Neuroarchitecture, an emerging field at the intersection of neuroscience and architecture, explores the profound impact built environments have on human cognition, behavior, and well-being. This chapter delves into the historical roots, principles, methodologies, and findings of neuroarchitecture. It reviews significant studies, shedding light on the intricate relationship between the brain and the built environment. Furthermore, it discusses the implications of neuroarchitecture in design practice, emphasizing its potential to create healthier, more sustainable, and user-centered spaces. In recent years, the interdisciplinary field of neuroarchitecture has gained traction, offering novel insights into how the design of physical spaces influences human brain function and behavior. Combining practices from neuroscience and architecture, neuroarchitecture seeks to optimize built environments to enhance well-being, productivity, and overall quality of life.

## Historical Roots

The roots of neuroarchitecture can be traced back to ancient civilizations where architectural design was informed by observations of human behavior and environmental interactions. However, the formal integration of neuroscience into architectural theory emerged in the late 20th century. Noble figures such as architects Juhani Pallasmaa, author of "The Eyes of the Skin: Architecture and the Senses,"<sup>2</sup> and Christopher Alexander, author of "A Pattern

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<sup>2</sup> "The Eyes of the Skin Review - Declad." n.d. Www.declad.com. <https://www.declad.com/the-eyes-of-the-skin-review>.

Language: Towns, Buildings, Construction,"<sup>3</sup> emphasized the importance of sensory experience and human-centered design, laying the groundwork for neuro architectural inquiry.

## Principles and Methodologies

Neuroarchitecture operates on several key principles derived from neuroscience and environmental psychology. Central to its approach is the understanding of neuroplasticity, the brain's capacity to adapt and rewire in response to environmental stimuli. Design principles such as biophilia, prospect-refuge theory, and evidence-based design are utilized to create environments that support cognitive function, emotional well-being, and social interaction. Biophilia will be further discussed in the next chapter and evidence-based design is exemplified in the studies presented below. The prospect-refuge theory is an architectural concept proposed by the geographer Jay Appleton in his book "The Experience of Landscape,"<sup>4</sup> published in 1975. This theory suggests that humans are drawn to environments that offer a combination of prospect (open, expansive views) and refuge (sheltered, protective spaces). According to Appleton, his preference for environments with both prospect and refuge is rooted in evolutionary psychology

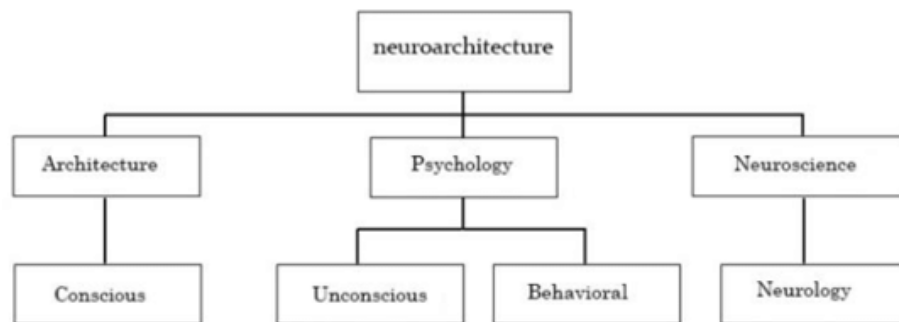


Figure 3: Neuroarchitecture Figure from "Understanding and Anticipating the User in Space"

<sup>3</sup> "A Pattern Language." 2024. Google Books. 2024.

<https://books.google.com/books?id=hwAHmktpk5IC&printsec=frontcover#v=onepage&q&f=false>.

<sup>4</sup> Bunkse, Edmunds V., and Jay Appleton. 1977. "Review of the Experience of Landscape." *Annals of the Association of American Geographers* 67 (1): 149–51. <https://www.jstor.org/stable/2562247>.

and reflects adaptive behaviors developed by early humans. To further clarify, prospect refers to open, unobstructed views of the surrounding environment. Humans are naturally attracted to spaces that offer panoramic views, allowing them to observe and survey their surroundings. From an evolutionary standpoint, prospect provides a sense of security and allows individuals to monitor potential threats or opportunities in their environment. Refuge pertains to enclosed or sheltered spaces that provide a sense of security and protection. These spaces offer a sense of safety and retreat from potential dangers or stressors in the environment. Examples of refuge spaces include caves, alcoves, or sheltered corners within buildings. According to the prospect-refuge theory, environments that successfully integrate both prospect and refuge elements are perceived as more attractive, comforting, and psychologically satisfying to humans. These environments evoke feelings of safety, exploration, and well-being, aligning with our innate preferences for spaces that offer both expansive views and protective shelter.

Methodologies employed in neuroarchitecture research include neuroimaging techniques, cognitive mapping, and physiological measurements to assess the neural and behavioral responses to architectural stimuli.

## Understanding Neuroarchitecture

Neuroarchitecture operates on the premise that the design of physical spaces significantly impacts human cognition, emotion, and behavior. Numerous studies have been conducted to understand this intricate relationship. For instance, research utilizing functional magnetic resonance imaging (fMRI) has demonstrated that exposure to natural environments activates brain regions associated with relaxation and stress reduction. Similarly, studies employing virtual reality simulations have revealed the impact of architectural elements such as lighting, spatial layout, and color on mood and spatial navigation abilities. Furthermore, longitudinal studies

assessing the health outcome of occupants in biophilic buildings have shown reductions in stress, improved cognitive performance, and enhanced overall well-being.

One notable study conducted by Ulrich in 1991, utilized functional magnetic resonance imaging (fMRI) to investigate the neural correlates, or the patterns of brain activity/psychological responses that correspond to specific mental states, sensory experiences, or external stimuli,<sup>5</sup> stemming from exposure to natural versus urban environments. Participants were exposed to images of natural scenes (e.g. forest, rivers, etc.) and urban scenes (e.g. city streets, buildings, etc.) While undergoing fMRI scanning. The results revealed increased activity in brain regions associated with relaxation such as the prefrontal cortex and the amygdala, when participants viewed natural environments compared to urban environments. This suggests that exposure to natural settings illicit a psychological response conducive to stress reduction and emotional well-being.

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<sup>5</sup> Nani, Andrea, Jordi Manuella, Lorenzo Mancuso, Donato Liloia, Tommaso Costa, and Franco Cauda. 2019. "The Neural Correlates of Consciousness and Attention: Two Sister Processes of the Brain." *Frontiers in Neuroscience* 13 (1169). <https://doi.org/10.3389/fnins.2019.01169>.

A study in 2024<sup>6</sup> utilized virtual reality simulations to investigate the impact of architectural elements on mood and spatial navigation abilities. Participants navigated through virtual environments with varying lighting conditions, spatial layouts, and color schemes. The findings indicated that environments characterized by ample natural light, coherent spatial organization, and warm color palettes elicited positive emotional responses and facilitated efficient spatial navigation. Conversely, environments with poor lighting, cluttered layouts, and cool color schemes were associated with negative effects and impaired spatial cognition.

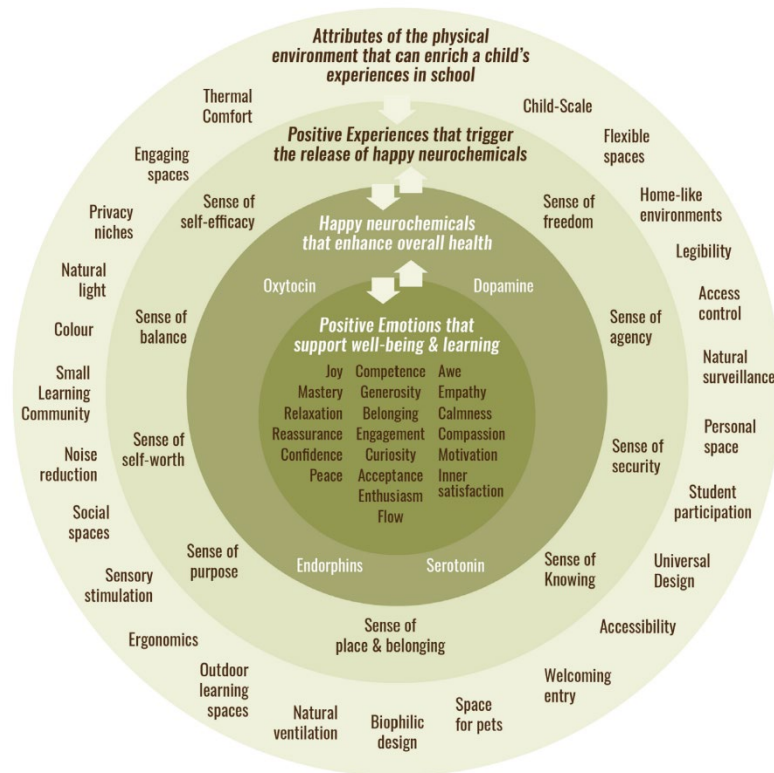


Figure 4: Physical School Environment's Role in Fostering Self-Actualization from Infographic: The Power of Neuroarchitecture

A longitudinal study conducted by Browning<sup>7</sup> in 2014 assessed the health outcomes of occupants residing in biophilic buildings over an extended period. Biophilic design principles such as incorporating natural materials, vegetation, and access to daylight, were integrated into the architectural design of the buildings. Participants' psychological and physiological well-being or measured through self-

<sup>6</sup> Sozialwissenschaften, Vom, Thomas Lachmann, and Kerstin Müller. n.d. "THE VIRTUAL EXPERIENCE -EXAMINING VISUAL, AUDITORY and HAPTIC CAPABILITIES and ASPECTS of SPATIAL COGNITION and USER EXPERIENCE in VIRTUAL REALITY." Accessed December 17, 2024.

[https://kluedo.ub.rptu.de/frontdoor/deliver/index/docId/8326/file/Beese\\_Dissertation.pdf](https://kluedo.ub.rptu.de/frontdoor/deliver/index/docId/8326/file/Beese_Dissertation.pdf)

<sup>7</sup> Ryan, Catherine O., and William D. Browning. "Biophilic design." Sustainable built environments (2020): 43-85.

report surveys, biomarker analysis, and cognitive performance tests. The results revealed significant reductions in stress levels, improvements in cognitive performance, and enhanced overall well-being among occupants of biophilic buildings compared to conventional ones. These findings underscore the therapeutic benefits of incorporating biophilic elements into architectural design for promoting human health and well-being.

There have also been studies focused more specifically on how architectural forms or individual design decisions can impact individual's experiences. A study by Vartanian in 2015 investigated the impact of ceiling heights on cognitive processes, particularly creativity. Participants were exposed to environments with varying ceiling heights, and their cognitive performance was assessed using standardized creativity tests. The results showed that environments with higher ceilings were associated with increased creativity compared to those with lower ceilings.

A study by Vartanian<sup>8</sup> in 2013 examined how the curvature of architectural spaces influences emotional responses. Participants were exposed to virtual environments with varying degrees of curvature, and their emotional states were assessed using self-report measures and psychological indicators such as skin conductance. The findings revealed that environments with greater curvature elicited more positive emotional responses compared to those with minimal curvature.

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<sup>8</sup> Llorens-Gómez, Mar, Juan Luis Higuera-Trujillo, Carla Sentieri Omarrementeria, and Carmen Llinares. 2021. "The Impact of the Design of Learning Spaces on Attention and Memory from a Neuroarchitectural Approach: A Systematic Review." *Frontiers of Architectural Research* 11 (3). <https://doi.org/10.1016/j.foar.2021.12.002>.

A study by Hedblom<sup>9</sup> in 2019 investigated the impact of window views on mental fatigue and cognitive function in office settings. Participants working in offices with different types of window views (e.g. nature view, urban view, no view) were assessed for mental fatigue and cognitive performance throughout the workday. The results showed that employees with access to natural views experienced less mental fatigue and demonstrated better cognitive performance compared to those with urban views or no views.

A study by Kuller<sup>10</sup> in 2009 explored the effects of lighting design on spatial perception and wayfinding in architectural environments. Participants navigated through virtual environments with different lighting conditions (natural or artificial lighting) and spatial layouts, and their spatial cognition and wayfinding abilities were assessed. The results indicated that environments with natural lighting and well-designed lighting schemes facilitated better spatial perception and navigation compared to those with poor lighting conditions. This underscores the importance of lighting design and architectural settings for supporting spatial cognition and wayfinding.

## Implications for Design Practice

The findings of neuroarchitecture have profound implications for design practice across various domains, including urban planning, healthcare facilities, workplace design, and residential architecture. By integrating neuroscientific principles into the design process, architects can create environments that foster creativity, productivity, and social cohesion. Furthermore, neural architecture offers innovative solutions for addressing contemporary

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<sup>9</sup> A study by Hedblom in 2019 investigated the impact of window views on mental fatigue and cognitive function in office settings.

<sup>10</sup> Costa, Marco, Sergio Frumento, Mattia Nese, and Iacopo Predieri. 2018. "Interior Color and Psychological Functioning in a University Residence Hall." *Frontiers in Psychology* 9 (August). <https://doi.org/10.3389/fpsyg.2018.01580>.

challenges such as urban stress, cognitive overload, and environmental degradation. Designing spaces that promote sensory engagement, access to nature, and social interaction can contribute to a more sustainable and resilient built environment.

## Conclusion

Neuroarchitecture represents a paradigm shift in architectural theory and practice, offering a holistic approach to design and formed by insights from neuroscience. By understanding the complex interplay between the brain and the built environment, architects have the opportunity to create spaces that enhance human well-being and facilitate meaningful experiences. As the field continues to evolve, interdisciplinary collaboration between architects, neuroscientists, and psychologists will be essential in advancing our understanding of how design shapes the mind and body. Ultimately, neuro architecture holds the promise of transforming the way we conceive experience and inhabit built environments.

## Chapter 4: Biophilic Design

### Introduction

Biophilic design, rooted in the innate human connection to nature, seeks to integrate natural elements and processes into the built environment. This chapter provides an in-depth exploration of biophilic design, tracing its historical origins, elucidating its underlying principles and methodologies, and examining empirical studies that demonstrate its benefits. Through an interdisciplinary lens, the chapter highlights the profound impact of biophilic design on human health, well-being, and environmental sustainability. Furthermore, it discusses the rationale behind the growing adoption of biophilic principles in contemporary architecture, emphasizing its potential to create harmonious and regenerative spaces that nurture both people and the planet.

### Historical Origins

The roots of biophilic design can be traced back to early human settlements and indigenous cultures, where architecture seamlessly coexisted with the natural environment. However, the formal articulation of biophilic design emerged in the late 20th century, influenced by the works of scholars such as E.O. Wilson and Steven Kellert. Wilson's concept of biophilia, defined as the innate human inclination to connect with nature, provided the theoretical foundation for biophilic design, inspiring architects and designers to integrate nature into the built environment.

### Principles and Methodologies

Biophilic design operates on several key principles derived from biophilia and environmental psychology. These principles include:

1. direct connection with nature: providing direct access to natural elements such as daylight, vegetation, water, and views of the natural landscape.
2. Indirect references to nature: incorporating design elements, materials, and patterns that evoke natural forms, textures, and processes.

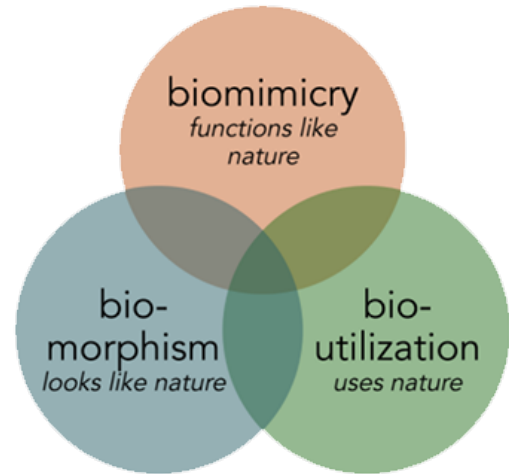


Figure 5: Bio- options from Biomimetic Coatings

3. Prospect and refuge: balancing open, expansive views (prospect) with enclosed, sheltered space (refuge) to create a sense of security and exploration.
4. Sensory experience: engaging all the senses through the use of natural light, materials, colors, sounds, and scents.
5. Biophilic urbanism: integrating nature into urban environments through green infrastructure, parks, green roofs, and urban agriculture.

Methodologies employed in biophilic design include site analysis, bio mimicry, and evidence based design research to assess the impact of biophilic innovations on human health, while being, and environmental sustainability.

## Empirical Studies and Results

Numerous empirical studies have demonstrated the positive effects of biophilic design on human health, well-being, and performance. Examples of this include:

1. stress reduction: research has shown that exposure to natural elements or biophilic elements within built environments can reduce physiological indicators of stress, such as heart rate, blood pressure, and cortisol levels.

2. Improved cognitive function: studies have found that environments with natural light, vegetation, and views of nature can enhance cognitive performance, creativity, and concentration.
3. Enhanced well-being: occupants of biophilic buildings report higher levels of satisfaction, happiness, and overall well-being compared to those in conventional buildings.
4. Health benefits: biophilic interventions, such as access to daylight, ventilation, and green spaces, have been associated with improved air quality, better sleep patterns, and faster recovery rates in healthcare settings.

## Rationale for Adoption

the growing adoption of biophilic design principles in contemporary architecture is driven by several factors:

1. Human-centered design: biophilic design Raises the well-being and comfort of occupants, aligning with the principles of human centered design.
2. Sustainability: by reconnecting people with nature and promoting ecological literacy, biophilic design contributes to the creation of more sustainable and resilient built environments.
3. Regenerative design: biophilic design goes beyond sustainability to embrace regenerative principles, fostering ecosystems that support biodiversity, carbon sequestration, and ecosystem services.
4. Market demand: increasing awareness of the benefits of biophilic design has led to growing demand from clients, developers, and occupants for buildings that prioritize nature and well-being.

## Connection to Neuroarchitecture

Biophilic design and neural architecture are two closely related disciplines that share a common goal: to create built environments that promote human well-being. While biophilic design focuses on integrating natural elements and processes into architecture, neuro architecture explores the intricate relationship between the built environment and the human brain. These disciplines intersect in significant ways, as biophilic design principles align with the neuroscientific understanding of how the brain responds to nature and architectural stimuli.

Neuroarchitecture posits that the design of physical space significantly impacts human cognition, emotion, and behavior. Research in this field has demonstrated that exposure to natural elements, such as sunlight, vegetation, and views of nature, elicit these physiological and psychological responses in the brain. For example, studies utilizing neuroimaging techniques have shown that exposure to natural environments activates brain regions associated with relaxation, stress reduction, and positive emotions. Biophilic design principles, which emphasize the integration of natural elements into architectural spaces, align with these findings by creating environments that stimulate the brain in ways that promote well-being and cognitive function.

Biophilia, the innate human affinity for nature, has been linked to neuroplasticity, the brain's ability to reorganize and form new neural connections in response to experience. Exposure to nature and biophilic elements within the built environment can stimulate neuroplasticity, leading to changes in brain structure and function that support cognitive health and emotional resilience. By incorporating biophilic design principles into architectural practice, designers can leverage neuroplasticity to create environments that facilitate learning, creativity, and stress reduction.

Biophilic design has been shown to reduce physiological indicators of stress and promote emotional well-being by providing opportunities for relaxation, restoration, and connection with

nature. Neural architecture research has demonstrated that exposure to natural environments can moderate the activity of the autonomic nervous system, leading to decreased heart rate, blood pressure, and cortisol levels. These physiological changes are accompanied by improvements in mood, attention, and overall subjective well-being. By integrating biophilic elements such as daylighting, natural materials, and indoor plants, architects can create environments that promote stress reduction and emotional balance through their impact on the brain.

Biophilic design has also been shown to enhance cognitive performance and productivity by supporting attention restoration and cognitive engagement. Neuro architecture studies have demonstrated that exposure to nature can improve cognitive function, creativity, and problem-solving abilities. By incorporating biophilic elements such as views of nature, dynamic spatial configurations, and sensory-rich environments, architects can create environments that stimulate the brain and foster cognitive engagement. These environments are conducive to focused work, collaboration, and innovation, leading to enhanced productivity.

## Conclusion

Biophilic design represents a holistic approach to architecture that acknowledges humanity's intrinsic connection to nature and seeks to create environments that nurture and inspire. By integrating natural elements, processes, and patterns into the built environment, biophilic design promotes human health, well-being, and environmental sustainability. As the evidence base for biophilic design continues to grow, its adoption is poised to transform the way we conceive, design, and inhabit built environments, fostering a deeper relationship between people, architecture, and the natural world.

## Chapter 5: Incorporating the Senses

### Introduction

Architectural design has been traditionally dominated by visual aesthetics, however, there is a growing recognition for the importance of incorporating multiple senses into the design process. This creates a more immersive and enriching experience. This shift towards multisensory design principles is rooted in an understanding of how sensory perception influences the architectural experience. While visual elements remain essential, other senses such as auditory, olfactory, tactile, and gestational play crucial roles in shaping special perception, emotional engagement, and user behavior within architectural environments.

### Synesthetic Design Principles in Architecture

Synesthetic design principles, which seek to create cohesive sensory experiences by integrating multiple senses at once, are gaining traction in architectural practice. By considering the interplay between different senses, architects can create environments that evoke specific emotions, enhance user satisfaction, and promote well-being. For example, the use of soundscapes, ambient lighting, and textured surfaces can enrich special experiences and create memorable architectural narratives. Moreover, incorporating elements such as natural ventilation, greenery, and aromatherapy can evoke a sense of comfort and connection with nature, contributing to a more holistic sensory experience.

### Investigating the Interaction Between Senses and Space

Empirical research investigating the interaction between senses and architecture has provided valuable insights into how sensory engagement influences special cognition, mood modulation, and user preferences. Studies employing diverse methodologies, including experimental research, neuroimaging techniques, and immersive simulations, have shed light on

the intricate relationship between sensory stimuli and architectural experiences. For instance, research has shown that exposure to certain stimuli can influence auditory perception, highlighting the interconnectedness of sensory modalities in shaping our perception of space.

## Challenges and Opportunities in Implementing Multisensory Design

Despite the growing recognition of the importance of multisensory engagement in architectural design, several challenges hinder its widespread adoption into practice. Limited awareness among architects, different disciplines operating fully independently of each other, and technical constraints pose barriers to integrating multisensory principles into architectural education and professional practice. However, emerging technologies such as virtual reality, interactive installations, and sensor-based systems offer new opportunities for exploring and implementing sensory design strategies. Additionally, ethical and cultural considerations must be carefully addressed to ensure inclusivity and accessibility in the design of sensory-rich environments.

## Interdisciplinary Approaches to Multisensory Architecture

As architects, designers, and educators increasingly embrace a multisensory approach to architecture and learning, there is growing momentum toward collaborative interdisciplinary efforts aimed at advancing these fields. By fostering dialogue between researchers, practitioners, and end users, architects can gain a deeper understanding of the complex interactions between sensory stimuli and architectural experience. Moreover, by prioritizing user experience and environmental sustainability, architects can create more inclusive, responsive, and culturally sensitive built environments.

## The Dominance of Visual Aesthetics in Traditional Architectural Design

In the realm of multisensory design, the concept of synaptic principles has gained prominence, aiming to create cohesive series that transcend traditional architectural boundaries. According to the Cleveland Clinic, synesthesia “is when your brain routes sensory information through multiple unrelated senses, causing you to experience more than one sense simultaneously.”<sup>11</sup> This serves as a guiding principle for architects seeking to elicit emotional responses through the integration of multiple senses in their designs. Figures such as Juhani Pallasmaa<sup>12</sup>, a renowned architect and author, have emphasized the importance of sensory engagement in architectural experience, advocating for a holistic approach that acknowledges the interconnectedness of sight, sound, touch, smell, and taste. Pallasmaa’s work has inspired a generation of architects to explore the potential of multisensory design, leading to a shift in architectural practice towards more immersive and experiential spaces.

## Creating Cohesive Sensory Experiences

Empirical research has played a crucial role in understanding how our senses engage with architecture. Studies have investigated the interaction between sensory modalities and spatial environments, employing various methods such as neuroimaging, psychophysics, and environmental psychology. Researchers like Charles Spence<sup>13</sup>, a leading expert in multisensory perception, have contributed significantly to this field, uncovering insights into how sensory cues influence human behavior and emotional responses. For example, certain visual stimuli can

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<sup>11</sup> Cleveland Clinic. 2023. “Sense and Sense Abilities: How Synesthesia Changes What People Experience.” Cleveland Clinic. Cleveland Clinic. May 3, 2023. <https://my.clevelandclinic.org/health/symptoms/24995-synesthesia>.

<sup>12</sup> Juhani Pallasmaa, a renowned architect and author, have emphasized the importance of sensory engagement in architectural experience,

<sup>13</sup> Spence, Charles. 2020. “Senses of Place: Architectural Design for the Multisensory Mind.” *Cognitive Research: Principles and Implications* 5 (1). <https://doi.org/10.1186/s41235-020-00243-4>.

evoke specific auditory sensations and vice versa as can be seen in the “Kiki/Bouba” effect. In the “Kiki/Bouba” experiment, performed by Wolfgang Kohler, participants were asked to label two abstract shapes, one jagged and sharp while the other was more smooth and curvy, with the nonsense words “Kiki” or “Bouba.” A majority of the participants associated the angular shape with “Kiki” and the rounded shape with “Bouba.” This phenomenon demonstrates the natural connection between the visibly angular shape and the sharp, percussive sounds of the consonant “K” compared to the opposing round visual and softer “O” vowel sound. By leveraging experimental approaches, scholars have gained a deeper understanding of the mechanisms underlying sensory perception in architecture, paving the way for evidence-based design strategies.

### Library Design Utilizing the Senses

When considering the implementation of sensory multisensory design in specific architectural settings, such as libraries, several factors must be taken into account. Designing a library to engage multiple senses requires careful consideration of spatial layout, material selection, acoustics, and olfactory elements. Challenges may arise in balancing sensory stimuli to create a harmonious and enriching experience for users, while also addressing accessibility and function. However, the benefits of incorporating multisensory design in libraries are multifold. By stimulating different senses, libraries can enhance cognitive engagement, improve information retention, and promote emotional well-being among visitors. Moreover, multisensory libraries have the potential to foster a sense of community and belonging, encouraging social interaction and collaboration among users.

## Emerging Technologies for Exploring Multisensory Design Strategies

Innovations in technology offer new opportunities for exploring multisensory design strategies and architecture. Virtual reality (VR) and augmented reality (AR) technologies enable architects to simulate and experience spatial environments in immersive and interactive ways, allowing for real-time feedback and experimentation. These tools facilitate the exploration of sensory stimuli and virtual environments, providing insights into how different design elements impact human perception and experience. Additionally, advances in material science and digital fabrication techniques offer novel possibilities for creating dynamic and responsive architectural environments that adapt to users' sensory preferences and needs.

## Connection to Neuroarchitecture

The exploration of incorporating the senses into architectural design strongly resonates with both biophilic design and neural architecture. It emphasizes moving beyond visual aesthetics to consider the role of multiple senses in shaping architectural experiences. This aligns with the core principles of biophilic design, which seek to integrate natural elements and processes into the built environment to evoke emotional responses and enhance the user's well-being. Just as biophilic design aims to create environments that connect people with nature through sensory engagement, synesthetic design principles in architecture aim to create cohesive sensory experiences by integrating multiple senses. Additionally, neural architecture underscores the significance of sensory perception in influencing spatial cognition, mood modulation, and user behavior within architectural environments. Understanding how sensory stimuli interact with the brain aligns with the exploration of how sensory engagement influences spatial perception and emotional engagement. By considering the interplay between different senses and architectural design, architects can create environments that stimulate the brain in ways that

promote well-being, enhance cognitive function, and foster emotional balance. Thus, integrating multisensory design principles into architectural practice reflects a shared goal across biophilic design, neural architecture, and the concepts discussed, to create immersive, enriching, and holistic architectural experiences that prioritize human well-being and connection with the built environment.

## Conclusion

In conclusion, the study of senses incorporated into architecture represents a shift towards a more holistic and experimental approach to design. By embracing synesthetic principles and leveraging empirical research, architects can create immersive and engaging spaces that cater to the diverse sensory experiences of users. Collaborative efforts between researchers, practitioners, and end users are essential for advancing the field of multisensory architecture and realizing its transformative potential in shaping the built environment. The integration of multiple senses into architectural design creates a more engaging, inclusive, and sustainable built environment. Insights from psychology, neuroscience, and architecture allow designers to harness the full potential of sensory stimuli for enhancing spatial experiences and fostering social interactions. Through thoughtful design considerations and innovative technologies, multisensory libraries and other architectural spaces can enhance human well-being, foster creativity and collaboration, and ultimately enrich the quality of life for individuals and communities alike.

## Chapter 6: Key Principles to Incorporate

### Introduction

Neuroarchitecture, biophilic design, and multisensory principles represent innovative approaches to architectural design, emphasizing the profound impact of the built environment on human cognition, behavior, and well-being. This chapter explores key insights from these disciplines highlighting design principles and methodologies that can be translated into achievable criteria for creating immersive and enriching spaces. By integrating neuroscientific understanding, biophilic connections, and multisensory engagement, architects can transform design practice to prioritize human experience and connection with the built environment.

### Key Points from the Research Studied

The historical roots of neuroarchitecture and biophilic design underscore the importance of integrating insights from neuroscience and environmental psychology into architectural practice. Understanding neuroplasticity informs architects that the brain's adaptability allows for the creation of spaces optimized for cognitive function and emotional well-being. Similarly, the principles of biophilic design emphasize the innate human connection to nature, advocating for the integration of natural elements into the built environment to promote human health, productivity, and sustainability. Moreover, the shift towards multisensory design principles recognizes the significance of sensory engagement beyond visual aesthetics, guiding architects to craft environments that deeply resonate with users, fostering emotional connections and enriching experiences.

Architects can leverage methodologies such as neuroimaging and physiological measurements to validate design decisions and create spaces that positively influence brain function and behavior. Evidence-based research in neuro architecture underscores the importance

of integrating biophilic elements to enhance occupant well-being, emphasizing the need for sustainable and regenerative design practices. Additionally, experimental studies in multisensory design provide insights into how sensory stimuli impact spatial perception and user experience, guiding architects to design environments that cater to diverse sensory preferences and needs.

The implications of neuro architecture for design practice suggest that architects can address contemporary challenges by designing spaces that support cognitive function, emotional well-being, and social interaction, contributing to healthier and more sustainable communities. By reconnecting people with nature, biophilic design offers opportunities for architects to create environments that prioritize human-centered design, promote ecological literacy, and foster a deeper connection with the natural world. Furthermore, integrating diverse sensory experiences into architectural environments enhances user satisfaction, emotional engagement, and overall well-being, emphasizing the importance of designing for a holistic sensory experience.

## Design Principles

From these key points, specific design principles can be derived including:

1. Integration of Natural Elements: Incorporating daylight, vegetation, water, and views of the natural landscape to provide direct connections with nature.
2. Sensory Engagement: Stimulate all senses through natural light, materials, colors, sounds, and scents to create immersive experiences.
3. Balancing Prospect and Refuge: Design spaces that offer both open, expansive views (prospect) and

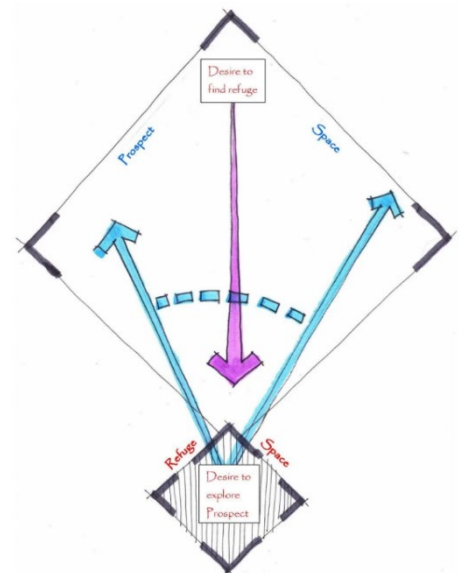


Figure 6: Understanding Prospect and Refuge by Qiang Wang

enclosed, sheltered spaces (refuge) to evoke feelings of security and exploration.

4. Evidence-Based Design: Ground design decisions in empirical research to ensure effectiveness in promoting human health, well-being, and environmental sustainability.
5. Synesthetic Principles: Integrate multiple sensory modalities to create cohesive architectural narratives and evoke specific emotions in users.

**Integration of Natural Elements:** Derived from biophilia, a concept introduced by biologist E. O. Wilson, this principle emphasizes the innate human connection to nature. It suggests that incorporating elements such as daylight, vegetation, water, and natural views into architectural design promotes well-being and enhances the human experience by fostering a direct connection with the natural environment.

**Sensory Engagement:** Rooted in environmental psychology and neuroscience, this principle recognizes the importance of stimulating all senses in architectural design. Drawing from research on sensory perception and its impact on human behavior, architects aim to create immersive experiences by utilizing natural light, materials, colors, sounds, and scents to engage users on a multisensory level.

**Balancing Prospect and Refuge:** Originating from environmental psychology and architectural theory, this principle is based on Jay Appleton's prospect refuge theory. It suggests that humans are instinctively drawn to environments that offer a balance between open, expansive views (prospect) and enclosed, sheltered spaces (refuge). By designing spaces that provide both elements, architects evoke feelings of security, exploration, and comfort.

**Evidence-Based Design:** Stemming From the field of evidence-based medicine and later applied to architecture, this principle emphasizes the importance of grounding design decisions in empirical research. By synthesizing findings from studies on human health well-being and

environmental sustainability, architects can ensure that their designs effectively address the needs and preferences of users while promoting overall Wellness and ecological balance.

**Synesthetic Principles:** Inspired by synesthesia, a neurological phenomenon where stimulation of one sensory pathway leads to involuntary experiences in another, this principle integrates insights from psychology and aesthetics. By combining multiple sensory modalities, architects create cohesive architectural narratives that evoke specific emotions and enrich the spatial experience for users, fostering A deeper connection between individuals and their surroundings.



*Figure 7: A sensory option in the form of a waterfall from Delight Waterfall Systems*

## Actionable Criteria

The principles of neuroarchitecture, biophilic design, and multisensory engagement offer valuable insights that can inform specific design criteria for creating immersive and enriching architectural spaces. To translate these principles into actionable criteria, architects can focus on incorporating natural elements, balancing spatial characteristics, utilizing evidence-based research, integrating multisensory elements, and fostering interdisciplinary collaboration.

Firstly, architects can prioritize the incorporation of natural elements such as daylighting, greenery, and water features into their designs. This criterion emphasizes the importance of

creating environments that establish a strong connection with nature, promoting well-being and environmental sustainability.

Secondly, the criterion of balancing spatial characteristics involves designing spaces that offer both openness and enclosure. This ensures that occupants feel secure while also encouraging exploration and interaction within the built environment. By carefully considering spatial layout and architectural elements, designers can create environments that cater to these dual needs.

Thirdly, grounding design decisions in evidence based research is essential. This criterion underscores the importance of utilizing empirical data to ensure the effectiveness of design interventions and ensure positive user experiences. By conducting research and evaluating outcomes, architects can refine their designs to better meet the needs and preferences of occupants.

Additionally, architects can focus on integrating multisensory elements into their designs. This criterion emphasizes the use of soundscapes, ambient lighting, and textured surfaces to create immersive environments that engage occupants on multiple sensory levels, enhancing spatial experiences and emotional connections.

Lastly fostering interdisciplinary collaboration is crucial for achieving inclusive and responsive design solutions. This criterion encourages architects to collaborate with neuroscientists, psychologists, and end users to gain diverse perspectives and insights that inform the design process. By working together, designers can create environments that prioritize human experience and connection with the built environment.

Incorporating these specific design criteria derived from the principles of neuroarchitecture, biophilic design, and multisensory engagement can help architects create

architectural spaces that are not only aesthetically pleasing but also promote well-being, productivity, and environmental sustainability.

## Conclusion

In summary, delving into neural architecture, biophilic design, and multisensory principles provides architects with valuable insights into how the built environment impacts human cognition, behavior, and well-being. These principles offer practical guidance for designing spaces that prioritize human experience and connection with nature. From understanding the brain's adaptability to recognizing the innate human connection to the natural world, architects can derive specific design principles and criteria. Grounding design decisions and empirical research further enhances the effectiveness of architectural interventions, ensuring that spaces promote human health, well-being, and environmental sustainability. By synthesizing these principles into actionable criteria, architects can create immersive and enriching space that promote human well-being, productivity, and ecological balance.

## Chapter 7: Program

### Program Abstract

With stress levels in students continuously rising, there is need and opportunity to rethink academic spaces and how they can reinforce focus and the ability to learn while improving mental health and physical well-being. Most university buildings have been designed with cost and functionality at the forefront of each project, leading to little consideration of the psychological effects structures have on their users. Concepts of neuroarchitecture and biophilic design offer principles that can be implemented to bring harmony back to the built environment.

The program of this thesis will encompass library and student housing typologies. Libraries, although believed by some to be a dying typology, are treasured community and student assets where individuals go to study outside of their living space and have access to valuable resources. This thesis will incorporate biophilic design elements such as natural lighting, views of the exterior environment, organic forms, and natural materials and/or living walls. These interventions are proven to reduce stress and rejuvenate the observer. Other factors stemming from neuroarchitecture will include designated study areas that have a stronger sense of enclosure and seclusion as well as main areas with high ceilings as a visual reprieve. Color theory and layout will also be considered when designing study rooms, larger collaborative/conference rooms for group work, computer access areas, traditional stacks, a cafe, a technology assistance area, and other productive resources.

## An Interview with Cindy Frank, Head of Art & Architecture Libraries

In the ever-evolving landscape of library design, the intersection of tradition, sustainability, and user experience plays a pivotal role in shaping the future of these institutions. During this meeting, the discussions surrounded the role of physical and digital resources, questioning traditional design norms, considerations of sustainability, and the importance of user-centered design principles in informing library design decisions. Libraries serve as vital hubs of knowledge and learning, but as technological advancements continue to reshape how information is accessed and consumed, the design considerations of libraries must adapt accordingly. This section explores key points from an interview held with Cindy Frank, head of the art and architecture libraries, surrounding library design, shedding light on how these factors influence the creation of functional, sustainable, and user-friendly library spaces.

Key points from the discussion and their impact on library design:

1. **A Hybrid Approach to Book Storage:** The conversation highlighted the enduring relevance of physical book stacks alongside the rise of digital resources. While acknowledging the shift towards digital materials, the importance of maintaining physical collections to complement the digital offerings must be emphasized. This underscores the need for libraries to adopt a hybrid approach to book storage, accommodating both physical and digital resources with their design.
2. **Questioning Traditional Library Design:** The discussion challenged traditional design norms, particularly regarding the allocation of space for physical stacks. By questioning the necessity of dedicating large portions of library space to stacks, there arises an opportunity to reimagine library layouts with a focus on functionality and user needs. Design considerations should be driven by the overarching mission of supporting

education and knowledge, rather than adhering to historical precedents. File the experience of moving through stacks is irreplaceable, there is an opportunity to use more concentrated book storage separate from selective stack arrangements to offer more usable square footage.

3. **Sustainable Considerations:** sustainability emerges as a crucial factor in library design discussions, encompassing considerations such as energy consumption, resource usage, and environmental impact. The conversation delved into the sustainability implications of both physical and digital library materials promoting the evaluation of ecological footprints due to design choices. Balancing sustainability with functionality becomes imperative in creating environmentally conscious library spaces.
4. **Role of Physical Books in Research:** Despite the proliferation of digital resources, the conversation recognizes the continued significance of physical books. In research-intensive disciplines like STEM, there is a need for the most up-to-date resources as research is ever evolving. In this environment, digital resources are the primary source of information. However, in many disciplines understanding history is imperative and the ability to look through physical resources can often draw your attention to a source that would not have been originally found or considered. Libraries must cater to the diverse needs of researchers and students by providing access to both physical and digital resources. This underscores the importance of designing spaces that accommodate various modes of scholarly inquiry and resource utilization.
5. **User-Centered Design:** User experience emerges as a central consideration in library design, with a focus on creating spaces that are intuitive, accessible, and conducive to learning. Incorporating elements such as natural lighting, access to nature, and ergonomic

furniture enhances the overall user experience within library environments. Designers must strike a balance between back-of-house operations and user-facing spaces to create libraries that meet the evolving needs of their patrons.

As libraries navigate the complexities of a changing information landscape, the key points discussed underscore the need for a holistic approach to library design. By embracing a hybrid approach to research storage, questioning traditional design norms, prioritizing sustainability, and centering user experience, libraries can create spaces that foster learning, innovation, and community engagement.

## Reverse Engineering Precedent Study

A reverse engineering experiment was performed to determine the existing square footages of programmatic elements in a precedent building. The chosen precedent was James B. Hunt Jr. Library (JBHJ) in North Carolina. JBHJ was “designed as a technology-forward learning library”<sup>14</sup> as North Carolina State University is a major research



Figure 8: James B. Hunt Jr. Library from NC State University Libraries

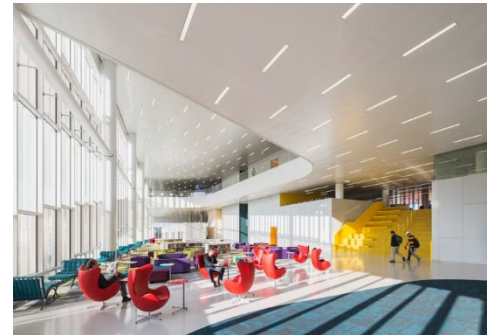


Figure 9: James B. Hunt Jr. Library from NC State University Libraries

university. The library utilizes color blocking in a mostly white interior to create “colorful ‘disruptive’ learning spaces,”<sup>15</sup> in addition to the dynamic furniture arrangements. There are technology zones, interactive digital surfaces, a game lab, bookBot (“an automated book delivery system”), and a green roof. When teasing apart the individual program elements there is a breakdown

<sup>14</sup> “James B. Hunt Jr. Library.” n.d. [www.lib.ncsu.edu/hunt](https://www.lib.ncsu.edu/hunt).

<sup>15</sup> “James B. Hunt Jr. Library.” n.d. [www.lib.ncsu.edu/hunt](https://www.lib.ncsu.edu/hunt).

allocating a large portion of the available square footage to the staff area including the back-of-house elements such as office space, book delivery areas, and non-public accessible meeting rooms.

The next largest portions of the program were the additional specialty spaces and the common working zones. From this, it is clear that there will be a considerable portion of the program dedicated

to interactive and collaborative spaces. Additionally, one of the smaller elements is the café. However, with the knowledge that students appreciate and gravitate toward working in café settings, the program size dedicated to this element will be larger in future design choices.

	TOTAL SF	% OF BUILDING
Lobby	12972	4.73%
Café	1084	0.40%
Event/Meeting Space	12645	4.61%
Staff Area	72874	26.58%
Restrooms	4740	1.73%
Lactation Room	223	0.08%
Reading Lounge	12172	4.44%
Quiet Reading Room	5301	1.93%
Tech/Help Space	7512	2.74%
Study Rooms	7670	2.80%
Common Working Space	37228	13.58%
Green Roof	11465	4.18%
Extra	52651	19.20%

Figure 10: Author's Breakdown of Program

## Programmatic Elements to be Included

Reviewing various precedent examples, the base program requirements for a university library include a lobby, café(s), event and gathering spaces, classrooms, stacks space, reading or lounging room, quiet study areas, restrooms, and staff space. Additional spaces that can enhance the library's areas of service include lactation rooms, technology help centers, makerspaces, and digital content creation spaces. To further the consideration of well-being, this library design will incorporate areas for relaxation or self-regulation in the form of green space, reflection rooms, used for reflection, meditation, prayer, yoga, etc. The program will also include gallery space to display student, faculty, and relevant work as well as children-oriented working areas that allow parents to bring their children with them, keeping them entertained while they study. The student housing program will include lobby space, common areas, and dormitories.

## Chapter 8: Site Selection and Analysis

### Site Selection Abstract

The site selection process for this thesis centers on universities, private colleges, and community colleges, assessing sites for library demolition, renovation, or new construction. There will be considerations regarding whether the site's square footage could accommodate the educational facility's needs and if the scale of the development would be a realistic feat for a semester-long project. Additionally, the consideration of the local climates' year-round growing potential and solar positioning will influence efficiency, sustainability, daylighting, and view curation decisions. The student body and campus growth will inform the potential for a new or renovation library project which will be identified based on the existing library's conditions and location. This information, in conjunction with students' opinions on the existing structure, will provide insight into the potential of improving or relocating the library so that it will be most useful and accessible to students, faculty, and visitors, both by car and by foot. Finally, assessing the stress levels within this school community will highlight schools that may be most in need of a design utilizing neural architecture and biophilic design strategies.

### The Criteria

The following site selection criteria are listed in order of relevance and weight to the decision of choosing a suitable site for this thesis.

1. **Development Potential:** How seamlessly will this site fit with the goals and potential design opportunities associated with neuroarchitecture and biophilic design?
2. **Size:** Is the site realistic square footage to be designed in one semester? Does the current site accommodate the existing and future student population growth?

3. **Growth:** Is the school and surrounding area population growing? Is the school developing/improving its campus?
4. **Goals:** Do the school's goals/principles align with this type of design strategy?
5. **Climate:** Year-round growing potential? Would the type of plant life available remain vibrant year-round?
6. **Solar Positioning:** How is the current building oriented on the site? How could a new building be oriented on the site?
7. **Built Development:** Does the site have an existing building? When was it built?
8. **Existing Documentation:** Are there existing drawings available?
9. **Accessibility:**
10. **Student Opinion:** Is the library situated in an accessible location on the site? How far is it from the residence halls? How far from parking?
11. **Stress:** Does the school present high stress levels?

## Site Options

### University of South Florida, Tampa

Located at 4101 USF Apple Dr, Tampa, FL 33620, this campus is 1646 acres with 29,197 undergraduate students. The existing library, known as the University of South Florida (USF) Tampa Library, grew from a 5-story building that opened in 1961 to a 7-story building by 1975<sup>16</sup> with 312,850 gross square feet. The student enrollment is expected to increase from 6919 to



Figure 11: Tampa Campus Library

<sup>16</sup> "University of South Florida | Tampa, FL." 2019. Usf.edu. 2019. <https://www.usf.edu/>.

6324 students enrolled. This is a 9.4% increase from 2021 to 2022. Over 65,000 students applied in 2022 which is approximately 15,000 more than had applied in 2021, a 30% increase. The USF Tampa campus has added more than 7,000,000 square feet of new buildings and facilities. Their goals as a university include student success, developing a diverse and inclusive community for learning and discovery, and having a strong base in sustainability and adaptability. According to the Köppen classification system, this area has a humid subtropical climate (Cfa) with a mean temperature of 72.5°F ranging between 60.2°F and 81.5°F. The existing building sits along an east-west orientation. Similarly across all of the sites listed within this chapter, there are available floor plans and campus maps, however, no sections could be found upon initial research. The site is accessible by two non-resident student parking lots and one staff parking lot directly next to the library and the closest residence hall is 0.3 miles or a 7-minute walk away. There is a record of noise complaints and issues with the existing parking accessibility. The University of South Florida has articles written about not having enough counselors to accommodate student stress levels and full web pages dedicated to stress comprehension and management. The current dropout rate at this university is 35.37%.

### **University of South Carolina**

Located at 1322 Greene St, Columbia, SC 29208, this campus is 444 acres with 25,634 undergraduate students.<sup>17</sup> The existing library, known as the Thomas Cooper Library, originally opened as the Mikissick library in 1959 and was the nation's first freestanding college library. An addition was built in 1972 to transform the building into what is known today as the Thomas Cooper Library. The building includes 289,000 square feet. In 2020, the university faced challenges related to providing adequate seated space for students to work. In the fall of 2023,

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<sup>17</sup> "University of South Carolina." n.d. Sc.edu. <https://sc.edu/>.

the university experienced a significant milestone by welcoming a record-setting class, with over 7300 new students, an increase of 12% compared to the previous year. The campus has undergone substantial expansion over the years, initially spanning 36 acres and growing to nearly 450 acres by 2018. Since 2010, the university has witnessed the construction of 930,000 square feet of new buildings and the renovation of 675,000 square feet of existing structures.

Additionally, the university has acquired approximately 16 acres of property for future development initiatives. The university's mission statement revolves around teaching, research, creative activity, and community engagement. Their values include a high-quality learning environment, collegiality, character, and



*Figure 12: University of South Carolina Library*

citizenship. According to the Köppen classification system, this area has a humid subtropical climate (Cfa) with a mean temperature of 64.0°F ranging between 45.2°F and 81.3°F. The existing building sits along a Northwest-Southeast orientation. There are three parking garages situated directly adjacent to the library, which include spaces designated for visitors. The nearest student parking area is located approximately 0.3 miles away from the library, requiring an approximate 8-minute walk. Additionally, there are two shuttle stops conveniently located in close proximity to the library. Moreover, there is a residence hall situated across the street from the library providing nearby housing options for students. Again, there was an issue with noise complaints however the building was generally well-liked. The school had many articles identifying stressors and coping mechanisms and they only had a 28.6% dropout rate.

## California State University, Long Beach

Located at 1250 N Bellflower Blvd, Long Beach, CA 90840, this campus is 322 acres with 28,353 undergraduate students. The existing library, known as the CSULB University Library<sup>18</sup>, was completed in 1972 and then remodeled in 2008. The building includes 160,708 square feet, however, it is attached to an academic building. The university has outlined a plan to increase on-campus student housing capacity by adding 1600 beds, effectively doubling the existing housing capacity. Furthermore, projections indicate that the university could accommodate approximately 5000 more students by the year 2035. In 2021, the university received a total of 67,122 undergraduate applications, representing a modest annual growth rate of 0.451%. The values of this university include teaching and learning, compassion, creativity, innovation, and diversity. They have a specific goal relating to cultivating resilience with a focus on health and well-being, sustainability, and withstanding climate uncertainty. According to the Köppen classification system, this area has a local steppe climate (BSk) with a mean temperature of 62.6°F ranging between 54.4°F and 71.5°F. The existing building sits along a mostly east-west orientation. The library is connected to a restricted



Figure 13: California State University, Long Beach Library

employee parking lot, providing designated parking for staff members only. There are three shuttle stops conveniently located near the library, however, offering accessible transportation options for students and faculty. The nearest general parking area is situated approximately 0.6 miles away from the library, requiring a 15-minute walk. Residence halls are located at varying

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<sup>18</sup> "California State University, Long Beach." 2019. California State University, Long Beach. 2019. <https://www.csulb.edu/>.

distances from the library, with the closest being 0.6 miles away, followed by others at distances of 0.8 and 1.8 miles. The existing library is generally regarded as a great space to study, however, there are issues with noise complaints and parking accessibility. This school has an American College health association article written expressing that 86% of CSU students are experiencing moderate to high stress levels and the school has a 38.1% dropout rate.

### Site Selection Conclusions

The final conclusion drawn from the site matrix would be that the California State University at Long Beach is the best choice for a thesis project of this nature. The Long Beach site would be a brand new development where a different location on the university campus is chosen to build a completely new structure while the project in South Carolina would likely be an addition and the project in Tampa FL would result in an adaptive reuse project. California State University also shares the values that strongly correlate with principles derived from biophilic design and neuroarchitecture while the other two universities have less of a focus on well-being and sustainability. The Long Beach site shows potential for growth and resides in a

<b>Sites</b>	<b>University of South Florida, Tampa</b>	<b>University of South Carolina</b>	<b>California State University, Long Beach</b>
<b>Development Potential</b> (10 points)	8	6	10
<b>Size</b> (5 points)	2	5	5
<b>Growth</b> (5 points)	5	4	2
<b>Goals</b> (5 points)	4	1	5
<b>Climate</b> (5 points)	5	4	4
<b>Solar Positioning</b> (5 points)	5	2	5
<b>Built Development</b> (5 points)	4	1	2
<b>Existing Documentation</b> (5 points)	3	3	3
<b>Accessibility</b> (5 points)	4	5	3
<b>Student Opinion</b> (5 points)	4	2	2
<b>Stress</b> (5 points)	4	3	5
<b>Totals</b>	48	36	55

Scale: 10 - 5 = Best, 1 = Worst

Figure 14: Author's Site Decision Matrix

climate that would allow for year-round greenery. The campus also shows a need for library relocation while the other properties only show a need for renovation.

## California State University, Long Beach (CSULB) Site Analysis

California State University, Long Beach (CSULB) is currently renovating their campus through a 2035 Master Planning initiative. The university intends to focus on today's students while embracing future generations with a plan that promotes inclusivity, sustainability, and resiliency, going beyond net-zero energy goals. Currently, CSULB is primarily a commuter campus, however, there is a push in the campus master plan to add to the existing residence halls to shift more students to live on campus. CSULB expects "the campus population [to grow] to an expected 33,000 full time equivalent (FTE) student commuters and 3,826 FTE faculty/staff."<sup>19</sup> In addition to the overall student body growth, "on-campus residential students (both undergrad and graduate) are expected to grow to approximately 3,000 students."<sup>20</sup> With the current housing renovation projects planned, the commuter student body is estimated to reduce from 28,809 to 26,666 FTE's and the on campus residents are anticipated to grow from 2,533 to 3,167 FTE's.

As of 2022, there were 38,973 students enrolled with 80.5 percent enrolled full-time. "In 2022, the most popular Bachelor's Degree concentrations at California State University, Long Beach were General Business Administration & Management (1,566 degrees awarded), General Psychology (528 degrees), and General Family & Consumer Sciences (403 degrees),"<sup>21</sup> however,

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<sup>19</sup> "Campus Master Plan." 2017a. <https://www.csulb.edu/Beach-Building-Services/Campus-Master-Plan>. June 7, 2017. <https://www.csulb.edu/beach-building-services/campus-master-plan>.

<sup>20</sup> "Campus Master Plan." 2017a. <https://www.csulb.edu/Beach-Building-Services/Campus-Master-Plan>. June 7, 2017. <https://www.csulb.edu/beach-building-services/campus-master-plan>.

<sup>21</sup> "California State University-Long Beach | Data USA." 2022. Datausa.io. 2022. <https://datausa.io/profile/university/california-state-university-long-beach#:~:text=6%2C288%20enrolled%20students->.

in speaking to Oscar Rodriguez, Head of Access Services at the University, he informed me that there is now a trend toward health, computer science, engineering, and business.

Looking into the university's enrollment records, the majors with the largest number of admitted students in 2022 were Liberal Arts at 20.7 percent, Natural Sciences and Mathematics with 18.02 percent, Engineering with 18.08 percent, and Health and Human Services at 13.26 percent. However, when you compare this to the majors that were applied for in 2024, there is a clear shift as the largest percentage is allocated to Health and Human Services with 20.95 percent, Engineering at 17.58 percent, Liberal Arts with 16.6 percent, and Business at 14.26 percent.<sup>22</sup> This shift shows growing demand for university facilities that offer innovative and technologically advanced spaces to support the changing needs of the student population.

California State University, Long Beach (CSULB) is outlined by multiple access roads including Atherton Street, Palo Verde Ave, State University Drive, and East Campus Drive.

There is also convenient access available from Interstate 405 to the north and northeast. Bouton Creek runs through the center of campus, significantly influencing its layout, including both pedestrian and vehicular circulation. The VA Medical Center, the University's largest neighbor, is located just south to southwest of the

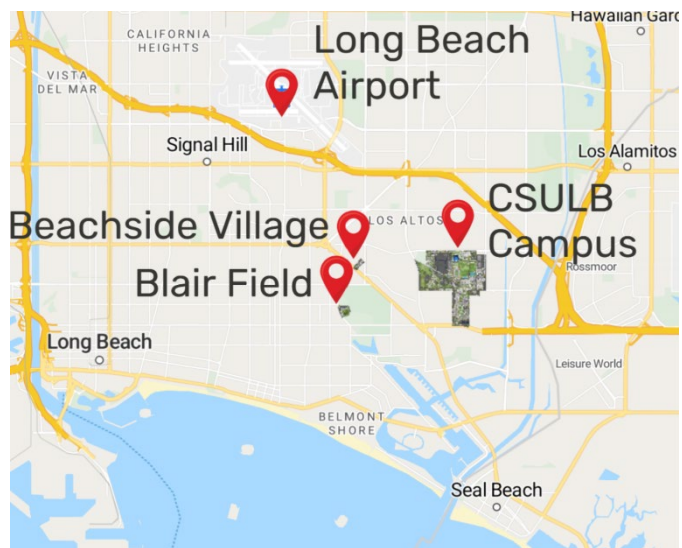


Figure 15: Author's Diagram of Area Amenities on CSULB Map

<sup>22</sup> "Workbook: Beach Data at a Glance - Undergraduate." 2024. Data.ir.csulb.edu. 2024. [https://data.ir.csulb.edu/t/IRA-Public/views/BeachDataAtAGlance/AtAGlance?:showAppBanner=false&:display\\_count=n&:showVizHome=n&:origin=viz\\_share\\_link&:isGuestRedirectFromVizportal=y&:embed=y](https://data.ir.csulb.edu/t/IRA-Public/views/BeachDataAtAGlance/AtAGlance?:showAppBanner=false&:display_count=n&:showVizHome=n&:origin=viz_share_link&:isGuestRedirectFromVizportal=y&:embed=y).

campus. To the East of campus, the Los Cerritos Channel and the San Gabriel River serve as major stormwater drainage systems.

The Campus is categorized into five districts with the current library located at the southern end of the South district. The proposed site is located at the heart of the campus in the central district surrounded by existing and proposed student hubs. This locating tied into the university's goals to create a strong central core of student interaction and activity.

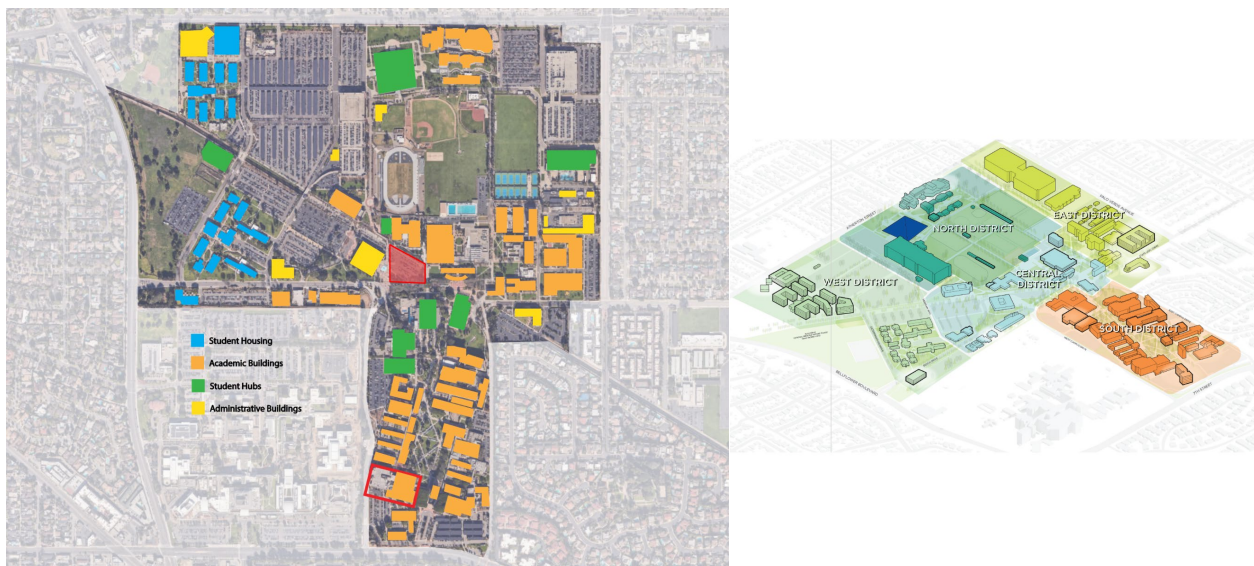


Figure 16: Author's Campus Typologies Diagram

Figure 17: CSULB Master Plan Districts Map

CSULB is working to create a safer and more inclusive campus community by implementing more late-night access buildings and nighttime pathways. These pathways run concurrently with three out of four of the site's edges, which is directly next to a major mobility hub. As previously mentioned, the campus is working toward increasing on-campus housing options. These developments will be expanding into the existing parking lots as the campus is grid locked. CSULB is unable to expand outward beyond its borders so the next logical step is to expand upwards.

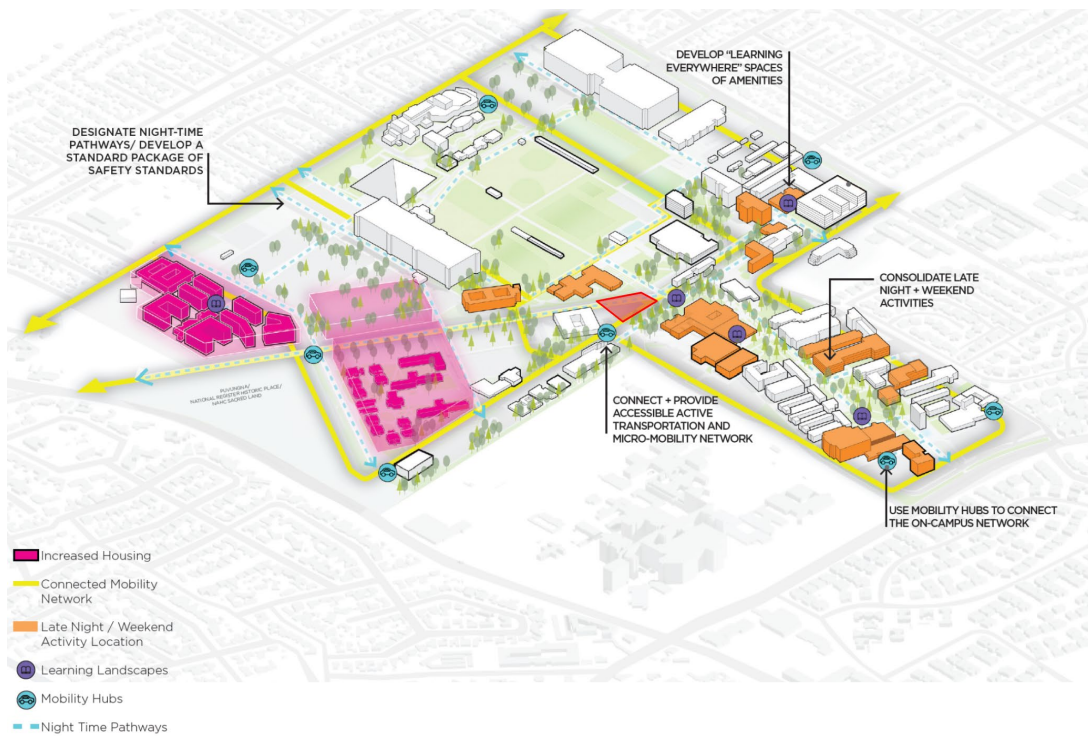


Figure 18: CSULB Master Plan Housing and Accessibility Map

The 2035 masterplan is working toward bringing wellness to the forefront of the university’s goals. One way they plan to achieve this is by incorporating “wellness walks” across campus. The largest portion of this network of paths terminates directly on the proposed site.

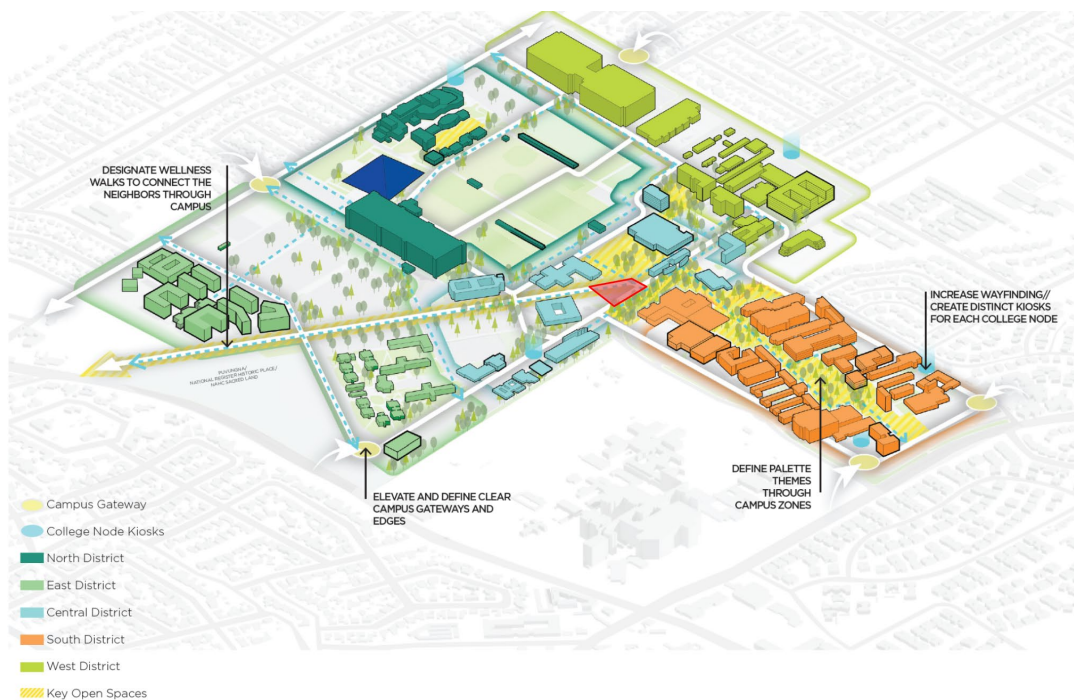


Figure 19: CSULB Master Plan Wellness Walks Map

The site is bordered by The Horn Center (North), Brotman Hall (West), the student union (South), and the kinesiology and health and human services academic buildings. The Steve and Nini Horn Center is an amenities building for students that contains ten classrooms and two lecture halls, the campus's largest open computer lab, printing services, and a technology help center. This is connected to the Kleefeld Contemporary Art Museum where exhibitions, talks with the artist, and art events are held. E. James Brotman Hall is an administrative center dedicated to student services. The student union contains dining options, bowling, swimming, video games, and space for student clubs.<sup>23</sup> These options in combination with the amenities offered in the Nexus, will establish a strong core for the campus.



Figure 20: CSULB Campus Map

<sup>23</sup> "Self-Guided Tour." 2024. Concept3d.com. 2024.  
<https://cms.concept3d.com/map/accessible.php?id=1314&tId=2478>.

The site currently exists as a parking lot with the northern portion covering directly over Bouton Creek. Because of this, the topography of the site is relatively flat as it was designed for vehicular accessibility and efficient drainage. This is also reflected in UC Davis Soil Surveys which designates the site as a “well-drained” drainage class with no flooding concerns. This means there will be very minimal need for substantial grading across a majority of the site. This is a steep incline at the southwest corner of the site where the terrain rises to meet the plaza level, however, this topography will be utilized to install an outdoor amphitheater. The actual soil composition of the site is 50 percent “Urban land” meaning “a soil material having a nonagricultural, man-made surface layer more than 50 cm thick that has been produced by mixing, filling, or by contamination of land surface in urban and suburban areas.”<sup>24</sup> This description is likely due to the installation of a parking surface on the site. The second largest composition is 20 percent “Thrms” which are “very deep, well-drained soils that formed in uplifted alluvium from mixed rock sources and have a thin mantle of human transported material at the surface.”<sup>25</sup> These soils are typically suitable for agriculture and engineering so it can be implied that the site is unlikely to be contaminated or damaged beyond the existence of the paved surface.

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<sup>24</sup> Pouyat, Richard V., Susan D. Day, Sally Brown, Kirsten Schwarz, Richard E. Shaw, Katalin Szlavecz, Tara L. E. Trammell, and Ian D. Yesilonis. 2020. “Urban Soils.” *Forest and Rangeland Soils of the United States under Changing Conditions*, 127–44. [https://doi.org/10.1007/978-3-030-45216-2\\_7](https://doi.org/10.1007/978-3-030-45216-2_7).

<sup>25</sup> UC Davis. 2019. “SoilWeb: An Online Soil Survey Browser | California Soil Resource Lab.” Ucdavis.edu. 2019. <https://casoilresource.lawr.ucdavis.edu/gmap/>.

## Chapter 9: Convergence

### Introduction

This chapter synthesizes the feedback received and outlines the subsequent steps to be taken in the thesis process. Emphasizing neural architecture and spatial typologies, the B3 meeting discussion highlights the integration of research findings, use of images and diagrams, and the development of concise text briefs to engage stakeholders effectively. Key areas such as physiological effects, site analysis, program considerations, and design principles are addressed to refine the direction of the thesis and enhance its impact.

Architectural design is a dynamic process that involves continual refinement and adaptation based on feedback and research findings. In response to the feedback received, this chapter outlines the steps to be taken to advance the design project, focusing on the integration of neural architecture principles and the exploration of spatial typologies. By consolidating research, utilizing visual aids, and refining design strategies the thesis aims to create a built environment that promotes cognitive, emotional, and physical well-being while integrating spatial efficiency.

### Feedback

During the thesis meeting, a comprehensive range of feedback was provided to enhance the future progress of this now design project. The discussion primarily focused on consolidating research efforts and emphasizing neuro architecture alongside the specific “8 commandments” derived as design principles. These “commandments” will be adjusted to better depict achievable programmatic or design choices. The importance of utilizing visual aids such as images, diagrams, and short text briefs to effectively communicate design concepts and bring visitors into

the discourse was emphasized. The structure of the presentation slides was highlighted for improvement, particularly regarding transitions between research segments.

A key area of emphasis was the need to substantiate design decisions with relevant studies, particularly those concerning the physiological effects of architectural environments on occupants. Research should be done looking into reactions in relation to brain activity, pulse rate, etc. Additionally, incorporating numerical data, such as real estate figures and precedents, was recommended to provide a factual foundation for design proposals.

The choice of the library typology as the central focus of the thesis was discussed in depth, emphasizing its significance within the broader context of the project. Furthermore, there was advocacy for a clear articulation of spatial typologies, which were deemed somewhat obscured within the existing framework of design principles.

The need for a thorough site analysis, including elevation changes and context buildings such as the student center and adjacent Plaza, was underscored. Additionally, attention was drawn to the importance of understanding the current usage patterns of the site, including parking lot utilization by different user groups.

Further recommendations included the exploration of alternative parti designs, closer examination of circulation patterns within the existing building and surrounding site, and the integration of principles such as biomimicry, biomorphism, and bioutilization. The importance of incorporating user-centric design principles and considering the well-being of occupants was also highlighted.

## Chapter 10: Conclusion: Thesis Design Solution

This thesis is realized as The Nexus, a dual typology building located at the heart of the California State University, Long Beach campus. The Nexus looks to create a new living/learning student hub in the form of a library with student housing on top. The 60,000-square-foot library will span two levels with access points on either floor. The second-floor access point will connect students to the raised plaza attached to Brotman Hall (west of the site) and the ground-floor access point will be directly across from the student union. Six floors of student housing will sit on top of this with green roof access.

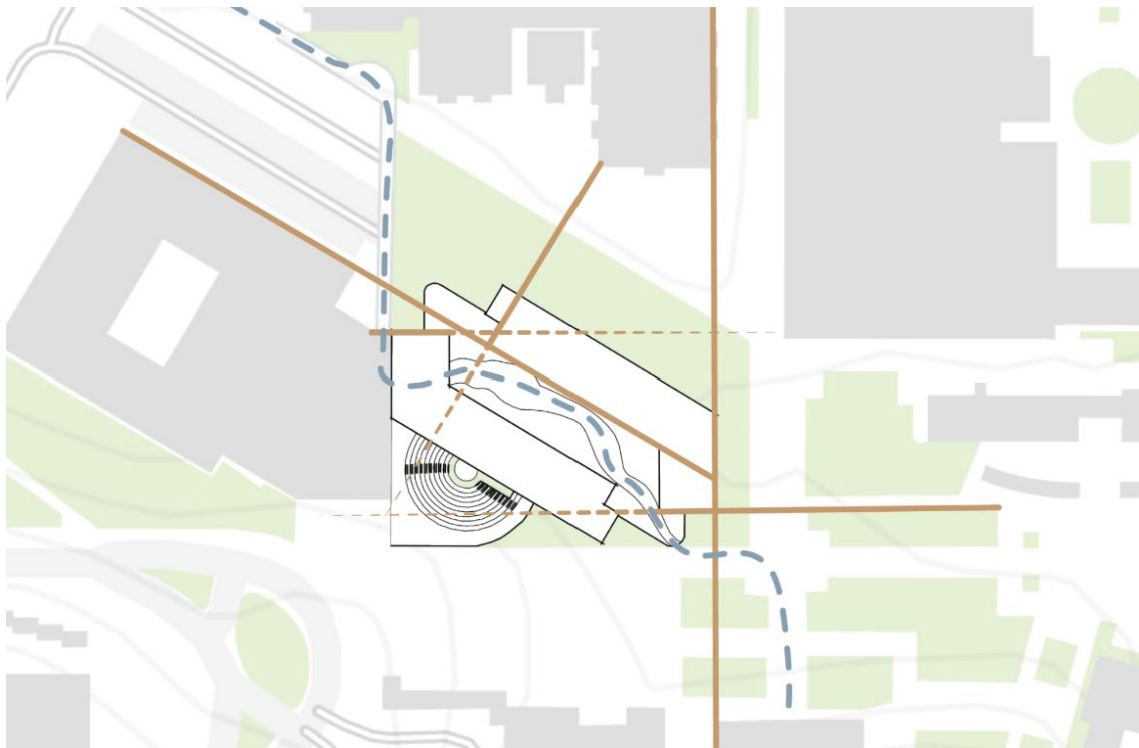


Figure 21: Author's Site Regulating Lines

The massing design for this building is tied to California's geographic conditions as it is meant to resemble a fault line splitting the building along the main pedestrian circulation route. Tying the student union and plaza level entrances together with a visual path through the

building also creates a physical continuation of the campus circulation/wellness walk. This split is further portrayed by the student housing taking the form of mirrored bars extending from the roof of the library. The divide of the building is also meant to allow natural light to enter the building.

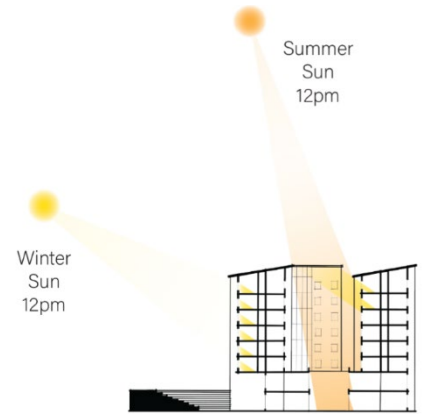


Figure 22: Massing Sun Study

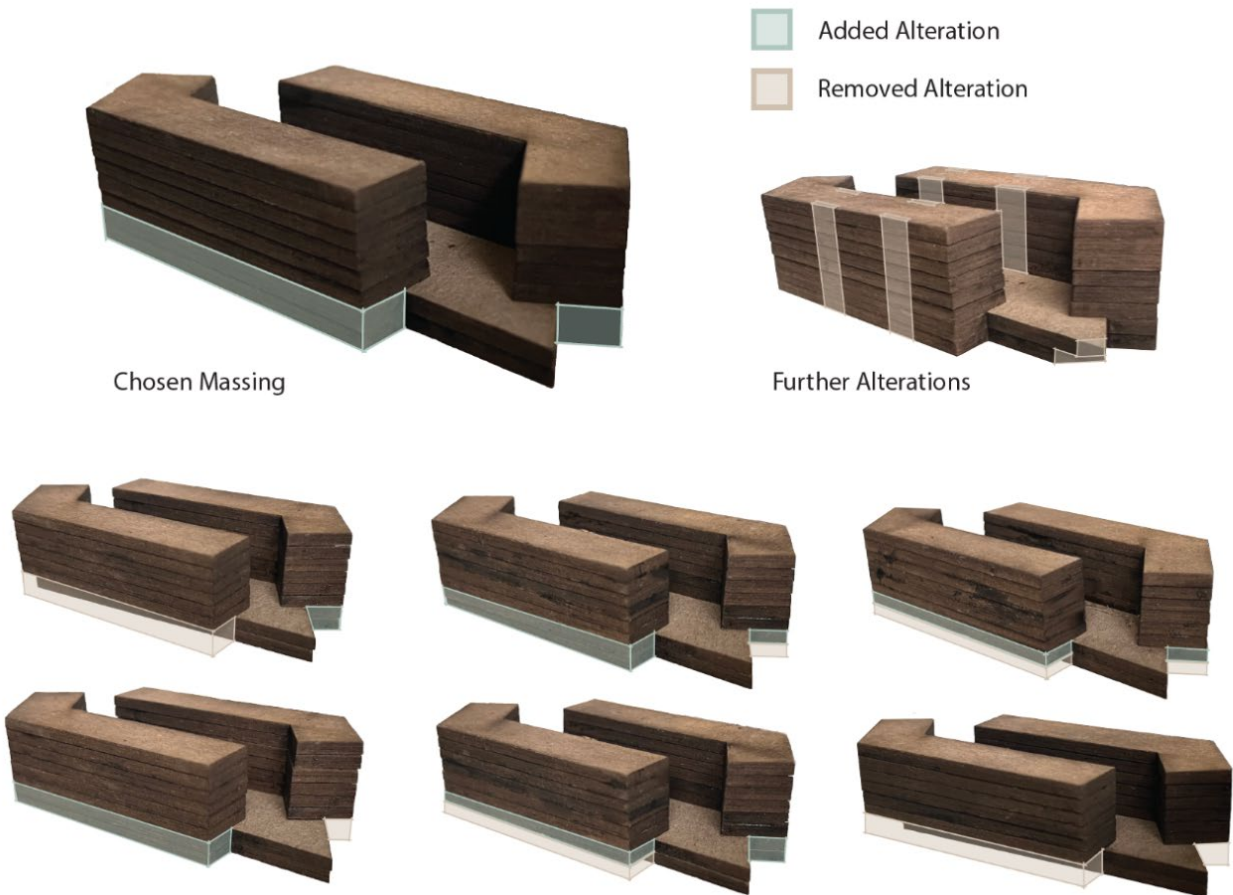


Figure 23: Author's Massing Models

The program within the building seeks to create a balance between enclosed and open/flowing space. Any program elements that require enclosed space, including the designated wellness and creative areas, have been located around the perimeter of the building with the central space left open. The stacks come in different heights to create nooks or pockets for students to fill. Lower stacks create visual access across the library while taller stacks are used to create more private areas for students to use.

- Service / Assistance
- Wellness / Creative
- Study / Meeting
- Food
- Housing

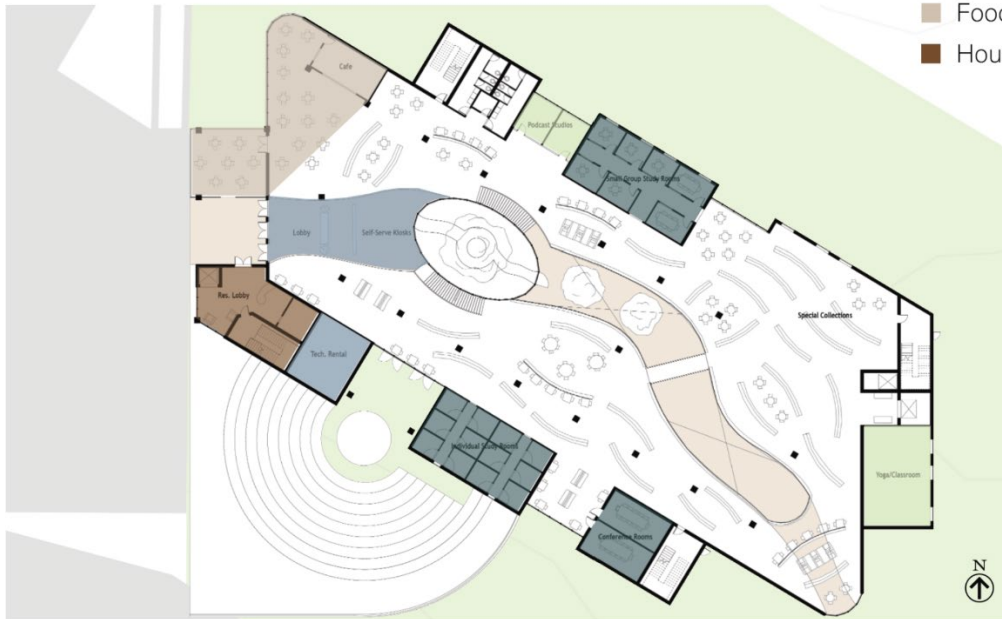


Figure 24: Author's Second Floor Plan



Figure 25: Author's Ground Floor Plan

A secondary connection between levels, circulation, and inside vs outside space is created by an outdoor amphitheater. The top level of the amphitheater will be aligned with the plaza while the lowest terrace will meet the ground level with a visual connection through the building into the indoor courtyard that provides a natural relief while inside the library.



Figure 24: Author's Second Floor Lobby

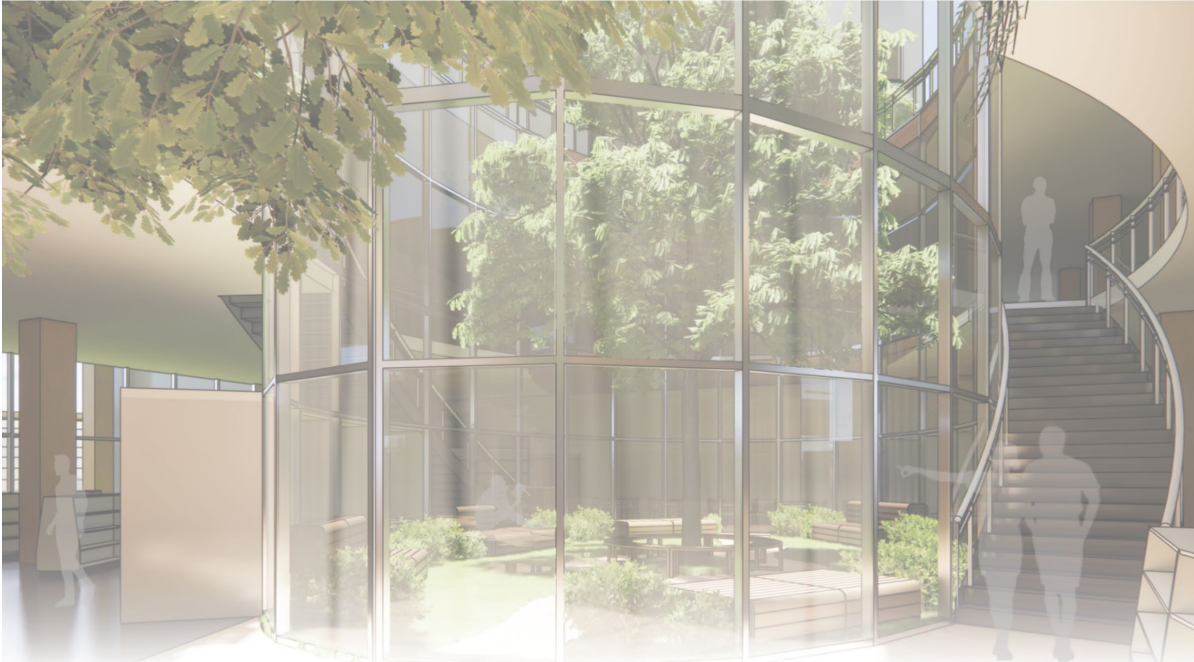


Figure 25: Author's First Floor Courtyard

The third level of the building includes a green roof and the typical dormitory floor plan.

There are 64 dorm rooms and two common rooms, that include kitchenettes, per floor.

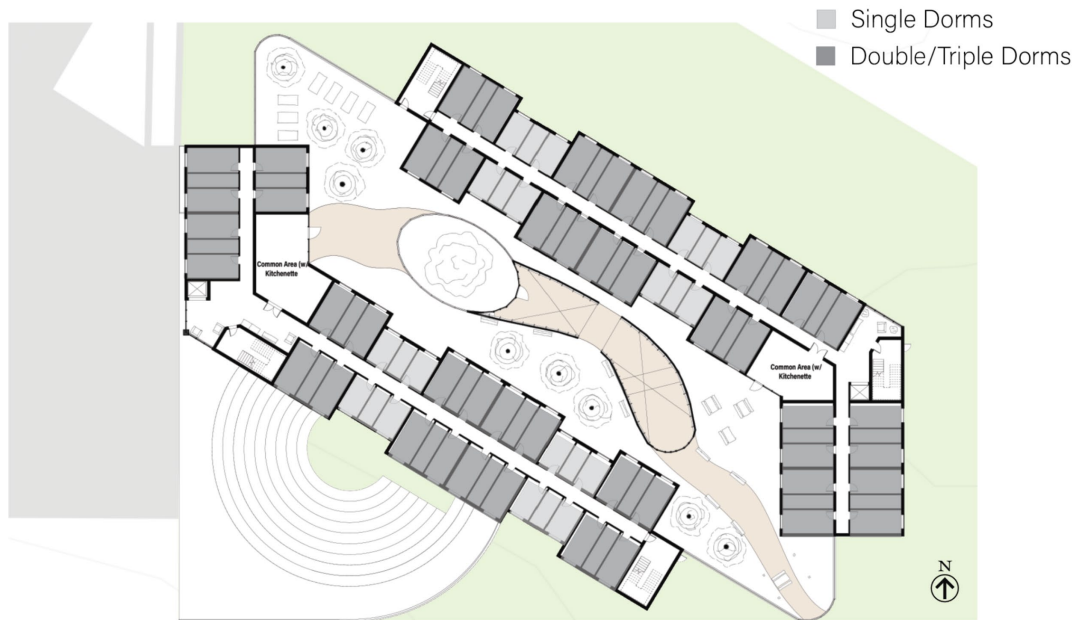


Figure 26: Author's Third Floor Plan

The dorms will include a combination of singles, doubles, and triples with the doubles and triples having the same square footage.

This allows the university to adjust the rooms as needed for an influx of students. Every dorm will have visual access to active green space in the form of the building's green roof or surrounding gardens. The inclusion of housing is an answer to our second thesis question, "how can universities discover a financially viable path to creating the library of the future?" Adding the housing typology



Figure 29: Author's Rendering of the Green Roof View from a Dorm

makes the project lucrative for the university, making a wellness-focused library design financially viable.

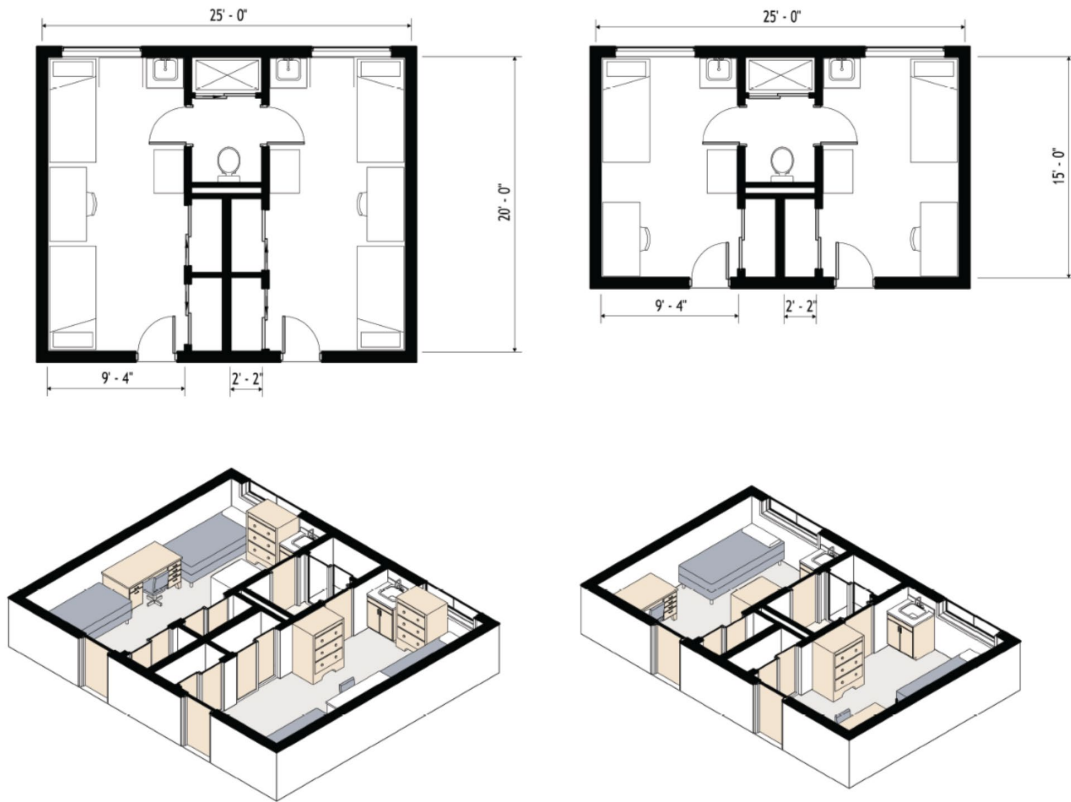


Figure 3027: Author's Dormitory Plans (Based on CSULB Beachside Floor Plans)



Figure 31: Author's Section Perspective

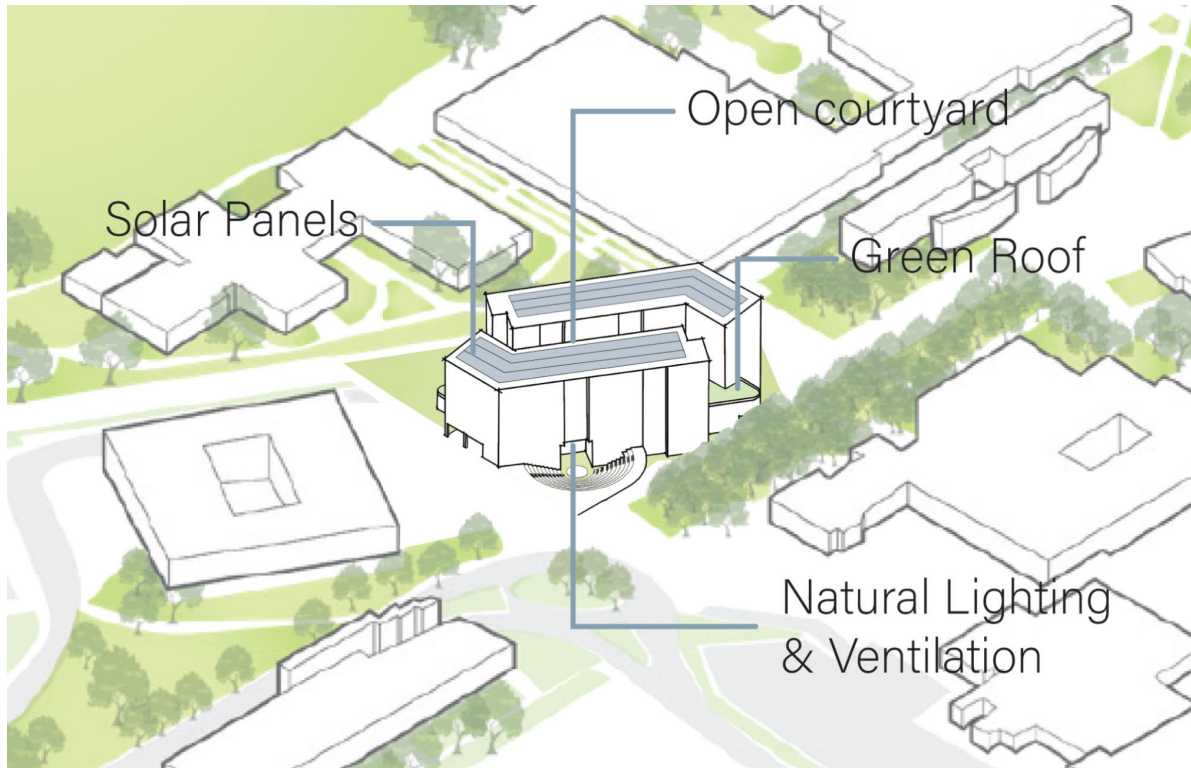
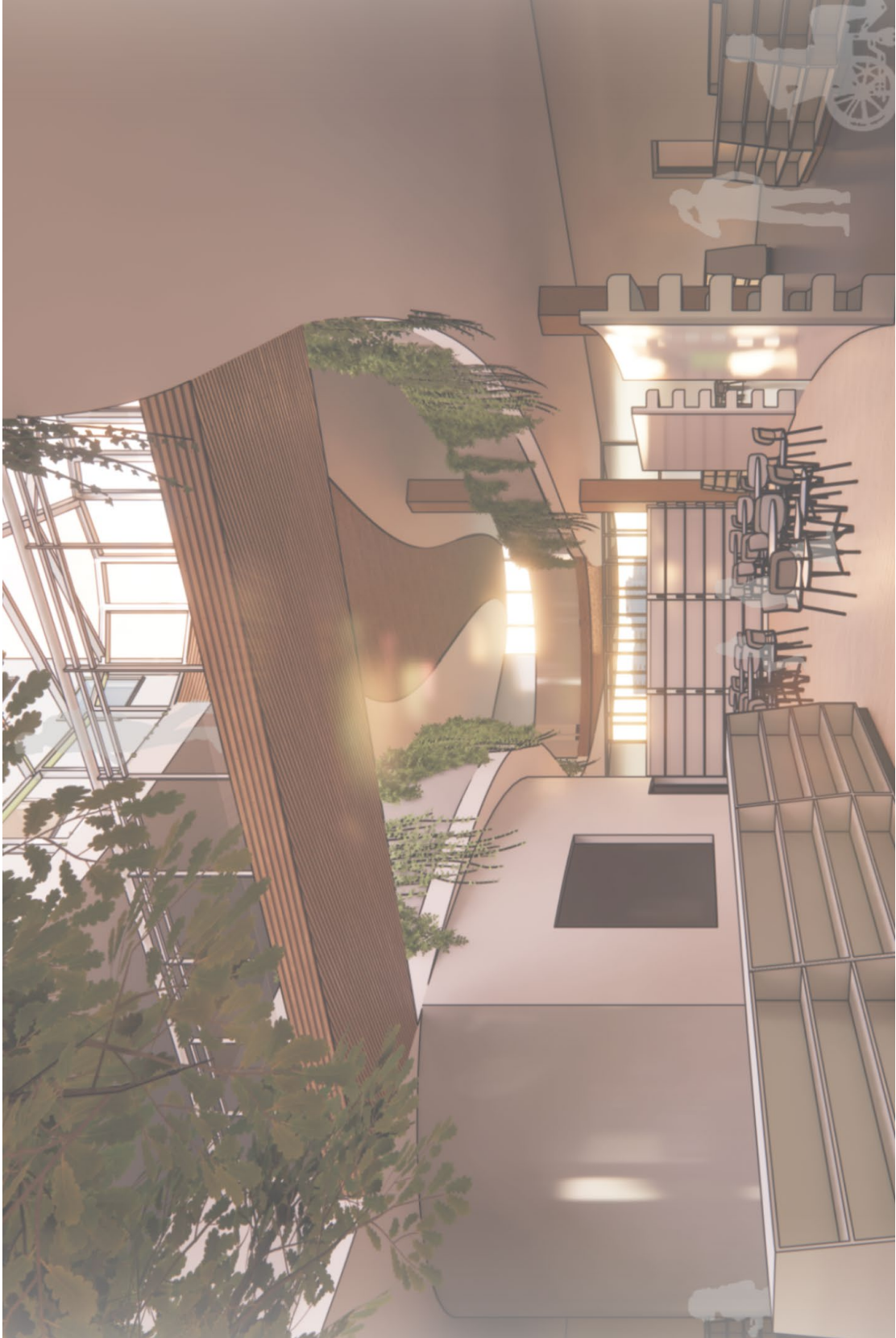


Figure 28: Author's Sustainability Diagram



Figure 29: Author's Landscaping Diagram



*Figure 30: Author's Rendering of First Floor Cafe Space*

## Appendices

1. Hala Medhat Assem, Laila Mohamed Khodeir, Fatma Fathy. "Designing for human wellbeing: The integration of neuroarchitecture in design – A systematic review." *Ain Shams Engineering Journal*, Volume 14, Issue 6, (2023)

Three university professionals in the fields of architecture and project management collected copious research in the form of articles written about perceived effects that different design choices had on the body and mind in order to find repetitive correlations. This journal article begins to define the term "neuroarchitecture" and explains that the built environment has tangible effects on our wellbeing. This is through four main areas (the four pillars): "physically [how the body is affected], intellectually [how the brain is affected], emotionally [how our emotions are affected] and socially [how our behavior is affected]." These authors studied academic journal articles, dated between 2015 and 2022, describing the effects (neuro-cognitive, emotional, physiological, and behavioral) of specific design decisions on humans. It was concluded that more research is needed, however, there are bodily, neurological, emotional, and behavioral responses triggered by different forms of architecture.

Keywords: "Neuroarchitecture, Human wellbeing, Interior design, Cognitive emotional design, Brain activation, Systematic review"

2. Higuera-Trujillo, Juan Luis, Carmen Llinares, and Eduardo Macagno. "The cognitive-emotional design and study of architectural space: A scoping review of neuroarchitecture and its precursor approaches." *Sensors* 21, no. 6 (2021): 2193.

This article works to provide a definition of and method for studying the topic of neuroarchitecture. While individuals typically show subjective opinions while describing architecture, neuro architecture works to provide objective and scientific data on how individuals

are influenced by the built environment. This review was performed following the “methodology: (1) formulation of objectives, (2) locating studies, (3) selection of studies, (4) analysis and synthesis, and (5) the presentation of the results.” It was determined that the built environment does show major effects on human cognition and emotions. It is noted that there are specific effects on human development, performance, and stress.

Keywords: “Neuroarchitecture, Emotional design, Neuroscience, Architecture, Built environment”

3. Wang, Sheng, Guilherme Sanches de Oliveira, Zakaria Djebbara, and Klaus Gramann. "The embodiment of architectural experience: A methodological perspective on neuro-architecture." *Frontiers in human neuroscience* 16 (2022): 236.

This article breaks down the discussion of neuroarchitecture as a multidisciplinary field into three sections: 1) Introduction to neuroarchitecture, objectives, and experimental research in the field, 2) methodology limitations related to current brain-imaging in relation to architecture, and 3) possible use of ecological psychology as a roadmap to solve these limitations. The article presents up-and-coming mobile brain/body imaging (MoBI) and ecological psychology as an exciting prospect for more reliable and accurate data pertaining to the links between neurological effects produced but one’s surrounding built environment. This comment on prospects of how to best collect data within the field is accompanied by a historical perspective on the evolution of architecture and the related effects on human lives.

Keywords: Neuroarchitecture, Neuroscience, Architecture, Mobile Brain/Body Imaging, Ecological psychology, History of neuroarchitecture

4. Just, Marcel Adam, and Sashank Varma. "The organization of thinking: What functional brain imaging reveals about the neuroarchitecture of complex cognition." *Cognitive, Affective, & Behavioral Neuroscience* 7 (2007): 153-191.

This article focuses primarily on the advancements made in functional magnetic resonance imaging (fMRI) that expose the relationship of “the mind to the brain.” This research challenges the common belief that there is a direct 1:1 connection between brain activity and psychological processes. These authors believe there needs to be a new framework, 4CAPS, because “thinking is a network phenomenon,” due to the dynamic collaboration of cortical areas. There are currently limitations due to resources on how accurately cognition can be recognized at cortical and cognitive levels.

Keywords: Neuroarchitecture, fMRI, Cognitive neuroscience, Cortical networks

5. Lee, Sanghee, Wooree Shin, and Eun Joo Park. "Implications of neuroarchitecture for the experience of the built environment: a scoping review." *Archnet-IJAR: International Journal of Architectural Research* 16, no. 2 (2022): 225-244.

This article describes a study utilizing a scoping review approach to analyze the emerging field of neuroarchitecture. In the study 25 separate papers were examined that focused on how the environment effects “health, performance, aesthetics, and emotions.” Using tools for brain imaging such as electroencephalography and fMRI, the researchers were able to collect physiological measures including electrocardiograms and cortisol levels. This data allowed them to study human responses in real and virtual environments. The results showed the need for further research and better resources to monitor mobile brain activity.

Keywords: Neuroarchitecture, Built environment, Physiological measures, Scoping review

6. Gillis, Kaitlyn, and Birgitta Gatersleben. "A review of psychological literature on the health and wellbeing benefits of biophilic design." *Buildings* 5, no. 3 (2015): 948-963.

This article focuses on biophilic design and the promotion of integrating natural materials into buildings with the intention of improving wellbeing. After reviewing psychological studies pertaining to biophilic design through a lens of environment restoration, the authors found that there is substantial evidence supporting the claim of improved wellness. The research was categorized into three separate experiences: 1) direct, 2) indirect, and 3) symbolic. It is currently shown that plant-life, water, natural light, natural geometries, and natural materials have stress reducing qualities, however, the article indicates that there should be additional research surrounding restorative environments and the relationship to biophilic design. This is further detailed stating that additional research is necessary on the specific elements of biophilic design that show effects on individuals.

Keywords: "Biophilic design, Restorative environments, Built environment. Environmental psychology"

7. Ryan, Catherine O., and William D. Browning. "Biophilic design." *Sustainable built environments* (2020): 43-85.

This article focuses on the concept of biophilia and an inherent connection between humans and nature. The authors indicate that there is a rising importance for the incorporation of natural elements into the built environment with the purpose of individual and public health. The paper examines the history of biophilic design and cites examples from different historical periods. The authors also lay out research showing that including nature in the space, natural analogues, and designing the nature of the space all had tangible effects on human wellbeing. A few of these

results included reduced boredom, irritation, fatigue, lowered individuals blood pressure and heart rate, and “positively impacted attitude and overall happiness.”

Keywords: Biophilia, Biophilic design, Health and wellbeing, Nature connecting

8. Zhong, Weijie, Torsten Schröder, and Juliette Bekkering. "Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review." *Frontiers of Architectural Research* 11, no. 1 (2022): 114-141.

This article looks at the growth of interest in biophilic design in the last decade. This study looks at various literature to answer three main questions: 1) How to define biophilic design and how it arose, 2) How can biophilic design contribute to sustainable architecture, and 3) What are the key design strategies within biophilic design? In defining the term, the article explains that biophilic design is much more than simply adding plants to a building, but rather considering the “physical, sensory, metaphorical, morphological, material, and spiritual aspects” that accompany this form of design. The authors use the UN Sustainable Development Goals as a metric to define how biophilic design applications benefit sustainable design. The article then continues to describe the benefits associated with this design style.

Keywords: Biophilic design, Sustainability, Sustainable Development Goals (SDGs), Nature-based solutions

9. Shinohara, Kristen, Cynthia L. Bennett, Wanda Pratt, and Jacob O. Wobbrock. "Tenets for social accessibility: Towards humanizing disabled people in design." *ACM Transactions on Accessible Computing (TACCESS)* 11, no. 1 (2018): 1-31.

In this article the authors discuss the true accessibility of mainstream technologies for individuals with disabilities. This is because, even with ongoing efforts in technology design for user-

centered devices, there is still much work to be done. This research investigates using a university course offering to see how students approach disability in design. There is also a feature on how designing for individuals who are and who are not disabled promotes an understanding of accessibility. The results of this study were that when students are presented with stakeholders that include individuals with and without disabilities, their comprehension of accessible design improves, and they better understand what is needed and how it may even benefit individuals who do not experience disabilities.

Keywords: Accessibility, Design education, User-centered design, Design for Social Accessibility, Inclusive design

10. Dischinger, Marta. Design for all Senses. Accessible Spaces for Visually Impaired Citizens. Chalmers Tekniska Hogskola (Sweden), (2000)

This study looks at how individuals both perceive and act within different environments. This is then compared to the effect of social rules and environmental factors on peoples' behavior. The study is specifically in the context of visually impaired individuals with a goal to improve their accessibility of open, urban environments. This study was conducted in Sweden and Brazil in areas that laced and special references or had excessive special information. "The study highlights the importance of considering non-visual attributes and diverse spatial qualities that impact accessibility in design practices." These studies also take a look at the different cultural, social, and health-related challenges faced by visually impaired individuals.

Keywords: Visually impaired, Spatial perception, Accessibility, Urban design, Design for social accessibility

11. Matoso, Marília. “Neuroarchitecture: How Your Brain Responds to Different Spaces.”

ArchDaily (2022): <https://www.archdaily.com/982248/neuroarchitecture-how-your-brain-responds-to-different-spaces>.

The author, Marília, an architect and writer for ArchDaily describes neuroarchitecture as a field that not only studies technical factors such as legislation and ergonomics but also subjective aspects including “emotion, happiness and well-being.” This approach to design has a focus on how “shapes, colors, and scales influence human perceptions.” The study of neuro architecture can be traced back to an American doctor named Jonas Salk in the 1950s. He found that he felt more inspired when visiting certain places such as the Basilica of St. Francis of Assisi. He later used concepts he learned on how to create invigorating, inspirational spaces when designing the Salk Institute for biological research. When applying neuroarchitecture to the design process one must consider acoustics, lighting, furniture design, vegetation, and color theory to develop spaces that will enhance the user experience.

Keywords: Neuroarchitecture, Salk Institute, Shape, Color theory, Scale, Lighting

12. Kellert, Stephen. “What Is and Is Not Biophilic Design?” Metropolis (2015):

<https://metropolismag.com/viewpoints/what-is-and-is-not-biophilic-design/>.

Stephen Kellert, a professor of Forestry and Environmental Studies at Yale University, notes that biophilic design recognizes humanity’s inherent connection to nature which is exemplified “throughout our evolutionary history,” because humans show an ability to thrive in environments that are shaped by natural forces. Being that most of our population dwells in urban settings, biophilic design poses an option to “satisfy our innate need for nature within modern structures and cities.” To create successful biophilic designs, Kellert describes a few key goals that must be met. 1) Focus on the aspects of nature that are proven to contribute to health and wellbeing. 2)

The design must be emphasized throughout the space, not only relegated to one instance.

Biophilic interventions must feel connected and complimentary to the overall environment. 3)

The biophilic design must foster repetitive connection to nature. Our modern society often lacks connection to the natural environment which leads to less natural stimuli and therefore a negative impact on wellbeing.

Keywords: Biophilic design, Consciousness towards nature, Integration, Connection, Evolution

13. Rashid, Waleed. "Define Biophilic - What Is It and Why's It Matter?" Woodland Pulse (2023): <https://woodlandpulse.com/blogs/decor/define-biophilic>.

Waleed Rashid, once a student and researcher in the field of medicine, now the co-founder and CEO of Woodland Pulse, has a focus on incorporating philosophies of biophilia into interior design. Waleed begins by explaining the origins of biophilia, a concept referred to as the biophilia hypothesis that describes a human's affinity toward nature, was coined by Erich Fromm and popularized by biologist E.O. Wilson. Humans have evolved surrounded by nature so now, in our modern society, we try to recreate this connection. A few key component in biophilic design would be the use of "natural materials, views of vegetation and water bodies, natural light, and nature-inspired textures and patterns." These design decisions can elevate the appearance of a space while also increasing mental and physical health, reducing stress, boosting productivity and cognitive function, and improving mood.

Keywords: Biophilia, Biophilic design, Origin, Evolution, Connection

14. Viktoria. “What Is Biophilic Design?” The Lifestyle Files (2021):

<https://www.thelifestyle-files.com/what-is-biophilic-design/>.

Viktoria, a Hungarian content creator and sustainable brand consultant, discusses her view on the urgent importance of sustainability for human wellbeing in the 21<sup>st</sup> century. Research shows that interacting with nature has direct benefits to one’s health so by mimicking natural elements, such as “light, ventilation, materials, shapes, and colors” in the built environment, buildings are able to reproduce these effects. Viktoria provides multiple examples of projects that have utilized biophilic design in both public and private projects. A few of the examples included were “Shangri-La Singapore's living wall, Thorncrown Chapel's glass and wooden structure, and the Khoo Teck Puat Hospital's rainforest-like landscape,” as well as a solar tree marketplace in Shanghai, a spa utilizing biomimicry in Utah, the Smithsonian American Art Museum in Washington DC, and a private villa in Bali. These examples were used to show the versatility in project type, climate and environment, theories used, and materials present.

Keywords: Biophilic Design, Biomimicry, Health and wellbeing, Living wall, Natural structure

15. Bhandari, Sanjeev. “Biophilic Design - Concept & Need in Modern Commercial Office Interiors.” linkedin (2023): <https://www.linkedin.com/pulse/biophilic-design-concept-need-modern-commercial-office-bhandari>.

Sanjeev Bhandari is a CEO of Livespace and an expert in the supply chain network and operations management with an interest in building sustainability. In this article, Sanjeev discusses the rising trend to include biophilic design philosophies in office environments. The incorporation of natural light and planting elements creates a more productive workspace and increases job satisfaction by providing a calming environment that reduces stress, anxiety, and depression, and improves focus. An additional benefit to including plants in the work

environment would be improved air quality which will result in fewer sick days from employees. Some examples of elements that can be included in offices are living walls, water features, natural lighting, and natural materials such as wood and stone.

Keywords: Biophilic Design, Office space, Living walls, Water features, Natural light and materials

16. Baldwin, Eric. "Biophilia: Bringing Nature into Interior Design." ArchDaily (2020):

<https://www.archdaily.com/935258/biophilia-bringing-nature-into-interior-design>.

Eric Baldwin, a senior editor at ArchDaily, discusses the human centered approach to contemporary interior design which focuses on physical, mental, and emotional health. In the article Eric notes the historical divergence from nature which was due to technological advancements and how we now see the importance of "reintegrating natural elements into [our] built environments." Terrapin's book *14 Patterns of Biophilic Design*, is mentioned in the article to touch on the points about how there are "universal human health and well-being concerns," and that biophilic design can be used to develop creative and productive spaces that foster overall well-being and harbor better connections with nature.

Keywords: Biophilic design, Human-centered design, Reintegration, 14 Patterns of Biophilic Design, Well-being

17. Vetter, Clara. "The Effects of Colors on Behavior." Neurofied (2019):

<https://neurofied.com/effects-of-color-on-behavior/>.

Clara Vetter, a PhD candidate for the Department for Precision Psychiatry at the Hospital of the University of Munich, describes the profound effects of color on one's behavior in different forms such as "evolutionary, artistic, cultural, physiological, and psychological" perspectives.

Clara explains how color has the ability to “attract attention, evoke emotions, influence decision-making, affect performance, and even alter perceptions of time and taste.” She offers examples of how color can be used in various fields such as marketing, psychology, and neuroscience. Color has an impact on how objects and spaces are perceived which is why it is important to understand one’s choices regarding color when it comes to “branding, product design, and workplace environments.” Clara also begins to describe the cultural significance that color can hold, giving it different types of power depending on who it is perceived by.

Keywords: “Attention, Behavioral Research, Cognitive Biases, Emotions, Marketing, Psychological fundamentals”

18. DeMaria, Kristine. “Biophilia and Interior Design: Creating a Multi-Sensorial Experience | TerraMai.” TerraMai (2018): <https://www.terramai.com/blog/biophilia-interior-design-create-multi-sensorial-experience/>.

Kristine DeMaria, a marketing specialist and freelance writer that focuses on marketing, product development, sustainability, and quality assurance, comments on the importance of using biophilic design to create multi-sensorial experiences that will promote health and well-being in commercial spaces. Kristine references examples of biophilic inclusive projects such as the Singapore Hospital and Newport Hospital Health Center to describe the effects that wood, water, and plants can have on an environment. These projects also offer examples on how “daylight, greenery, and reclaimed wood,” lead to “reduced stress, improved mood, and foster connectivity.” Kristine also produces a hospital example where natural materials and plant life may not be present, but the buildings are still able to induce the benefits of biophilic design through the use of natural patterns in addition to an artificial circadian lighting solution that help the occupants sleep and wake schedules.

Keywords: Biophilic design, Multi-sensorial experience, Hospital design, Artificial lighting solution, Natural materials

19. Alokita. “Making a House Accessible for a Visually Impaired Person.” WeCapable (2017): <https://wecapable.com/adaptations-house-office-visually-impaired-person/>.

Alokita, a polio survivor and commerce graduate, writes about the importance of making homes more accessible for those who are visually impaired. There is a common focus on wheelchair ramps and other elements designed for those who experience general mobility related disabilities. However, it is less common that accessible homes come retrofitted for those who experience visibility impairments. Alokita suggests five main categories where modifications can be made to enhance accessibility: lighting, color contrast, tactile effects, safety, and organization. Well-lit areas are very important for those that experience low-light blindness, contrasting colors make different spaces easily identifiable, and tactile markers aid in navigation, identification, and creating barriers. Installing grab-bars and reducing clutter and slippery surfaces are a few simple methods to improve safety within a home.

Keywords: Safety, Accessibility, Lighting, Color, Tactile environment, Visibility impairment

20. Carrillo, Gabriela. “Building for the Blind.” Architectural Review (2020): <https://www.architectural-review.com/buildings/building-for-the-blind>.

Gabriela Carrillo, an architect based in Mexico, describes one of her projects designed in conjunction with Taller de Arquitectura Mauricio Rocha. She states that the project, designed for the visually impaired, “challenges conventional perceptions by prioritizing senses beyond sight.” In working on a renovation for the library for the blind in Mexico City, the architects wanted to create a space that engaged all of the user’s senses, with more of an emphasis on sound, touch, and smell. During the process, the team collaborated with blind and visually impaired individuals

to get their feedback. An interesting process adjustment was working around the barrier of traditional visual representation styles such as renderings, plan drawings, etc. The project incorporated “elements such as acoustic insulation, aromatic gardens, and tactile surfaces,” which enhanced the special experience not only for those experiencing visual impairments but also sighted individuals. This project presented a shift in architectural philosophies where there is more importance placed on engaging our senses outside of just our sight.

Keywords: Visual impairment, Senses, Blind perspective, Design representation, Atmospheric

21. An M, Colarelli SM, O'Brien K, Boyajian ME. “Why We Need More Nature at Work: Effects of Natural Elements and Sunlight on Employee Mental Health and Work Attitudes.” PLoS One (2016): doi: 10.1371/journal.pone.0155614.

The authors, four professors with backgrounds in public health, business, and psychology, performed a study on how having natural elements in the workplace would affect 444 participants’ mental health and work attitudes. It was found that natural elements resulted in reduced depression and higher job satisfaction. “Natural elements have a restorative effect on mental fatigue,” because it captures one’s curiosity. Not allowing individuals to fixate on work for long periods at a time so that they cannot get to the point where they experience mental fatigue. Meanwhile, sunlight had stronger effects on mental health outcomes. Direct light exposure (outdoor exposure without any interference) seemed to be associated with increased anxiety along with job satisfaction, and organizational commitment, while indirect sunlight (refracted sunlight through windows) corresponded to decreased depressive moods and increased organizational commitment with no influence on anxiety. Exposure to sunlight effects Vitamin D absorption and immune function, sleep cycle, alertness and vitality, as well as serotonin production.

Keywords: Workplace environment, natural elements, sunlight exposure, employee well-being, job attitudes

22. Lewinski P. "Effects of classrooms' architecture on academic performance in view of telic versus paratelic motivation: a review. *Front Psychol.*" (2015): doi: 10.3389/fpsyg.2015.00746.

This text was a review on the "influence of classroom architecture on academic performance" with a focus on "acoustics, light, color, temperature, and seat arrangement." The author, from the Amsterdam School of Communication Research, describes Apter's reversal theory of telic versus paratelic motivation and notes that environments in which a telic motivation state is promoted, would be preferred for academic spaces. Peter explains that telic motivation describes an individual that is focused on achieving goals and experiences a preference for "low arousal environments with an end state being relaxation." However, paratelic motivation is more focused on the activity itself rather than the end result. This tends to be triggered by boredom so these individuals are drawn to highly arousing environments. The results of the individual factors studied include noise negatively effecting learning and health, and high luminance levels leading to "discomfort, [distraction], and damage to furniture and fixtures." Some sources believe "colors like red impair cognitive performance" while blue and green are more calming. However, color theory tends to be less influential. Alternatively, temperature is a significant factor stating "temperatures between 68 and 74°F are optimal for learning."

Keywords: "Academic performance, learning outcomes, learning environment, classroom design, reversal theory"

23. Bennett, Hannah. “Buildings with Brain Power: Library Architecture in Neural Terms.”

Library.ifla.org. Lyon, France (2014): <https://library.ifla.org/id/eprint/777/>.

Hannah Bennett, head of the School of Architecture Library at Princeton University, writes about library design in relation to neuroarchitecture research that promotes “healing, growth, and intellectual cultivation.” Libraries have adjusted to the demand for “wireless environments, cafes, and group study spaces,” yet there is now a debate that these typologies are losing their essence and purpose. The author links library design and neuroarchitecture through the concept of a "productive research environment" which speaks to the importance of “environments conducive to creative and collaborative engagement.” However, these concepts begin to diverge around aspects of simple function compared to the symbolism of certain space typologies. The author believes that these topics can work together to create spaces with both identity and functionality that adapts to contemporary needs and technology.

Keywords: “architecture, neuroscience, libraries, design, research environment”

24. Minhas, Parul, Prakash Nair, Louis Sirota, and Aia. NEURO ARCHITECTURE - Health, Happiness & Learning. (2023):

[https://educationdesign.com/wpcontent/uploads/2023/04/Neuroarchitecture-Whitepaper\\_Web.pdf](https://educationdesign.com/wpcontent/uploads/2023/04/Neuroarchitecture-Whitepaper_Web.pdf).

The authors, one with a PhD in Health Promoting School Design and two architects that specialize in school design, discuss the “importance of designing schools to promote a healthy neuroendocrine balance and enhance emotional health, crucial in combating the negative effects of stress on children.” Stress can lead to long-term health consequences by affecting “brain structure, immune function, and hormone balance” which can be especially detrimental when experienced in childhood. The authors note the various stressors experienced in an academic

setting and that a well-designed environment could help to reduce stress by triggering the release of certain neurochemicals and promoting well-being. There are also recommendations to create “proportionate spaces, flexible learning environments, personalized workspaces, and stimulating playgrounds,” to benefit children in learning environments with the use of biophilic design, neuroscience research, and small learning communities.

Keywords: Neuroarchitecture, school design, well-being, stress reduction, emotional health

25. Tulay Karakas, Dilek Yildiz, “Exploring the influence of the built environment on human experience through a neuroscience approach: A systematic review.” *Frontiers of Architectural Research*. Volume 9, Issue 1. (2020): 236-247. ISSN 2095-2635.  
<https://doi.org/10.1016/j.foar.2019.10.005>.

The authors, faculty of the architecture department at Istanbul Technical University, describe the history of the field of neuroarchitecture and how it has developed from purely behavioral studies towards insights from neuroscience. This article identifies “key theories, methodologies, and emerging concepts” within these fields while also commenting on new areas of study such as cognitive architecture and neuroarchitecture. The human response to architecture is measured using techniques such as “environmental mapping, psycho-physiological measurements, and [other] digital tools.” The authors note the importance of interdisciplinary work with the goal of furthering this type of research as it is a very complicated task to measure the complex data related to the human experience.

Keywords: “Architecture, Neuroscience, Human experience, Built environment, Cognitive architecture, Neuro-architecture”

26. Bower IS, Hill AT, Enticott PG. “Functional brain connectivity during exposure to the scale and color of interior built environments.” *Hum Brain Mapp* (2023): 447-457. doi: 10.1002/hbm.26061.

The authors, from the Cognitive Neuroscience Unit in the School of Psychology and the school of architecture at Deakin University, performed a study emphasizing the need for brain-based evidence to understand the “effects on cognitive, attentional, perceptual, and emotional functioning” related to the built environment. The study used “electroencephalography (EEG), virtual reality (VR), and indoor environmental quality monitoring to investigate how design elements of an interior room impact brain functional connectivity networks.” The study concluded that brain activity is influenced by scale and color meaning that this approach could effectively be used to “explore the health implications of time spent within built environments.”

Keywords: “brain connectivity, cortical oscillations, electroencephalography (EEG), environmental psychology, immersive virtual reality, spatial cognition, visual perception”

27. Writer, Staff. “Top 10 Tips for Creating a Study Space at Home | Joyce University.” Joyce (2022): <https://www.joyce.edu/blog/10-best-study-space-tips/>.

A staff writer for Joyce, University of Nursing and Health Science, writes about the best methods for creating a study space. A few of the focus points include “privacy, good lighting, comfort, noise control, and organization to promote productivity and focus.” Some of these points are focused of habit such as turning off extra devices like phones to prevent distraction, organizing with desk organizers, and managing time effectively. However, other topics relate back to design and environmental conditions when including “natural light, choosing a comfortable chair, managing noise with ambient sounds, [and] using scents like essential oils to increase concentration.”

Keywords: Nursing students, Study space, Productivity, Organization, Comfort

28. Abdel, Hana. "School for Blind and Visually Impaired Children / SEALab." ArchDaily (2022): <https://www.archdaily.com/984721/school-for-blind-and-visually-impaired-children-sealab>

Hana Abdel, an architectural project curator, discusses the School for Blind and Visually Impaired Children in Gandhinagar, Gujarat. "Initially housed in a converted primary school, the new academic building features ten classrooms arranged around a central courtyard, offering space for academic activities and recreation." The design incorporates interesting features that facilitate navigation using senses other than sight. Contrasting textures, sounds, smells, and skylights orientation all serve to help students navigate the space without sight. "Tactile models and 3D prints helped students and teachers understand the design." The design also incorporates multiple sustainable features including rainwater harvesting and a landscaping with over 1000 plants.

Keywords: Visually impaired education, Inclusive school design, Sensory navigation, Tactile communication, Sustainable architecture

29. The Green Office Solutions. "Embracing Nature: The Power of Biophilic Design in Educational Spaces." Www.linkedin.com (2023): [https://www.linkedin.com/pulse/embracing-nature-power-biophilic-design-educational-oxanc?trk=public\\_post\\_main-feed-card\\_feed-article-content](https://www.linkedin.com/pulse/embracing-nature-power-biophilic-design-educational-oxanc?trk=public_post_main-feed-card_feed-article-content).

The author, a company dedicated to biophilic design and interior landscaping, "traces the history of biophilic design from ancient civilizations to modern times, highlighting its recognition as a formal concept in the mid-20th century." The author speaks to the benefits of including vegetation and biophilic design elements such as "improved student performance, enhanced

well-being, increased productivity, better air quality, energy efficiency, positive environmental impact, community building, inspiration, creativity, and educational opportunities.” The article also includes tips for incorporating biophilic design such as “selecting suitable plants, maximizing natural light, incorporating water features, using natural materials, creating green walls, engaging students, and ensuring regular maintenance.”

Keywords: Biophilic design, Educational spaces, Nature integration, School facilities management, Student well-being

30. DeLauer V, McGill-O'Rourke A, Hayes T, Haluch A, Gordon C, Crane J, Kossakowski D, Dillon C, Thibeault N, Schofield D. “The Impact of Natural Environments and Biophilic Design as Supportive and Nurturing Spaces on a Residential College Campus.” *Cogent Soc Sci* (2022): doi: 10.1080/23311886.2021.2000570.

The authors, from Franklin Pierce University and Husson University, discuss how “natural environments can positively impact college students' well-being by reducing stress.” The study asks students to “share their perceptions of their well-being in a residential academic setting.” The study also takes into account gender differences in resilience and self-esteem. The research methods used included questionnaires and focus groups, describing their perception of the campus environment. The study is intended to “investigate the perceived well-being of college students, focusing on demographic differences such as grade level and gender, and how these differences relate to factors like employment, sleep, coping mechanisms, and social support.”

Keywords: “Stress, nature, restorative, university, college, biophilic design, health geography”

31. Harrouk, Christele. "Psychology of Space: How Interiors Impact Our Behavior?"

ArchDaily (2020): <https://www.archdaily.com/936027/psychology-of-space-how-interiors-impact-our-behavior#:~:text=Environmental%20psychology%20or%20Space%20psychology>.

In this article, the author Christele Harrouk, an architect and urban designer, discusses how interior spaces impact our behavior. This is known as environmental or space psychology and it looks into the influence of space on our emotions, behaviors, and well-being. Key factors such as lighting, color, layout, and materials interact with our senses and contribute to our experience. Historically, functionality has taken precedent over psychological considerations in terms of design, however, architects are beginning to "recognize the importance of designing spaces that promote safety, social connectedness, ease of movement, and sensory stimulation." Balance and proportion contribute to harmony and different colors and lighting can influence emotions, yet there is still difficulty in "translating research findings into specific architectural guidelines."

Keywords: Environmental psychology, well-being, functionality, sensory stimulation, proportions

32. Galvez-Pol, A., Nadal, M. & Kilner, J.M. "Emotional representations of space vary as a function of peoples' affect and interoceptive sensibility." *Sci Rep* 11, 16150 (2021): <https://doi.org/10.1038/s41598-021-95081-9>

In this paper, three neuroscience, health, and human evolution and cognitive research professors discuss the traditional approach to design compared to the factors that link to positive emotions in spaces. A study was performed during the Covid-19 lockdown, asking the participants to fill out self-reporting questionnaires on affective state and interoceptive sensibility as well as

shading a map to indicate where they experienced happy and sad memories and where they wanted to go after the lockdown. The results showed a preference toward outdoor spaces and a desire to visit natural environments post lockdown, “suggesting the restorative potential of such spaces.”

Keywords: Geographical self-report, emotional mapping, psychophysiological traits, natural environments, covid-19 lockdown

33. Bradshaw, Jon. “The Psychology of Space, Part 1 – International Association of Venue Managers.” *International Association of Venue Managers* (2015): <https://iavm.org/the-psychology-of-space-part-1/>.

Jon Bradshaw, a keynote speaker and trainer on the behavioral science that powers human interaction, discusses why architects are increasing psychological integration into event space design. Jon highlights key points such as the effects from space design “can be non-conscious, and adaptation over time can diminish the impact of the environment. Flexible and adaptable spaces are favored as they cater to individual preferences and allow for longer-term adaptation.” The author also presents research about spaces that change regularly and offer autonomy for personalization and the enhanced psychological comfort and well-being associated with this design choice. Spaces also need to provide sufficient but not excessive stimulation for the user. Room size and shape also offer different effects. For example, “large, open spaces promote openness and creativity, while curvilinear spaces elicit more positive emotional responses.”

Keywords: Space psychology, optimal arousal levels, curvilinear spaces, event spaces, human behavior

34. Cubicoon. "Psychology of Space: How Interior Design Impacts Our Mood and Behavior." Cubicoon.com (2021): <https://cubicoon.com/2021/09/01/psychology-of-space-how-interior-design-impacts-our-mood-and-behavior/>.

This author, a blog centered around architecture and interior design, describes environmental psychology and how it explores the various elements in the spaces we inhabit and their influence on our mood, behavior, and wellbeing. "Key aspects of interior design that influence mood and behavior include creating a sense of spaciousness through design tricks like lighting and organization, maximizing natural light to uplift mood and energy, choosing color palettes that evoke desired emotions, incorporating artwork to add personality and reduce stress, and integrating natural elements and Feng Shui principles." These elements create a space with harmony that reduces stress and anxiety.

Keywords: Interior design psychology, environmental psychology, Feng Shui, color psychology, spatial energy

35. House, Andy. "Drivers of Emotions and Experiential Space Design." Work Design Magazine. Last modified May 20, 2021. <https://www.workdesign.com/2021/05/drivers-of-emotions-and-experiential-space-design/>.

In this article, the author, workplace client leader at BHDP Architecture, discusses the "intersection of experiential design with psychology, emphasizing the crucial role of emotion in shaping people's perceptions of physical spaces." It is extremely important to be able to understand clients' emotional needs and with this the emotional and decision-making influence that physical space affects. Empathy, excitement, and informed decision-making and key principles are integral to creating spaces that resonate with and benefit the user. The author also discusses "the impact of design on happiness, memory, and engagement, emphasizing the lasting

effects of emotionally resonant experiences.” This suggests a need for experiential design that works with the “cultural, social, and behavioral characteristics of the people using the space.”

Keywords: Experiential design, emotional connection, design principles, memory and design, engagement through design

36. Harris, Ted . “Are Libraries Still Relevant? Um.... Yes! But Why?” Imaginary House. (2023): <https://imaginaryhouse.com/en-us/blogs/news/are-libraries-still-relevant#:~:text=Libraries%20are%20a%20vital%20part>.

Ted Harris, a part of Imaginary House a book publishing company, argues for the continued relevance of libraries in the digital age. Ted highlights their diverse benefits and roles within communities. Libraries serve as “free resources, community builders, safe spaces, literacy promoters, and intellectual challengers,” making them so much more than just repositories of books. The assistance that libraries provide in terms of “access to information and assistance, support to job seekers and entrepreneurs, providing safe environments for children, and fostering a love of reading and exploration,” is invaluable to community members. The author also notes the importance of creating beautiful libraries for underrepresented schools, to offer inclusive and inviting library spaces that further promote literacy and education.

Keywords: Libraries, relevance, community, literacy, resources

37. Thompson, E. G. “Yes, Libraries Are Still Relevant.” EveryLibrary. (2022):

<https://medium.com/everylibrary/yes-libraries-are-still-relevant-514d998d6a50>.

The author, E. G. Thompson a librarian, argues that “despite the widespread availability of information online, public libraries remain crucial due to factors such as equitable access to resources, including high-speed internet, and the provision of books and media for those who

cannot afford them.” Thompson claims that the perception of libraries being obsolete stems from individuals who do not rely on them. Many Americans lack reliable internet access, and this "digital divide" exemplifies the need for libraries to provide those essential resources for free, “ensuring equal access to information and educational opportunities.”

Keywords: Libraries, relevance, internet access, digital divide, equity

38. “How to Make Your Library Great.” Project for Public Spaces (2009):

<https://www.pps.org/article/libraryattributes>.

This unspecified author lists out 14 key components to a great library. These strategies include: 1) offering a broad mix of community services, 2) fostering communication, 3) showcasing history and information, 4) building capacity for local businesses, 5) becoming a public gathering place, 6) boosting local retail and public markets, 7) offering easy access, 8) making the surrounding area vibrant, 9) providing multiple attractions and destinations, 10) designing to support function, 11) offering a variety of amenities, 12) changing with the calendar, 13) depending on wise management, and 14) catalyzing community revitalization. “These approaches help libraries fulfill their potential as community anchors and multi-use destinations.”

Keywords: Community services, communication, history and information, local businesses, public gathering places

39. Pew Research Center. "Part 4: What People Want from Their Libraries." Pew Research Center: Internet, Science & Tech (2013):

<https://www.pewresearch.org/internet/2013/01/22/part-4-what-people-want-from-their-libraries/>.

According to the Pew Research Center, Americans have varied interests when it comes to new library resources. Services that the public deems essential for public libraries to offer include: 1) Librarianship or the presence of knowledgeable librarians, 2) Book Borrowing, 3) Free Access to Computers and Internet, 4) Quiet Study Spaces, 5) Programs for Children and Teens, 6) Research Resources, 7) Job, Employment, and Career Resources, 8) Free Events and Activities, and 9) Free Public Meeting Spaces. "Pre-loaded e-readers and digital media labs had lower interest levels, but certain demographic groups showed more interest, particularly black and Hispanic respondents. Librarians expressed varying levels of interest, citing issues like copyright concerns and budget constraints."

Keywords: Library services, Public interest, Demographic preferences Implementation challenges, Privacy concerns

40. Burgstahler, Sheryl . "Equal Access: Universal Design of Libraries | DO-IT."

Www.washington.edu (2018): <https://www.washington.edu/doiit/equal-access-universal-design-libraries>.

In this article the author, Sheryl Burgstahler an author and professor at the University of Washington, provides a comprehensive checklist for ensuring that libraries are welcoming, accessible, and usable for all individuals, including those with disabilities. Sheryl also brings up the importance of following legal requirements outlined in acts such as the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990. A few key points discussed in the article

include 1) Universal Design, 2) Legal Issues: Libraries must comply with laws prohibiting discrimination, 3) Guidelines and Examples, 4) Communication Hints, and 5) Additional Resources. “The document serves as a valuable guide for libraries to promote inclusivity and ensure that everyone can fully utilize library services and resources.”

Keywords: Universal Design, Accessibility, Libraries, Disabilities, Inclusivity

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