# Impermanence of Light and Shadows in Early Education:

## Specialized Art Camp for Children in Seattle

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## Abstract

Impermanence of Light and Shadows in Early Education:
Specialized Art Camp for Children in Seattle

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With artificial light eliminating shadows from every nook and corner of the room, returning to using daylight as the primary light source of interior spaces grows more and more vital. Human beings desire to see variability in luminous environments found in daylight. Uniform artificial lighting in schools prevents kids from learning, especially when they do a variety of activities. This thesis arose from research into the lighting design of historic Japanese architecture and explores the value of impermanence and strategies to help children experience change in an educational setting. I designed a specialized art camp in Discovery Park to enhance children's connection with the present moment through experiencing change.

Figure 1. Zoji Temple in the Autumn.


## *Acknowledgements*

*I thank my friends and family for being part of my journey of completing the Master of Architecture program. Thank you to Ken Tadashi Oshima and Mehlika Inanici for working hard to provide me with critical insight that kept me on the right path in my thesis project and to Ryan Webber for providing me with attentive copyedits.*

*And I want to especially thank my father for giving me the confidence that I can achieve anything if I believe in myself and for his endless support to help me get to where I am today.*

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Figure 2. Yanohara House on a rainy day.

# Chapter 1: Introduction

Humans evolved alongside variations of natural light, the observation of which helps us perceive that things change through time in our surrounding environments and in states of our mind and body. Ever since artificial lights became commonly used to keep a permanent light level, lighting conditions inside buildings have failed to satisfy adequate visual variability. This has especially affected children's classroom environments. Children need dynamic lighting conditions to supplement the variety of activities that occur in early education.

In the pre-electric past, architects relied on daylight as the primary source of lighting. Historic Japanese architecture emphasized changes in natural light and shadows in a society that valued impermanence. Their rooms had a subtle gradient of natural light that disappeared into the shadows. Ever since LED lights became widely used, shadows have been eliminated from everywhere in a room. This thesis focuses on coastal cities on the Pacific Rim, especially in Seattle and Tokyo, cities that lack daylight throughout the school year. How can the use of light and shadows from historic Japanese architecture enhance sensory experience of children in educational environments around the Pacific Rim?

The effective design strategies found in historic Japanese architecture are further explored through a design project of a specialized art camp for children located in Discovery Park, Seattle. With a similar abundance of nature and frequent overcast skies, lighting strategies from Tokyo can be applied to architectural projects in Seattle. Activities taking place in a specialized art camp consist of hands-on activities and physical movements which enhance children's learning efficiency and need an interactive lighting design. This thesis claims that the continual change of natural lighting and shadows present in historic Japanese architecture will improve the learning environment in early education and facilitate children's development by allowing them to contemplate change and impermanence.


Figure 3. Structural pattern in Tokyo International Forum.

# Chapter 2: Literature Review

*"We find beauty not only in the thing itself but in the pattern of the shadows, the lights, and the darkness which that thing provides."*[1]

*In Praise of Shadows* by Junichiro Tanizaki

Humans evolved to follow the natural daylight cycle for hundreds of thousands of years. Our human instincts seek variation in lighting because the change in light provides information about time, surroundings, and our position in the present moment. However, artificial lights disrupt our

[1] Tanizaki, Jun\'ichirō. *In Praise of Shadows*. 30.

relationship with natural light. While this invention gave us the freedom to bring light into a dark space and stay productive past sunset, we now spend most of our time under a permanent source of light.

## Section 2.1: Relationship Between Natural Light and Human Instincts

Light informs us of life through multiple forms of consciousness. Life on Earth exists in large part due to the light from the sun; humans evolved to instinctively react and receive information from light. The circadian rhythm follows the daylight and dark cycle. Our daily routine matches the change in the sun's color and intensity as it travels across the sky.

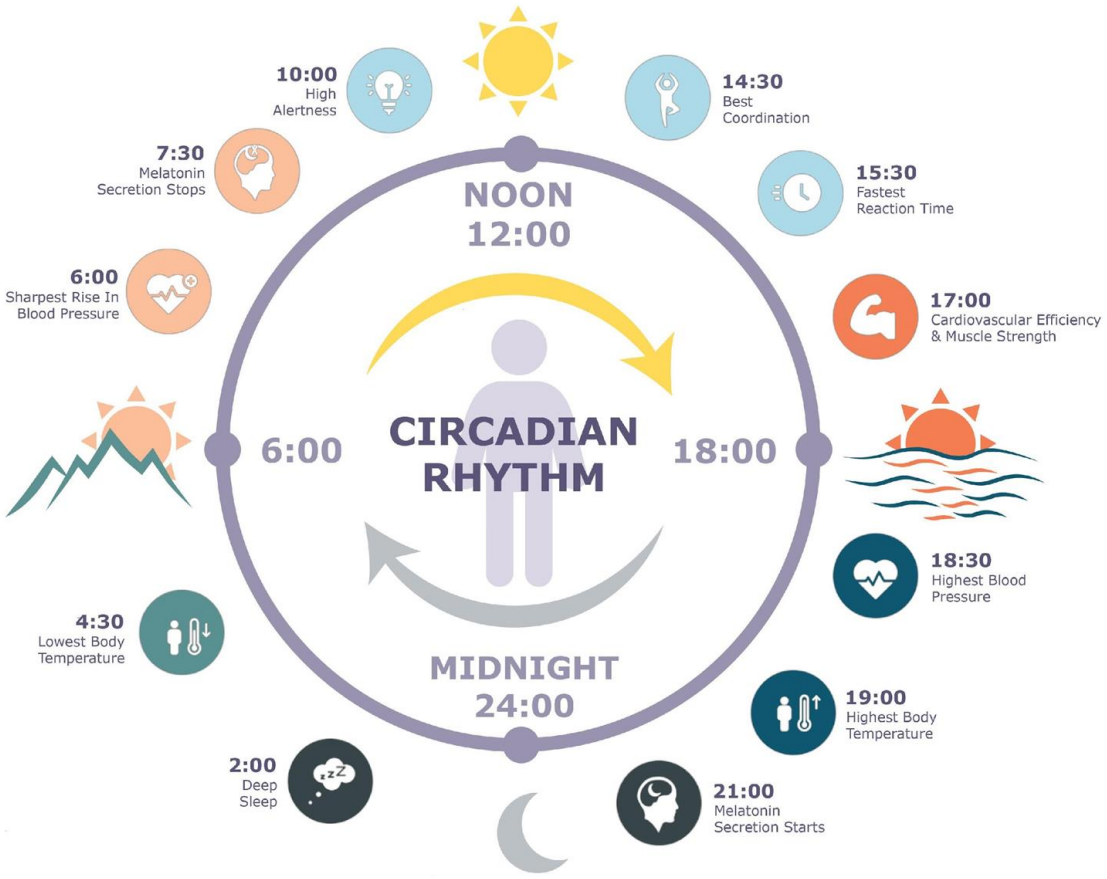



Figure 4. Relationship between circadian rhythm and the sun cycle.

**Consciousness**

Daylight reminds us of our position in the presence and the temporality of the moment. As Henry Plummer claims in his book *Poetics of Light,* artificial lights create an optical permanence that fail to trigger our consciousness of this temporality. [2] The change in natural light helps us be more aware of the passing of time. According to American philosopher Susanne Langer,

> The phenomena that fill time are tensions – physical, emotional, or intellectual. Time exists for us because we undergo tensions and their resolutions. Their peculiar building-up, and their ways of breaking or diminishing or merging into longer and greater tensions, make for a vast variety of temporal forms.[3]

Humans perceive time largely through the assistance of daylight. The changing weather also proves that today is different from yesterday: the quality of the natural lighting depends on the clouds present in the sky. As we age, the colors seem duller and light appears dimmer. Our mental well-being alters the saturation and brightness of our vision as we go through the highs and lows of our lives. The changes in the way we perceive natural light are a reminder of the temporality of a moment, making us more self-aware of our existence.

[2] Plummer, Henry. *Poetics of Light*. Tokyo: A+u Pub. Co., 1987. 143 – 145.
[3] Langer, Susanne K. "The Primary Illusions and the Great Orders of Art." *The Hudson Review* 3, no. 2 (1950): 222. https://doi.org/10.2307/3856641.

Figure 5. Sunrise

Figure 6. Waking up.

Figure 7. Clear Sky

Figure 8. Working hard.

Figure 9. Sunset.

Figure 10. Jogging.

Figure 10. Night sky.

Figure 11. Sleeping

The energy levels of our bodies match the color and intensity of the sun throughout the day and the year. We struggle to get up in the morning, feel energized by the middle of the day, and then get tired by the end of the day. We are more active in the summer and less active in the winter, just like how daylight lasts longer in the summer and goes away more quickly in the winter. We developed biological internal rhythms that match the daily, seasonal, and lunar rhythms.

Figure 13. Summer sunset at a beach.

Figure 14. Snow on a mountain.

We appreciate light more at night in the endless pool of shadow as it gives us hope when we are stuck in the dark. We search, respond, and chase light. Humans are phototropic species on a quest to find light, according to Plummer.[4] Darkness consists of a de-energized phenomenon. Bright sunlight makes us feel lively, joyful, and positive while dark nights make us lose energy. We become drowsy, vulnerable, and inactive as we wait for light to

[4] Plummer, Henry. *Poetics of Light*. 77 – 83.

return. Human bodies have evolved to respond to diminishing daylight through psychological and physiological slowdowns. We feel the darkness draining away our energy to be able to fall asleep and recharge at night.

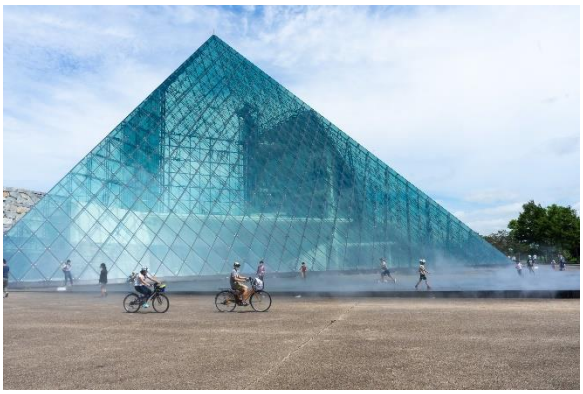


Figure 15. Active cyclist during the day.

Figure 16. Abandoned bicycle at night.

## Architectural Space

We cannot observe the physical space hidden in the shadows. We imagine the space that lies in the shadows because of our suppressed visual perceptions. Our eyes cannot collect information without light. Shadows look optically unsafe and uncomfortable, yet, as Plummer acknowledged, they give our creative minds the freedom to imagine what's hidden in the darkness. [5] The world changes as we breathe. We discover the truth when the light returns.

[5] Plummer, Henry. *Light in Japanese Architecture*. Tōkyō: Ē and Yū, 1995. 76 – 77.

Figure 17. Artificial lights in office buildings are traces of life at night.

Darkness is only the absence of light, and shadow is necessary to complete the experience of light. We cannot see the beauty of light or shadow without the presence of their juxtapositions. Light reveals phenomenal reality whereas darkness reminds us of the unknown and sparks our imagination.

Contrasts in lights and shadows are desirable. Because humans lived under natural light for thousands of years until artificial lights were invented, we evolved to notice the change in light to stay informed of our surroundings. The variation in lighting stimulates our sensory experience.

Figure 18. Sunlight passing through curtains.

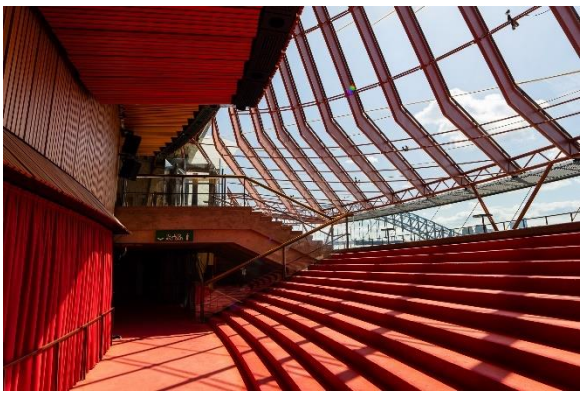


Figure 19. Sharp shadows on a sunny day.

When considering the lighting design of an architectural space, it is important to consider the orientation, shape, and material in response to the quality of the natural lighting. In *Light Revealing Architecture,* Marietta Millet emphasized that the surface of the material alters under different light conditions like a chemical reaction.[6] Light gives purpose to the material surface, and in return, material expresses the beauty of light. Daylight changes the tone and intensity of the color of material finishes as the sun travels across the sky.

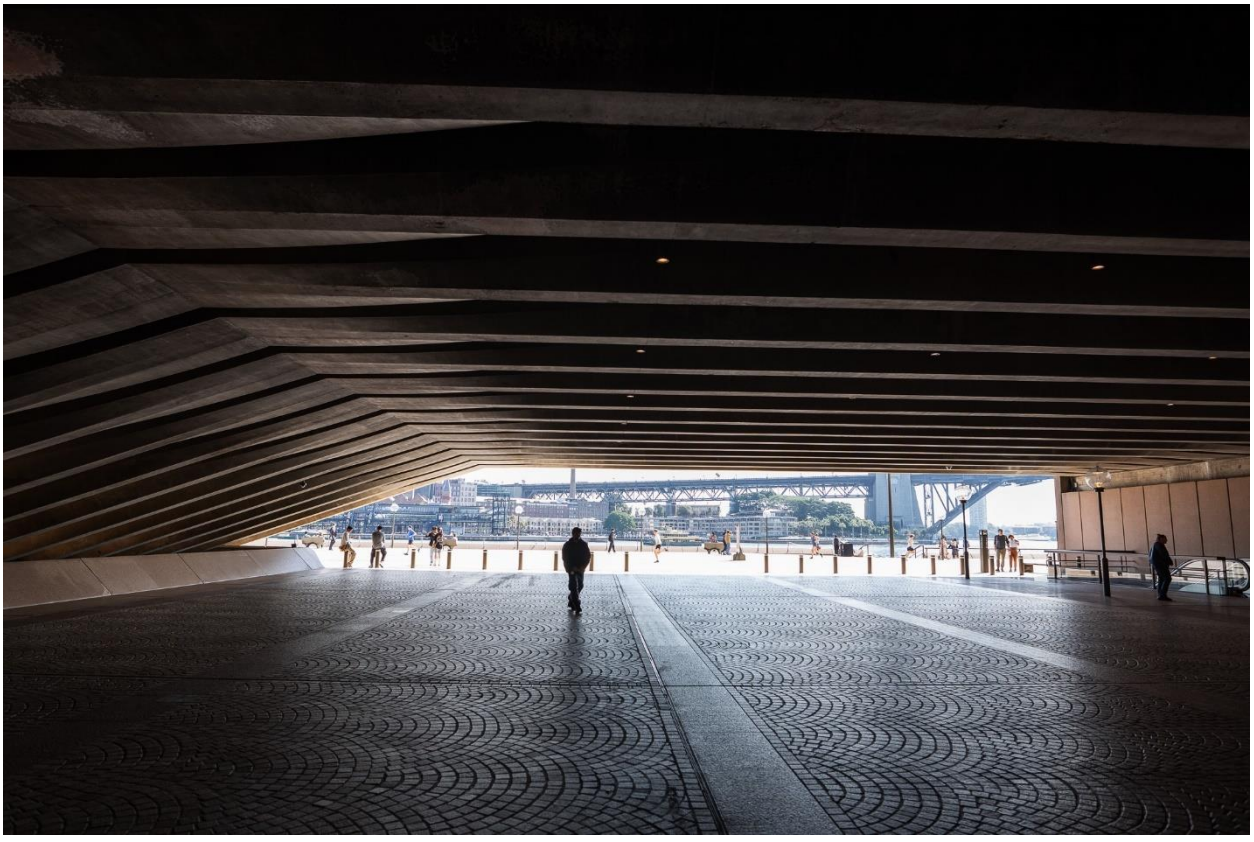


Figure 20. Natural light highlights concrete and cobble stone textures.

[6] Millet, Marietta S., and Catherine Jean. Barrett. *Light Revealing Architecture*. 14.

**Environment**

Light physically exists as a form of energy. Plummer pointed out this phenomenon in nature. The Volcanoes and fires are bright bursts of light. The sun provides energy to plants chemically reacting through photosynthesis. Animals' bodies biologically react to daylight to maintain a comfortable body temperature by absorbing or reflecting light. As plants change colors in response to the change in seasons and daylight, the color and brightness of animal fur change to camouflage into the surrounding environment for safety.[7] Natural light stores its energy in alternative forms through plants and animals. Life on earth would not thrive without the sun.

The lighting conditions also inform us of our surrounding environments, such as the temperature and the climate of the region. In movies, filmmakers add filters to replicate the sensory experience of the natural lighting in the city of the setting. Cold and snowy environments may have a diffused, cool-toned filter while dry and hot ones may have a sharp, warm-toned filter.

[7] Plummer, Henry. *Poetics of Light*. 13.

Figure 21. Bryce Canyon with snow.

Figure 22. Grand Canyon under sunlight.

Japan's primary historic lighting design strategized diffusing natural lights. Back when artificial lighting was far less common, architects designed buildings in Japan to take advantage of this diffused light by incorporating dimness into the beauty of their lighting design. Their lighting designs revolved around the material surface, fenestration, and the overall structure of the building. Dim light overall compliments the materiality of Japanese architecture, which allowed light into indoor spaces through the architects' understanding the conditions of natural lighting. With daylight being only present in necessary areas of the room, lighting design evokes the feeling of tranquility.

Figure 23. Tranquil photo of the Hara House.

## Artificial Lights Disrupted Our Relationship with the Natural Light and Dark Cycle

Humans evolved to live under natural light. Not until 1879 did Thomas Edison create the first artificial light. While artificial lights gave us the ability to continue working past sunset, it removed from us many of the benefits of natural light. Productivity increased at the cost of our mental and physical health.

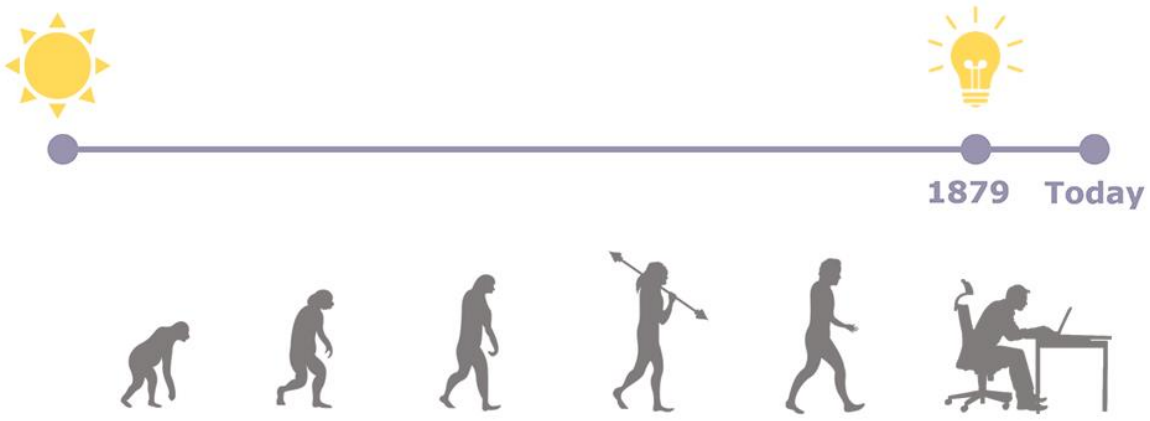



Figure 24. Humans evolved to live under natural light.

In the past, lighting designers faced problems with illuminating dark space. Natural light and the brightest source of light invented up to then limited brightness. Lighting designers overcame this challenge by designing both natural lights and shadows to appear beautiful. Ever since LED became widely used, this problem has been resolved. However, a lack of variability in lighting now exists due to the absence of changing natural lighting and shadows.

Figure 25. Lighting in Historic Japanese architecture (Kouka House).

Figure 26. Contemporary Office Lighting.

With artificial lights becoming more common, reliance on bright lights has increased. In historic Japanese architecture, a gradient of natural light disappears into the shadows on the corners of the room. We appreciate indoor space being dimly lit by natural light less today due to a fear of darkness hindering work efficiency.

Humans need light, but not all the time. Artificial lights emit constant and permanent levels of light. Since the dawn of time, humans evolved to desire variability of light because natural lighting has never been a constant resource. The quality of natural light changes depending on the sun's position in the sky, weather, and the climate. In response to the change in natural light, humans change to adapt.

It is unnecessary to add excessive lighting to reduce shadows if enough lighting allows the occupants of an indoor space to perform expected

tasks. The change in natural lighting appears more evident when spaces look dimmer. By learning to design light with shadows, there are more opportunities to highlight the beauty of change in natural light. Humans are impermanent, and impermanent lightning allows us to recognize the passing of time.

## Section 2.2: Impact of Daylight in Early Education

Natural light especially impacts children. Because they are so energetic, they move around a lot. It is important to carefully consider the light level on the floors and variety of surfaces to accommodate their variety of actions. Natural light also has a greater impact on their health as they grow. Children are weaker and benefit more from exposure to daylight than adults. Due to their curiosity, children also have a short attention span. A variability in light would satisfy their sensory experiences and help them concentrate in educational settings. Lastly, although childhood is a temporary part of life, the moments experienced have a tremendous effect on adulthood.


Figure 27. Characteristics of children.

## Daylight Improves Learning Efficiency

As shown in the results (see fig. 28), the Heschong Mahone Group from California Board of Energy Efficiency observed an improvement in children's learning efficiency when more natural light is present in classrooms. The variation in lighting increases their attention span by stimulating elementary school students' brains[8].

| Seattle | Analysis Results | | | | Percentage Effect | |
|---|---|---|---|---|---|---|
| ITBS | Difference in | | Statistical Certainty | | Difference as a a % of | |
| Iowa Test of basic Skills | Average Test Scores | | | | District Average | |
| NCE Scale 1-99 | (NCE percentage points) | | | | Score | |
| Spring Scores | Reading | Math | Reading | Math | Reading | Math |
| **Combined Daylight Model** | | | | | | |
| Daylight, Min. to Max. | 7.5 | 5.6 | 99.9% | 99.9% | 13% | 9% |
| **Separate Skylight and Window Model** | | | | | | |
| Windows, Min. to max. | 7.7 | 8.7 | 99.9% | 99.9% | 13% | 15% |
| Skylights, Min. to Max. | 3.9 | 3.4 | 99.9% | 99.8% | 7% | 6% |

Figure 28. Heschong Mahone Group, *Summary Daylight Findings for Seattle* (California Board of Energy Efficiency, 1999), 20, fig. 10.

## Prevention of Myopia

Studies by Arumugam Muralidharan et al (2021) have found an association between rising cases of myopia and lack of outdoor time in children. Sunlight delays, and even prevents, the development of myopia. Natural light has a varying pattern in luminance level, high color contrasts,

[8] Heschong Mahone Group. "Daylight in Schools." *An Investigation into the Relationship Between Daylighting and Human Performance*. California Board for Energy Efficiency, 1999. 20.

and high intensity of light. [9] The benefits found in natural light are the unique features that cannot be replicated by artificial lights. Exposure to daylight at a young age (while the body grows more rapidly) reduces myopia progression.

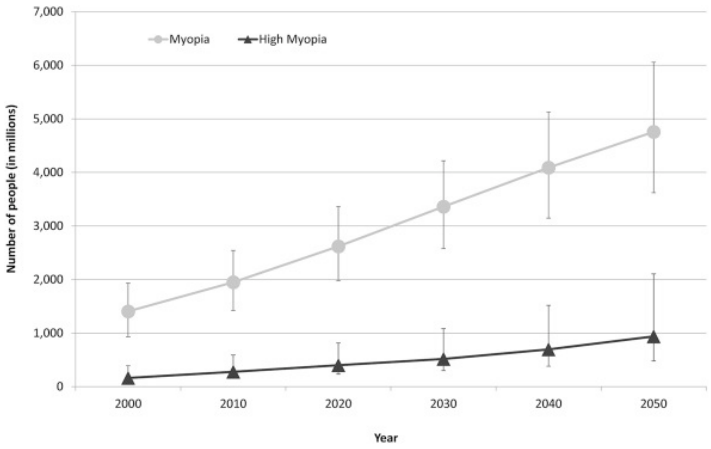



Figure 29. Brien, Holde a, et al, *Graph showing the number of people estimated to have myopia and high myopia for each decade from 2000 through 2050.* (PubMed, 2016), fig. 2.

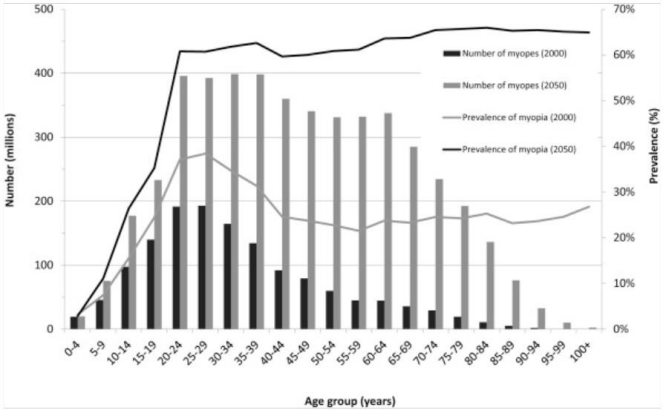



Figure 30. Brien, Holde a, et al, *Graph showing the distribution of people estimated to have myopia across age groups in 2000 and 2050.* (PubMed, 2016), fig. 3.

[9] Muralidharan, Arumugam R, et al. "Light and Myopia: From Epidemiological Studies to Neurobiological Mechanisms." Light and myopia: from epidemiological studies to neurobiological mechanisms, December 19, 2021. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8721425/.

## Reduction of Seasonal Associative Depression Symptoms

Seattle has a high case of seasonal associative depression cases due to the vitamin D insufficiency caused by the lack of daylight exposure. Seasonal Depression is especially common in children and teens.[10] In Seattle, students are trapped in school buildings during winter's short daylight hours. Designing classrooms with daylight would reduce depression symptoms in children.

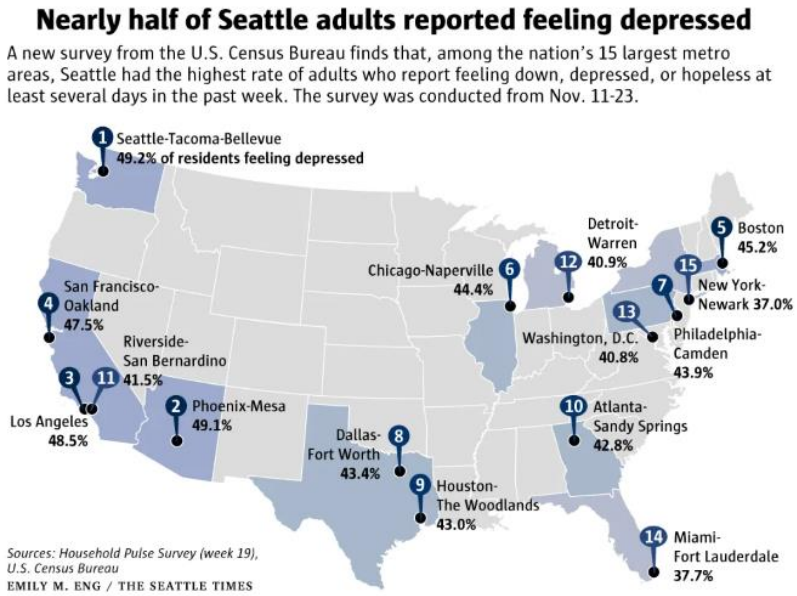
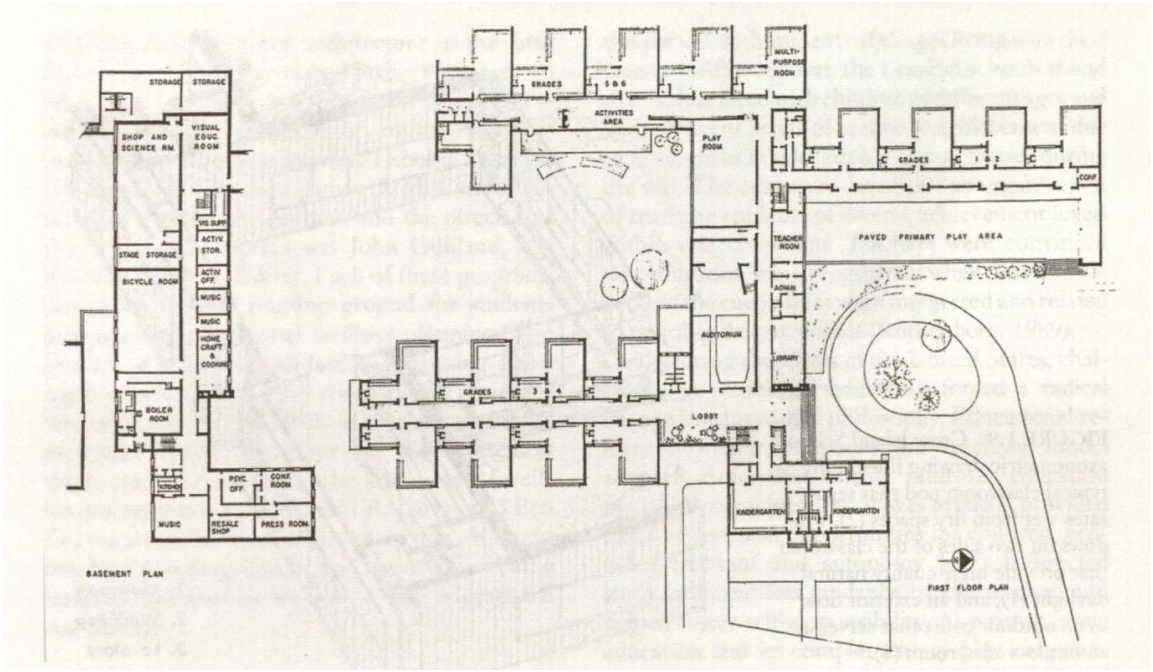



Figure 31. Eng, Emily M, *Household Pulse Survey (week 19), U.S. Census Bureau.* (The Seattle Times, 2023), fig. 2.

[10] "The 2023 Ultimate Guide to Seasonal Affective Disorder." Carex, February 28, 2023. https://carex.com/blogs/resources/guide-to-seasonal-affective-disorder.

## Daylight in Schools

Before fluorescent lighting became prevalent in the 1950s, daylight was the primary source of light in schools. The California Department of Education had daylighting standards for classrooms built in the 1950s and early 1960s. To meet the codes, architects used to follow a Finger Plan layout to maximize daylight in classrooms. The buildings consist of multiple rows of single classrooms with windows on two sides. However, the code was eliminated due to the high construction costs, challenges faced by engineers, and a lack of evidence supporting claims on the importance of daylight on education.[11]




[11] Heschong Mahone Group. "Daylight in Schools." *An Investigation into the Relationship Between Daylighting and Human Performance*. California Board for Energy Efficiency, 1999. 4-5.

Figure 32. Finger-plan school.

Figure 33. Gellner, Arrol. *THE "CALIFORNIA" FINGER-PLAN SCHOOL*. April 7, 2020. *Architext*.

Many schools built after artificial lights became common lack windows. It is more cost efficient and faster to build four walls with minimal windows. Many schools located in Seattle lack windows. The building design (see fig. 34, fig. 35, and fig. 36) almost resembles a jail. With clear sky days being rare during the school year (autumn to spring), children are barely exposed to daylight while in school.

Figure 34: Marbel, Joe. *The African American Academy Building in Seattle*. 2010.


Figure 35: Swedes, Geeky. *The Webster School in Seattle.* 2017.


Figure 36: Martin Luther King Jr. Elementary School in Seattle.

Figure 37. A classroom well-lit from daylight.

Figure 38. Callahan. "Seating Arrangements," 2012.

Lighting designs of schools are gradually becoming cold and bright, like office spaces and hospitals designed to maximize productivity. Just like the lighting in historic Japanese architecture, old schools used to have a gradient of sunlight diminishing into the shadows. Newly built schools have three solid white walls uniformly illuminated with bright ambient-recessed light fixtures. To make matters worse, some rooms align tables and chairs to make students face their back towards the one and only wall with windows (see fig. 38) because their shadows are no longer on the table surface by daylight. They cannot see the view of the outside from their classroom, making schools feel like a prison.

As artificial lights became more accessible, school designs began to prioritize productivity over the wellbeing of students. Like how light fixtures only emit permanent lights, contemporary schools are designed to be permanent; students cannot feel the change in time. Is this why students

often stare at the clock during lectures to see time passing by? The clock's hands are the most impermanent feature of a classroom without daylight.

## Section 2.3: Architectural Lighting in Seattle and Toyko

The daylighting strategies from historic Japanese architecture in Tokyo are applicable to Seattle due to the similar envrionmental conditions. Both cities are on the Pacific Rim. They both experience drastic seasonal changes. Architects design buildings to emphasize the beauty of nature and the local climate.

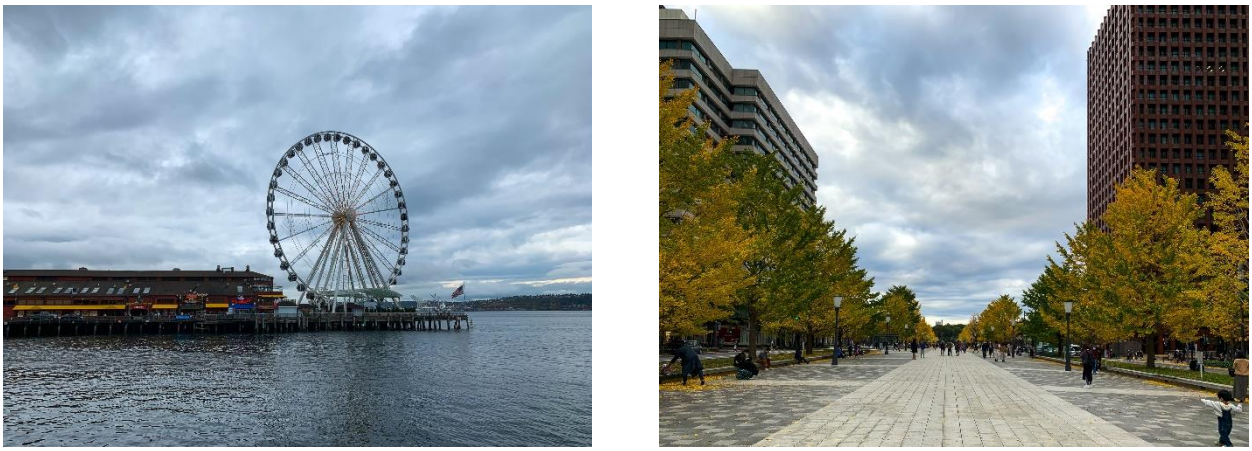


Figure 40. Overcast skies of Seattle (left) and Tokyo (right).

In addition to that, with the frequent overcast skies throughout the year, there is a lack of sunlight. It is necessary to design buildings with large windows to bring enough daylight into indoor spaces. As shown in the graphs of Figure 41 below, the sky cover range and latitude of Seattle and Tokyo are the following:

- Seattle: 68% mean cloud cover | 47 °N
- Tokyo: 62% mean cloud cover | 35 °N

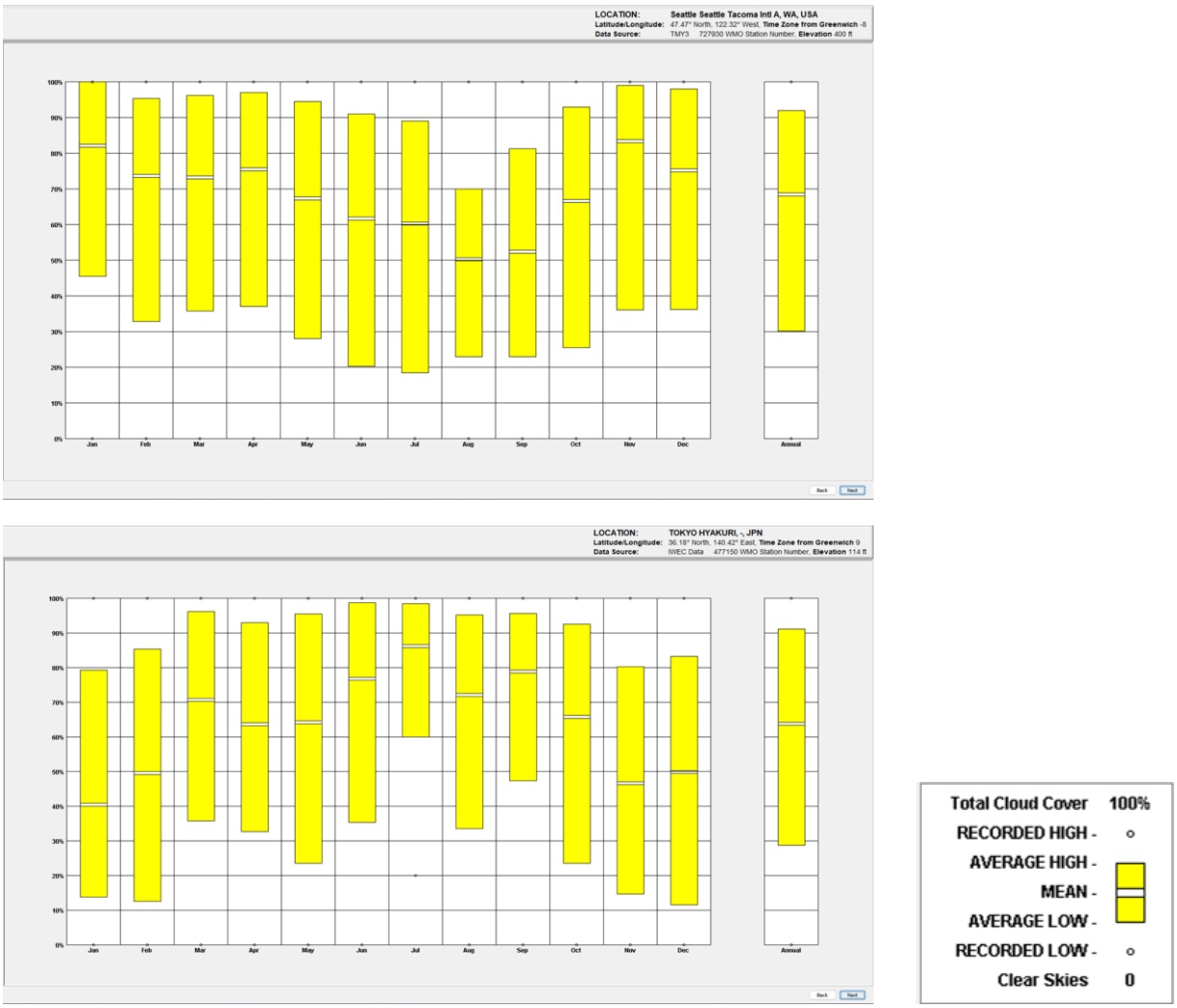



Figure 41. Mean cloud cover of Seattle (top) and Tokyo (botton) from Climate Consultants.

Both Seattle and Tokyo are located on the Ring of Fire – a region with high seismic risks. Buildings have strong structural systems to resist the lateral force during earthquakes. Buildings with exposed wood beams and columns, like the Japanese Guest House in Seattle and Saint Alban's Church in Tokyo, add contrasts to light and shadows. The subtle change in daylight is more visible in shadows with more details and varying levels of darkness.

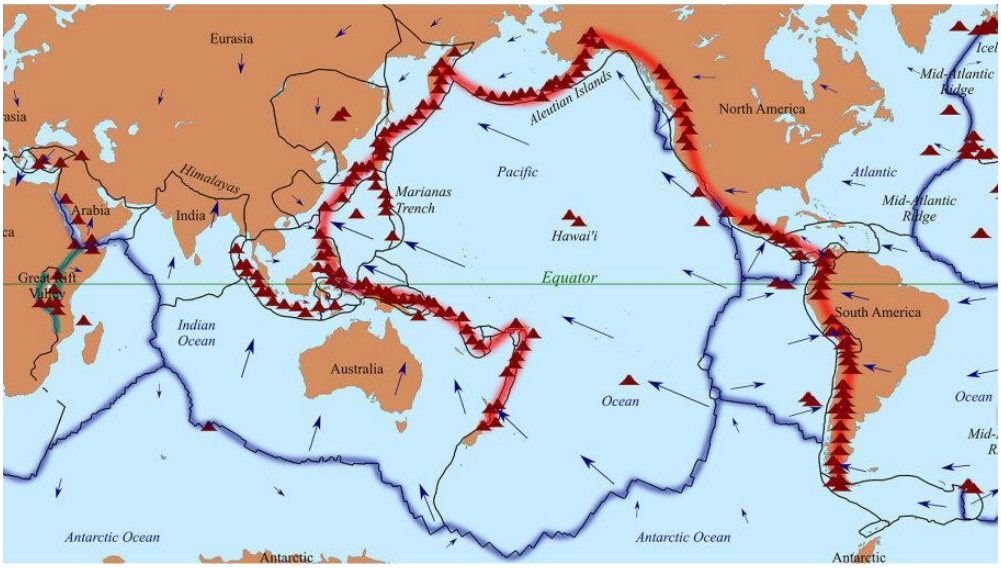



Figure 42. Ring of Fire.

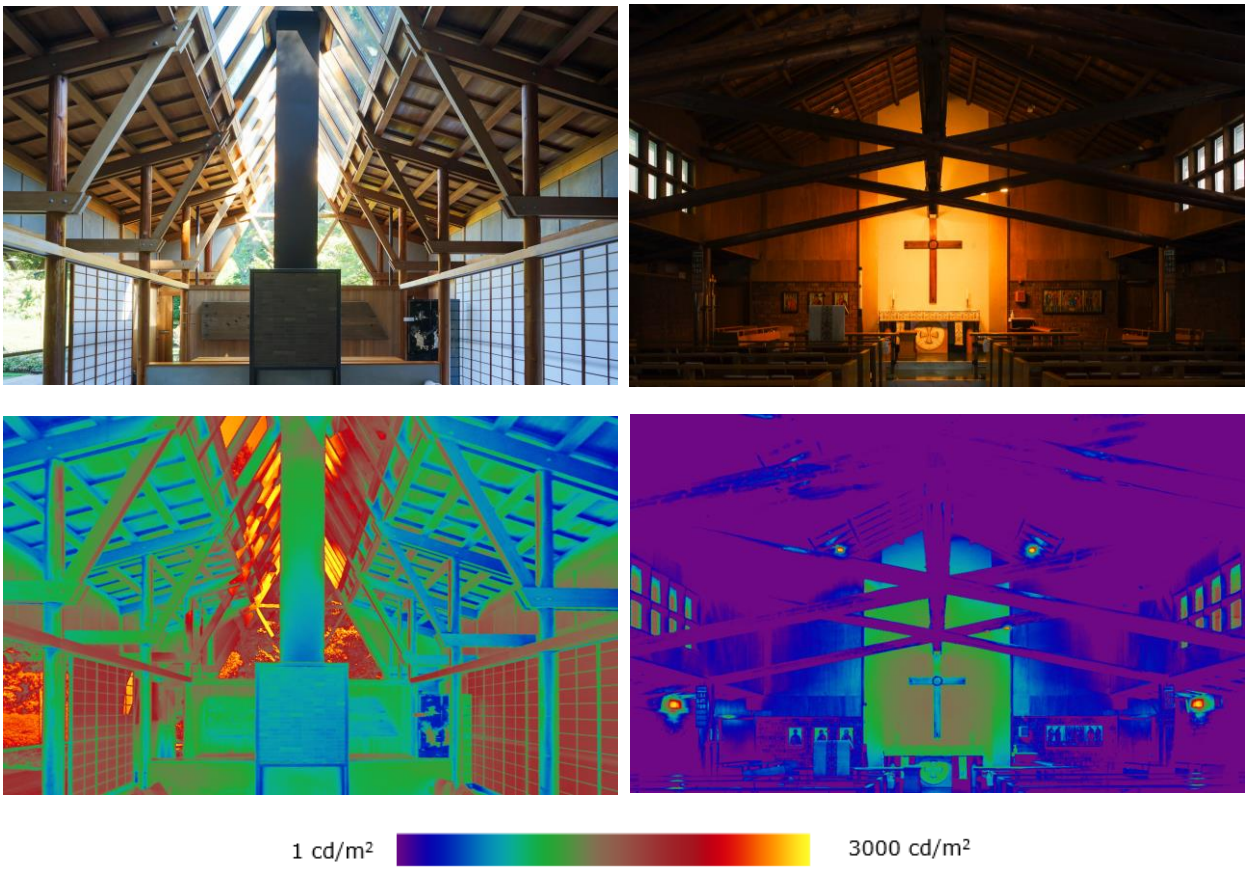



Figure 43. Japanese Guest House in Seattle (left) and Saint Alban's Church (right) in HDR photo (top) and false-color image (bottom).


Figure 44. Photographing Grace Episcopal Church.

# Chapter 3: Methodology

The thesis project starts with research on lighting design approaches of historic Japanese architecture. I collected lighting data of existing buildings by manually making HDR photos and generating lighting data. The findings from the research were then explored through a design project: a specialized art camp for children in Discovery Park.

The concept exploration began with abstract sculptures and drawings. After finding a common pattern between iterations, I created a parameter for the massing studies to explore study placements of lights, shadows, and programs. Afterwards, interior lighting design of a library, an art space, and

classrooms proposes strategies to allow students to experience the impermanence of daylight and people.

## Section 3.1: Lighting Data Analysis using HDR Photos

HDR photos of historic Japanese architecture were taken during the day to generate daylight analysis. False-color luminance images present detailed properties of the lights and shadows present in the photographed interior space.

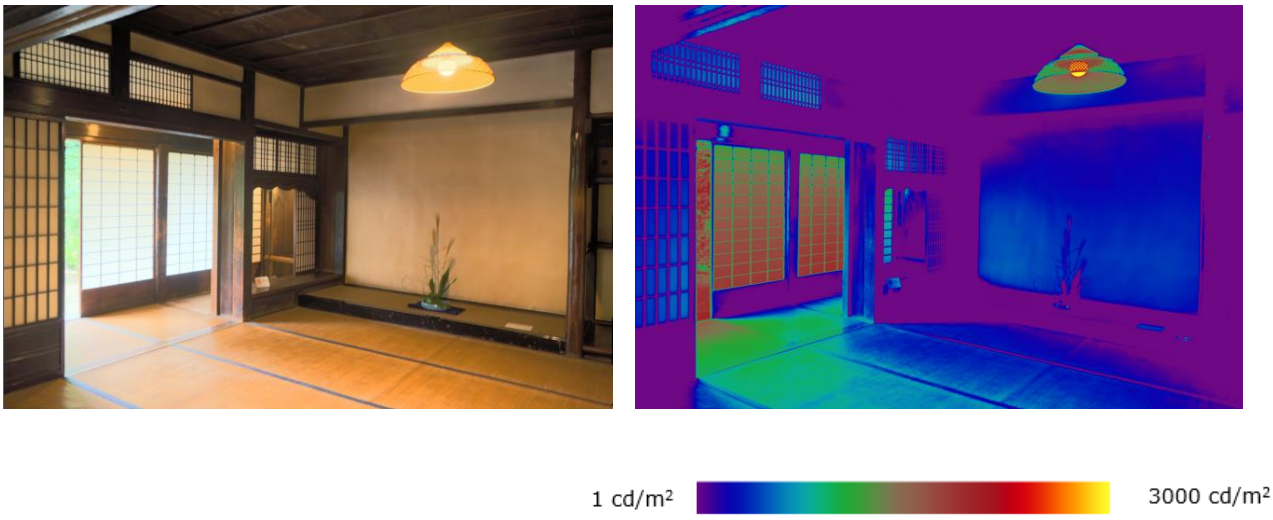
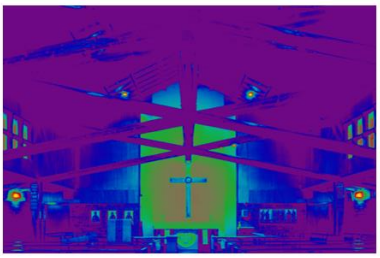
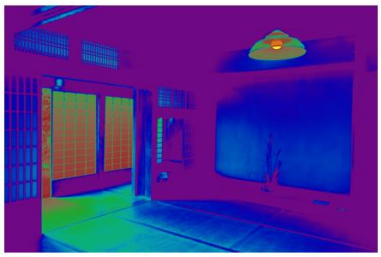



Figure 45. HDR photo (left) and false-color image (right) of Yanohara House.

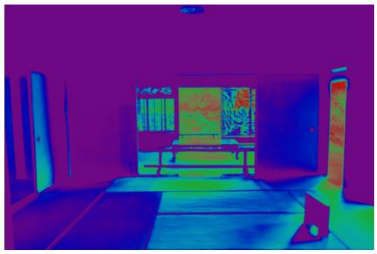
I visited several buildings in Tokyo and Seattle to collect data on the lighting conditions. By taking photos of interior spaces with the settings specified below in the HDR Photo Procedure, I manually made HDR photos on Photosphere. Afterwards, I saved them as HDR files and imported them into HDRScope to generate lighting data.



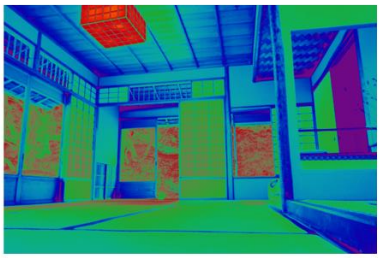
Saint Alban's Church
Tokyo



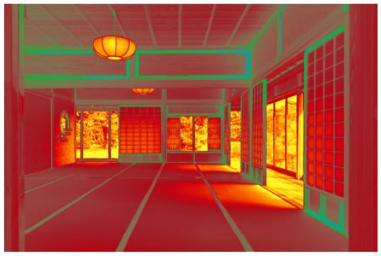
Yanohara House
Tokyo



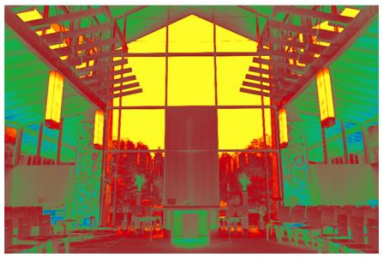
Hara House
Tokyo



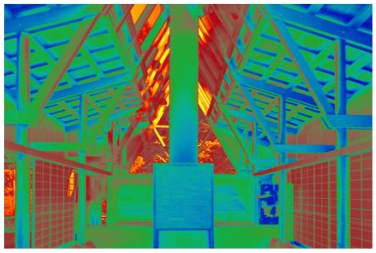
Kouka House
Tokyo



Matsu-No-Ochaya
Tokyo



Grace Episcopal Church
Seattle



Japanese Guest House
Seattle


Figure 46. Building precedents of the daylight research.

## HDR Photo Procedure

To take photos to convert to HDR photos manually, I set my DSLR camera on a tripod and took photos with the following settings:

- Aperture f/11
- Daylight white balance
- ISO 100
- Taking a photo at each shutter speed
- Avoiding capturing people and motion

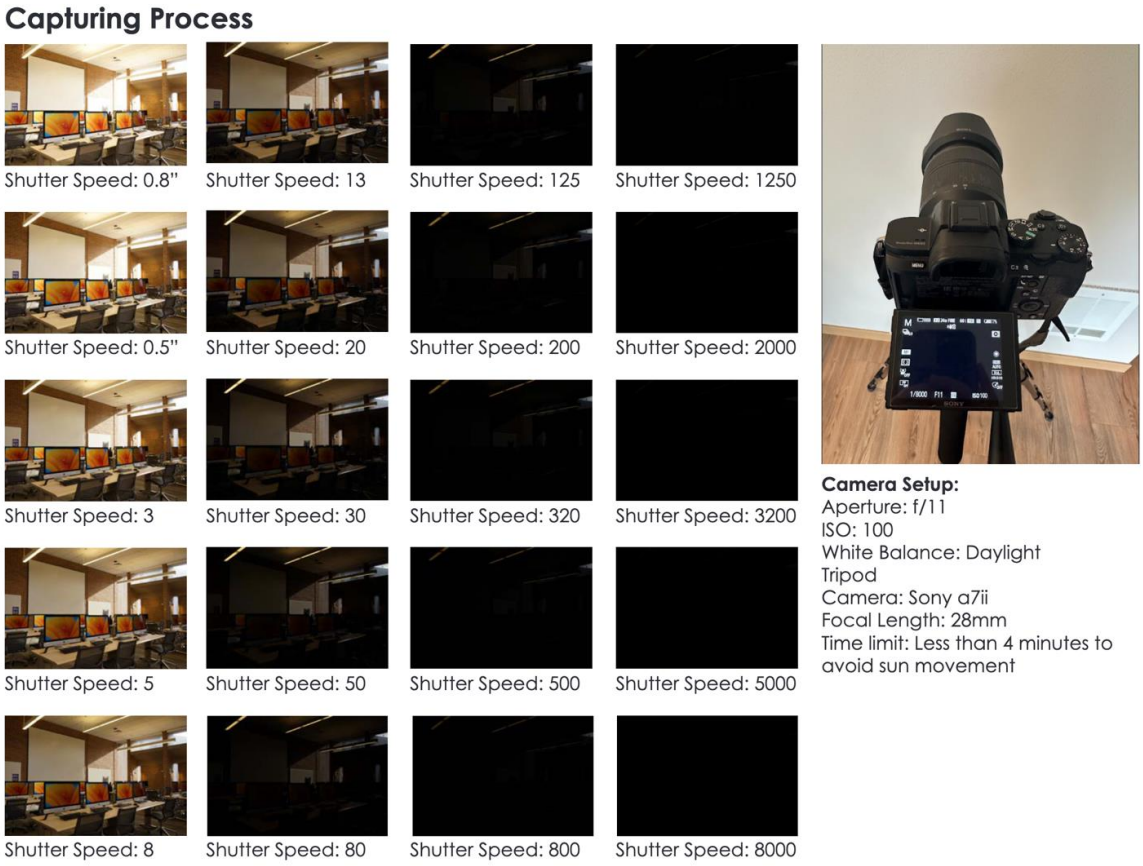



Figure 47. HDR photo capturing process.

## Section 3.2: Computer Simulation of Lighting Design

The computer simulations of my massing studies and interior lighting designs estimate the lighting conditions of the intended light and shadow designs. I generated diagrams on the computer-aided design (CAD) software Rhino and a Rhino plug-in called Climate Studio. The following are tools from Climate Studio used in this project: Point-In-Time Illuminance, Site Analysis, and Radiance Rendering.

### Point-In-Time Illuminance

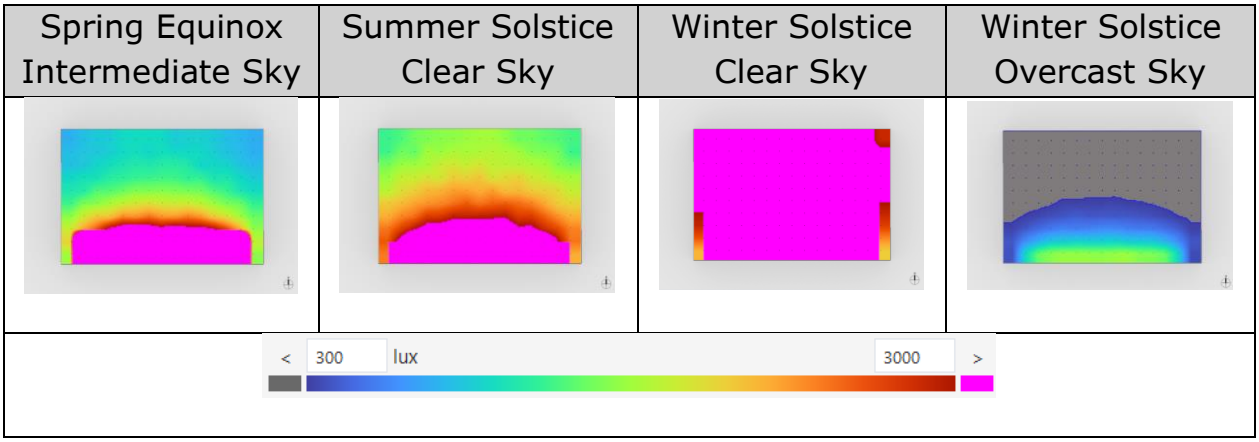



Figure 48. Point-in-time illuminance simulation examples.

Point-In-Time Illuminance shows the illuminance level of each sensor on a work plane that is either on the floor or offset to the height of the table surface, depending on the use of the space. Magenta shows overlit (glare) areas and gray shows the underlit areas.

## Site Analysis

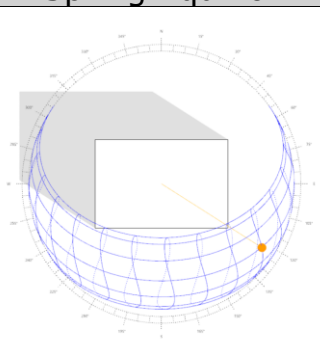
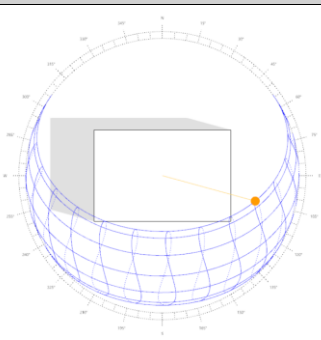
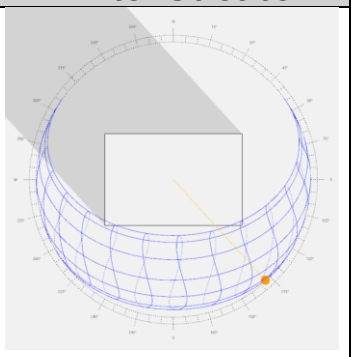
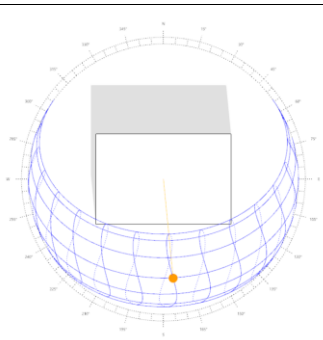
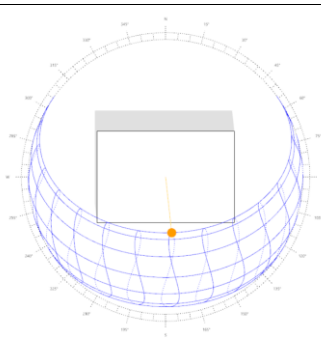
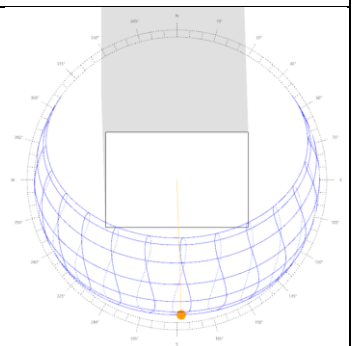
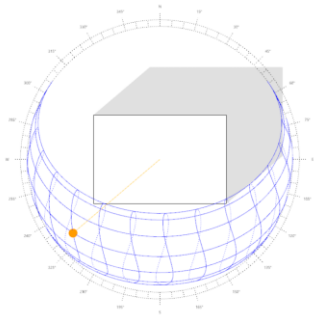
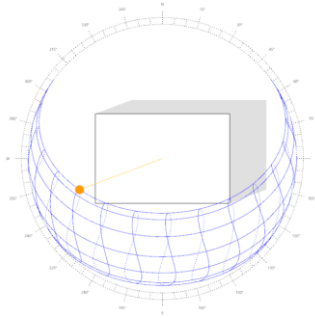
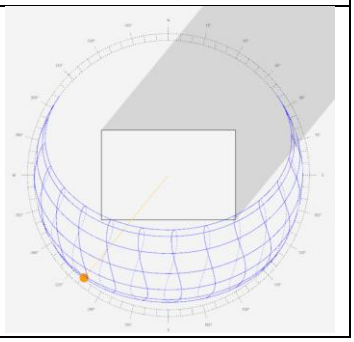
| | Spring Equinox | Summer Solstice | Winter Solstice |
|---|---|---|---|
| 9AM |  |  |  |
| Noon |  |  |  |
| 3PM |  |  |  |

Figure 49. Site analysis simulation examples.

The shadow studies at different times of the day and year assist in visualizing the shadows from the building. When considering program arrangements, shadow studies help identify areas of the site with more daylight.

A site diagram shows the change in shadows between sunrise and sunset. This is helpful when studying the shadows from shades, building massing, and vegetations in the landscaping.

**Radiance Rendering**

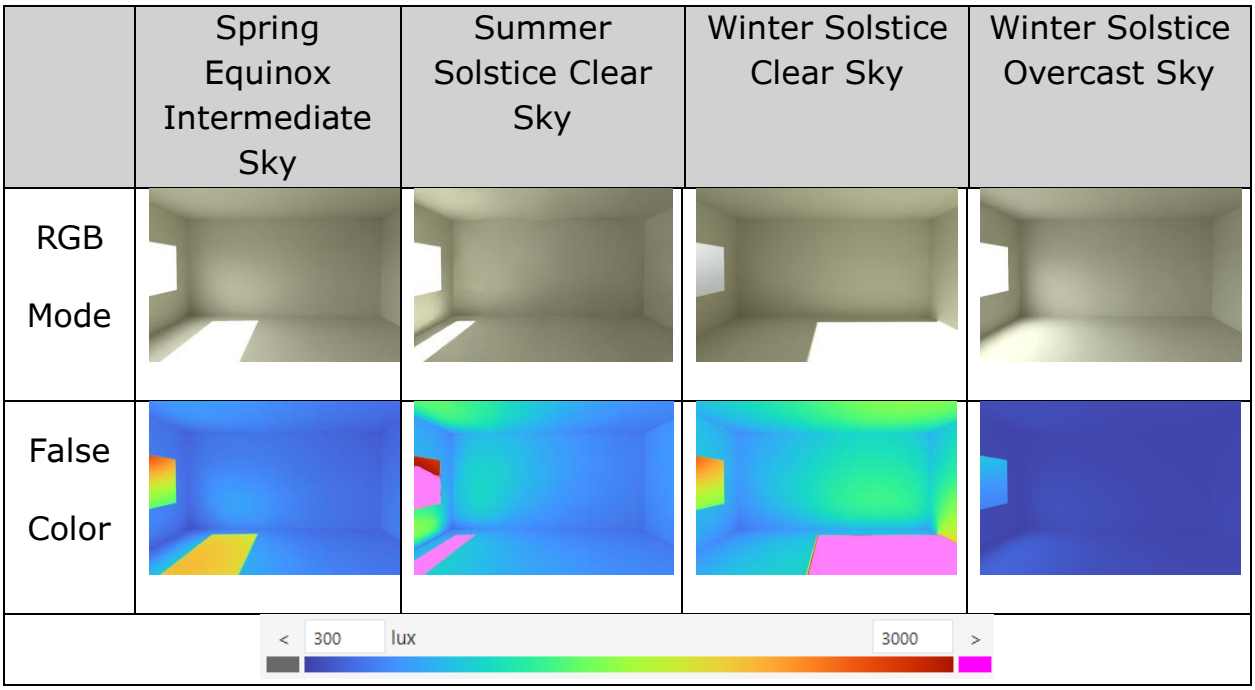



Figure 50. Radiance rendering simulation examples.

The Radiance Rendering is a one-point perspective of luminance to help visualize the relationship between material surfaces and daylight on the specified time, region, and weather. The RGB mode is useful for realistic renderings, and the false-color mode helps visualize the lighting conditions and highlight the overlit and underlit areas of the room.

**Window to Wall Ratio**

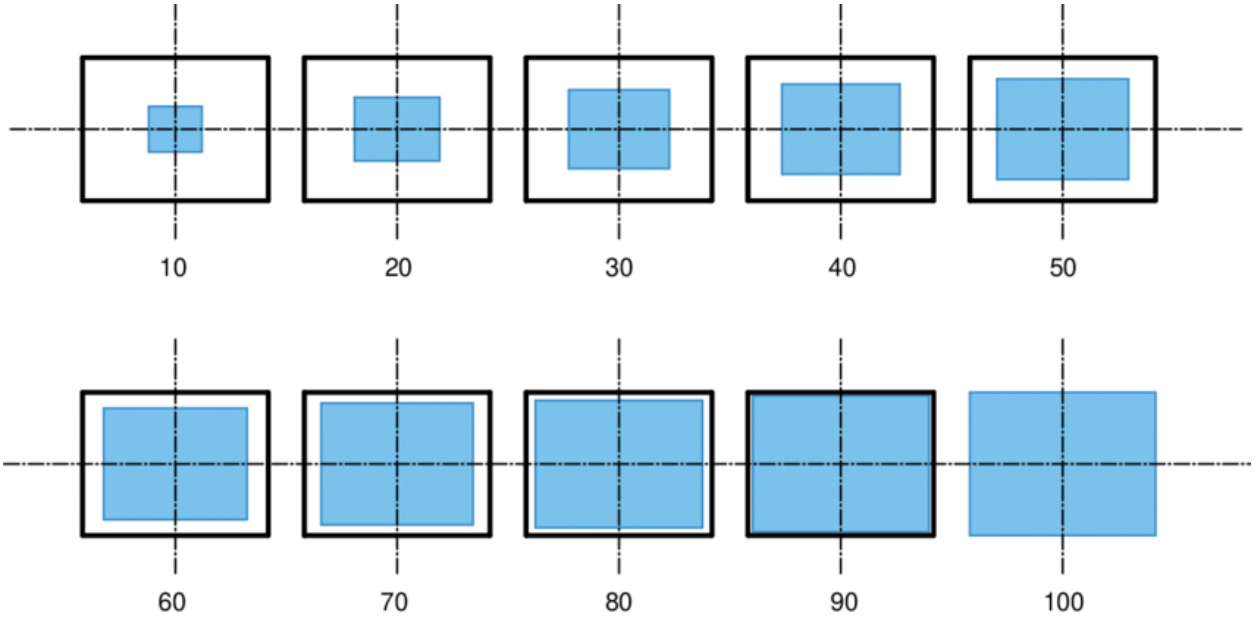



Figure 51. Ochoa, Carlos Ernesto, et al. *Examined window size variations, Amounts expressed in percentage window-to-wall ratio (WWR).* 2012, fig. 3.

The set glazing material for windows is clear double-glazing. To adjust the amount of daylight entering the room, I chose the window-to-wall ratio based on the program type and activity occurring in the rooms.

## Custom Translucent Materials

The texts of a radiance file for custom-made translucent materials are generated on Radiance Trans Material (see fig. 52).[12]

To import the radiance file into Climate Studio, I copied and pasted the text onto the Note app and saved it as a radiance file. Afterward, I added the folder path in Manage Radiance Material Libraries in the Radiance Rendering Select Material window to load the custom-made translucent materials on Climate Studio.

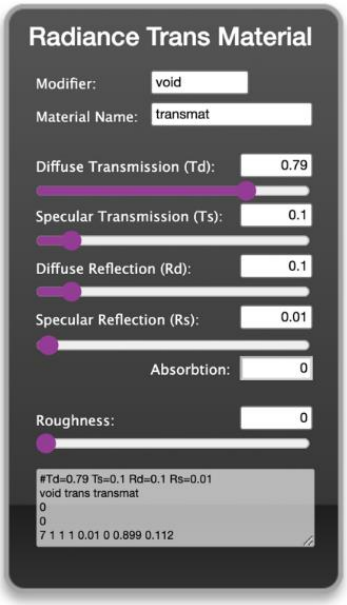



Figure 52. Radiance Trans Material, n.d. https://gaia.lbl.gov/people/andy/public/transwidget.

Custom made Specular Transmission: 0.01, 0.05, and 0.075, double glazing

Control variables:

- Diffused Transmission: 0.79
- Diffused Reflection: 0.1
- Specular Reflection: 0.01
- Absorption: 0.39
- Roughness: 0

[12] Radiance Trans Material, n.d. https://gaia.lbl.gov/people/andy/public/transwidget.

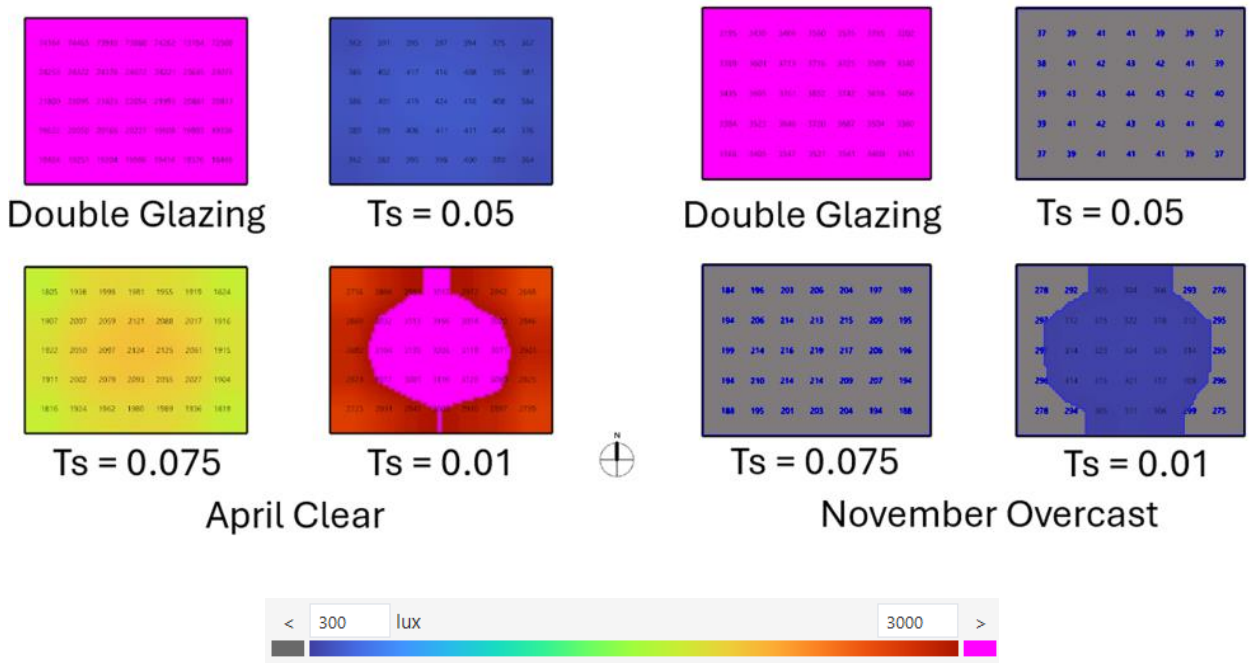



Figure 53. Point-in-time illuminance simulations of different specular transmission levels.

Figure 54. Discovery Park

# Chapter 4: Design Framework

I demonstrated the lessons on the approaches and principles of lighting design from historic Japanese architecture as I designed a specialized art camp for children in Discovery Park.

Historically Japanese culture expresses a huge appreciation for impermanence. The word *wabi-sabi* translates to the appreciation of impermanence and imperfection. The Japanese culture values change because nothing is permanent. Unlike the West, where buildings are designed to try to be permanent, Japanese architecture is designed to be fixed and temporary due to the frequent natural disasters. They accepted

the impermanence of physical buildings by expressing change in time through daylight and nature.

## Section 4.1: Lessons Learned from Japanese Architecture

Japanese architects treated both light and shadow as two materials that complement each other's distinct beauty. The dimly lit space of historic Japanese architecture was achieved by keeping dark shadows in space to emphasize the change in daylight. Its beauty was highlighted through the use of materiality, Japanese architectural elements, and interior decor. Shadows emphasized a different form of beauty in architectural elements that only the darkness can reveal.

### The Floor is the Brightest and the Ceiling is the Darkest

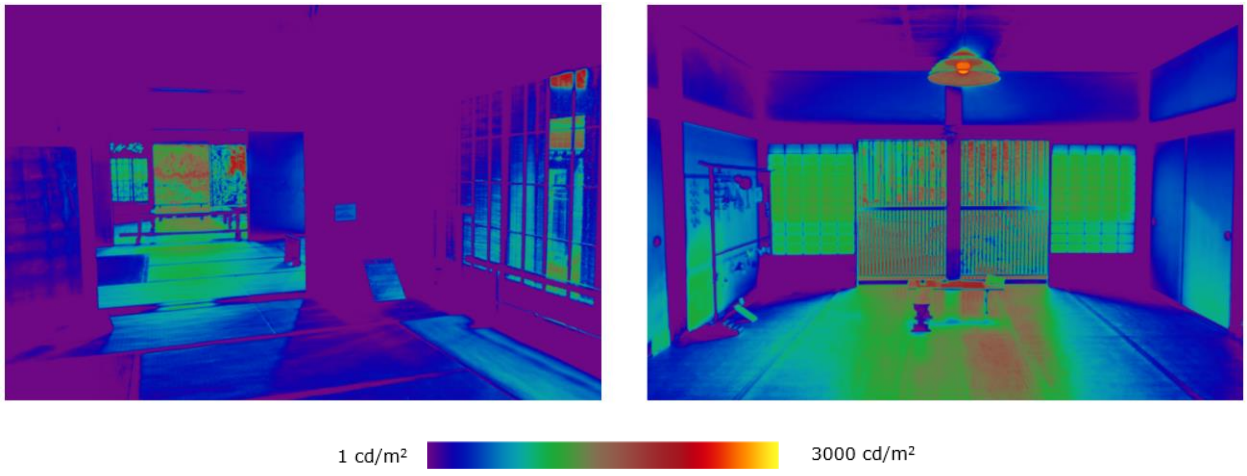



Figure 55. False-color image of Hara House (left) and Yanohara House (right).

As we can see in the false-color analysis of the Hara House and Yanohara House (see fig. 55), the floor is the brightest surface and the

ceiling is the darkest surface in historic Japanese architecture. Contrarily the ceiling is the brightest and the floor is the darkest in contemporary architecture. Historically Japanese people used to sit on the floor as they culturally normalized doing social gatherings, meetings, and daily routines on the floor without any furniture, and so Japanese architecture kept the shadows in the ceiling to present the change in daylight and the light only on the floor.

**Subtle Gradient of Shadows**

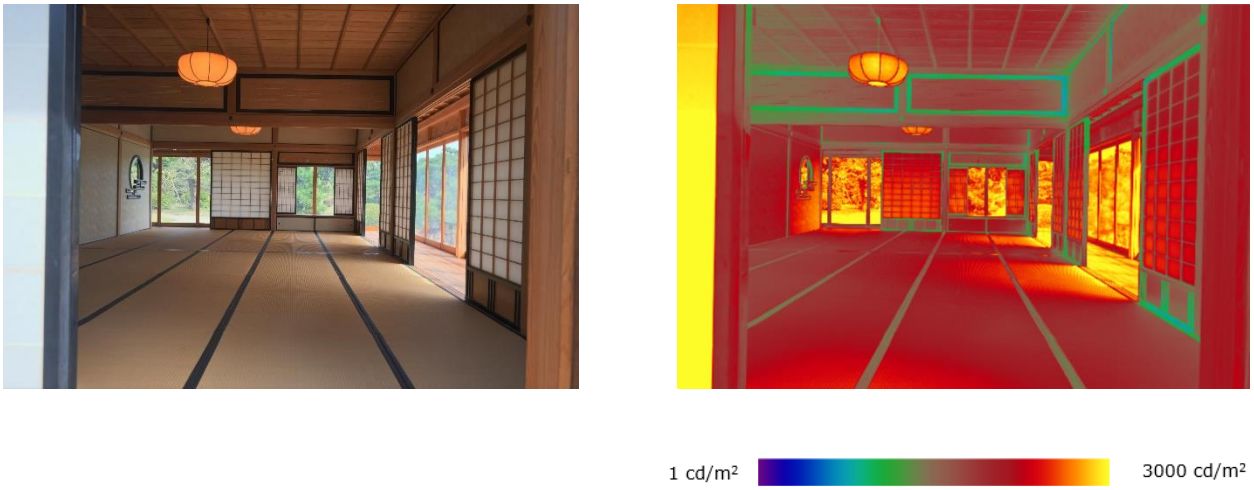



Figure 56. HDR photo (left) and false-color image (right) of Matsu-No-Ochaya.

The shadow looks sharp in the corridor with wooden flooring, but the shadow has a gradient when the harsh light reaches tatami (see fig. 56). The sunlight loses its intensity when it hits the floor of the corridor that

frames the room. The light entering the room is reflected off the wood floor finish, preventing glare caused by the harsh sunlight in the room. Then, the texture of tatami makes natural lighting diffuse on the floors. The texture of the woven rush grass scatters the shadow, making the light even less sharp and appear diffused.

### Comforting Narrow Range of Light Level

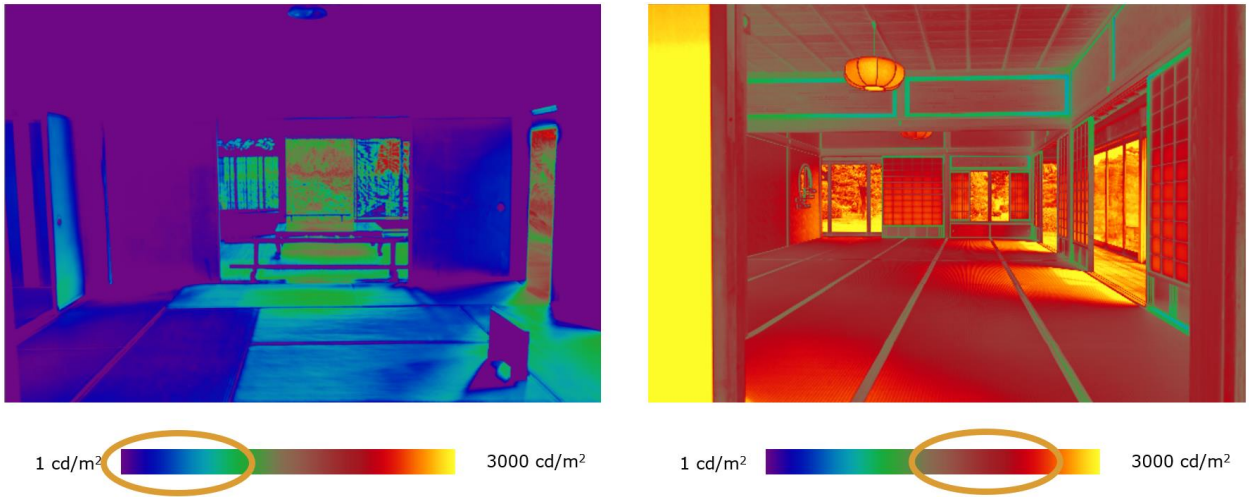



Figure 57. HDR photo (left) and false-color image (right) of Matsu-No-Ochaya

Despite having a high contrast of shadows, the range of the light level is narrow. A high range of the light level would be uncomfortable because the eye would need to quickly adjust to drastically different light levels. The low range of the light level present in historic Japanese architecture satisfies

our desire to see a variation in light without causing discomfort in our visual experience.

### Surrounding Rooms with Shades and Filters

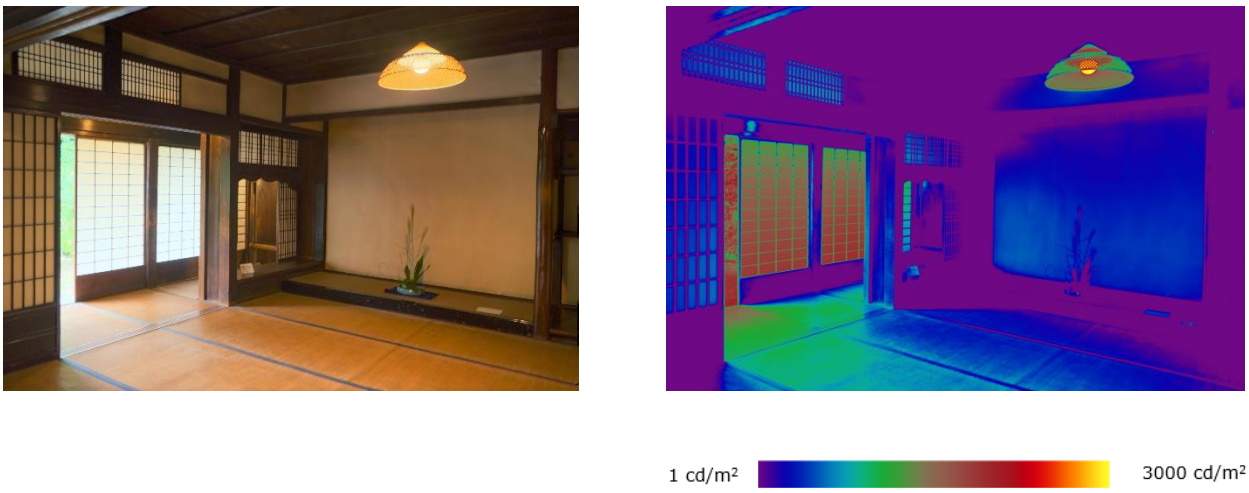



Figure 58. HDR photo (left) and false-color image (right) of Yanohara House.

A shoji is the brightest part of the room, and an alcove is the darkest part of the room (see fig. 58). The pale, white paper juxtaposes the darkness with its soft glow of natural light. Shoji has the property of filtering natural light into a soft glow and activating cross-ventilation by sliding the panels open and accepting the sound from the outside. Its overall presence in the room makes the space look airy and brighter.

Historic Japanese homes have exterior overhangs and corridors framing the rooms. There is an opening with wood shading on the alcoves of

the corridor to bring in diffused natural light from above (see fig. 59). As we move further away from the corridor and into the central part of the building, there is less natural lighting. Sunlight loses its illuminance after passing through the garden to travel beneath the eaves and through the corridor.

By the time it reaches the center of the building, the sunlight appears to be powerless, draining away the complexity of life as it dimly shines in the central space. The amount of light that can reach the room is low enough for the daylight to go through dramatic changes without causing glare concerns, regardless of the time of the day, season, or weather.

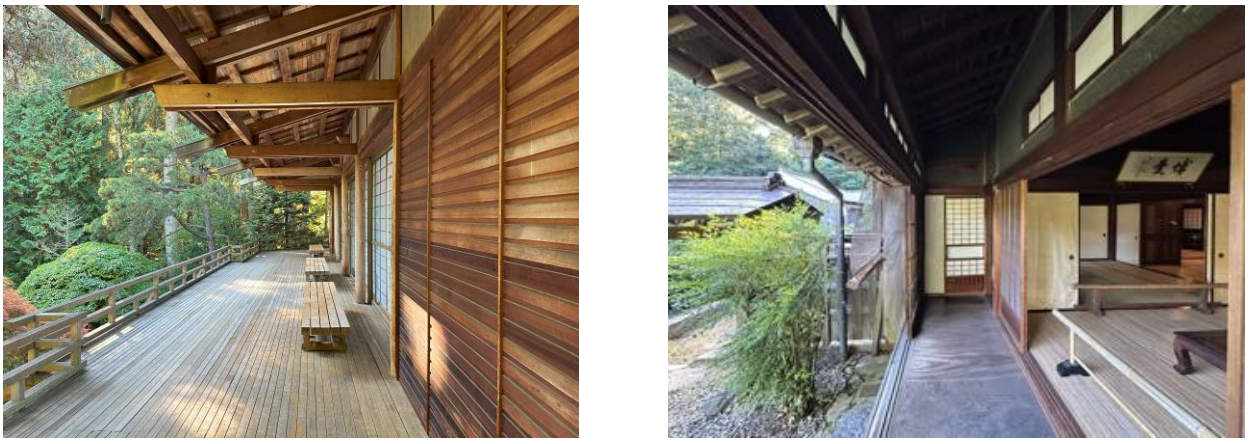


Figure 59. Overhang in Japanese Guest House (left) and corridor in Hara House (right).

## Connecting with Nature from the Room

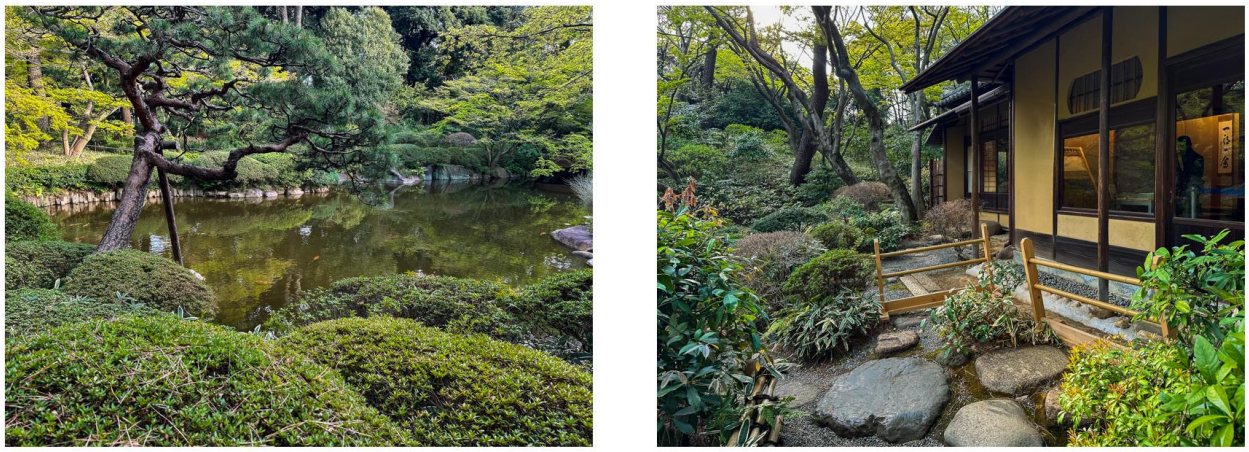


Figure 60. Kouka House landscape.

Historic Japanese architecture is surrounded by a landscape full of vegetation. The large windows offer a view of the change in season and light filtered through the surrounding trees. The shadows from the plants change as the wind blows, daylight shifts, and leaves change their colors and shape.

## Seeing Changes in Daylight without Leaving the Building

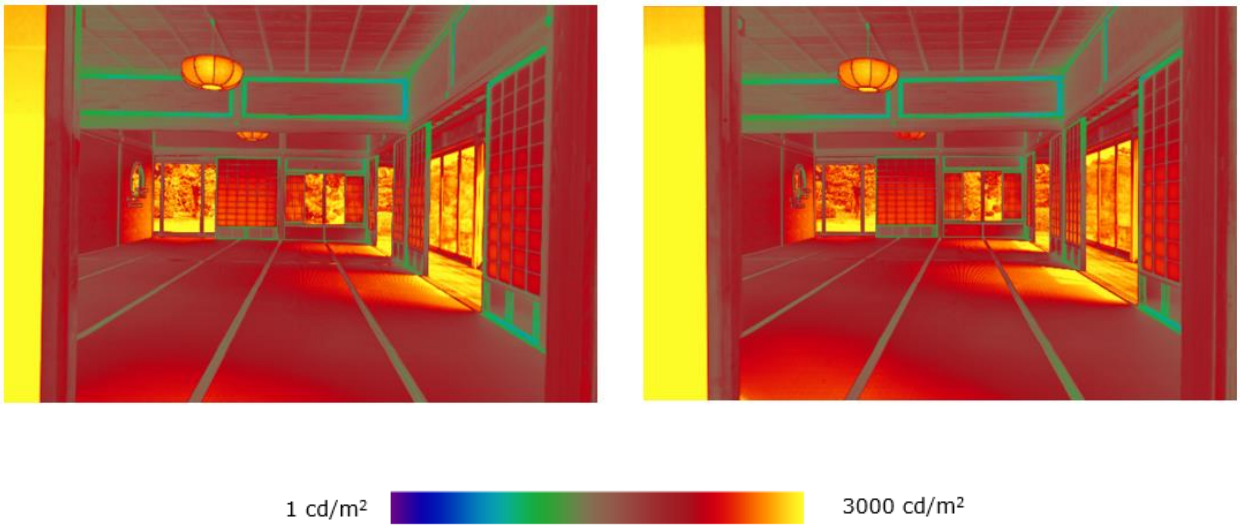



Figure 61. False-color imags of Matsu-No-Ochaya in autumn (left) and spring (right) at noon.

Throughout the year, the intensity of the daylight changes as the Earth orbits around the Sun. The light in autumn appears brighter than the light in spring, but the light in spring appears sharper. With the seasons, nature changes. Trees lose their leaves in the autumn and grow them back in the spring. There are less shades from trees in the autumn and winter when the sun cycle is shorter, and there are more shades in the spring and summer when sunlight stays in the sky longer.

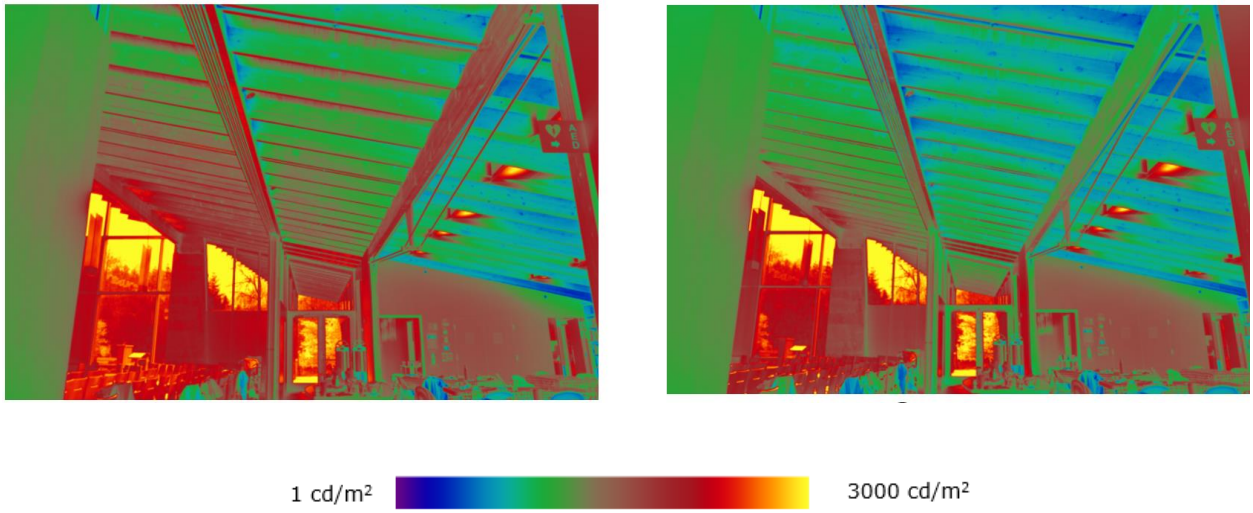



Figure 62. False-color images of Grace Episcopal Church under clear sky (left) and overcast sky (right).

As the daylight changes the shadows on the wood texture, the subtle shift in the weather and time are visible on the wood finishes. Users can experience the change in the exterior surroundings, without leaving the building by observing the light and shadows in indoor spaces.

## Allowing Users to Easily Adjust the Light Level

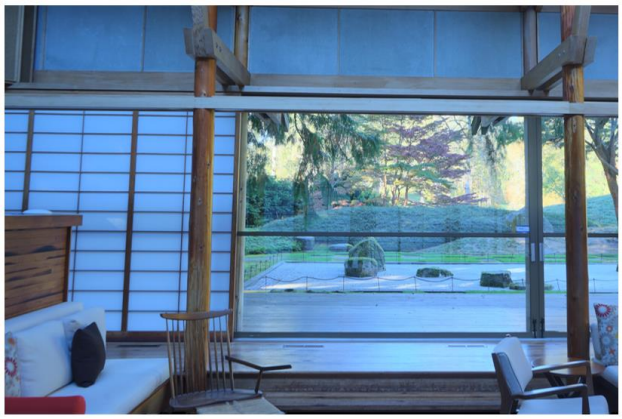


Figure 63. Shoji in Japanese Guest House.

Figure 64. Lamp in Yanohara House.

It is easier to accept the presence of daylight in a room when the user has control over the light level. When daylight causes discomfort, we block it out of the room by completely closing the shading device. Sliding shoji panels on the window allow users to adjust the brightness of daylight depending on the weather and the activity occurring in a space.

There are times, like on overcast days or at night, when there is not enough lighting to use the space for the desired tasks. While using daylight as the primary source of light is desirable, artificial lighting should provide supplemental lighting on dark days and at nighttime.

## Structures and Ornaments Add Contrasts to Light and Shadows

The structure of historic Japanese architecture is hidden in the darkness of the ceiling to add a pattern to the shadows. The wood textures on the beams, columns, and the panels add lines of the wood grain texture to the shadows to add further details to the shadows. With highly complex shadows, a subtle change in natural light can drastically change the shadows on the structural systems.

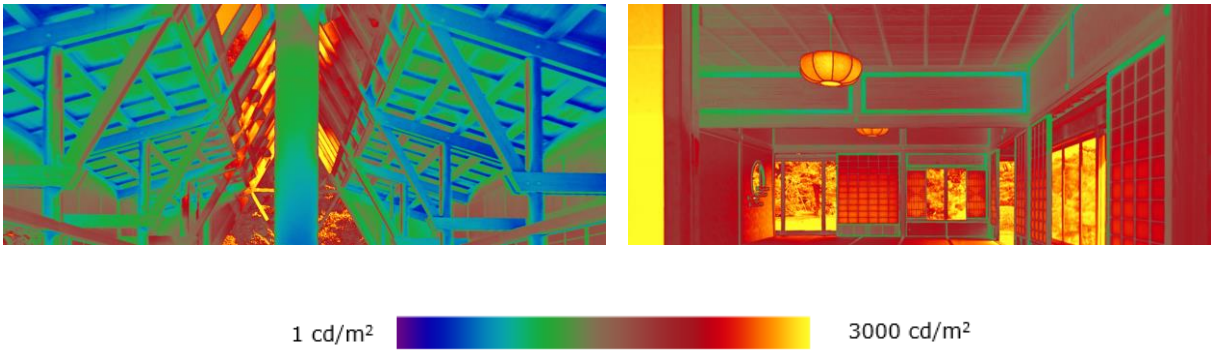



Figure 65. Wood ceilings of Grace Episcopal Church (left) and Matsu-No-Ochaya (right).

The minimalistic interior decorations were carefully chosen to highlight the darkness of the space. Decor, such as scrolls and flowers, are not used as ornaments but rather to emphasize depth to shadows. Scrolls blend into the darkness of the alcoves to highlight the shadows. The flower vase is placed at a proximity to the wall to create a sharp shadow.

Figure 66. Scroll on alcove of Hara House.

Figure 67. Flower in Yanohara House.

The color of the wallpaper also plays an important role in bringing out the beauty of dimly lit spaces. The wallpapers in Japanese architecture are neutral colors to allow dying rays of sun to disappear into the walls. The neutral color minimizes the distraction and brings our attention to the gradient from the natural lighting of the south facing wall (see fig. 68).

Gold shines more magnificently in dimly lit spaces than in brightly lit ones; it should be left in a dimly lit room to let it shine softly under faint light. Its shininess can be seen more effectively in dimly lit rooms. Gold makes its object brighter by reflecting light, but its reflection is less noticeable under a clear sky because its surroundings are brighter than the soft glow of the gold.

Figure 68. Wallpaper in Yanohara House.

Figure 69. Gold in Hara House.

**Seek Opportunities to Experience Change**

Historic Japanese architects found opportunities to enhance change because, like time and natural light, humans are impermanent. The Japanese architectural elements were placed in the shadows to add contrasts that emphasize the shift in daylight. Shadow can be a form of communication that presents the change in light. Darkness allows users inside the building to sense the impermanence of the moment.

But light and shadows do not need to be the only things in space that are impermanent. Nature is impermanent: the weather, vegetation, and seasons. Allowing users to experience the change with nature helps them connect with time and the surroundings. Another impermanent feature of architecture is people occupying the space. People are constantly changing.

Watching other people go through their daily lives reminds us that we are impermanent.

## Section 4.2: Site Analysis of Discovery Park

As a site, Discovery Park has an abundance of existing vegetation and a view of Puget Sound. Residents of the surrounding neighborhood visit to take a break from the busyness of Seattle. Tourists come to visit the famous lighthouse on the coast.

Figure 70: Site photo.

Address: 631 Washington Ave. Seattle, WA 98199

Parcel Number: 1525039042

Lot Size: 77987 sf

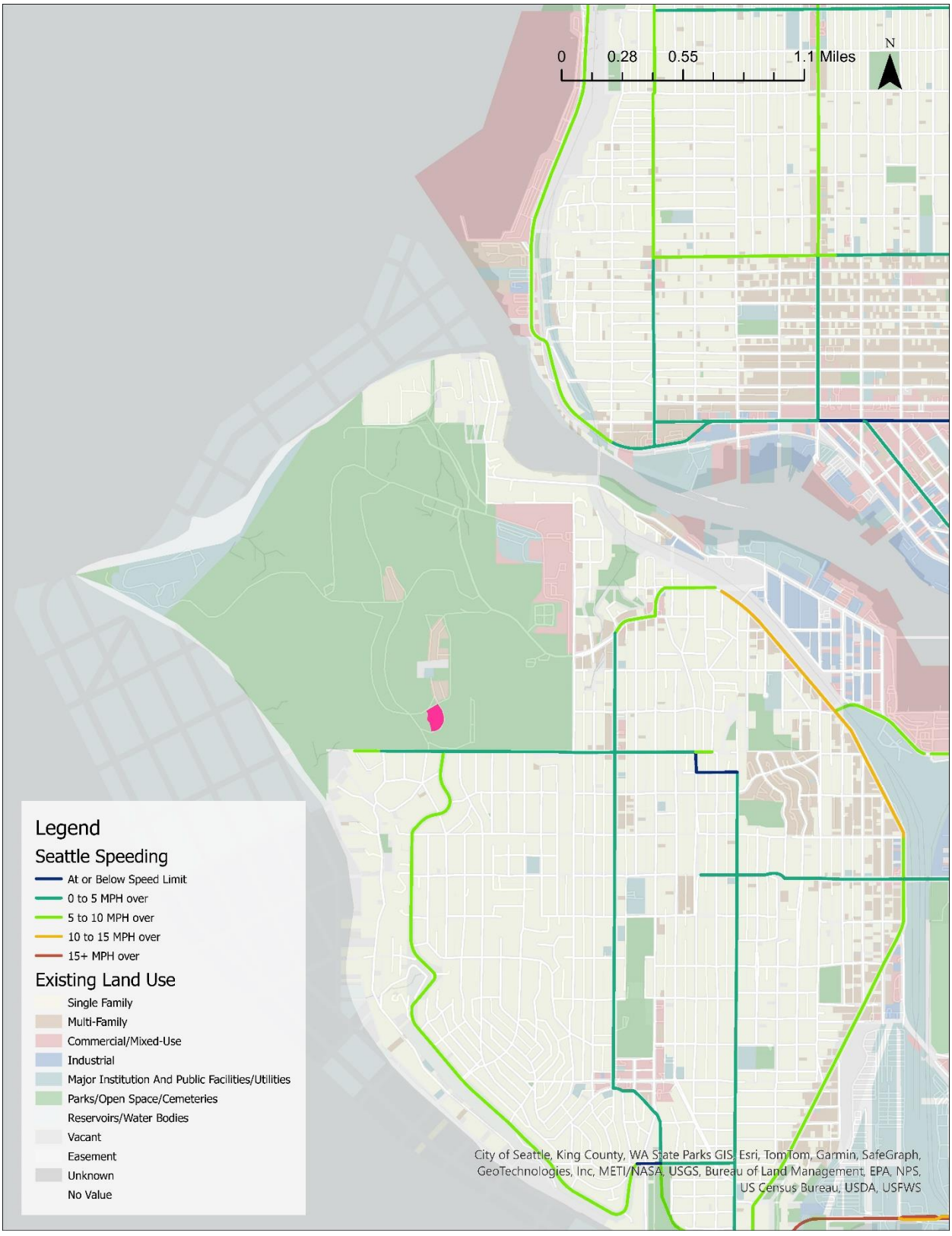



Figure 71. Safety analysis.

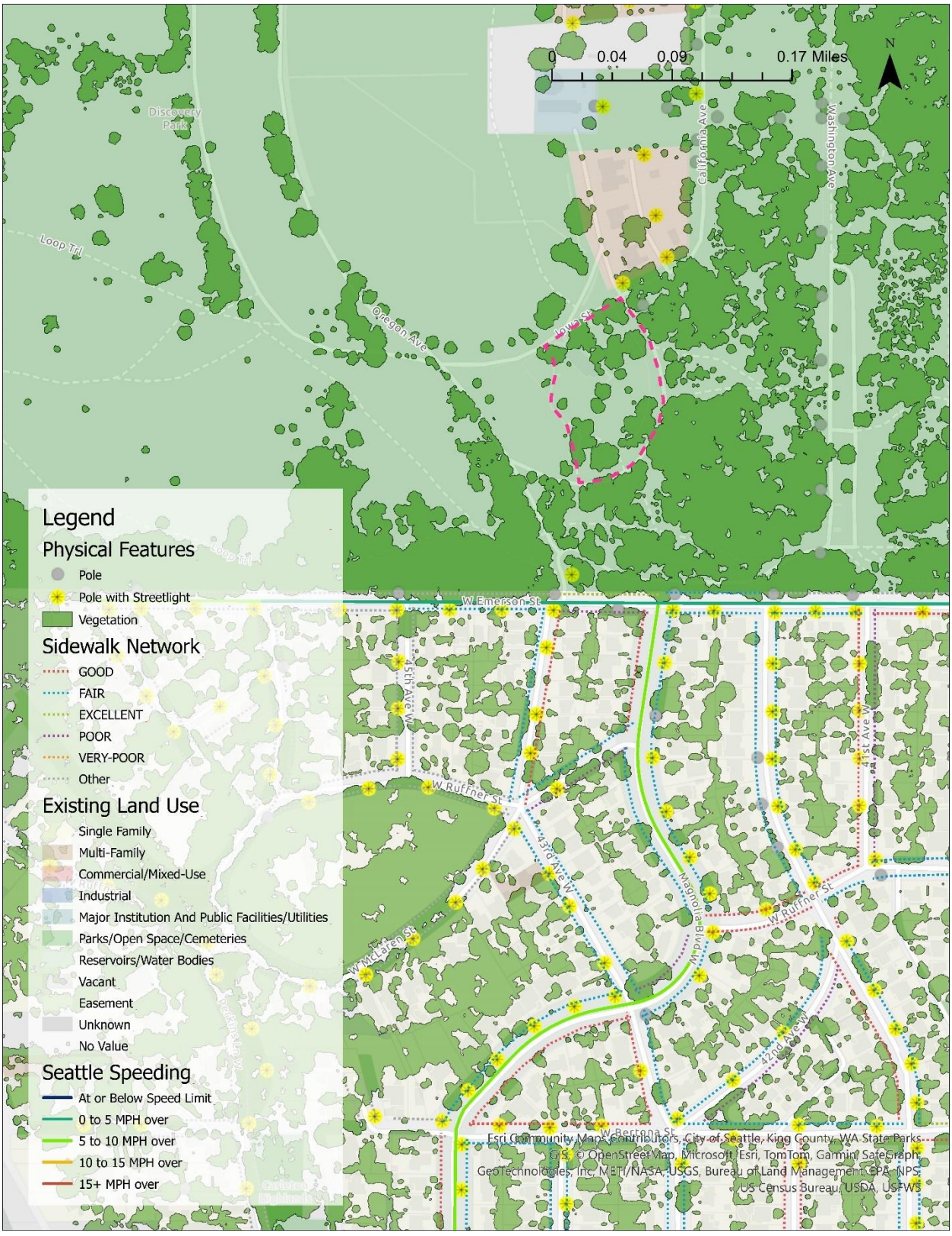



Figure 72. Vegetation analysis.

Figure 71. Aerial views of the site.

**Safe Area within a City of High Crime Rates**

Discovery Park is a safe area to start a specialized art camp for children. The speed limit does not exceed 25 mph and the sidewalk conditions are safe enough for students to walk to school. With many single-family houses around the neighborhood of Discovery Park, many families with children live near the site. This area of Seattle is far safer than downtown. Students can also come here to ease their hypervigilance and destress through art and nature. The sense of safety allows students the freedom to be creative and explore their curiosity.

**Nature of the Pacific Northwest**

With the abundance of trees on site, the existing landscaping offers the opportunity to experience the four seasons of the Pacific Northwest. The specialized art camp is surrounded by the forest of Discovery Park. As the seasons change, the flowers bloom, green leaves turn orange, and snow covers the leafless branches. Children will experience changes through nature.

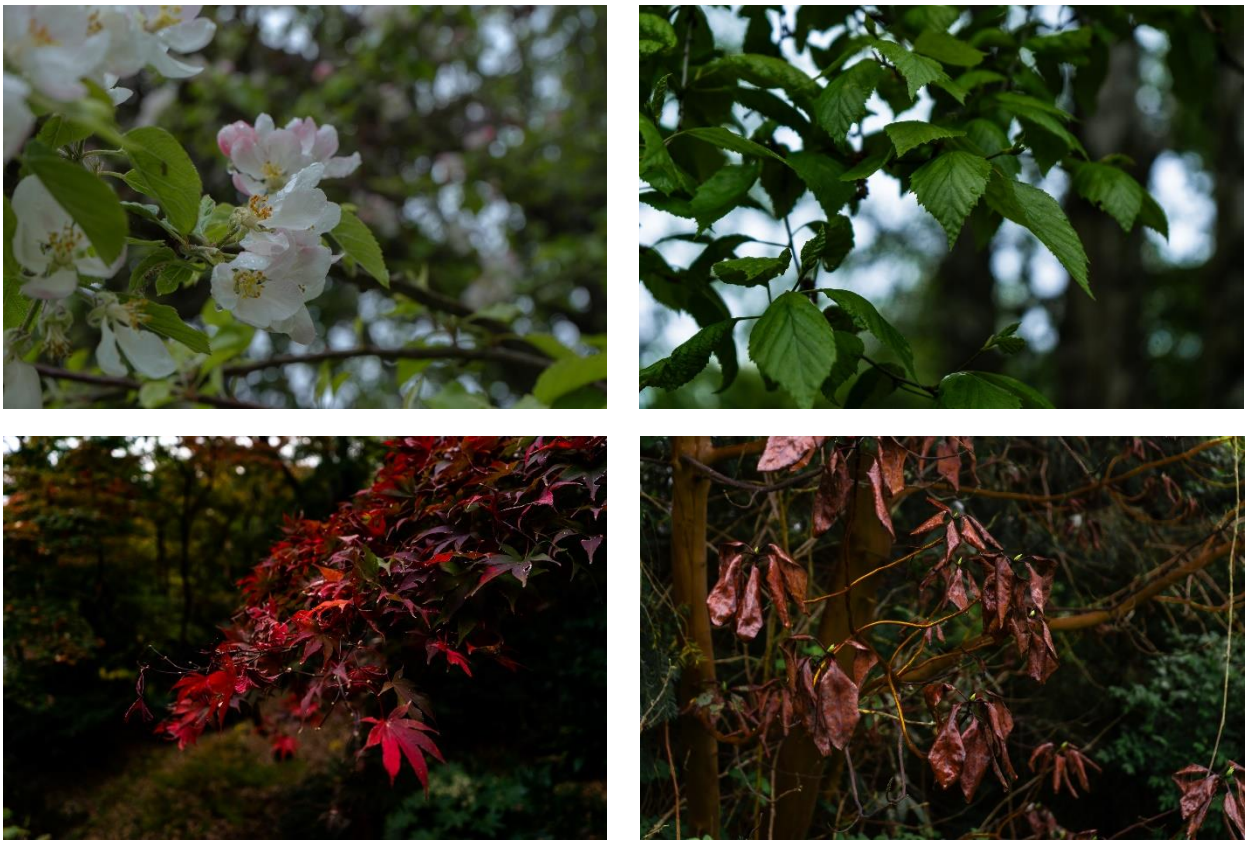


Figure 74. Four seasons of Discovery Park.

## Section 4.3: Lighting of a Specialized Art Camp for Children

The design project explores the possible lighting design of a specialized art camp for children. Children learn effectively though hands-on activities. With a lot of physical movement, it is important to create a lighting condition that can support a variety of activities. This building would offer many opportunities to explore lighting design and the relationship between children, nature, and daylight.

Figure 75. Activities in a specialized art camp for children.

Figure 76. Art space rendering.

# Chapter 5: Design Project

The specialized art camp in Discovery Park is a space for children to discover themselves by experiencing the impermanence of light and nature. With many schools designed to be permanent and increase productivity without considering the wellbeing of students, the goal of this design project is to reject this design approach to remind students that everything is continuously changing. Going through every day of our lives expecting ourselves to be permanent is harmful when we ourselves are impermanent. Children should be in an environment that teaches them to go through every moment, valuing the impermanence of both the present moment and human life.

## Section 5.1: Light and Shadows in Specialized Art Camp

The initial step of the massing studies is exploring the presence of light and shadows in a specialized art camp using origami. Origami is the art of folding paper from the Japanese culture. Children play with origami by cutting leftover papers into a square and folding it into a 3D model of their favorite animals.

Once folded, it will never return to its original form of being a smooth sheet of paper. Light and shadows on the creases are a record of the journey from folding a paper into a strong structure.

Figure 77. Origami folding process.

Like a child, I folded the paper until it resembled a single-story building. Like molding clay, I adjusted the shape until achieving the desired form. The paper is stronger in areas with more folds because the paper is denser. To form those structural supports, the areas around them were

unfolded to resemble a single-story building. As a result, under a direct light, the model has a gradient of shadows around the parts that are structurally stronger. The folded areas have sharper shadows, and the surrounding unfolds cast a subtle shadow.

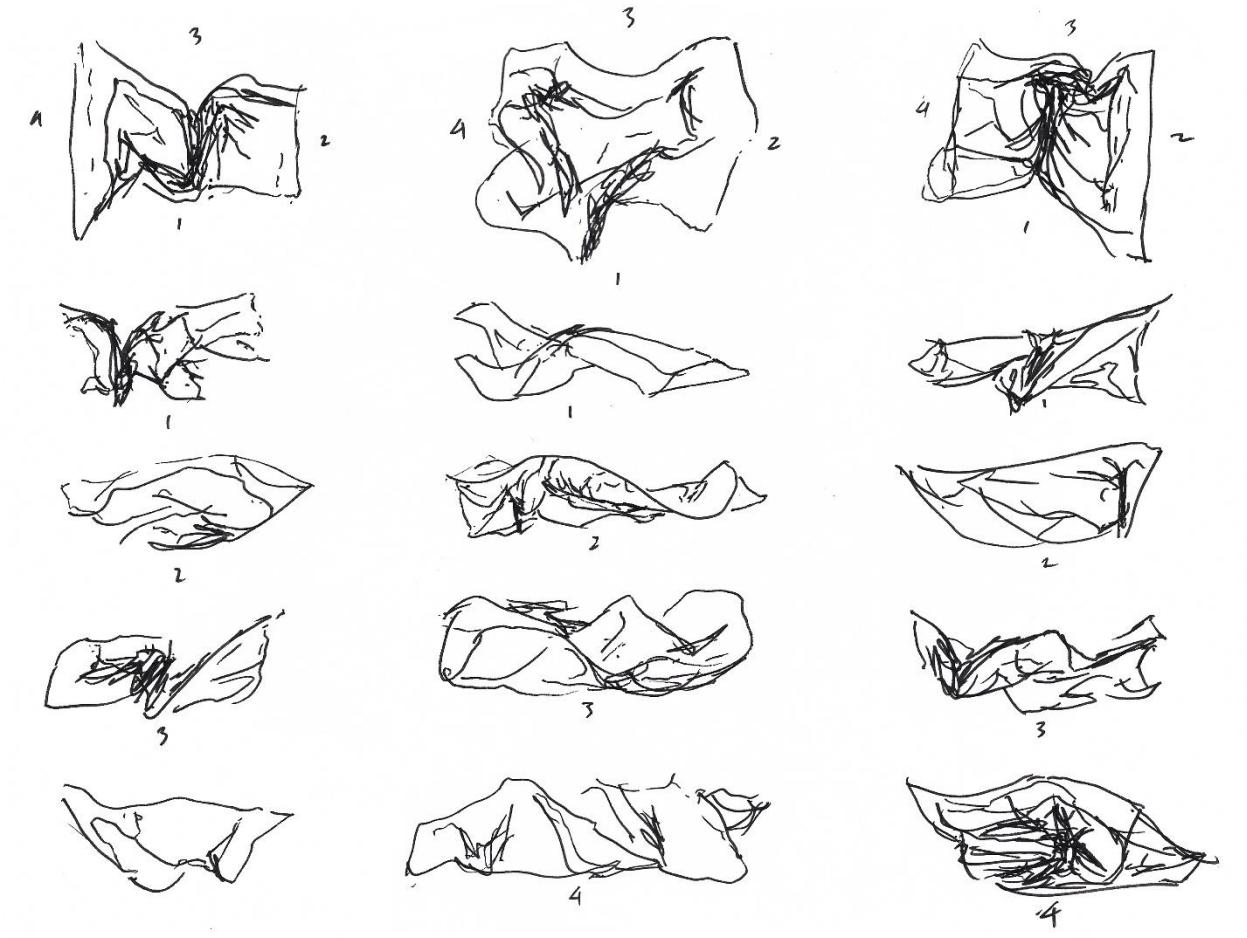


Figure 78. Origami folding process pen sketches.

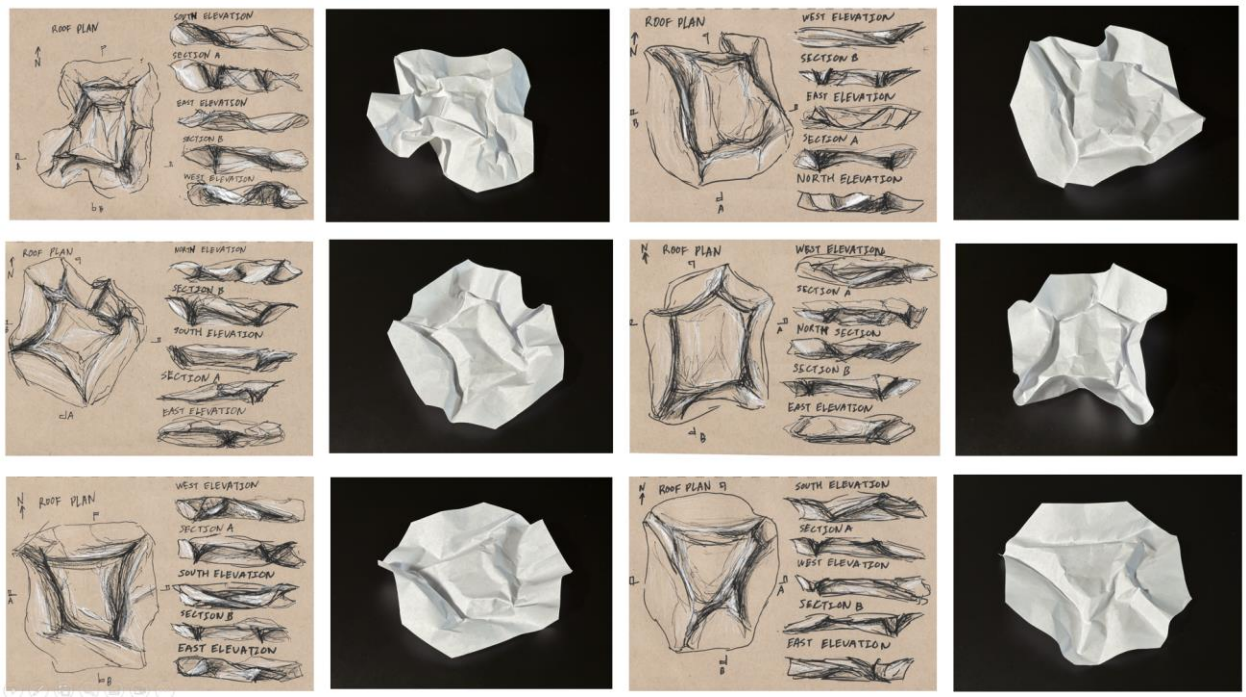



Figure 79. Origami folding process shading sketches and 3D models.

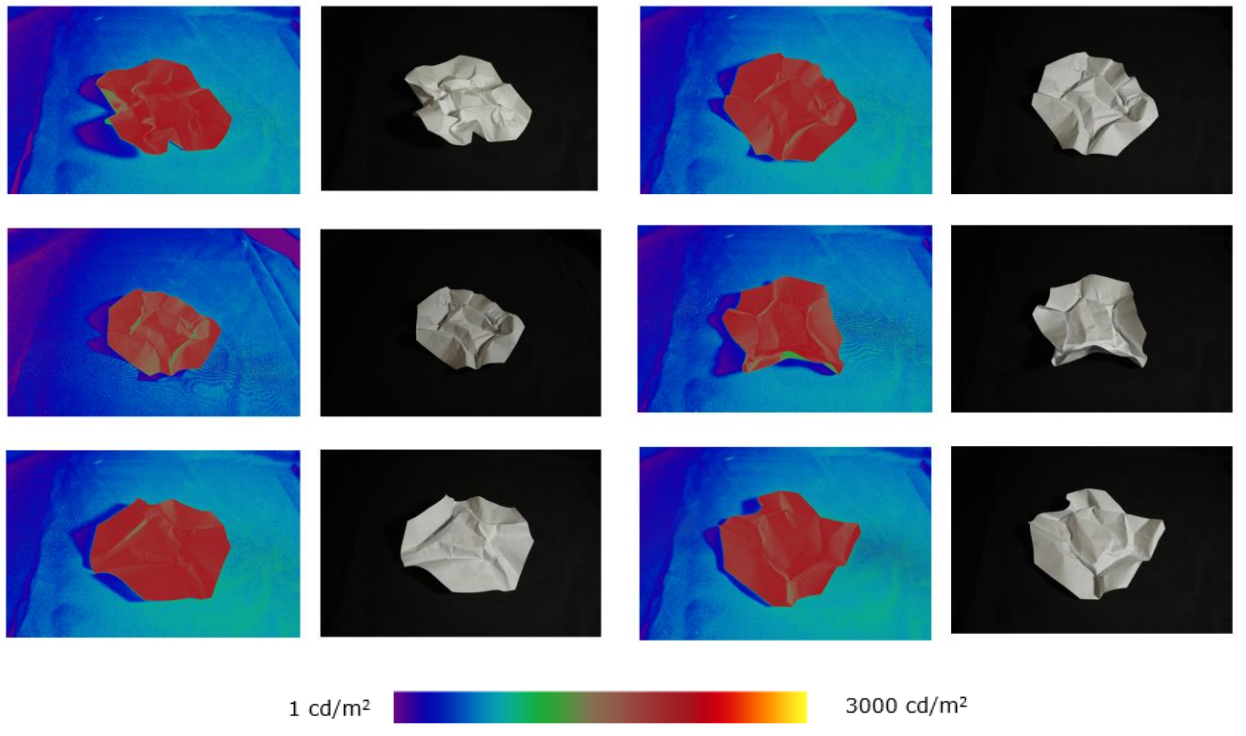



Figure 80. False-color images of 3D models.

**Parameter**

After discovering a common pattern in all the models and drawings, I created a parameter for the floor plan. As seen in historic Japanese architecture, the less important elements of the building are hidden in the darkness to add more contrasts between light and shadows. Thus, they gain the purpose of making dimness beautiful through a variation of darkness.

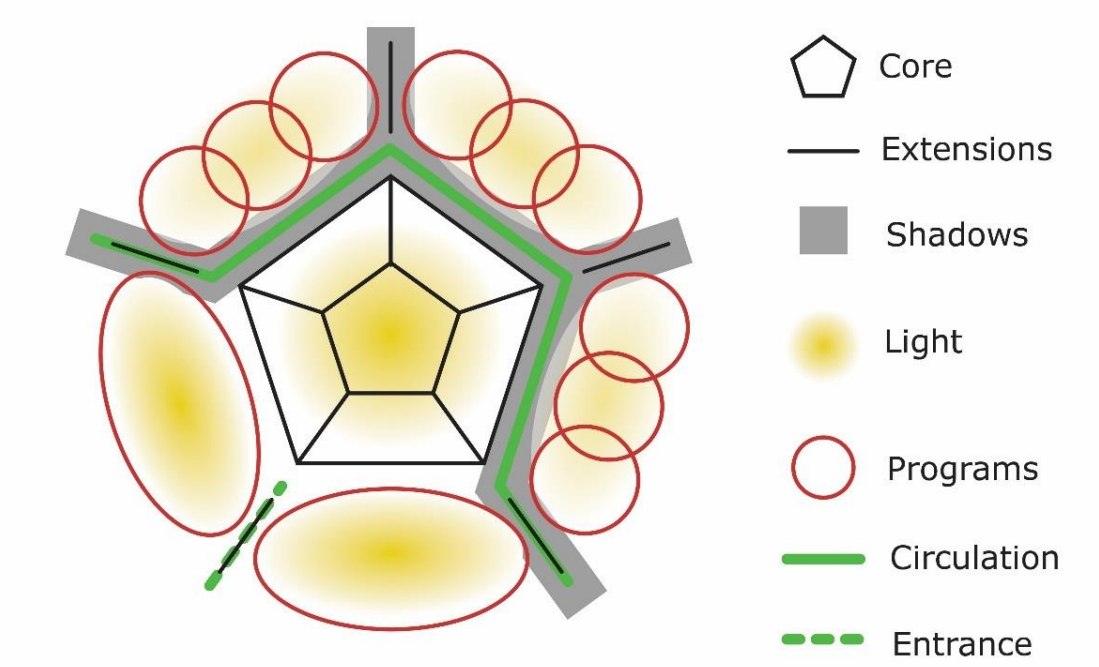



Figure 81. Floor plan parameters.

**Floor Plan | Structures | Light and Shadows**

In the specialized art camp, I brought in light in public spaces and hid the structural systems and private spaces (such as restrooms, offices, and

the teacher’s lounge) in the shadows. Dimly lit corridors that connect the public and private spaces resets students’ eyes as they transition between classrooms with different lighting designs. Structural systems and the private spaces are the foundation of the school but don’t directly engage with the students, like how shadows highlight the beauty of light.

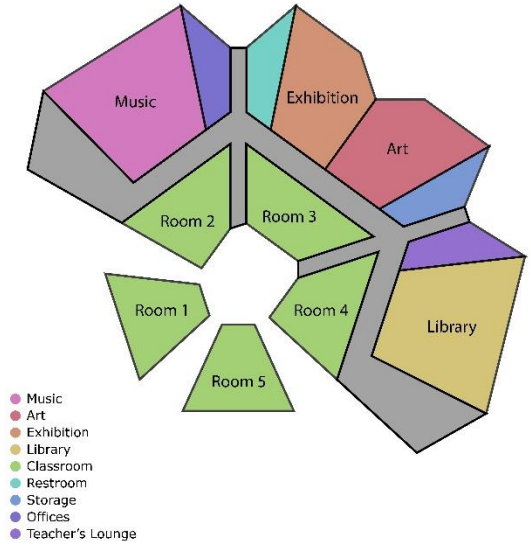



Figure 82. Floor plan.

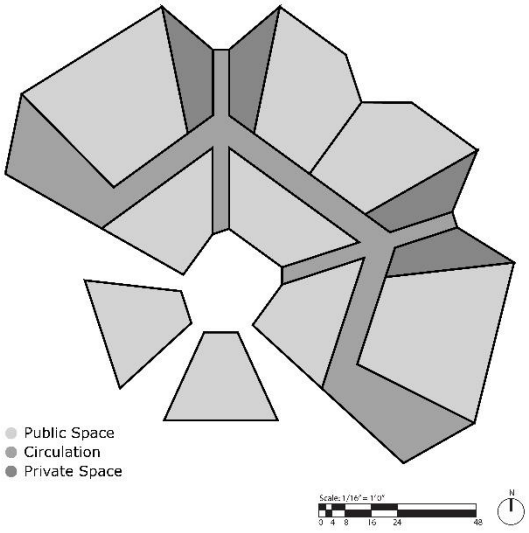



Figure 83. Floor plan shadings.

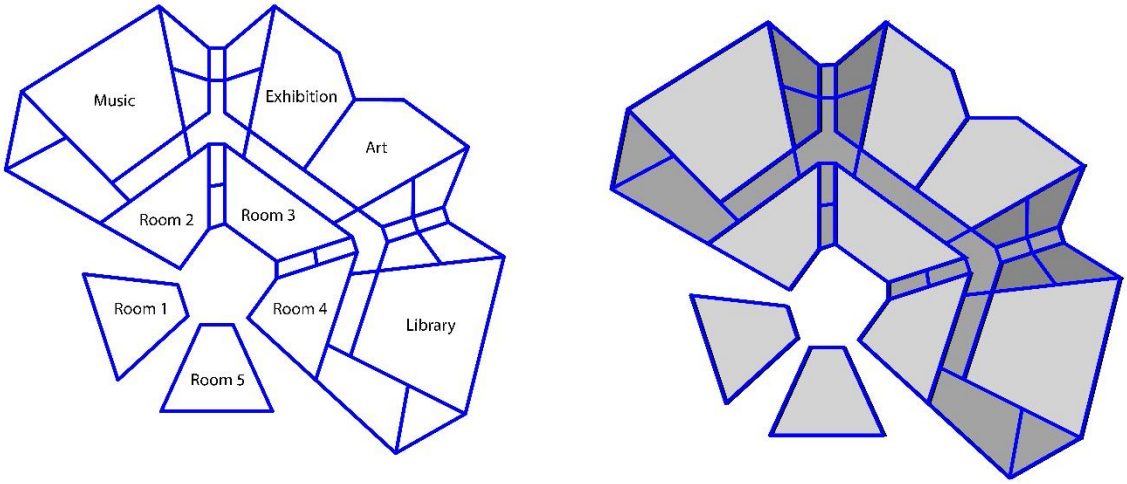



Figure 84. Structural floor plan.

The structural system consists of wood beams, wood columns, and cross-laminated timber (CLT) roof panels. Wood beams with a span of less than 16’ have a nominal depth of 12” and those with a span of greater than 16’ have a nominal depth of 18”. The nominal square column size is 8”, which can support a total tributary area of around 1000 $ft^2$. 3-layer CLT roof panels can support up to a span of 16’ with a depth of 3”.

**Activity Areas by Season**

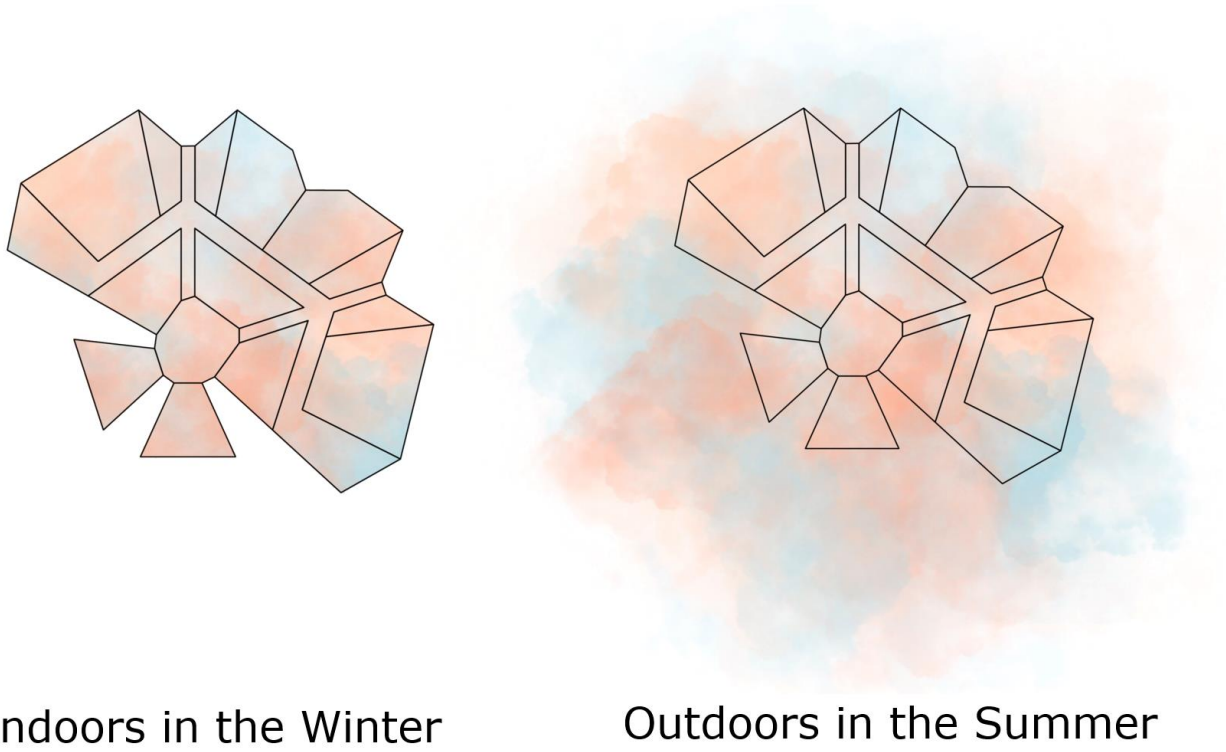



Figure 85. Activity areas by season.

The activity area changes by season in Seattle. People stay indoors in the cold winter, and the activity area spreads out to the outdoors in the summer. The outdoor space is a temporary space that is only useful when the weather can provide a comfortable environment to support the activities. The shift in activities shows the temporality of warmth.

## Light and Shadows of the Massing Studies

The three Point-In-Time Illuminance simulations were created to ensure that the light and shadows are present in the intended areas of the floor plan. Each program type has a different window translucency level, window-to-wall ratio (WWR) and ceiling height, depending on the intended use of the space.

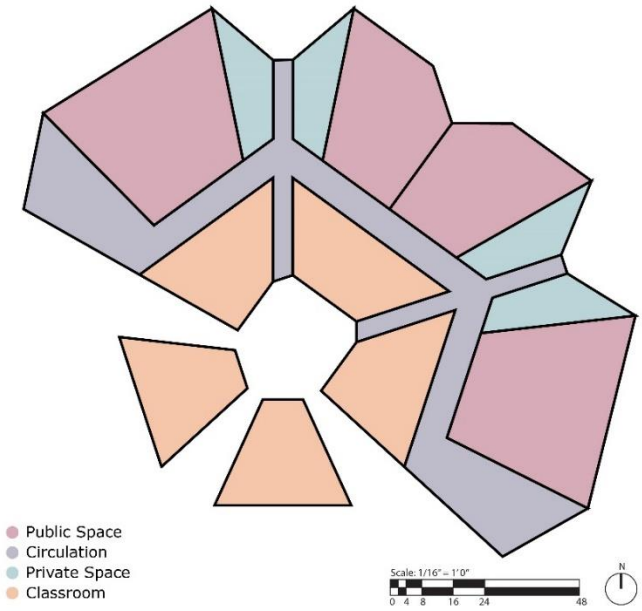



Figure 86. Light and shadows massing studies floor plan.

| | Translucency Level | Window-To-Wall Ratio | Ceiling Height |
|---|---|---|---|
| **Public Space** | Clear double-glazing | 60% | 15ft |
| **Private Space** | Clear double-glazing | 40% | 10ft |
| **Circulation Walls** | N/A | 0% | 8ft |
| **Circulation Skylight** | Specular Transmission: 0.01 | 100% | N/A |
| **Classroom Walls** | Clear double-glazing | 60% | 8ft ~ 10ft (Sloped ceiling) |
| **Classroom Skylight** | Specular Transmission: 0.05 | 60% | N/A |

Figure 87. Light and shadows massing studies table.

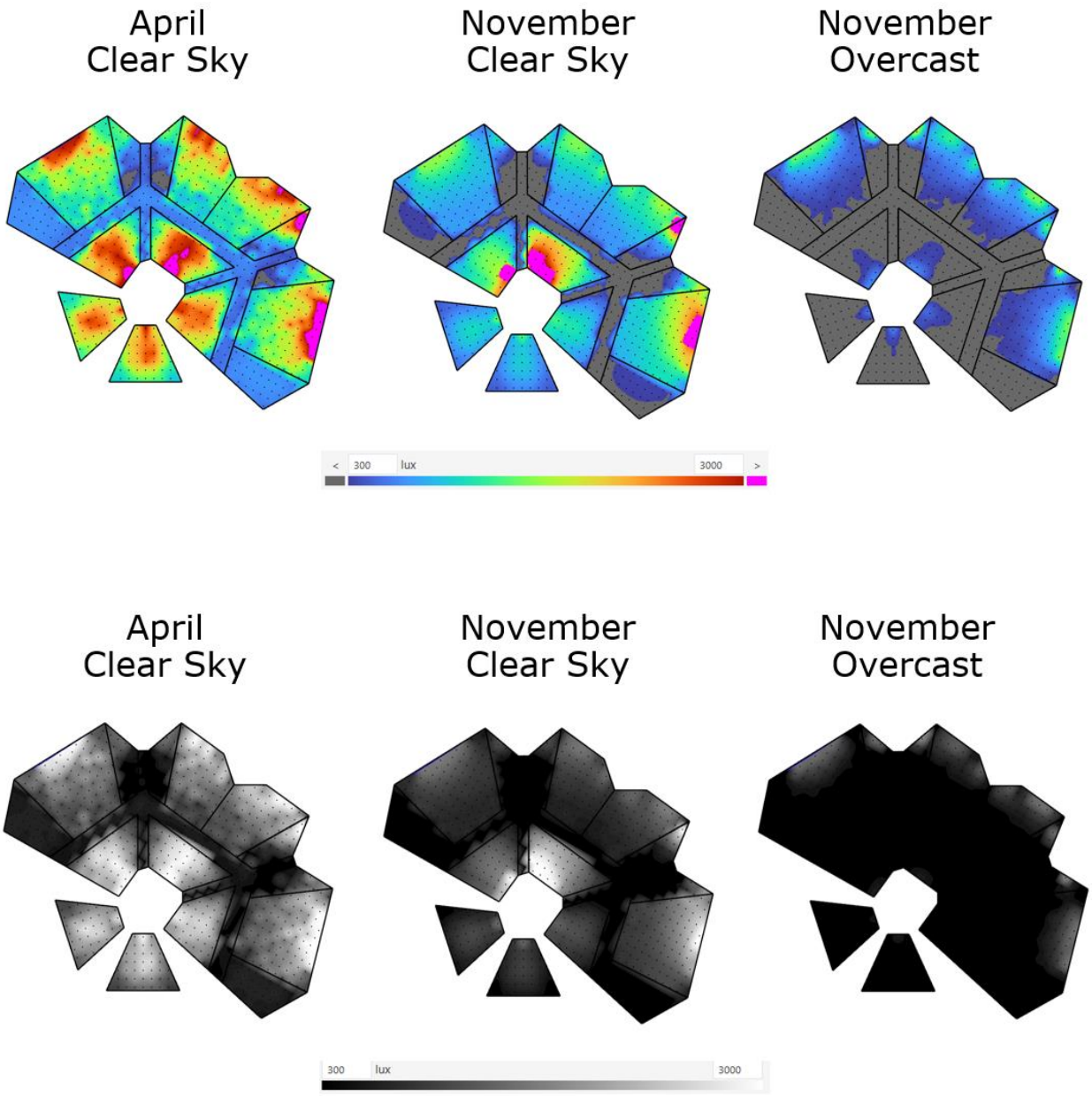



Figure 88. Point-in-time illuminance diagrams of floor plan.

## Vegetation and Shadows on the Site

Depending on the time of the year, leaves change colors, and the sun travels a different path in the sky. The site analysis shows the changes in shadows on the building at different times of the day and year.


Figure 89. Site plan.

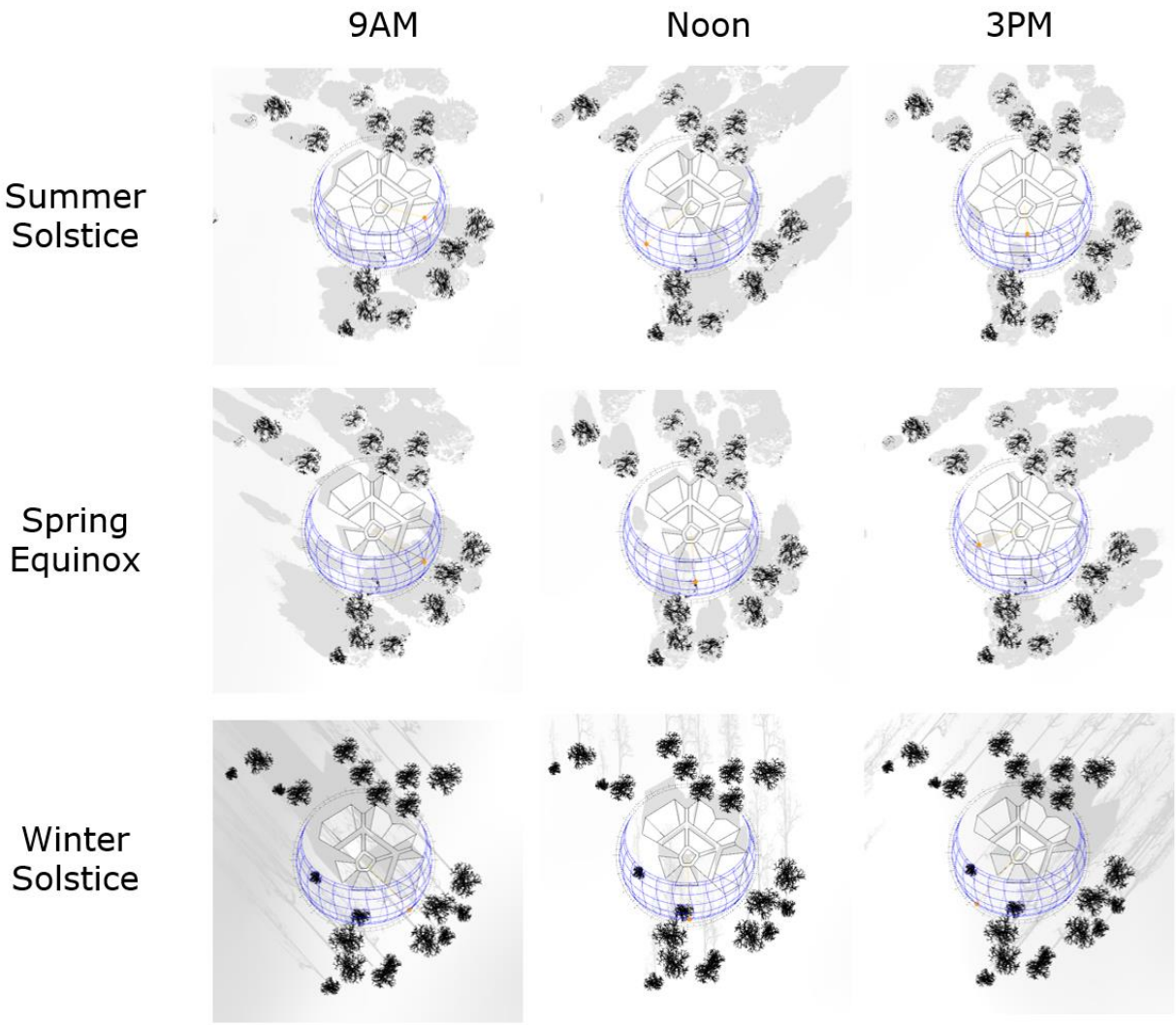



Figure 90. Sun studies of the site and building.

## Section 5.2: Library – Contrasts of Light and Shadows

The lighting design for the library is an exploration of ways to add contrasts to light and shadows. Children sit on the floor or the beanbags as they read because they are energetic beings who cannot sit still in a chair. The noticeable change in daylight through the shadows of the architectural elements helps students concentrate on reading. With the view of the outdoors, they can see the change in nature and watch other children run around the forests.

Figure 91. Library rendering.

## April clear sky

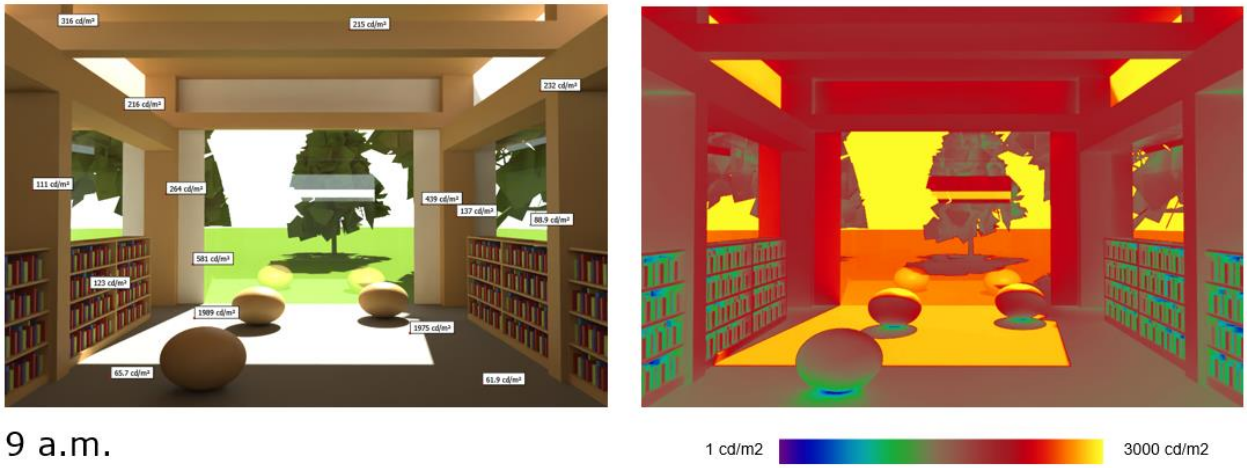



Figure 92. April clear sky radiance renderings.

## November clear sky

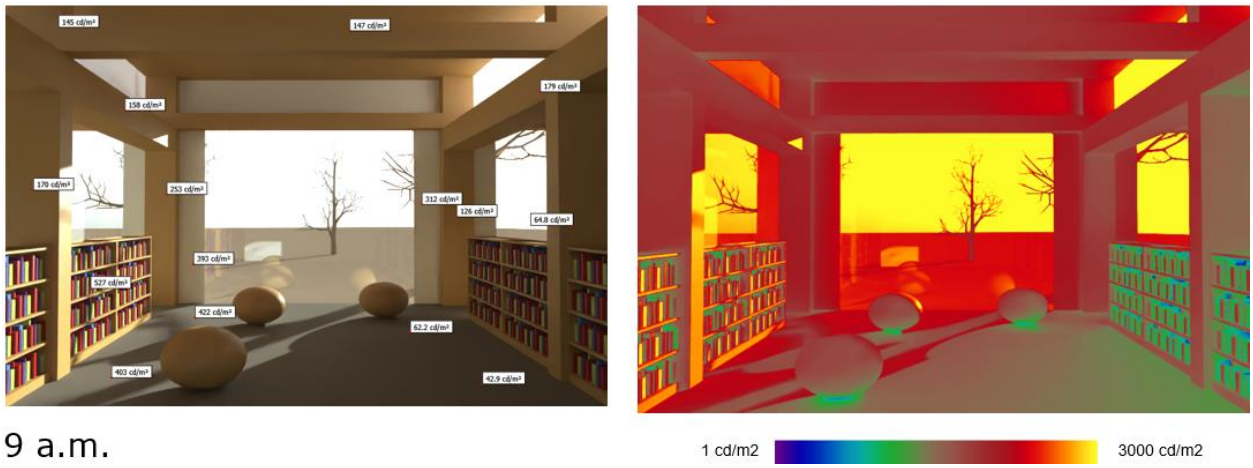



Figure 93. November clear sky radiance renderings.

## November overcast sky

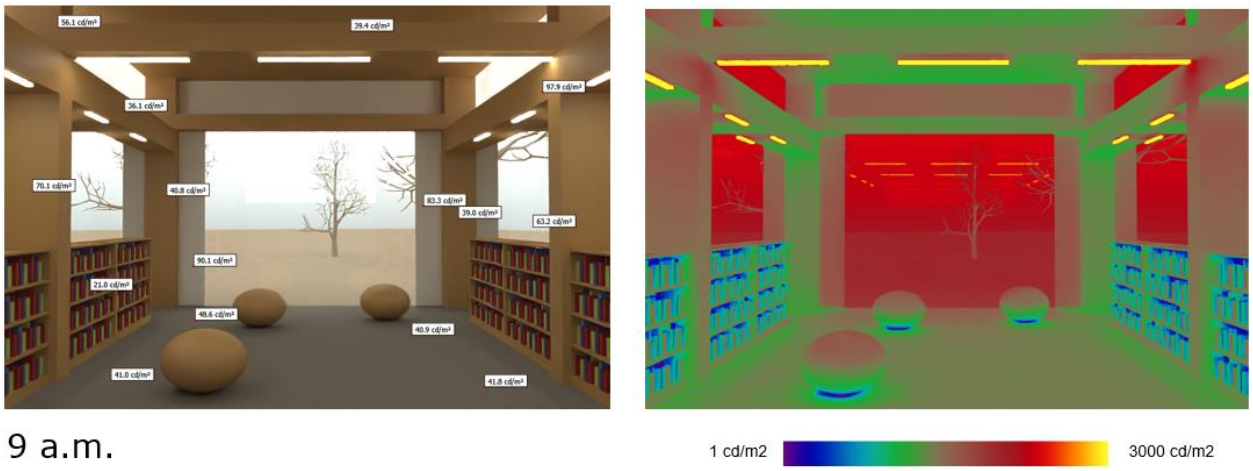



Figure 94. November overcast radiance renderings with artificial lights.

The Point-In-Time simulation ensures that the light level of the daylight is an ideal lighting condition for reading, and the artificial light provides supplemental lighting on dark days and at night when there is a lack of natural light. Artificial lights are placed under the beams so that only daylight illuminates them, emphasizing the beauty of light and shadows on wood structures.

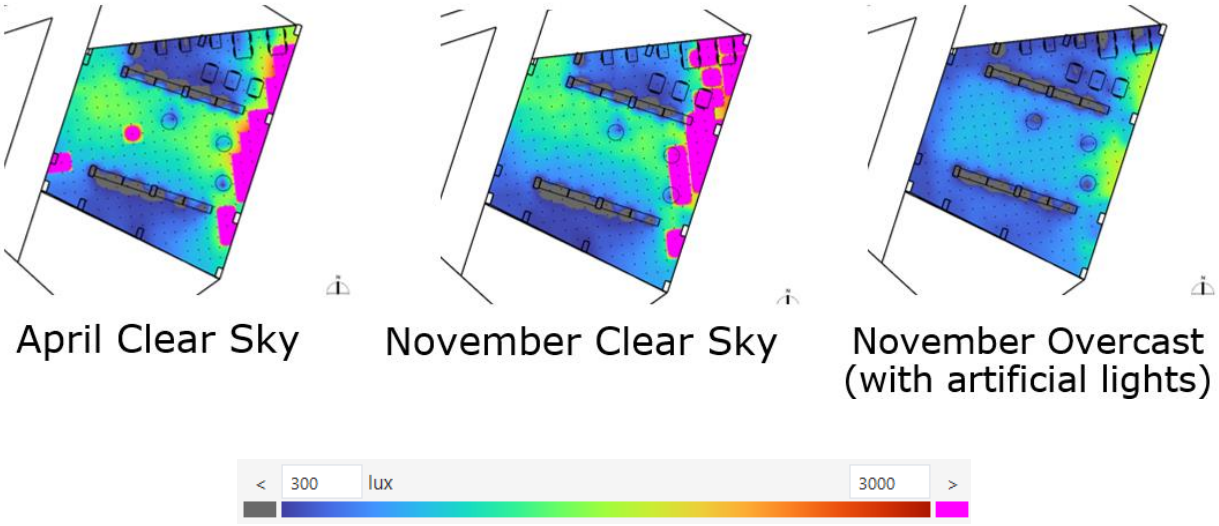



Figure 95. Library point-in-time illuminance diagrams.

Just like in the historic Japanese architecture, the ceiling is the darkest surface, and the floor is the brightest surface. Each surface of the beams and columns has a different luminance level, and the shadow sharpness changes as the daylight changes. The rough texture of the wallpaper and carpet add detailed shadows that only appear when the daylight is intense.

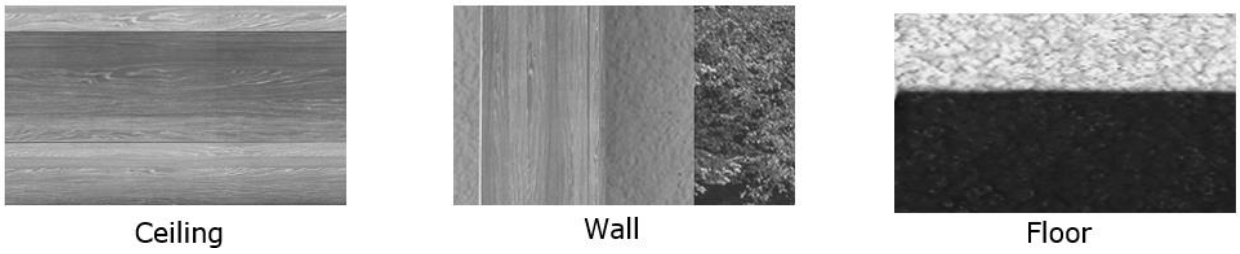



Figure 96. Shadows on ceiling, wall, and floor.

Objects with different darkness of shadows, such as bookshelves and beanbags, change every time someone touches them. When books return to the bookshelves, they are often put back randomly, varying the shadows on each book spine. Beanbags are made of a soft fabric that changes its form every time someone touches it. These objects can never cast the same pattern of shadow after each time people interact with them.

Figure 97. Shadows on bookshelves and a beanbag.

## Section 5.3: Art Space – Adjusting Levels of Light

Allowing users to adjust the light level is as important as creating an interior lighting design that mainly use daylight. It is easier for users to appreciate the daylight if they don't need to block it to prevent glare. With the curtains and artificial lights on the ceiling, the art space can serve multiple purposes regardless of the daylight conditions while allowing students to get inspired by nature from indoors.

Figure 98. Art space rendering.

## Block Harsh Sunlight During Art Lesson on a Bright Sunny Day

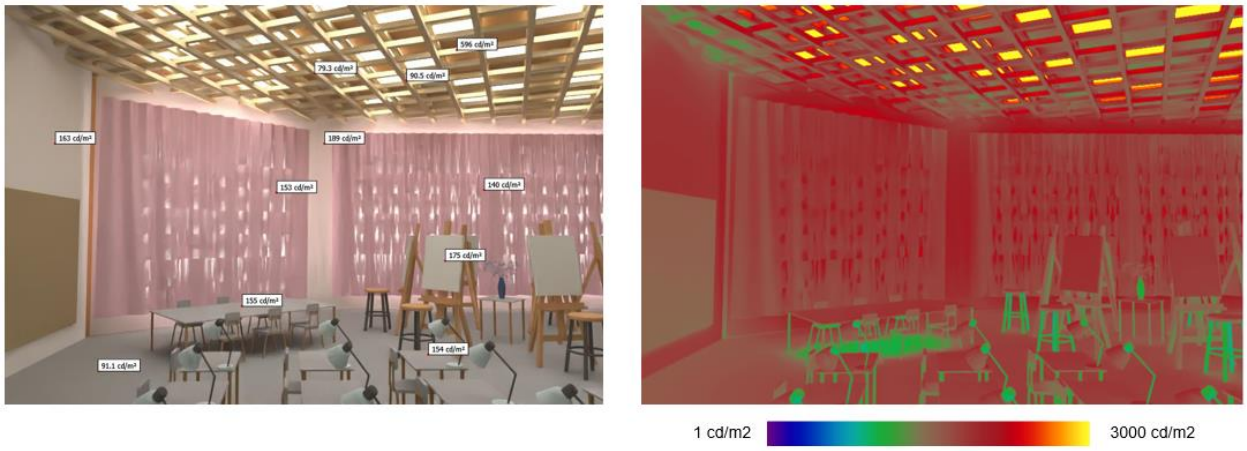



Figure 99. HDR photo (right) and false-color image (right) of art space on a sunny day.

## Paint Nature from Indoors with Artificial Lights on a Cold Overcast Day

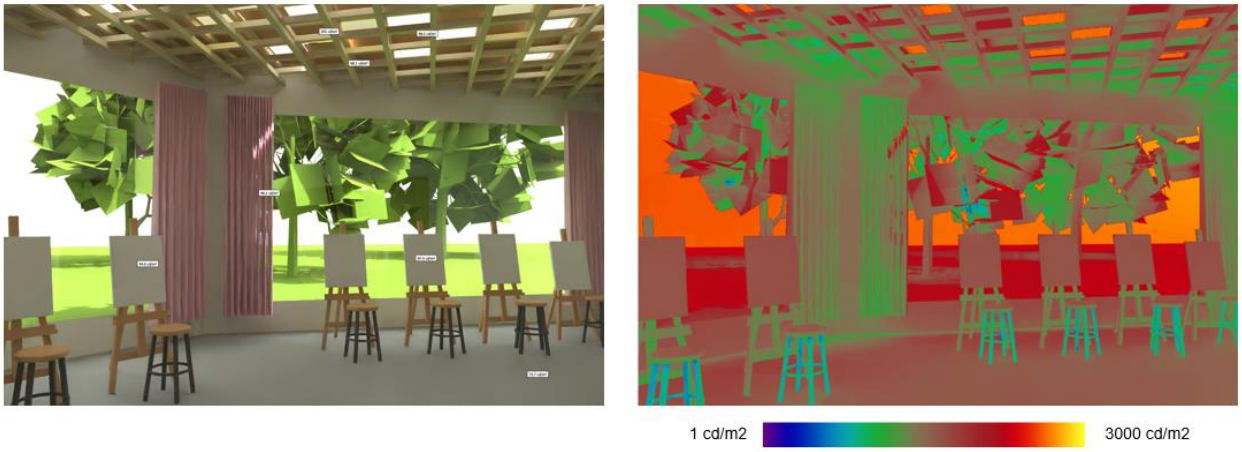



Figure 100. HDR photo (right) and false-color image (right) of art space on an overcast day.

## Art Exhibition at Night

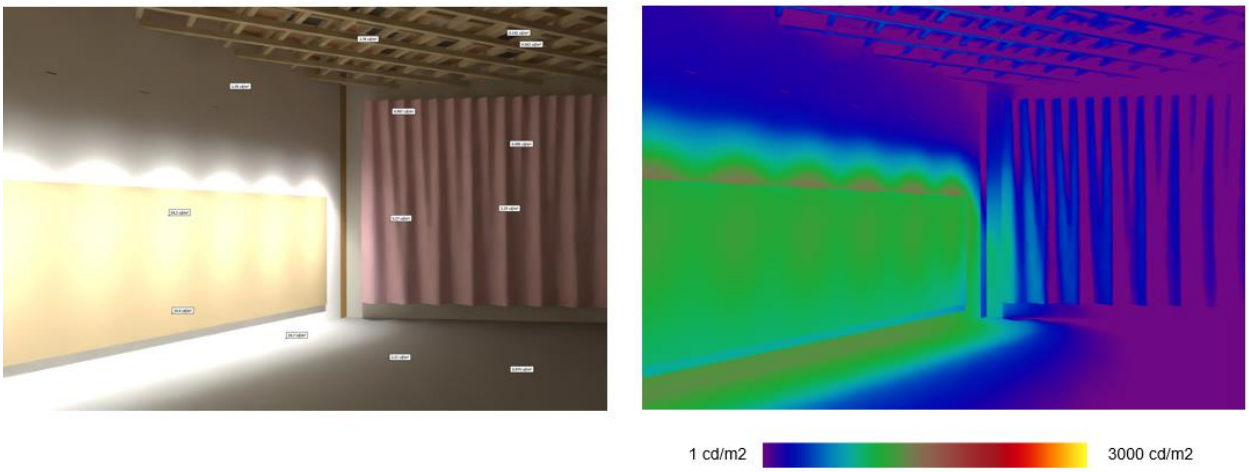



Figure 101. HDR photo (right) and false-color image (right) of art space at night.

## Reflected Ceiling Plan Pattern

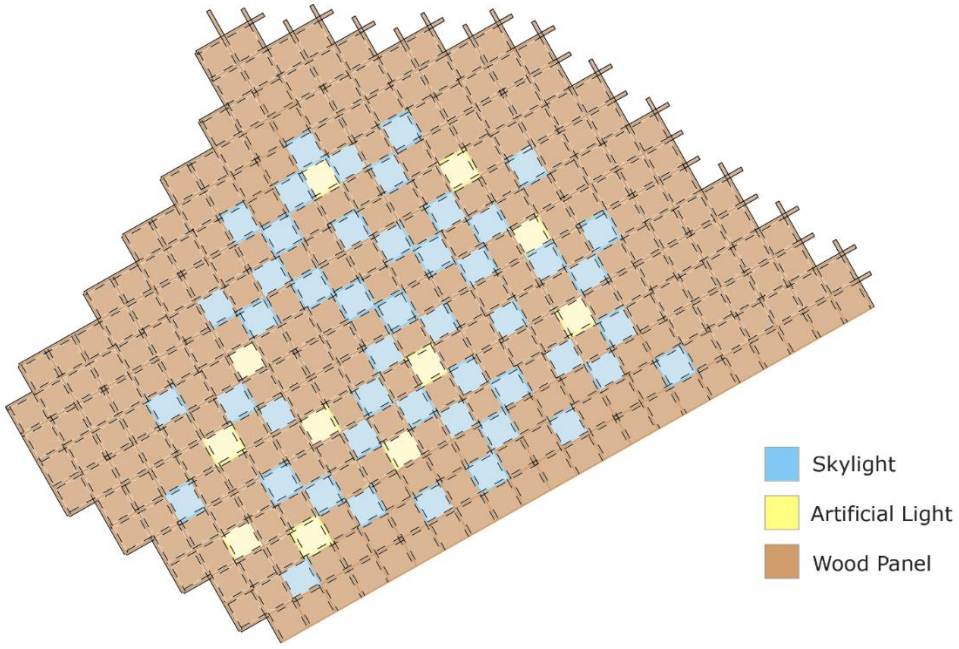



Figure 102. Diagram of the reflected ceiling plan pattern.

The pattern on the ceiling does not get disrupted by the change in lighting. Square artificial lights and skylights are mixed with solid wood panels on the wood grid. When no sunlight passes through the skylights on overcast days or artificial lights are turned off, these square panels would blend into the shadows with the solid wood panels. The language on the ceiling isn't impacted by users' adjustability of light; the change adds a variation in the pattern of shadows.

## Section 5.4: Classroom – A Sense of Change in Time, Nature, and People

The classroom is a playful area where students sense the change in time, nature, and people by observing their surrounding space. The space explores alternative ways to allow students to experience change in addition to light and shadows.

### Summer

Figure 103. Classroom rendering in the summer.

## Autumn

Figure 104. Classroom rendering in the autumn.

Students can see the community garden change as both the students and the plants grow together throughout the school year. The color of nature changes with the seasons. Students can also watch their classmates grow up too. The shadows on the ceiling change with the presence of daylight. Considering the common overcast skies of Seattle, adding a prism filter on a

skylight would cast a rainbow on the rare sunny days and engage with students' curiosity.

| | Summer | Autumn |
|---|---|---|
| Children |  |  |
| Community Garden |  |  |
| Sharpness of Shadows |  |  |
| Prism on Sunny Days |  |  |

Figure 105. Ways children experience change of seasons.

Figure 106. Sunset at Golden Gardens Park.

# Chapter 6: Conclusion

Light and shadows allow users to experience the impermanence of a moment to satisfy visual comfort and connect with the present moment. Without shadows, we wouldn’t notice the variation of luminance levels in daylight. Architects designing buildings with the sense of permanence in mind do so to make us productive, yet we can’t be productive forever. Like the sun, our energy levels fluctuate, and we need time to recover.

Analyzing lighting data from HDR photos of historic Japanese architecture, the presence of shadows helps us recognize changes in lighting. The false-color images showed the importance of placing shadows

in areas of the room irrelevant to our work environment, such as the ceiling, structures, and ornaments. This allows shadows to be present in the room without disrupting our productivity, creating a balanced space of work and rest. Like how light needs shadows to express its change, humans also need to be in an environment that accepts our own imperfection and impermanence: the *wabi-sabi* valued in the Japanese culture. This raises the question of the necessity of using bright and uniform light fixtures in contemporary buildings, especially schools where children learn.

The specialized art camp for children in Discovery Park proposed suggestions for early educational spaces designed to value impermanence. The dynamic interior lighting design improves children's learning efficiently by providing enough lighting for hands-on activities and a variety of physical movements. While the light source is primary daylight, users can adjust the light level to prevent unwanted glare and set the ideal luminance level for different tasks when the natural light causes distraction. Users are more likely to accept daylight as the primarily light source when they are easily controllable like artificial lights. In addition to light and shadows, children experience the temporality of the moment through nature and interactions with other students. This early educational space of the Pacific Rim brings children the opportunity to experience change through light, shadows, nature, and other human beings.

Humans are impermanent like daylight. Surrounding children with permanent light gives them the illusion that the world is permanent. We should occupy spaces that continually change with us, and architecture should change as time passes to allow humans to acknowledge their own impermanence.

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