MULTICORN

Design Thinking & Innovation
Web Project Portfolio

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Multicorn presents...
The Making of Enchanted Oasis
Deliver Phase [Part 4]

Table of contents

Table of contents

01

Problem Statement

description of the issue to be addressed and improved upon

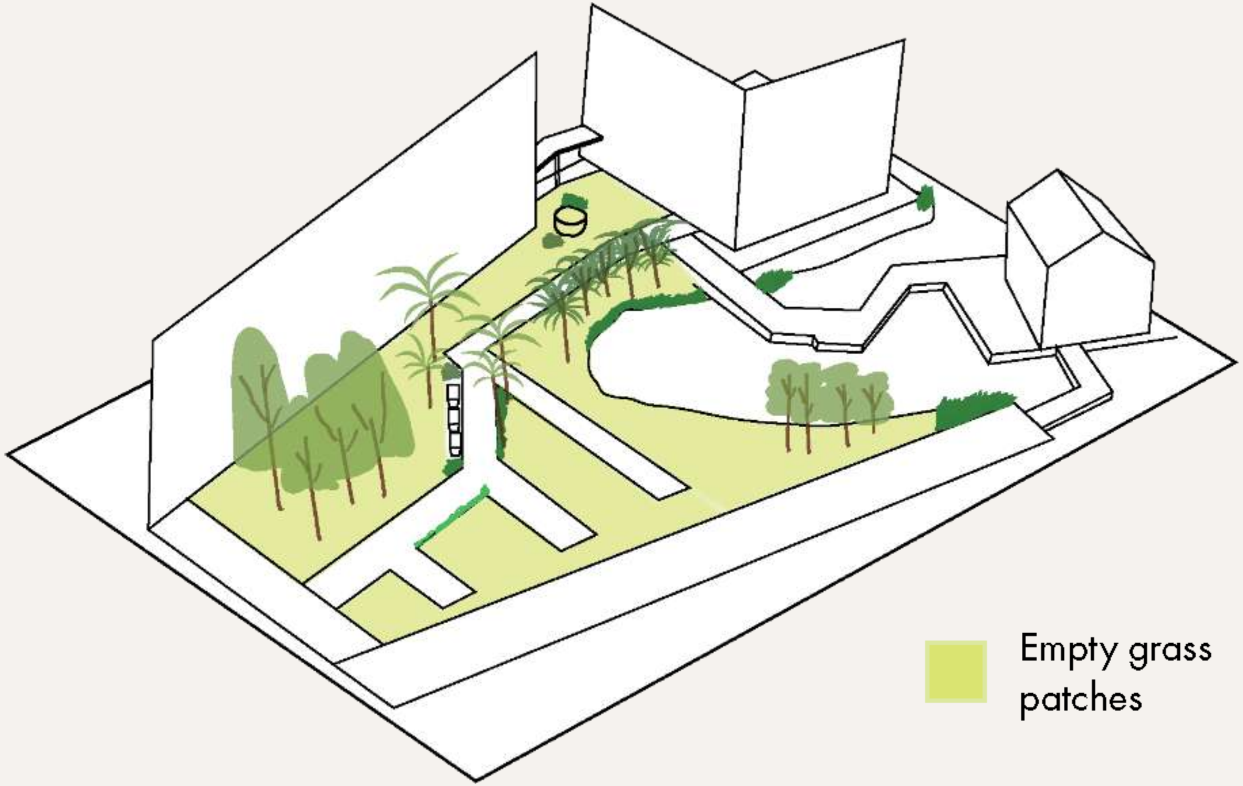
How might we leverage on the hostel park to create a space where busy students can go to relax and de-stress ?

–Multicorn

02
Chosen Site: Hostel Park

+ key takeaways

Environment



Empty grass patches

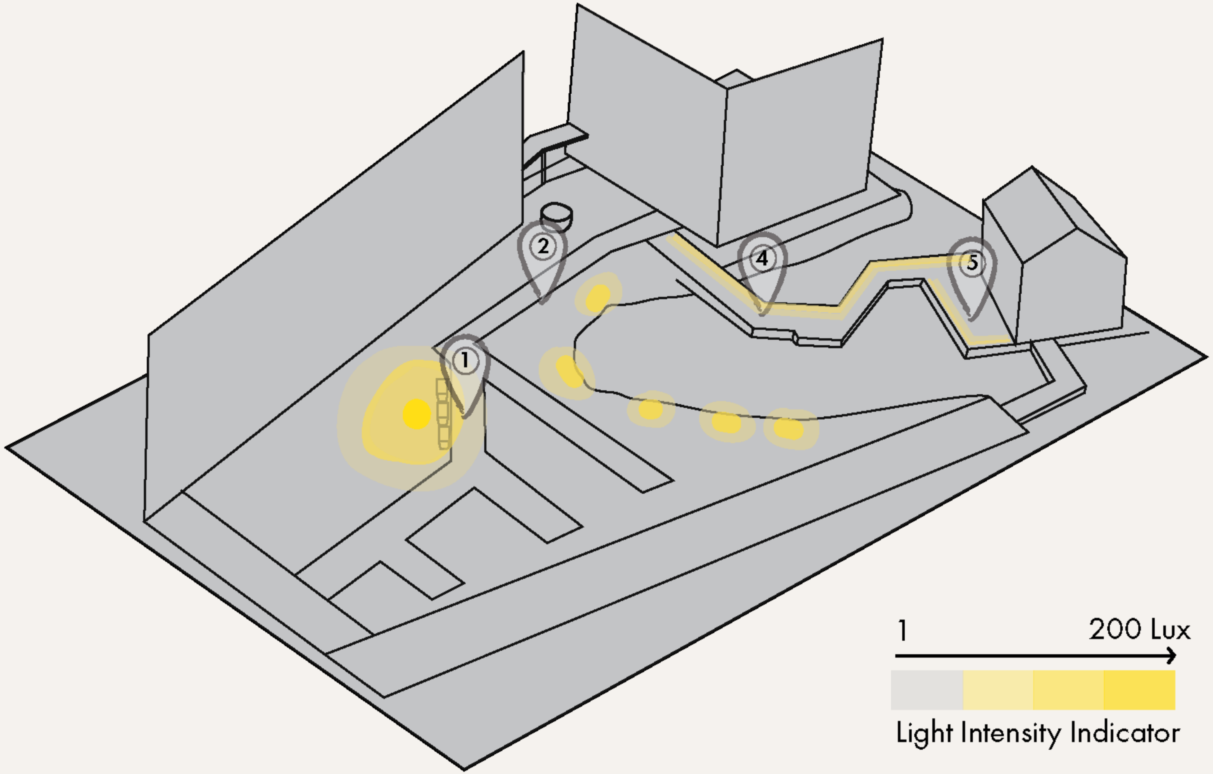
Environment

The chosen site has an area of 1745sqm, it is surrounded by a large number of bushes and trees that looks similar to each other. There are a few large patches of empty grass across the site. There are 3 benches to serve the entire site, and there are no shelters available.

Colour Palette

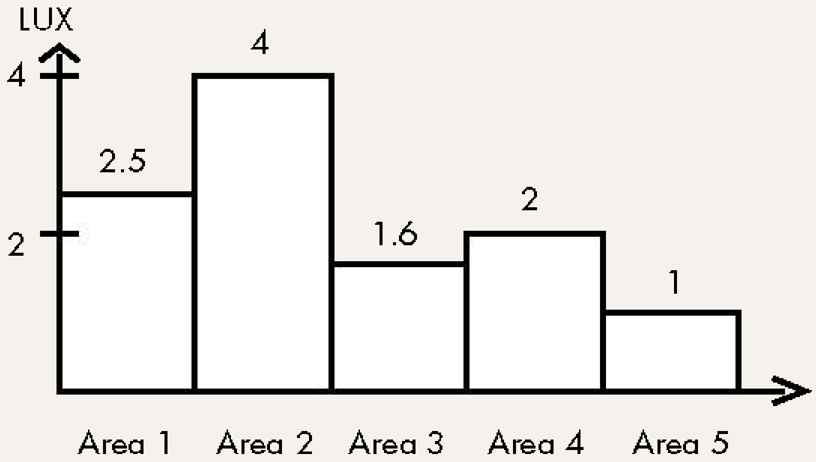
Pond	Tree	Bush	Pavement	Sky

Luminescence

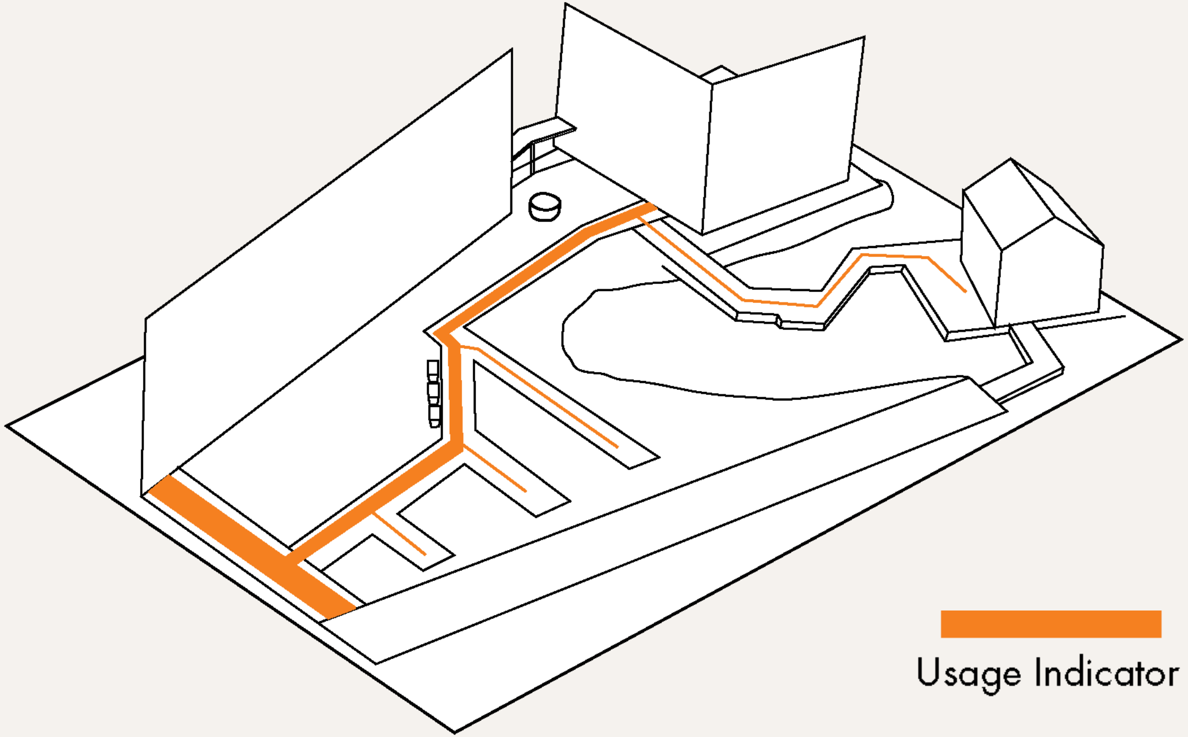


Luminescence

In general, the average Lux level of the garden is very low at night, ranging from 1 to 4, which is adequate for visitors to see what is ahead but not enough to see the surroundings with detail. Below park's requirement of 5 Lux for street lighting



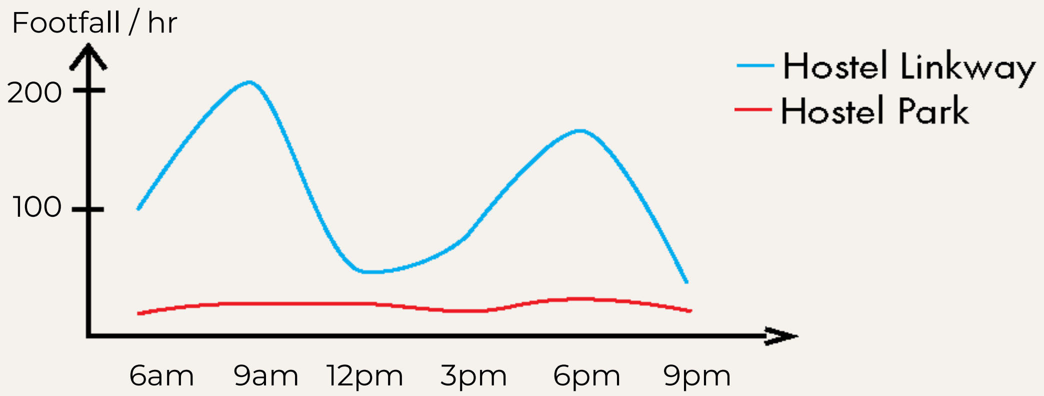
Footfall



Usage Indicator

Footfall

The diagram depicts footfall on a normal day. On average there are 1 to 3 people in the garden and they do not stay long. Many people walk by the garden as they go between blocks 57 & 59 while heading to class or returning to the hostel. The footfall is also affected by the time of the year when students may be on holiday or an event is taking place.



Key Takeaways

Uncondusive space for relaxation

Key Takeaways

Area lacks comfort

- Presence of insects
- Limited space to sit and relax
- Lack of shelters makes site unappealing on hot day

Visually unappealing

- Garden has little variety of sight
- Colour palette of environment is monotonous
- Not well maintained

Unsettling atmosphere at night

- Low lighting coupled with darkness of night causes a creepy aura
- Thick vegetation in concentrated areas amplifies its eeriness

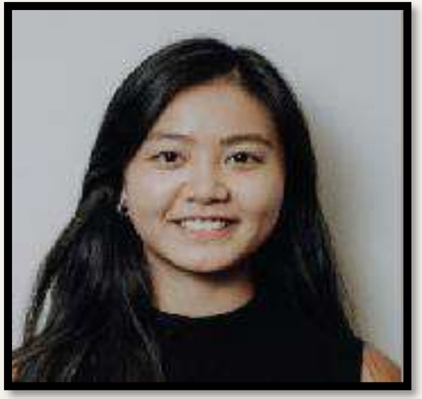
03
Users

Description + Their needs

Users

Alex

Busy international student with side business



Emily

Social butterfly capstone student

Steve

Freshmore introverted student

Name: Alex
Age: 23
Marital Status: Dating

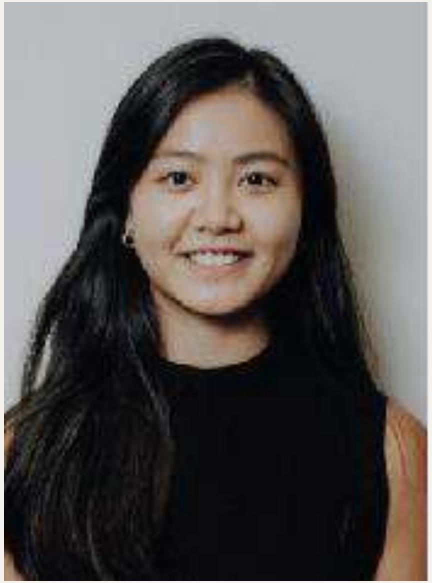
Alex, studying alone in Singapore, maintains a Long Distance Relationship (LDR). Limited hostel privacy prompts him to walk to the park for calls despite discomfort. Juggling university workload and running his own company, he prioritizes accessible, quiet call locations.

Frustrations:
- No privacy in hostel
- Homesick

Goals:
- Do well in school
- To get married

Needs/Desire:
- Time
- Money

“I find it hard to search for a nice private space where I can go to videocall my girlfriend. The hostel is so densely packed I can never seem to find a place to sit alone and talk to her in private. It takes so much time to find a place that has this."



Name: Emily
Age: 23
Marital Status: Dating

Emily, a capstone student at SUTD, has held multiple exco positions, leaving her extremely busy with no personal time. She lacks opportunities to relax or de-stress and hopes for some "me-time" during short breaks to unwind.

Frustrations:
- Too busy
- No time to spend with boyfriend

Goals:
- Maintain scholarship
- Graduate with High Distinction

Needs/Desire:
- To receive praise
- To be admired

“Although I’m enjoying my last year of uni and making full use of it, I barely have time for myself. It is always classes, then fifth rows, then its meetings. There is almost no time for me to sit back and relax with the 15 minutes I have or so between things."

Name: Steve
Age: 21
Marital Status: Single

Steve has just one friend in class, feeling disconnected from school. He values solitude and finds solace in the hostel garden but discomfort from mosquitoes keeps him away from the place.

Frustrations:
- Class too noisy
- No personal space

Goals:
- Do well in school
- Graduate without drama

Needs/Desire:
- Personal space and time
- Peace and quiet

"I like to visit the hostel gardens during my free time, however i get bitten by mosquitoes every time I go there. It also give me the creeps at night due to its low visibility. I fear I might run into a snake by accident or step on a rat.”

04
Design Goals

Objective

Our design goals are:

- ❑ To create a space that helps students to relax & de-stress
- ❑ Enhance the Hostel Park's visual appeal
- ❑ Utilize the Hostel Park's current features & elements

05
Proposed Solution

Enchanted Oasis

By leveraging on the natural elements of the Hostel Park, Enchanted Oasis embodies the enchanting beauty of nature. Combining nature with colourful, mesmerizing, evolving fractal lights, Enchanted Oasis creates an ethereal experience that facilitates relaxation and serves as a getaway for busy students from the hecticness of the SUTD student life.

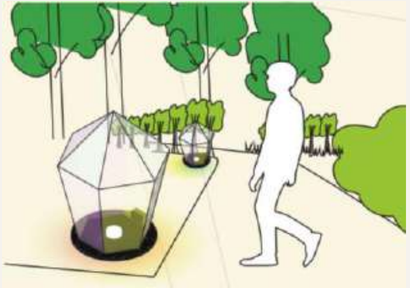
How?
Enchanted Oasis enhances the Hostel Park with a gazebo housing a beautiful rotating dome roof that is tinted with special holographic material. Accompanied by glowing crystal lamps that adorn the Hostel Park, these structures emit enchanting, vivid, fractal light shadows, illuminating the whole Hostel Park.

Critical Image

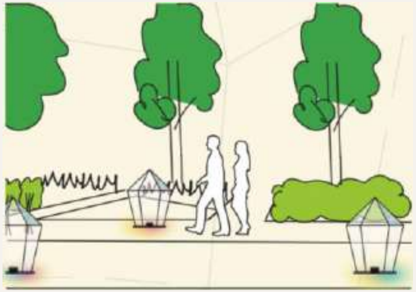
We took pictures of the Hostel Park in the same spot during both day and night. Then, we added the rendered image of the gazebo and crystal at the correct angle and used photoshop to imitate the lighting effects of our solution in real life.

06
User Journey

Experience map,
Touch points, Storyboard



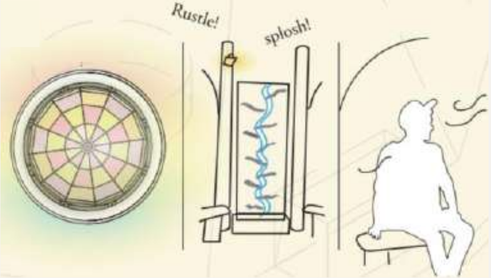
1. The Enchanted Oasis experience first greets its users with glowing crystal lamps



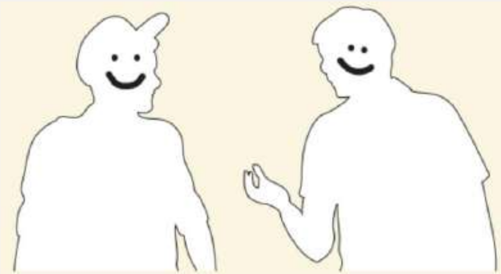
2. As users walk around the park, the crystal lamps light up their path

3. Enchanting Gazebo illuminates the Hostel Park

4. Users sit and relax in Gazebo



5. Users view the rotating roof and lights, the water feature, and scenery of the park. Ambient sounds of the rustling leaves, water can be heard. They feel a cooling breeze



6. Users feel relaxed and refreshed

07
Design +Fabrication Process

Timeline:

I

Discussion of concepts

II

Exploration and refinement of ideas

III

Low fidelity prototype and exploration

IV

High fidelity prototype

V

Fabrication of functional prototypes

VI

Finalised prototype

Discussion of concepts

Step 1

Discussion of concepts

Discussion in meeting room

We compiled and discussed our ideas from Part 3 to see which components can be used in our final product.

We ranked everyone's Part 3 components based on:

i) Feasibility
ii) Uniqueness to SUTD
iii) Sustainability
iv) Difficulty of implementing
v) Value added to the area

Exploration & refinement of ideas

Step 2

Exploration of Final Solution

Rudimentary sketches

After ranking and comparing each component from Part 3, we decided to choose the **gazebo idea** as the main feature of our final solution.

We also chose to include floor lanterns around the hostel park to complement our gazebo.

Our aim and target is to use natural elements in our solution. We have chosen to use **natural day light** and **water**.

We have also opted for our solution to be sustainable by operating with a **minimal carbon footprint**. We achieved this by removing the need for artificial light during the day and using **solar panels** to power our solution.

Exploration of Gazebo Designs

Rudimentary sketches

As we wanted the roof of the gazebo to have interactions with light, we explored the concepts of implementing **refraction of light** into our roof.

At first, we explored the idea of making our gazebo an **igloo** (where the gazebo will look like a hemisphere).

Another idea was to make the roof of our gazebo **a fan** (to make the gazebo cooler).

We also took inspiration from Jewel Changi, making our roof a **concave dome**, with **water** flowing on the roof to **disperse the light rays**.

Exploration of Gazebo Designs

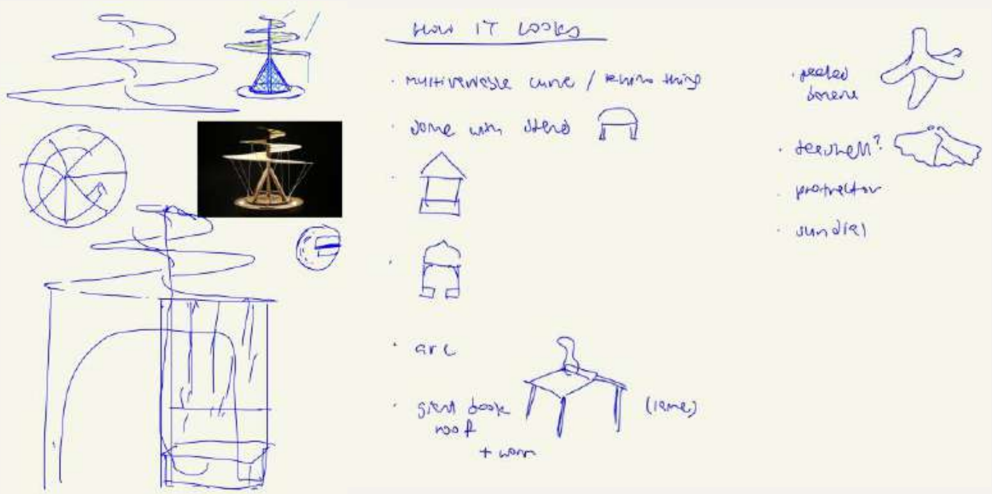
Rudimentary sketches

After exploring the ideas from Jewel Changi, we explored ways to make the refracted light rays **non-stagnant**.

We then took inspiration from Modelling Space and Systems, by making our roof look like a **saddle point**.

As we wanted to make the light rays non-stagnant, we considered making the roof **move**. We then explored the designs of a **potato chip** to see how we can **split the roof panels**.

Exploration of Gazebo Designs

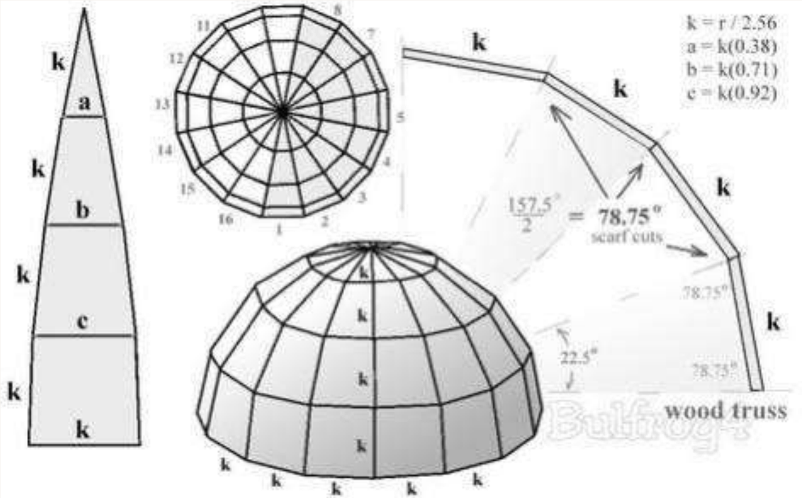


Rudimentary sketches

We also explored the idea of **Da Vinci's Helicopter** as the design of our roof, where water will flow from the top and spiral downwards.

The idea of making the roof of the gazebo a **sundial** was also considered.

Exploration of Gazebo Designs



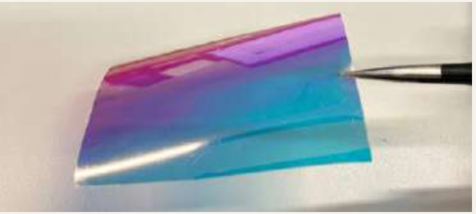
Dome design sample

After much considerations, we decided to go with a **dome shape** for the roof of our gazebo.

We went online to get some inspirations and looked through different types of domes. However, in the interest of time, we decided to go with the dome design in the figure.

The chosen design is relatively easier to fabricate and assemble as the panels are symmetrical.

Exploration of Gazebo Designs



As we are trying to use the roof of the gazebo to produce light effects by refraction, plain glass will not refract light by a lot.

Hence, we decided to paste **holographic films** to the panels of the roof. This will further allow the light to refract and display more colourful effects through **thin-film interference**.

We then dived deeper into the idea of **manipulating light rays.** After much discussions, we decided to make the roof **spin at a slow speed** to constantly alter the light rays, .

To further catalyze the relaxation process of our solution, we decided to make the roof spin at a slow speed.

Observing slow rotating objects can help one notice more and look a little deeper.

Observing art slowly has an effect on the brain and can also trigger the release of feel-good chemicals, such as serotonin and dopamine.

In addition, observing distant objects may relax strained eyes.

References:
https://mindworks.org/blog/what-happens-to-your-mind-brain-and-body-during-meditation/
https://dialecticalbehaviortherapy.com/mindfulness/observing/
https://www.scientificamerican.com/article/a-moving-experience-mind-jan-10/

Exploration of Gazebo Designs

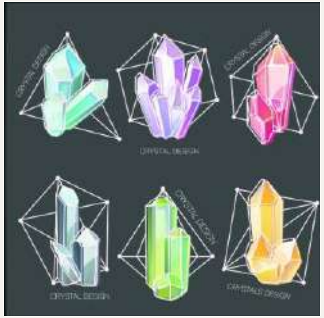





Design Conclusion

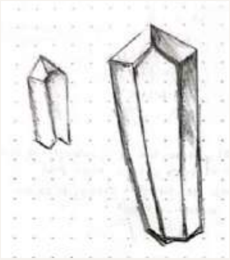
After concluding on the design of our roof design, we used generative AI to create samples of our gazebo based on our hand-drawn sketches to draw inspiration for what our final product would look like.

Exploration + Sketches of crystal designs



Research on Google

Research on Pinterest



Design sketch

Design Conclusion

From the site analysis, we found that the hostel park area is very **dark**. To solve this problem, we decided to add **floor lanterns** around the area.

We decided to go with a **crystal design** for the floor lanterns, as crystals fit the enchanted and mystical theme we were implementing

We got inspirations from Google and Pinterest to get the final design.

Exploration of Water Element

We decided to add a **water element** to our solution to further enhance the relaxation experience.

To confirm that the water element will catalyze the relaxation experience, we managed to do research on a few studies.

A study showed that gazing at bodies of water can help lower your heart rate, blood pressure, and increase feelings of relaxation.

Another research by the University of Exeter shows that the sound of the ocean may help reduce stress and create a sense of calm. Being near to or hearing the ocean is recognized as bringing a sense of calm and perspective.

References:
https://www.ucdavis.edu/curiosity/blog/what-are-health-benefits-viewing-water
https://phys.org/news/2018-05-evidence-ocean-stress-calm.html

Low fidelity prototype and exploration

Step 3

Gazebo Structure Prototype

From our finalised design of the dome roof, we made a low-fidelity prototype of the roof and gazebo using **paper** and **ice-cream sticks**

Crystal Floor Lights Prototype

For the floor lights, we explored the design with **foam paddings.** We hollowed the structures and placed lights under them with coloured Post-it notes to tint the lights.

Water Flowing Experiment

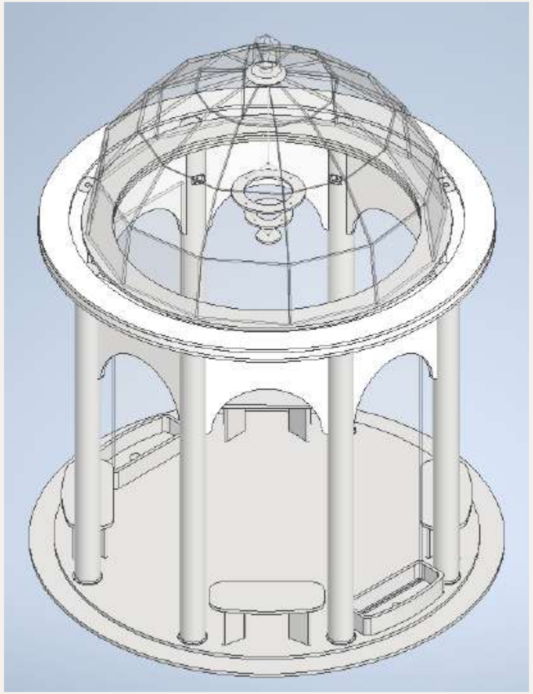
As we decided to include the **water element** in our gazebo, we tested whether the water follows the bends at the edges of the acrylic panel.

After studying the flow of water, we got a better understanding of how water moves and affects light when designing the water element into the product.

High fidelity prototype

Step 4

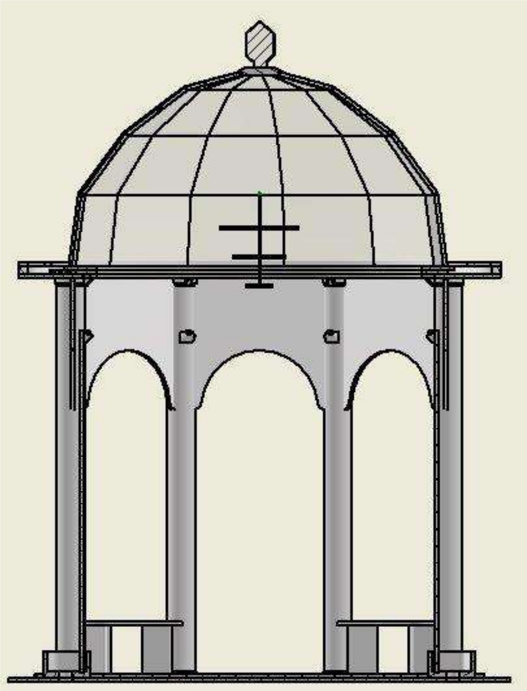
Final Model of Gazebo



Our dome roof will be supported by **8 pillars**.

The gazebo will have 2 water fountains between the pillars. The function of the water fountain is to **enhance relaxation** by creating a **waterfall effect** which **scatters the light** and **creates the sound of water flowing**.

Final Model of Gazebo



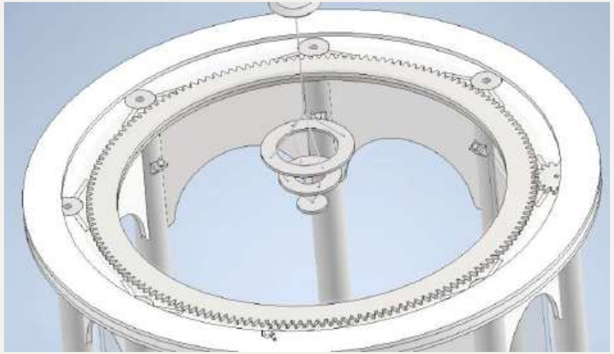
Section view of gazebo

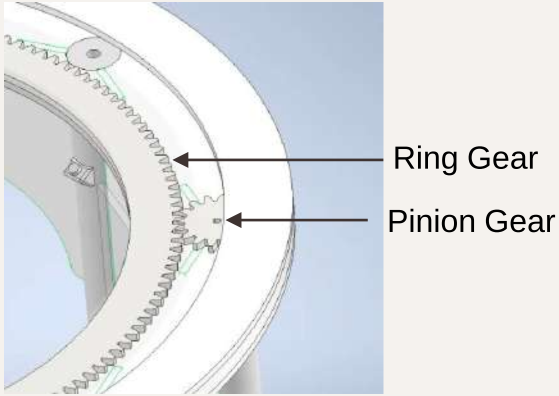
The dome roof panels, gazebo base, pillar arches, benches, chandelier, roof support ring panel, and panels for the water fountain are made from **acrylic**. Acrylic was chosen as it requires less time to laser cut compared to 3D printing. Laser cutting is also a lot more precise than 3D printing and can be done a lot quicker.

We used **standard PVC water pipes** as the pillars of the gazebo. However, the diameter of the PVC pipes was bigger than what we had expected. The acrylic pieces had already been cut by then.

To rectify the problem, we 3D printed **connectors** for the pillars to the base and supporting ring panel of the roof.

Spinning Roof of Gazebo



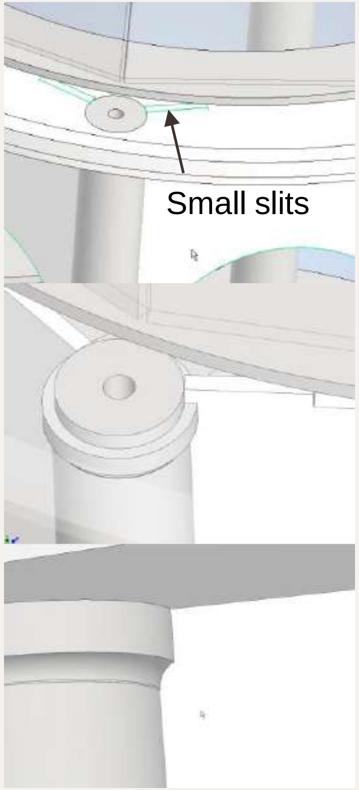


To make the roof spin, we decided to use a **gear system**.

A DC motor will be attached to a pinion gear.
The pinion gear will then drive the ring gear.
The dome roof will be placed on the ring gear.
The ring gear will then spin the dome roof.

The gear ratio of the pinion gear to the ring gear is very large, which results in a slow movement of gears.
The gear ratio is **1:10**.

Arches of Gazebo

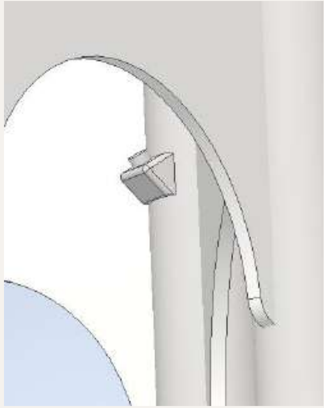


The arches of the roof are locked in place with the roof through **small slits**.

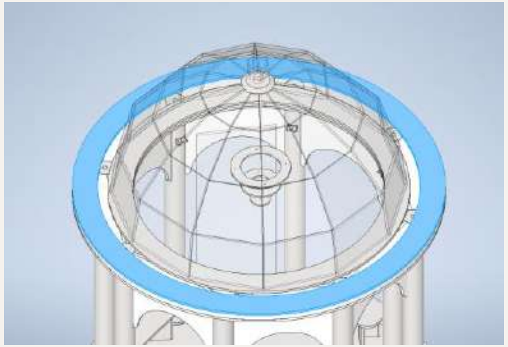
The arches also lock the pillar connectors in place.

This is because the motor will be placed in one of the pillars, and the torque to spin the gears is very large This will result in the connector spinning instead of the pinion gear. Therefore, the arches have been put in place to **prevent the pillar connectors from spinning**.

Lights of Gazebo



Pillar lights



Ring panel

As our gazebo utilises natural light during the day, we would need to install lights in the gazebo for the night.

Since the roof will be spinning, it is very challenging to connect electrical wires to the roof of the gazebo.

Hence, there will be 4 lights angled upwards installed on 4 alternating pillars of the gazebo.

Lights will also be installed around the dome roof on the supporting ring panel to illuminate the exterior of the gazebo.

The ring panel is painted white to reduce the intensity of the light by causing it to diffuse.

Mini Gazebo Dome Roof Prototype

1st Mini Dome

2nd Mini Dome

For the dome roof, we decided to add **holographic film** to enhance the refraction of light.

We fabricated **2 mini domes** to see the effects of light on different holographic films. The roof is constructed using **laser-cut acrylic panels with holographic film**.

We explored different techniques to construct the dome.

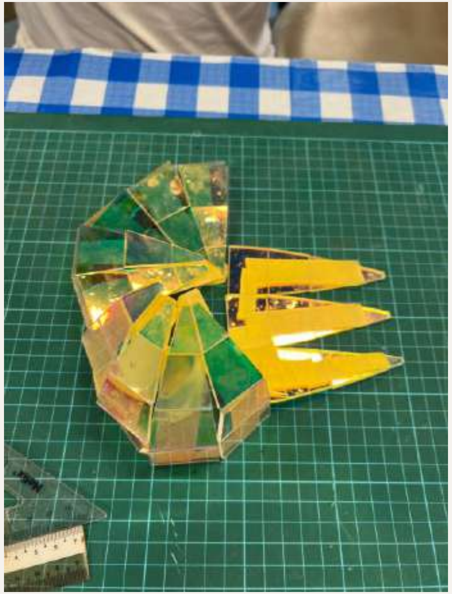
For the first mini dome, we taped the inner side of the dome and super-glued the acrylic panels from the inside.

For the second mini dome, we taped the outer side of the dome and super-glued the acrylic panels from the inside. The second dome produced a dome that was more rigid and uniform in construction.

Mini Gazebo Dome Roof Prototype

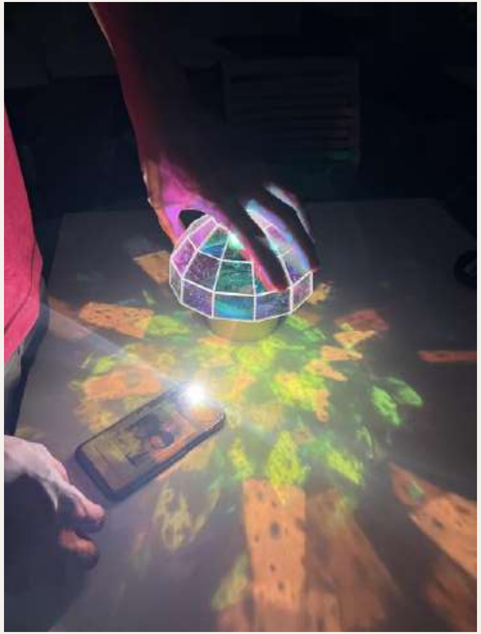
Laser cut acrylic pieces with holographic films attached

Mini Gazebo Dome Roof Prototype



Initial attempts to form dome shape for roof

Mini Gazebo Dome Roof Prototype

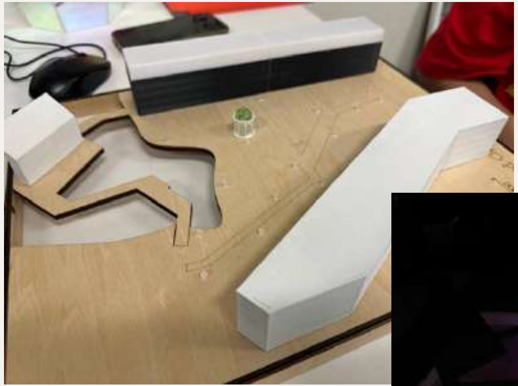


Testing the effect of light of different holographic films

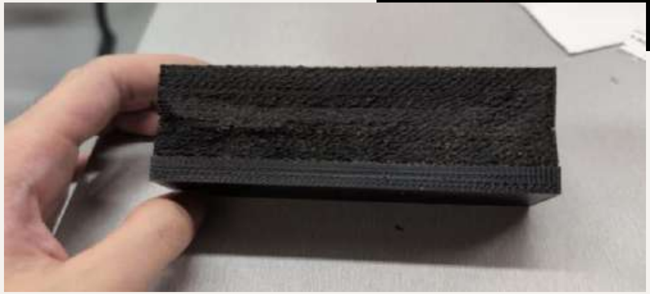
Fabrication of Scale and Functional prototypes

Step 5

Site Scale Model



Site scale model



Failed 3D Print

We used a scale ratio of **1:200** for the site model. The paths of the site were **laser-engraved** onto a piece of plywood, whereas the buildings were **3D printed**.

Challenges faced

The height of the buildings was not built to scale at first. However, after receiving feedback, we decided to 3D print additional blocks to scale the building height. This required the height of the buildings to be almost 20cm tall and was a concern as this was outside the dimension of the SUTD's 3D printers. It would take an extremely long time for such a large model to be printed. We would also have a few our 3D prints fail.

Site Scale Model

Impossible angle with taller blocks

Solution

We added to the heights of the initial prints to make the building to scale. This made the buildings detachable so they could be removed. This was done to not obstruct the main components of our site model. As seen in the pictures, some views of the garden in our scale model would be blocked by the buildings.

This was the reason why we had originally decided not to print the building to scale. However, now our solution kept the site entirely to scale while keeping the garden easily visible.

Site Scale Model

Uneven paint

Pooling of paint

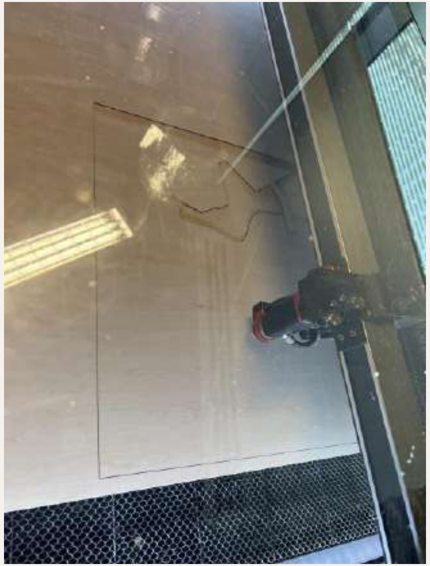
Challenges faced

When spray painting the building of the site scale model, we found that the paint had a lot of trouble sticking. This was due to the 3D printer provided not being very precise, causing the surfaces to be uneven and warp in some parts of the print. We also sprayed our paint directly on the print at first, causing the paint to frequently pool.

Solution

We used sandpaper to sand the surfaces of our prints to create a more even surface. Thus, allowing the paint coat to be applied far more easily. We sprayed lighter coat and gave the paint more time to dry. Then, creating more layers to give it a smoother surface.

Site Scale Model



Laser cutting and engraving

Site Scale Model

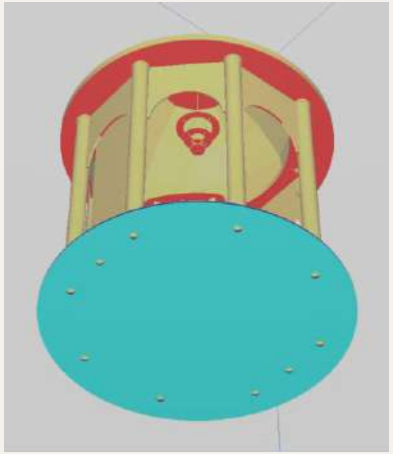
Reference information

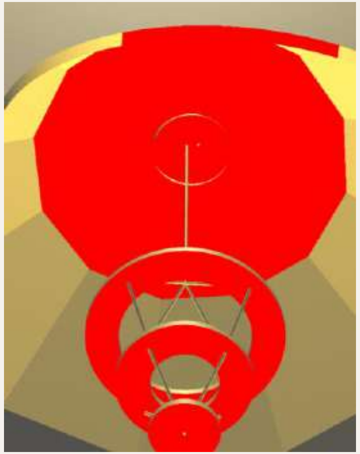
Cutting out the pond area

Site Scale Model

Scaled model of gazebo and crystal floor lights

Site Scale Model



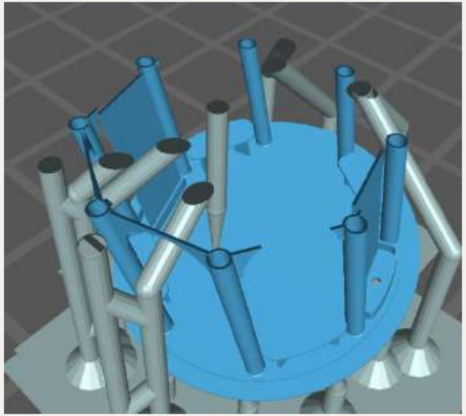


Challenges faced

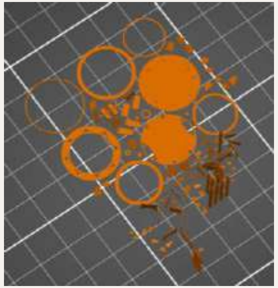
Originally, we directly exported the dimension of our Gazebo and scaled it down to the size of the site scale model, planning to 3D print it. However, we did this without considering how small certain parts of our gazebo would be once scaled down.

Here our STI file, it shows the line holding up our chandler is almost invisible. Which would be impossible to print with the entire print being less than 2cm wide and 2cm in length.

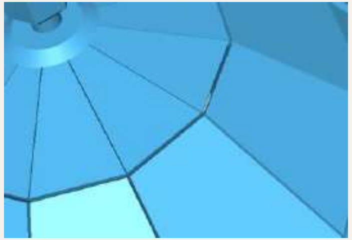
Site Scale Model



Internal view



Disassembled parts



Gaps in our model

Challenges faced

We were not familiar with putting together the different parts we had sketched in Fusion 360. We had failed to merge our parts before trying to print our model.

We later found out that we could separate them into individual objects, as shown in the pictures. Luckily, this was pointed out to us by our printing supplier.

We also had not viewed the internal parts of our model. Our supplier discovered that our pillars were hollow. If not fixed, it would have comprised the structure of 3D printing due its thinness.

Site Scale Model

Final Model

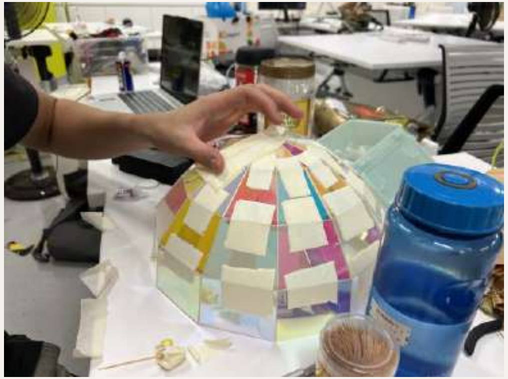
3D Resin Model

Solution
Taking his feedback into account, we worked to remove all the faults of our model. We properly merged all the pieces of our model to become one solid piece. Thus, giving us final the result you see on our site model. Which is void of any small and fragile pieces apart from the roof crystal

Site Scale Model

Lights were installed under the scale model base board to demonstrate the lighting effects of our solution at night. Holes were drilled from under the board to allow the light to pass through from under the base.

Functional Prototype

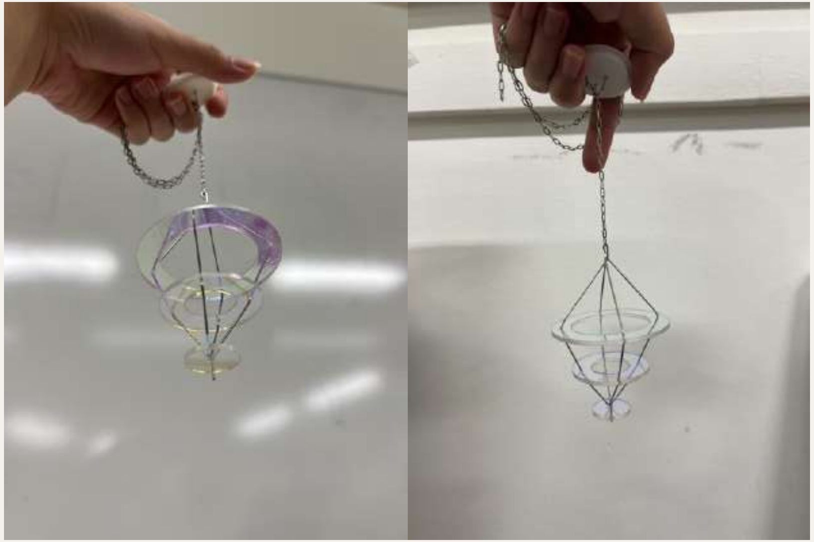


Gazebo Dome Roof:
Learning from the process of building the 2 mini domes, we decided to build the dome **layer-by-layer**, starting from the bottom.

We decided to use a **mixture of the 2 holographic films** we tested on the roof of the functional prototype.

We taped the layers from the outside and super-glued them from the outside as well. This is because we found that there will be a lot of marks formed by the superglue if we glued from the inside.

Functional Prototype (Chandelier)



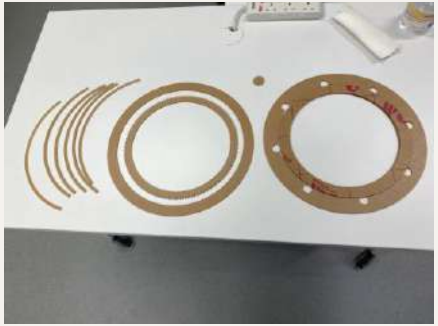
Chandelier

Gazebo Chandelier
We decided to add a chandelier inside the gazebo to enhance the effect of the refraction of light.

The panels of the chandelier are made from **laser-cut acrylic pieces**. Holographic sheet is pasted on the surface of the acrylic to give the chandelier a reflective effect.

Functional Prototype (Motor Drive)

Dome base ring components



Assembled dome base ring

Dome Base & Ring Gear

The acrylic components of the supporting dome base panels and the ring gears are laser-cut and assembled.

Dome on base ring

Functional Prototype (Motor Drive)

Motor with gear box

Motor attached to pillar connector

Motor hidden in pillar

Motor Drive

The micro motor and gearbox are installed and hidden within one of the eight pillars. The motor wire is run through the pillar and out of the underside of the base.

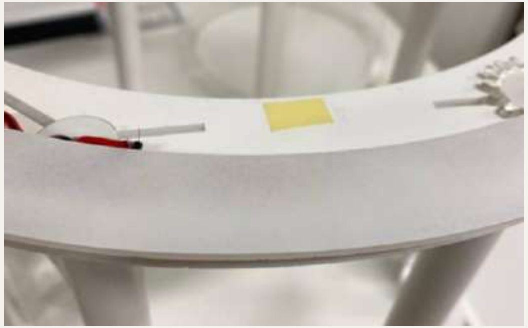
Challenges faced

After painting the ring of the Gazebo, the friction between the rings of the gazebo became too great for the motor to rotate the ring.

Painted dome base ring causing high friction

Functional Prototype

Low friction sheet

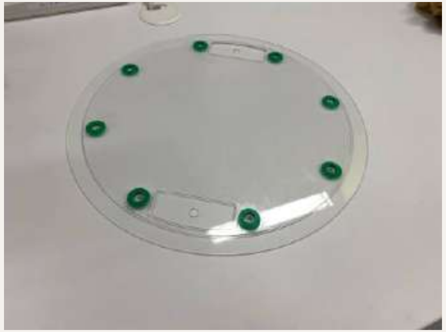


Lubrication

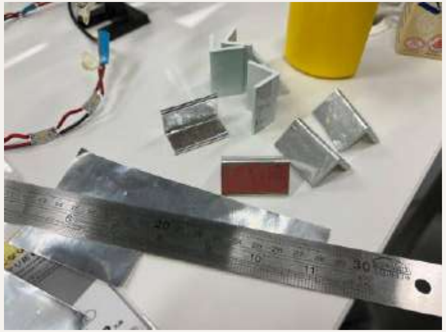
Solution
We decided to use our holographic sheets as mini low friction sheets, by pasting them between the ring gear and the surface of the roof ring.

We also sprayed WD-40 lubricant between the surface of the gear tooth and the roof to reduce friction between the surfaces and the gear.
With these improvements, the gear could spin freely.

Base and Components of Gazebo



Gazebo base



Legs for benches

Pillar connectors,
base of fountain and
legs of benches

Gazebo Floor Base

The acrylic base of the gazebo was **laser cut,** and the trough of the water fountain, pillar connectors and legs of the benches were **3D printed**.

Functional Prototype

Water Source

Water pipe

Water Fountain

To make a water fountain, we used a **water pump** to pump water from the base of the gazebo to the top of the fountain.

We then made many **small holes in the water pipe** to distribute the flowing of water.

Challenges

During our initial tests, the water flowing from the pipe would frequently flow off the acrylic and fall outside the base of the water fountain due to high speed of water flow.

Functional Prototype


Final gazebo


Initial Test


Water fountain

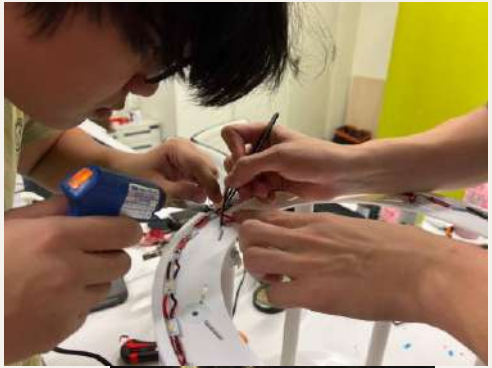
Solution

Through multiple iterations, we resolved this water flow issue. At first, we considered warping the acrylic in a concave shape. Then we tried cutting different holes in the pipes to reduce the water flow.

Finally, we settled on glueing **small stones** to the panels of the water fountain to make the water flow more evenly and slowly. Not only did this solution resolve the problem. It also made the water fountain more beautiful with artwork added to both water fountain surfaces.

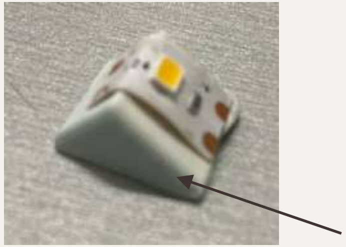
Functional Prototype (Gazebo Lighting)

Lights on the outer ring



Wires in the pillar

Final Product



LED Seat

Pillar Light

Outer ring light

The electrical wires for the lights of the gazebo were installed by **soldering**. The lights are installed in a **parallel circuit**. Each piece had to be cut and soldered individually for the light to be spaced evenly in the circular ring. The original light strip was unable to bend at the angles we needed.

Pillar light

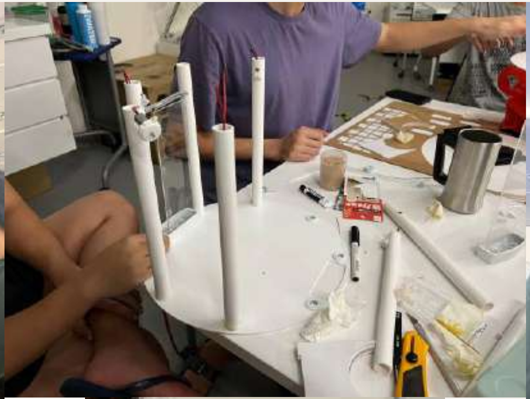
The Pillar light were installed by drilling the pillars and running the wires from the top ring. The LED sits on a 3D printed LED seat.

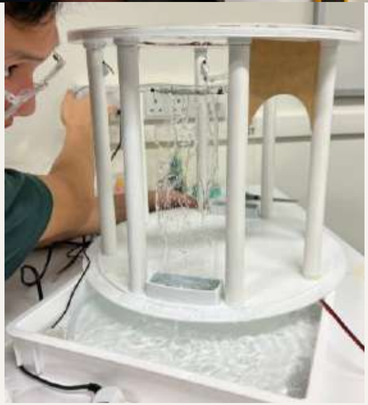
Functional Prototype (Crystal Knob)

Crystal Knob
At first, we decided to create a **small crystal light** using resin at the peak of the dome roof. However, due to time constraints, the complexity and the cost of resin, we decided to replace it with a crystal knob instead.

The knob was originally for a table drawer, but it had all the features and effects we wanted for the crystal light. Hence, the knob could act as a low-cost replacement for the crystal light.

Gazebo Assembly



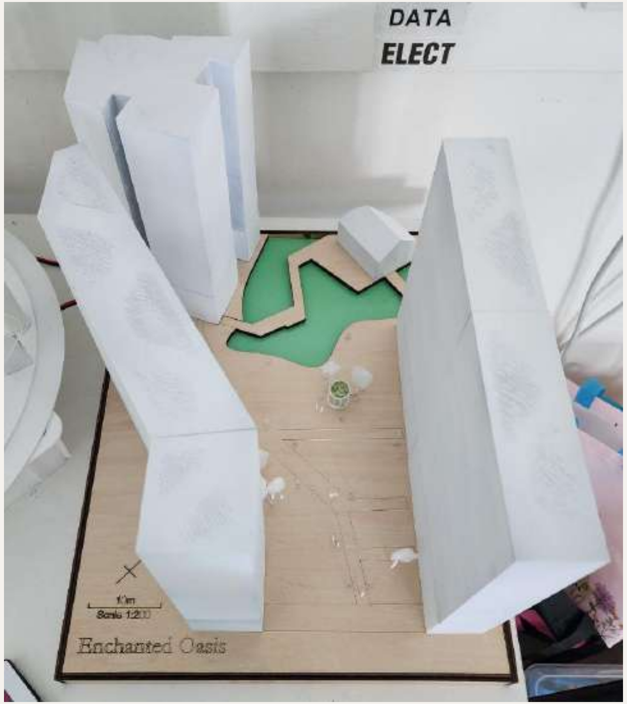


Stayed **U**p **T**ill **D**awn
(SUTD)

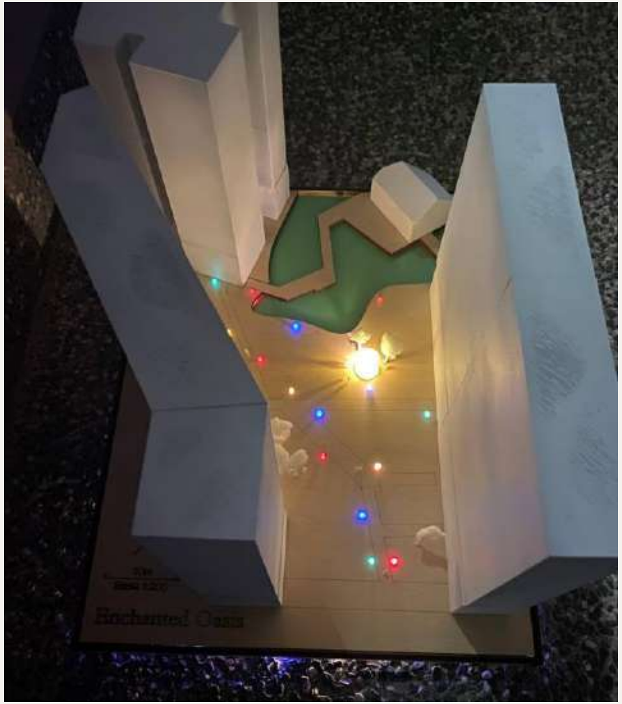
Completed Prototype

Step 6

Site Scale Model



Day View



Night View

Crystal Floor Lights

Crystal during the day

Crystal during the night

Gazebo

Internal View

08
User Validation/Testing

feedbacks

Immersive Experience

As our project's success heavily relies on user feedback and user validation, we decided to make our user experience as immersive and as close to the real thing as possible.

Since we cannot build the actual structure, we found an alternative way by using a 360-camera combined with a VR goggle to 'scale' the human down to our prototype size.

This would allow them to feel as though they are in the structure itself and experience it from a first-person view.

YouTube link of 360 video: **https://youtu.be/vi2DUsZI_KY**

360 - Camera

We used the GOPRO 360 MAX camera to shoot our 360 video. The idea was to use the 360 video and turn it into a VR format for our user validation.

Display screen which allowed us to see our footage while recording

Two 180 capture camera lens – this allowed us to capture the 360 videos

Editing 360 Video

Stretched 2D video

When we exported the video from the 360 camera to edit it came out as a stretched 2D,which was not what we wanted.

Davinci Resolve Software

To solve this issue, we imported it into Davinci Resolve and use a plugin called KartaVr to stitch the video in the editor itself for us to view it as a 360 video while editing.

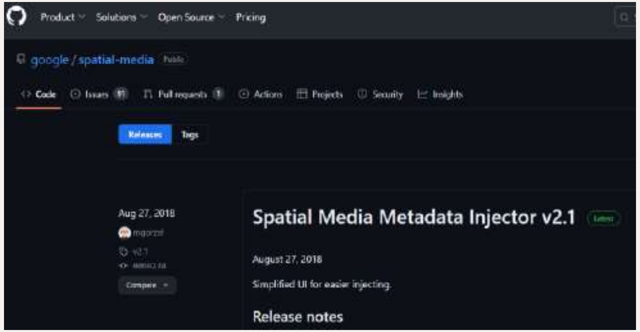
We proceeded to add the sound effects of water and birds chirping to mimic the part area.

The KartaVr Plugin also allowed us to remove the stitch line that was present in the raw footage of the 360 video

KartaVr Plugin

Exporting 360 video

Stretched 2D rendered video

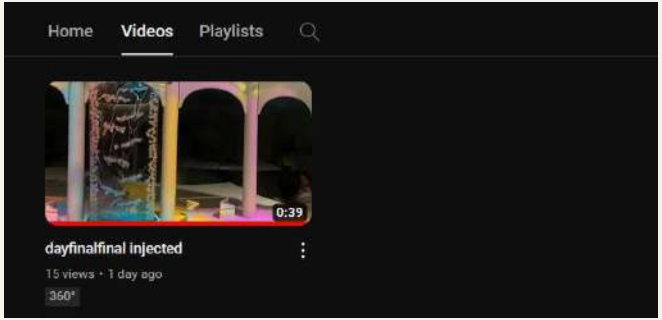


Google Spatial Media Injector
Github

After rendering our edit, we ran into another issue. Where the video once again came out as a stretched 2D format. Any VR viewer also did not recognize it as a VR style format.

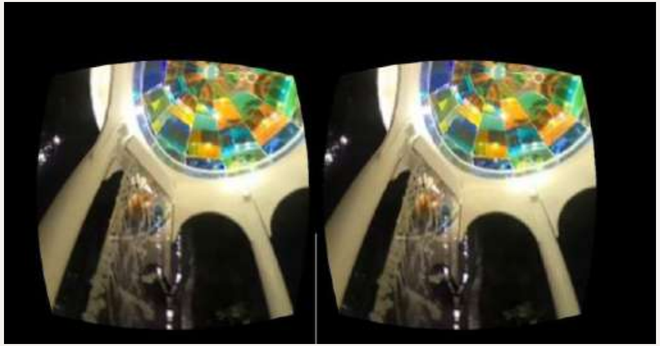
We found a solution to this by using a Python script that 'injects' and coverts the flat rendered video back to a true 3D VR video.

Viewing the VR video



Stretched 2D rendered video

To view the 360 video in a VR format and for us to loop it repeatedly we decided to use YouTube VR. Hence, we uploaded our videos onto YouTube.



The YouTube VR makes the video format compatible to be used with a VR goggle that we purchased when we slot in our phone.

Viewing the VR video

The VR goggles has two lenses which would allow the users to see the 360 video in a more immersive way.

The phone is placed in this holder, and it is slotted inside the goggles.

Users with VR Goggles

As intended, our users were immediately immersed when they started wearing the Goggles

09

Next Step

Sustainability aspects

Sustainability Aspects

As mentioned earlier, one of our goals of our solution is to be sustainable by operating with a minimal or close to zero carbon footprint using light.

We achieved this by removing the need for artificial light during the day and using solar panels.

Our solution can be solely run on **16 household-sized** solar panels.

The most power-consuming component of our solution is the **motor** and **water pump** of the gazebo.

To reduce the energy consumption, we decided to use an **occupancy sensor** to **detect the presence of a user/users** in our gazebo. The motor and water pump of the gazebo will only be activated when there are users in it.

Occupancy sensor

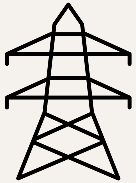
Sustainability Aspects

Estimated Energy Consumption

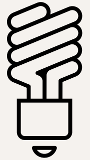
Energy Generated by 1 household solar panel per day is about 2kWh *[1]*= **7.2×10^6 J**

Water pump energy usage per day = 500 Watts *[2]* x 86400s = **4.32×10^7J**

LED Lights strips in gazebo energy usage for 12 hours (7pm – 7am):
7.38W/h per metre of LED light strips = 2.7×10^4J *[3]*
For 12 hours = 2.7×10^4J x 12 = 3.2×10^5J
Estimated total of 20m = 3.2×10^5J x 20 = **6.38×10^6J**

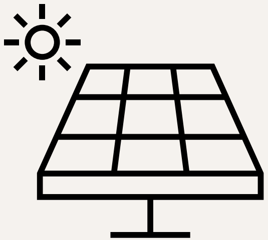


LED Spotlights in gazebo energy usage for 12 hours (7pm – 7am):
45W LED spotlight per hour = 45W *[4]* x 3600s = 1.62×10^5J
For 12 hours = 1.62×10^5J x 12 = 1.94×10^6J
5 LED spotlights = 1.94×10^6J x 5 = **9.72×10^6J**



Sustainability Aspects

LED Lights for surrounding floor lamps energy usage for 12 hours (7pm – 7am):
15W LED lights per hour = 15W x 3600s = 5.4×10^4J
For 12 hours = 5.4×10^4J x 12 = 6.48×10^5J
For 20 LED lights = 6.48×10^5J = **1.3×10^7J**



Motor energy usage per day (5 hours):
2kW motor energy usage per day = 2kW x 5 = 10kWh = **3.6×10^7J**

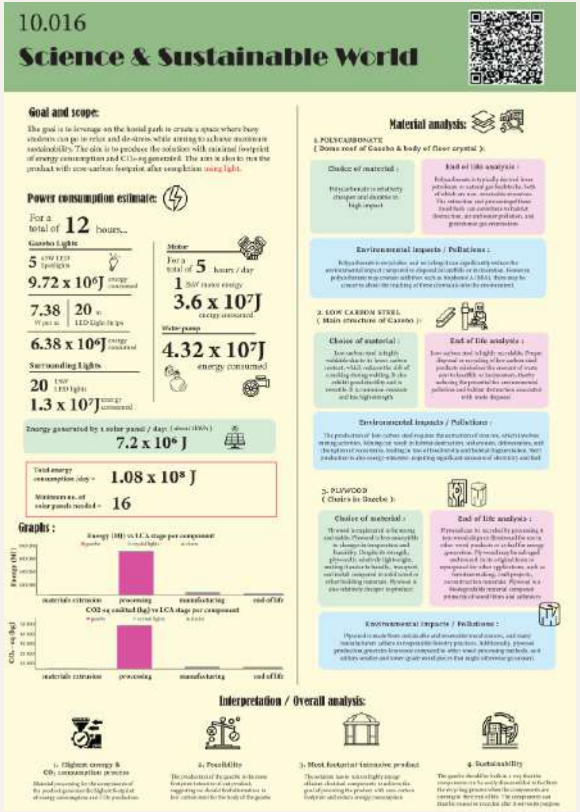
Total energy consumption per day = **1.08×10^8J**
Minimum number of solar panels needed = 1.08×10^8J / 7.2×10^6 J = 15.04 **(16) panels**

References:
[1] https://www.solarreviews.com/blog/how-much-electricity-does-a-solar-panel-produce#:~:text=On%20average%2C%20a%20solar%20panel%20will%20generate%20about%202%20kWh,TV%20for%2024%20straight%20hours
[2] https://www.hunker.com/12467557/power-consumption-of-water-pumps
[3] https://wasserstein-home.com/blogs/smart-home/do-led-lights-use-a-lot-of-electricity#:~:text=On%20average%2C%20a%2016%2Dfoot,add%20up%20to%2078.84%20kWh
[4] https://www.linkedin.com/pulse/how-many-watts-led-lights-good-home-use-winny-wen#:~:text=Most%20LED%20light%20bulbs%20are,3%20watt%20bulb%20is%20sufficient

Design Thinking Project II Posters

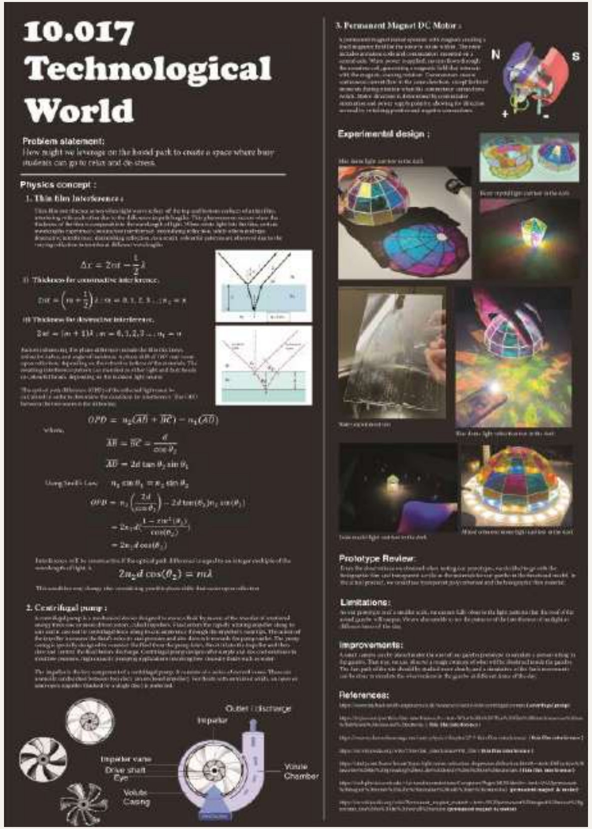
10.016 Science for a Sustainable World
10.017 Technological World

10.016 Science for a Sustainable World



Link to SSW DTP Poster:
https://tinyurl.com/2s4axrnw

10.017 Technological World



Link to TW DTP Poster:
https://tinyurl.com/yeybc7jt