Testing and Modeling of Ecotherapy for Healthcare Design

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Introduction

The artificial lighting hits the dark walls, and the air in the room is musty. The patient inside is suffering from a terminal illness and will not be able to see more than a sliver of the light through the window in the hospital. In Washington D.C., a pediatric cancer patient at a children's hospital had a wish to go outside one last time. Unfortunately, his wish was unable to be granted due to the lack of equipment accessible to outdoors. The child passed away in a hospital where nature was not the main concern in design and where the patient's experience was not fully considered. Designers started to bring nature into hospitals such as Bunny Mellon Healing Garden at Children's National Hospital. This story inspired me to pursue Ecotherapy design research that can provide a natural environment with healthcare settings. My question that comes along with this is what design components can be used in a healthcare setting by using the concept of Ecotherapy. As the main research methods, I studied modeling and simulation approaches that can test design scenarios and building components for Ecotherapy. In PURE research, I used Building Information Modeling (BIM), parametric modeling, and daylighting simulation.

I focused on building components that can bring nature into indoors by capturing light, fresh air, or plants. It was also important to understand which components are efficient and available to improve the environment. I build parametric models of terrarium, balcony, and skylight for Ecotherapy design. Ecotherapy is a form of therapy that stimulates healing. A research article states that “Ecotherapy is an umbrella term for a gathering of techniques and practices that lead to circles of mutual healing between the human mind and the natural world from which it evolved” (A look at the Ecotherapy Research Evidence, Chalquist). This type of therapy engages the human relationship with the outdoors to design better healthcare environments. Not to mention, many studies show that there is a positive relationship between these natural environments in hospital spaces and patients' faster recovery time.

Case Study

The first research phase was a case study. A few hospitals have been built or are being built around the world that focus on Ecotherapy. I was able to find four hospitals that value ecotherapy, and the human relationship with nature. The first case is Children's National in Washington D.C. This hospital stood out to me because of the impressive healing garden designed for terminally ill patients. These patients can now access the views of D.C. regularly while getting fresh air and time to themselves.

The second hospital is Copenhagen Children's Hospital. This hospital not only focuses on incorporating the outdoors but also reflects a child's perspective into space design. "The power of play" concept is used throughout the space to create skylights, gardens, and balconies in view of children's perspectives. These playful details make the hospital environment more welcoming and brighter. The space design and varying views show children interacting with their outdoor environment and escaping
The next hospital is North New Zeeland Hospital that is being built in the Capital Region of Denmark. Nature and healing have a strong correlation in this space. The design goal was healing the body in harmony with landscape. To make this harmony come to life, the indoor space includes healing gardens, balconies, larger windows with views to strictly nature, and natural materials.

My last case study is a design proposal by B.I.G., a leading design firm for the NYT Hospital in Nordsejælland, Denmark. The site sits on an old hunting ground with ponds and hills. B.I.G. was inspired by this unique natural site context. Bjarke Ingles, a founder of B.I.G. stated “Studies show that daylight and views to green areas and plants have a healing effect on bed lying patients.” This statement proves that the healing process and natural components are vital to the design of this space. Within the space, patients will be able to access courtyards and have views of greenery and wildlife. All of these case studies emphasize the importance of good design with nature and enhance how to use ecotherapy in a healthcare setting.

Site Visit

The second research phase was a site visit. I conducted a site visit in the summer and fall of 2019. After reviewing a series of key cases and articles, I was able to select hospitals that have strong design components. The first hospital that I visited was Rush Medical Center in Chicago, IL. This hospital originally stood out because of the creative terrarium that is used as a focal point from the main lobby. This terrarium brings light through the ceiling and allows for guests to look at the growing plants all year round. It also brings life into the environment and can stand as a metaphor in an unhealthy space. The skylights were another component that also stood out to me. There were three skylights in the main lobby that brought in natural light throughout the day. These skylights were able to cast light on the ground in their shape and were used as a form of wayfinding to the front desk. Finally, the living walls made concrete and brick walls come to life. The ivy and greenery on the wall brought in more texture to space and contrast.

The second hospital that I visited is Parkland Hospital, Dallas, TX. This hospital also had diverse design components. The most promenade component for ecotherapy is the healing garden. This space had winding pathways for patients to walk on. There were colorful flowers and benches for guests to enjoy. Additionally, there was a fountain in the center that was comforting to noise and statutes for art for people to admire. The next component is the indoor planters. These planters lined long hallways to break up space and add life to the room. They were also used for wayfinding and can be changed to match the season. The last component is the curtain wall system and the design of the system. The curtain wall stretched across multiple levels of the hospital to bring in natural light and views of the city. However, some glass panels were engraved with designs. An example of this would be the words that are engraved in the main panels at the entrance. The words were names of people who had been
Parametric modeling, simulation, and visualization

After the case studies and site visits in person, I was able to narrow down the design criteria for modeling and simulation. I was also able to understand the importance of these components for daily life. It was important to break down these components to identify their design needs in a space. Main components I simulated are skylights, terrarium, healing garden, curtain wall system, and balcony.

The first component was a balcony. The typical balcony is 3’-4’ deep. This depth is required for a small table or for people to sit down. If the balcony is smaller than the dimensions above, then it is just for people to stand. Using the balcony just for standing will not be acceptable for a health care setting because of wheelchairs, and the equipment that patients might have. The railing that goes along the side of the space needs to be at a 3’ height to meet ADA codes. It is important to incorporate correct shading for the balcony and take into considerate the sunrises in the east and setting in the west when determining the location for space. Also, the materials used to create the balcony should be natural to blend into the surrounding setting. This will enhance the relationship between nature and humans. An example of natural materials is wood, stone, and living walls.

Following the healing garden is the skylight. It is important to think about where this feature will go in the hospital before designing. This component will mostly be used in patient rooms because the patients are typically in their rooms for the longest period of time and it allows for patients to be laying down but still look at a view of the outside. Skylights also bring in a lot of natural light but still allow for privacy. To design the skylight, the shape must be considered and the slope of the roof. The shape will be reflective on the floor so understand that what is underneath the component might have a glare.

The last component is the terrarium. This space is designed to have floor to ceiling glass with an opening on the roof. The parameters for the height and the width will have to change accordingly based on what model it is being used for. Space can also be built at different angles to capture different paths of the sun at certain times of the day. Not to mention, it is also critical to think about the plants and landscaping that will be placed inside. Incorporate plants that can survive all seasons if being used in a colder climate, or enclose the space to let the plants be indoors. Also, consider plants that vary in height to add more depth to the enclosed area. There is a quote from the University of Minnesota that states, "Research done in hospitals, offices, and schools have found that even a simple plant in a room can have a significant impact on stress and anxiety" (How Does Nature Impact Our Wellbeing? University of Minnesota). This statement proves that this component is extremely beneficial to the healing process and can strongly enhance the use of ecotherapy in the space with the terrarium.

For modeling and simulation, I used parametric modeling in Revit. In parametric modeling, a
single model can change its dimensions and proportions based on parameter changes. From here, I was able to use voids and solid extrusions to place into a basic space. When this was complete, I ran daylighting and solar radiation simulation on how each component changes the performances based upon the varying weather and sun positions. Modeling and simulation allowed me to understand better the most efficient angles and sizes for each design component. After each component was completed, I was able to apply them to a generic space.

For visualization, I created rendering images and walkthrough animations of my thesis project. This visualization allows people to virtually experience the space and the components designed by using the concept of Ecotherapy. I plan to calibrate the report and my thesis project further and disseminate the findings and outcomes to healthcare professionals and researchers. Since ecotherapy is an up and coming design theory, it is more important to educate future designers. Sharing the data that I design will strive for hospitals and architects all over the world to use ecotherapy as a way of thinking.

**Conclusion**

Ecotherapy design in hospitals is still in infancy. It is clear that with the appropriate design elements for the hospital, nature can significantly improve a person's setting while staying in a hospital environment. Each component varies its role for Ecotherapy design. The skylight, for instance, brings different views to the room that you cannot see from a vertical and flat window and allows patients to look up from their bed without moving their neck. Next, the healing garden brings in a sense of retreat to space. Patients can walk through or sit down in the garden to get away from the basic hospital views. The gardens will bring new scents and can attract harmless insects for viewing. The patient balcony will allow for some of the same features like the garden but will enclose more privacy and individual space. Additionally, the terrarium will be a compromise for the inside space with the outdoor environment. Plants will be able to bloom inside this space all year long, and it will be a focal point for the facility. All of these components incorporate nature and excel in connecting people with wildlife. This connection is what ultimately brings in the use of ecotherapy. More holistic research and empirical experiment about Ecotherapy design will enhance patience's experience in the healthcare facilities.

This PURE research report is written to present the research process, methods, and outcomes from three main research phases of case study, site visit, and parametric modeling/simulation.

**Acknowledgement**

This work was supported by PURE Research Funding (Human Environmental Sciences Program for Undergraduate Research Experience) at University of Missouri Columbia.

Date: 15 December, 2019
Created by Victoria Workman, Architectural Studies
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Case Study
Bunny Mellon Healing Garden, Washington D.C.

Background:
"The idea of creating a Healing Garden was inspired by a young patient whose last wish was to go outside." (Children’s National Health System). The child was not able to go outside because of his condition and the equipment needed. After this incident the hospital decided to design this space for children who want to get fresh air and play outside.

Components Used:
The main component in this space is the healing garden. However, there are plants, trees, benches, water features, pathways, and natural materials that make this space effective.

Why it is significant:
"Children with serious illnesses often have very limited access to nature and miss feeling the warmth of the sun. Our spacious 7,200-square-foot rooftop garden advances our commitment to providing the best possible care and experience to each patient" (Children’s National Health System). This example makes the space important because it gives patients the opportunity to interact with nature and see views of the city that they typically would not be able to have.
Case Study
North New Zeland Hospital

Background:
This is a new hospital that is being built in The Capital Region of Denmark. The architect, Vilhelm Lauritzen’s goal is to make the space focus on healing. The building will be “in harmony of the landscape.” With this being said, it is clear that the designers goal in mind is to create a space that relaxes patients in the healing setting.

Components Used:
There are plenty of components in this space that incorporate nature. For example, there are healing gardens for patients that want a retreat. There are private patient balconies from patient rooms for guests who might not be able to make it to the healing garden but still want to enjoy the outdoors, and windows with views to plants and greenery for looking outside to see the seasons, time of day, and weather.

Why it is significant:
This hospital is significant because it intentionally uses design and components to enhance the patients relationship with nature throughout the healing process.
Case Study
Nyt Hospital Nordsjælland, Denmark, BIG Proposal

Background:
The site for this project is an old hunting ground. There are ponds, and hills that are incorporated into the design. Bjarke Ingels stated: “Studies show that daylight and views to green areas and plants has a healing effect on bed lying patients.” With this being said, the views of the site and natural daylight have been a main priority to the new design.

Components Used:
Throughout the hospital, there are courtyards that are created around patient rooms and treatment spaces. There are healing gardens for patients to sit outside and think. There are also rooftop spaces with grass for walking, large windows in patient rooms and operating rooms that show the view of the landscape, and patient balconies for a private get away.

Why it is significant:
This hospital is significant because the proposal is able to use so many design components in one space. It is also a new design that shows how critical it is to include a human connection with the outdoors in a hospital.
Case Study
Copenhagen Children’s Hospital, Copenhagen, Denmark

Background:
This hospital will be completed in Copenhagen, Denmark, in the year 2024. The goal for this space was to include “play” into the design. This was achieved by the shape of the hospital. The shape comes from two hands overlapping to create hospital wings. Play is also used with the colors and the material choices so that the children feel more comfortable in the space.

Components Used:
The design incorporates components that enhance the patients relationship with nature and with play. The first component of nature is the gardens. There are courtyards throughout the hospital that patients can access while outdoors. These gardens are more interactive and allow for patients to go on walks and clear their minds. However, there are also trees planted throughout the building to bring nature indoors and for patients to see and enjoy. Additionally, the colorful curtain wall exterior allows for light to come through on all sides of the hospital. Lastly, the atrium spaces allow for sunlight to come through the building from the ceiling and touch the ground.

Why it is significant:
This space stands out because it shows that a design concept does not have to suffer to use nature. It also shows that nature can be used in a playful way, and that the components do not have to be strict on guidelines.
Component: Plant Terrarium

Why it matters: The terrarium in the hospital shows life in the space. It is more significant than a simple planter or a large window. Allowing plants to grow in this space is also a metaphor for human life throughout the rest of the hospital. This terrarium is also visible from the upper levels.

Component: Glass Walkways

Why it matters: These glass walkways allow guests and patients to walk from one department of the hospital to another while being able to see outside. These hallways are light during the day from the sun, and allow views of Chicago.
Component: Skylights
Why it matters: The skylights in the lobby bring in natural lighting. This is also a more private way for patients to get natural lighting without using large windows. The circle shapes leave a circle pattern on the ground.

Component: Living Walls
Why it matters: The living walls are able to bring life to the facade of the building. The grass and plants cover up areas of the wall that are dull. Also, when living walls are used indoors they are able to bring more plants inside the space.
Site Visit
Parkland Hospital, Dallas, TX

Component: Healing Gardens
Why it matters: These gardens are spaces where patients can go to get their mind off of their treatments. There are water features that create noise for guests to listen to. There are benches hidden within the plants so people can sit and relax without being seen by everyone.

Component: Curtain Wall System
Why it matters: The curtain walls used in the hospital are the main source of light. They stretch over three levels of the hospital. This curtain wall systems gives views of Dallas from the corridors. Patients are able to see the light during the day.
Component: Indoor Planters

Why it matters: These planters are used throughout the main hallways of the hospital. There are many of them in a row to guide people throughout a long corridor. The plants also bring a sense of life into the space and add a connection with the outdoors.

Component: Glass Panel Design

Why it matters: The panel design is able to create a focal point for the front of the building. It is able to still bring natural light in but also allows for a more creative touch. There are designs that include water, and also writing. These focal panels are a great feature for wayfinding.
Parametric Modeling and Simulation
Design components for Ecotherapy
Skylights

Terrarium

Healing Gardens

Curtain Wall System

Balcony
Terrarium Modeling and Simulation
Terrarium Parametric Modeling 1
Rectangle form

The basic dimensions for the mass are 100' by 100'. I created a parametric model that can change the position and angles of terrarium. The five cases were generated from the single model.

Case 1

Case 2
The constant dimensions for the cube are 100' by 100'.

Case 1

Case 2
Case 3

Case 4

Case 5
These Revit Models have parameters that are assigned to their own Revit Family. I variated the Radius of the top circle and the bottom circle of the void for each model to represent five different configurations.

Case 1:
Void of Radius on Top: 50'
Void of Radius on Bottom: 60'

Case 2:
Void of Radius on Top: 70'
Void of Radius on Bottom: 40'

The constant radius of the circle is 50'.
Case 3:
Void of Radius on Top: 30'
Void of Radius on Bottom: 60'

Case 4:
Void of Radius on Top: 70'
Void of Radius on Bottom: 70'

Case 5:
Void of Radius on Top: 40'
Void of Radius on Bottom: 30'
Terrarium Parametric Modeling 4
Rectangles

These Revit Models have parameters that are attached to their own Revit Family. I changed the dimensions of the top and bottom of the void for each model.

Case 1:
Void of Dimension on Top: 50'
Void of Dimension on Bottom: 20'

Case 2:
Void of Dimension on Top: 30'
Void of Dimension on Bottom: 10'

The constant dimensions for the rectangular prism are 50' by 100'.
Case 3:
Void of Dimension on Top: 20’
Void of Dimension on Bottom: 50’

Case 4:
Void of Dimension on Top: 20’
Void of Dimension on Bottom: 10’

Case 5:
Void of Dimension on Top: 70’
Void of Dimension on Bottom: 40’
The solar radiation simulation enabled me to understand the potential solar gain for each surface, which is critical for interior space, lighting, and heating/cooling. The south and west walls have the highest solar radiation. Additionally, the walls in the atrium that face south and west sides also have the highest solar radiation.
The rooms that receive the more light could be the public spaces and the patient rooms that constantly occupied by users. Having more light in these spaces will allow for better living conditions with the patients. Also, these rooms do not need as much artificial lighting during the day. However, they will potentially need more heating in the winter, and cooling in the summer. Overall, the best parameter values for the atrium to gain the maximum light and ecotherapy range from 40 feet to 70 feet.
Balcony Modeling and Simulation
Balcony Parametric Modeling

These Revit Models have parameters that are assigned to their own Revit Family. I manipulated the parameters of the top rectangle and the bottom rectangle. Then I runned solar radiation simulation for each case. It shows how the sun affects the solar radiation distribution of the surface having balconies.

Case 1:
Top width: 30’
Bottom width is 50’

Case 2:
Top width: 50’
Bottom width 50’

The constant dimensions for the rectangular prism are 50’ by 100’. The height is 50’.
Case 3:
Top width: 50'
Bottom width: 30'

Case 4:
Top width: 10'
Bottom width: 50'

Case 5:
Top width: 50'
Bottom width: 20'
By analyzing the solar radiation of each surface, I can understand the impact of a cantilevered balcony on the illumination distribution of the building façade. The solar analyzing shows where the light is hitting the building and how much sunlight the balconies have. This information will allow me to determine whether I need to make the balconies larger, smaller, change their shape, or design them in a different sun path.
Total Surface Value

Case 1:  
Case 2:  
Case 3:  
Case 4:  
Case 5:
From this study, we can see that the best choice would be the balcony that is 90 degrees and perpendicular to the ground. The solar analysis graph showed an average amount of light coming through space. It is important that Sunlight is still getting into the building, but there is not too much sunlight to create an uncomfortable setting. Sometimes, too much sunlight in a patient’s space can cause more headaches and poor resting conditions. However, they should still have a connection to the outside if they choose to.

I will now go more in depth with the 90 degree balcony and assess the overhang sizes. This study is important to see if one balcony receives a significant amount of light over another. I will be changing the balcony three different times and comparing the results.
Case 1:

This case shows that having the same balcony size on each floor will allow for the same amount of light to hit each floor beside the top floor. This is because there is no overhang above it.

Case 2:

The balcony sizes in this case stagger and get a foot larger as they go down to level one. This allows for more sunlight on the lower levels, but also makes the sizes of the balconies vary which can complicate the design.

Case 3:

Lastly, this balcony keeps the same dimensions on each level to make the spaces even. However, there is a roof overhang above the top balcony to shade the space from too much sun and allow for an even distribution of light.
Skylight Modeling and Simulation
Skylight Parametric Modeling

The skylight is a critical part of bringing in light while still allowing the space to be private. These cases will analyze how much solar radiation hits the top level of the building. The skylights will change in dimensions and in shape in each case.

Case 1:
Skylight is 30’ Diameter

Case 2:
Two Skylights that are 15’ Diameter
Case 3:  
Square that is 15’ wide

Case 4:  
Two rectangular skylights 5’ x 20’
Skylight simulation shows where the light is hitting the building and how much light touch the floor. From this graph, I can tell which skylight would be best to use in the space depending on the amount of light.

The 30’ circle skylight is proven best for the building because the light is not interrupted by angles. Also, there is less shading in the space throughout the day and the light is distributed evenly.
Daylighting and Solar Analysis
Ecotherapy Hospital Proposal
Phase 1 of Solar Analyzing the Building:

This rendering only shows level 1 in my thesis design project because level one is where the most public interaction occurs. The dark blue is where there is no direct sunlight from above, while the yellow shows the highest amount of direct sunlight. The dark blue in my design has windows and curtain walls that allow light to enter the space in a different way than just from the roof. The dark blue will also be impacted by the bright yellows because the light of the skylights and the main terrarium (in the center) will spread light throughout the space.
This image is of the second phase of the solar analysis. This analysis was taken from the first phase and was put directly into my Revit model. For this rendering, the red indicates the darker places in the building, while the light blue and yellow are the lightest.

Furniture plan corresponding to light:

After analyzing the top image and the building's main light paths, I was able to develop rooms and place furniture in the space. For example, the main dining room will be around the center terrarium so that the guests can enjoy the light while eating. Also, the children's play space will be on the northeast wing of the building so that it is a vibrant and bright place to play.
Illuminance Level Simulation
Light Luminance Rendering:

This is a luminance rendering that shows the amount of sunlight coming from each area of the building. This image shows mainly the terrarium space and the skylights which are the components with the most solar radiation.

Rendering Image:

This is the same image only rendered to look realistic. From here you can see how much daylighting is brought into space by the skylights and the terrarium. It is also clear how the users interact with space and lighting. For example, people use the terrarium staircase or sit under the light while eating at the cafe.
Walk Through Visualization
Walk through of level 1:
Use your phone to scan the bar code and look at this space online!