HOW CAN DESIGN IMPROVE THE USE OF NATURAL LIGHT IN DARK, INTERIOR SPACES TO IMPROVE THE ENVIRONMENT FOR PLANT GROWTH AND HUMAN LIVING CONDITIONS?

By: Ellie Tretola environment

(Photo by Ellie Tretola)
A Design Capstone submitted to the Department of Urban Horticulture and Design of the State University of New York, Farmingdale State College

By Ellie Tretola in partial fulfillment of the requirements for the Bachelor’s in Landscape Development May 2018 Long Island, New York

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Table of Contents:

1. Abstract
2. Keywords

3-4 Statement of Intent:
   a. Problem Statement
   b. Project Typology
   c. The Claim
   d. Theoretical Premise/Unifying Idea
   e. Project Justification

5-13 The Proposal:
   a. Narrative of Design Research
   b. User/Client Description
   c. Major Project Elements
   d. Site Information
      Site Analysis, Quantitative
      Site Analysis, Qualitative

14. Site Summary
15. Case Studies
16.-20 Case Study Summary
21.-22 Historical Context
23. Programmatic Requirements
24. Capstone Goals:
25-26. References
27. Design Elements:
   a. Process Documentation
   b. Digital Representation
   c. A photograph of the final installed project
28.-30. Plan for Proceeding

31. Previous Course Experience

32. Personal Identification Page
Abstract

The purpose of this research is to determine how a design regarding natural light enhancement can be used to remedy the problem of little natural lighting in urban apartments in hopes to improve the lives of residents and advance the growth of indoor plants. This proposed design is in a 600 sqft, one bedroom, north facing apartment, located in Washington Heights, Manhattan, NY. By creating a method of interior light enhancement, this design can create an improved environment for people and enhance plant growth in limited natural light apartments.
Keywords:

Air purifier, apartment, dark spaces, interior design, landscape design, lighting, light refraction, lighting solutions, natural lighting, plants, plant growth, seasonal affective disorder (SAD), urban
Statement of Intent

Problem Statement: Urban apartment buildings are often placed closely together and do not always have an ideal number of windows to allow for optimal sunlight exposure. Limited light availability makes it difficult to grow indoor plants and can also have negative mental affects on the resident. This leads to the question of how can an innovative light enhancement design be used to improve a low-lit apartment in an urban setting to help grow indoor plants and maximize natural brightness in dark spaces?

Project Typologies: Urban design, interior design, green interior plantings, apartments

The claim: Enhancing natural light in poorly lit apartments using light dispersion will improve the space by allowing plants to grow in otherwise inhabitable spaces. Additional light availability can therefore create a more enjoyable and livable place for both humans and plants.

Theoretical Premise/Unifying Idea:

As a horticulture student, I often share my passion for plants with the people around me in everyday conversation. One day while discussing plants with my sister Tara, she expressed to me that she was in need of some houseplants but did not think they would survive in her apartment due to her limited natural light availability. Having spent several years at Farmingdale State College (FSC) studying the varieties and needs of plant material, I began to think about how I could create a plant friendly space in an apartment with limited windows and lack of ideal sunlight. I came to the conclusion that by enhancing the amount of available light in a normally dark environment (urban apartment), that the quality of life would improve for the resident and also allow for indoor plants to thrive.

This design affects the resident of the urban apartment (Tara) by allowing for more natural light to enter the space and make it possible for her to grow indoor plants for aesthetic and functional purposes. This design may also affect guests of hers with similar problems regarding light accessibility and may influence them to implement this design in their own apartments. Green interior designers may also be influenced by this design if proven a viable solution to a common urban issue of designing a poorly lit interior space with plants in mind. They may choose to implement this design for future clients and further progress the development of other potential light enhancement solutions.
Project Justification:

Apartments in urban areas can lack natural illumination due to either location or window availability, making light exposure limited and plant health difficult to maintain. By creating a design for a natural light enhancing mechanism that could be placed near a small window and made adjustable for changing sun pattern, the quality of living for people + plants could improve dramatically.

Natural lighting and plants provide benefits to the settings they exist in, such as improved quality of life in regard to mood and energy efficiency. It has been determined by individuals in the medical field such as Rachel Nall, RN, BSN, CCRN that lack of sunlight can lead to symptoms of Seasonal Affective Disorder (SAD) which is common during the winter season. It is also recommended that receiving anywhere between 5-15 minutes of sunlight on one’s hands, arms and face, 2-3x a week is enough to take in the optimal amount of Vitamin D needed for healthy body function (Nall). Along with symptoms of SAD, it has also been noted that many urban apartments lack enough daily light to grow/ maintain the health of indoor plants.

In my design, I seek to provide at least 2 hours of extra light per day to promote the health of not only humans but to allow for plants to take in the suggested amount of at least 2 hours of sunlight needed to thrive as well (Allman).
Narrative Design Research:

Plants and sunlight possess great value to people and it is my goal to spread my passion for horticulture to those around me. By proposing a solution to a problem many people often encounter, regarding lack of light + plants in urban apartments; this knowledge could be put to great use.

This design entails the research of previous natural light enhancement designs, to better address the lighting problem in my site. It is my belief that horticulture should not be limited to large open spaces but instead, spread to all settings. Instead of neglecting spaces that may not be ideal for plant growth, green designers should seek solutions so that people of all dwellings can enjoy the benefits of natural light. Given the stressful nature of New York City and the often tight and dark living conditions, bringing plants to an urban setting can significantly impact people who reside there.

User/ Client Description:

This project is designed for people who live in urban apartments who do not have access to ideal daylight sources. This project may also extend to dimly day lit office building owners, who may wish to purchase the mechanism to improve lighting conditions for employees. The people who may wish to use this design will have to be able to physically change the direction of the mirrors as the sun moves throughout the day which may be difficult for senior citizens and handicapped individuals. One person should be able to move the mechanism by themselves.

Major Project Elements:

The major elements involved in this design include methods of reflection, direction of changing sun patterns, ideal color choices to boost mood as well as light dispersion and proposed implementation of indoor plants.

Urban apartment buildings:

- Urban apartment buildings with limited natural light availability. The building chosen is North facing and located tightly between two buildings. The proximity to neighboring building inhibits light availability in some parts of the apartment.

Natural light enhancing mechanisms:
-This design uses a mechanism that is placed above an available window in the apartment and uses an inward facing series of angled mirrors that will disperse the light from the window into the apartment to allow for maximum light intake. The mirrors on the ceiling are divided in the middle by a strip that can be adjusted to change their direction, based on the changing sun pattern throughout the day.

**Surrounding environment:**

- The area surrounding the apartment building is in a dense urban metropolis and exists primarily among tightly packed walk up apartment buildings. Based on sameness of building structure, it is likely that many residents in this neighborhood are experiencing similar problems regarding natural light availability,
Site Information:

The chosen site is a north facing 600 square foot, one bedroom apartment located in Washington Heights, Manhattan, NY. Washington Heights, best known for establishments such as Columbia Presbyterian Hospital, Yeshiva University, and the Cloisters, serve as a melting pot for a diverse population of over 214,000 inhabitants (DiNapoli).

Around the 1870’s and 1880’s residents of Manhattan, NY began to complain about the loss of natural light and decreased quality of air due to the increase of structural developments and rising population. Around this time is when considerations on how to amend such issues became a topic of conversation. In 1901 the Tenement Act (City Planning) became the first regulation instilled to control the heights of residential apartment buildings. This was the beginning of many zoning laws to come which would continue to change as the progression of NYC’s industrial and population rates continued to grow.

For the most part, the resident of the apartment spends a majority of her free time in her apartment. There are few well-kept parks within walking proximity to her apartment, making it difficult to experience natural elements in an urban setting. For her, and other city dwellers, it is very important to have a peaceful place to unwind after a day spent in transit among large crowds of people. Providing the resident with natural light and the potential to grow plants, this design can help to relieve stress in an environment that is often chaotic.
A map of Manhattan, NY which spans over 22 miles and is home to over 1.63 million people.

A map of Washington Heights, Manhattan NY, home to over 214,000 people.
The location of the apartment building in Washington Heights, NY

A close-up view of the apartment building from the outside.
A close-up view of the neighborhood that surrounds the apartment building, used for the site of the design. Buildings are placed very closely together.
Site Analysis

Quantitative:

There are 5 windows in the chosen apartment being used for this design. The apartment is about 600 sqft and contains 4 separate rooms consisting of the kitchen, the living room, the bathroom and the bedroom. There is at least one window in each room of the apartment.

Qualitative:

The first window when entering the apartment, is small and is located in the kitchen. The window faces a neighboring building and is half covered by counter space, substantially taking away from light availability in the room. This window would be an ideal location to install my design. The second window is in the bathroom and is one of the most well-lit rooms in the apartment. It is centered in the bathroom among white walls making it an ideal source of natural light.

The third and fourth windows are in the living room area, during the summer one is occupied with an air conditioner that takes away 50% of available natural lighting. This is the room the resident spends most time in and the room that she would have the space to grow houseplants. Two light enhancers would be placed on each window. The fifth window is located in the resident’s bedroom but is partly covered by a bed frame. This window would also be an ideal place to implement the design to maximize room brightness.
Back of Living room

Front of Bedroom

Photo by Ellie Tretola

Photo by Ellie Tretola
Site summary

The site located chosen for this research is in a one bedroom 600 Sqft North facing apartment in Washington Heights, Manhattan, NY. This site was chosen because during prime sunny hours of the day, not all of the apartment is exposed to natural lighting due to limited windows per room. The apartment has 5 windows, two in which are blocked by large light inhibitors at some point in the year.
Case Studies

“Case Study: Municipality Brings Natural Light into New Ashburn, VA Firehouse” (FEBRUARY 1, 2017) (LeBrun)

“The Lowdown on the Lowline, the World’s First Underground Park” (May.5, 2016) (Quirk)

“Rjukan sun: the Norwegian town that does it with mirrors” (Nov, 2013)(Henley)
In 2017 a 1,300-square foot old firehouse located outside of Washington D.C was the model used as the inspiration for the design and construction of a new firehouse that would be used to replace it. The replacement firehouse, built at 35,000 square feet would have much more room for a larger number of firefighters + provide more modern amenities than its predecessor. While creating a lighting plan for the new building, the idea of the sun tunnels were presented by architect Peter Edivan to the fire chief, Lieutenant Fox. Fox immediately showed great interest in the utilization of natural sun lighting, along with cost efficiency benefits that would follow in the future.

In designing this lighting system, several tubular devices called VELUX Sun Tunnels were connected from the rooftop of the new firehouse down into the building to brighten the existing rooms below. The tubes transferred the natural light from the top of the building with the help of reflective materials within them, that took the light from the sun and allowed for it to bounce back and forth down the tube and into rooms with no windows, bedroom skylights, locker rooms, lounge areas, break rooms and bathrooms. To mimic natural lighting patterns, the tubes that measured up to 20 feet long, were spaced 12 feet apart to create evenly distributed light within their...
given rooms. It took 27 tubes measured at 22 inches in diameter to light the desired parts of the firehouse. It has been noted by Chief Fox that the sun tubes have entirely replaced electricity in some areas and that during the daytime, people will often go to turn off light switches to find that no electric lights are on. This case shows the great impact that natural lighting can have when enhanced in an environment where humans spend substantial amounts of time.

The decision of opting for a natural light solution to save energy and enhance the lives of inhabitants is very important when considering interior lighting solutions. According to Edivan, “The design process for the new facility took six months, and construction required an additional 18 months to complete”. The cost came to $8 million dollars which was primarily donated to the firehouse. On top of the benefits of enhanced lighting for people and cost efficiency, the Chief has admitted a sense of pride to have this design implemented in his firehouse claiming, “When I take people on tours in the station, it’s one of the things I point out,” Proving that innovative light solutions can bring its inhabitants a feeling of distinction. (LeBrun).
In 2009 the proposal for a groundbreaking idea of an underground park that would be located on the lower East side in Manhattan, NY was released. The location of the lowline would be in an underground abandoned trolley terminal built in 1903. The proposed site measured at 60,000 square feet or 1.5 acres with vaulted 20 foot ceilings and steel columns make it an ideal location for a project of this size.

Using fiber optics to manipulate natural light, the proposed park would be illuminated entirely from sun tracking panels known as heliostats which would take in the sunlight, concentrate it through light tubes fitted with mirrors and lenses to bring the sun from outside, underground. Once the light is brought in, an anodized aluminum canopy will be set up on the ceiling to spread the light and can be directed in any way needed. The distributed light would allow photosynthesis to take place, making it possible to grow plants and even trees within the underground park.

There is currently a lowline lab located at 140 Essex Street that was created as a miniature model of what the final project would be. The end product is expected not to have any electric light at all and it is estimated that their sunlight concentration system will make the light 30x brighter than regular sunlight. The sunlight collectors and mirrors will have coatings on them that will act as filters to keep out infrared light which would make the system too hot and cause damaging heat problems on plants. This design would provide a solution to limited green park locations in the winter season, for urban residents to enjoy. This case supports the demand for human exposure to plants on a year-round
basis and promotes a sense of community. Their dream is to provide a place for art, farmers markets, live music for people to enjoy in the off season to help represent the spirit of the lower east side. James Ramsey is the inventor of the optical system to be used in the lowline and Dan Birsch has acted as executive director on the project. The project which was released to the public in 2009 is expected to open in 2021 to the public.

A project based in NYC for an underground park, where naturally within a building, for
“Rjukan sun: the Norwegian town that does it with mirrors” (Nov, 2013) (Henley)

In November of 2013, Norway implemented a 3-mirror system on top of the peak of Gaustatoppe which sits at 1,800 meters high surrounding the city of Rjukan, Norway. This system uses reflection with the direction of a computer system down below while utilizing solar power to follow the movement of the sun and reflects light into the town below. The city is home to 3,400 people who reside in shadow for a majority of the year. (Henley)

To remedy this problem of low light accessibility, a Norwegian engineer named Sam Eyde invented a solution to the problem by coming up with a design that would shine natural sunlight down on the darkened city. Eyde created a three 17 sq. meter glass-mirrored system that sits on top of the mountain 450 meters up aiming down at the town. (Henley) The computer-controlled mirrors continuously track the rays of the sun, reflecting it downward into the center of town for all to enjoy. The town which had previously only received 2 hours of light a day from 12 to 2:00 pm, now receives light in the center of town until sun down. Initially the townspeople had spoken out against this proposed project as they thought it would be a waste of time and resources but responses from people have been positive, with some even calling it “mentally warming”.

The importance of bringing light to a community who resided in a dark environment was the prime focus for this installment. This solution can be considered when assessing the problem of tall building’s shadows by incorporating similar systems on top of buildings aimed into the city below that may otherwise exist in the dark.
Itstorical Context

Throughout history, there have been many advancements in the development of lighting, following basic invention and utilization of light in everyday life. The topic of natural lighting in urban settings has been a subject of conversation since the 1800’s and advancements have continued to be made as time has passed and developers have continued to make great strides leading up to modern day.

In the 1900’s, zoning laws went into effect in New York City (NYC). In the late 1800’s, residents of NYC had begun complaining about lack of light and air pollution in regard to the tall buildings and dense population taking over the city. Around this time is when considerations on how to amend such issues began to develop. Soon after, the state legislation of New York began to develop building height restrictions such as the Tenement House Act of 1901 (CPH) which limited heights of residential buildings. As NYC continued to expand and new problems such as industrial growth began, older policies became null in void and new updates to zoning laws continued to change to accommodate a booming industrial city.

In the 1970’s the importance of lighting in design became noted by an architect of lighting design, Richard Kelly, who became predominately recognized for his focus on the impact of lighting as a design element. Kelly tapped into the relevance of light distribution and how lighting could change a space entirely as well as change the attitude of the person viewing it. His best-known ideas regarding the importance of lighting design included: Focal glow, ambient luminescence and play of brilliants (Petty). To this day, these concepts are still recognized as some of the most iconic ideas behind modern lighting design. His work has proved the power of meaningful lighting design as well as helped to exemplify the effect that light has regarding a space as well as to the people who experience it.
In the 2000’s, the extension of studies regarding human response to light continued to be examined by psychologists and doctors. One study that linked the effect that light had on its human subjects is done by James Russell, who discussed the relation between lighting and human stimulation.

In this article, he discusses the correlation between lighting, color and temperature and its impact on human distress, relaxation, sleep, excitement and arousal. Studies such as this, further progressed the idea that lighting had significant impacts on the moods of people. In conclusion, Russell determined that when entering a new environment, people categorize their mood into one of 4 quadrants including: Unpleasant, sleepy, pleasant and arousing. His conclusions revealed that the lighting and overall tone in a space could drastically change the mood of the occupant in a matter of seconds.

(Davis)
Programmatic Requirements

In order to have the most effective design, the site must have at least one window source to pull in natural sunlight from. The design of the light enhancer consists of an angled mirror-paneled fixture that will be mounted on the ceiling in front of a window source. This fixture will be divided in half by a strip that will have an extender that is reachable to people from ground level that can be adjusted based on orientation of the sun. The panels, made of a mirrored material are designed to optimize the amount of light accepted from the sun outside. It is recommended that the rooms they are installed in should be painted white or tones of blue that will bring added calming benefits to the resident of the space. The design is intended to bring peace to the resident by providing a well-lit setting where plants can be grown for aesthetic and functional purposes.
Capstone Goals

This design research will entail the study of past, natural lighting enhancement solutions to dark areas. Using prior research of other lighting solutions, I will then begin to organize my method of design given my site information and specified restrictions. Once I have developed a good understanding of a plausible design regarding space and function, I will then begin the process of drafting the design by hand or by means of computer design (CAD) until I can arrive at a point of closest accuracy.

- Researching best natural light enhancement solutions in past and present development.
- Using past design to help me develop my own idea based off relevant practices.
- Develop an informed and accurate design based off findings.
- Design the model based on actual scale of the chosen urban apartment

I am determining what materials, textures and colors would be best suited for the design + provide supportive facts to back my choices. The site must also need to have a strong ceiling to mount the mechanism up above the window.

Ideally this design will be used with any amount of sunlight throughout the day and my goal is to add an extra 2 hours of sunlight in the apartment daily, to reach the minimum of 2 hours needed for indoor plants to survive indoors (Allman). Upon further research, mirroring systems seems to be the most effective way to disperse light within a room which will be my primary material to focus on.

The light quality should surpass that of a light bulb and it is my goal that at certain times of the day, electric will not be at all necessary to illuminate the apartment. If the design proves to be a viable solution for limited natural lighting in urban apartments, I predict that the resident will see an improvement in her mood and she will also be able to grow plants where she was unable to, prior to the implementation of the design.
References


Consideration of Topic: Lighting enhancement mechanisms

Outdoor system used to track sun patterns

Product rather than design element

Consideration of Topic: Ice melt for roads infused with element to prevent algae blooms in summer

Considering setting that lack natural light availability

Office Building

Access to urban apartment setting = ability to study site

Light enhancer designer for people or plants?

Design based on reflection or colors?

Both
Plan for Proceeding

**Week 1. Research urban-low light settings**

Begin researching urban areas-common lack of lighting + why?
- Get statistic on how many urban apartment spaces get less than ideal amount of natural light exposure making them unable to grow plants.

**Week 2. Research existing light enhancement designs**

Start to consider current innovative lighting sources for poorly lit areas (use and method)

**Week 3. Begin to gather details for design development**

- Brainstorm ideas for materials, quantity, best color, textures, movement

**Week 4. – Continue to revise Stage 1 and begin planning for Stage 2**

Research relevant historical facts
Collect pictures for case study summaries

**Week 5. Location details:**

Get information on site: (Sister’s apartment in Washington Heights)

- Window per room count + possible light blockers (air conditioner)
- Proximity to neighboring buildings
- Measurements of window frames.

**Week 6: Begin to plan for first CAD design**

- Organize measurements ex: width, length of materials
- Use window count to get an idea for how many enhancers would be needed in the apartment (etc.)

**Week 7: Start first draft of CAD design**
- Design with specific apartment details in mind

**Week 8: Begin to create material list w/ pricing for proposed design**
- Quantity of items
- Cost of items (if necessary)

**Week 9: Figure out where materials could be purchased**
- Include location
- Online or in person?

**Week 10: Finalize CAD design**
- Labeled
- To scale w/ apartment measurements

**Week 11: Begin to plan where design could be built/ how long**
- Realistic weight/ size
- Can it be carried up 6 flights of stairs?

**Week 12: Create checklist of all necessary requirements**
- Design aspects
- Proper documents
**Week 13: Begin printing documents/design**

- Make sure everything is accounted for
- Spell check everything
- Confirm that design print looks good/no mistakes

**Week 14: Assemble board/organize all documents**

**Week 15: Review checklist and confirm that everything has been completed**

- Revise if needed before due date
Previous course experience

Bachelors in Landscape Development

Fall 2015:

| HOR 110T 01 | Horticulture I Theory- Prof Iverson |
| HOR 131T 01 | Landscape Drafting I Theory- Prof Fogelburg |

Spring 2016:

| HOR 111T 01 | Horticulture II- Prof Iverson |
| HOR 133T 01 | Landscape Drafting II- Prof Fogelburg |

Fall 2016:

| HOR 207T 01 | Landscape Plans I- Prof Flynn |
| HOR 340T 01 | The Sustainable Garden- Prof Veracka |

Spring 2017:

| HOR 220T 01 | Landscape Plans II- Prof Flynn |

Fall 2017:

| BIO 355T 01 | Plant Ecology- Prof Morgan |
| HOR 371T 01 | Landscape CAD I0- Prof Famulari |

Spring 2018:

| HOR 372T 01 | Site Engineering- Prof Schmidt |
| HOR 474 01 | Design Capstone Project – Prof Famulari |
Personal Identification page

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“Those that plant trees, love others besides themselves”

-Thomas Fuller

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