I’m Blinded by the Lights [BBTL]

Presents

03.007: Design Thinking and Innovation

REM

A project by SC11 Group 10

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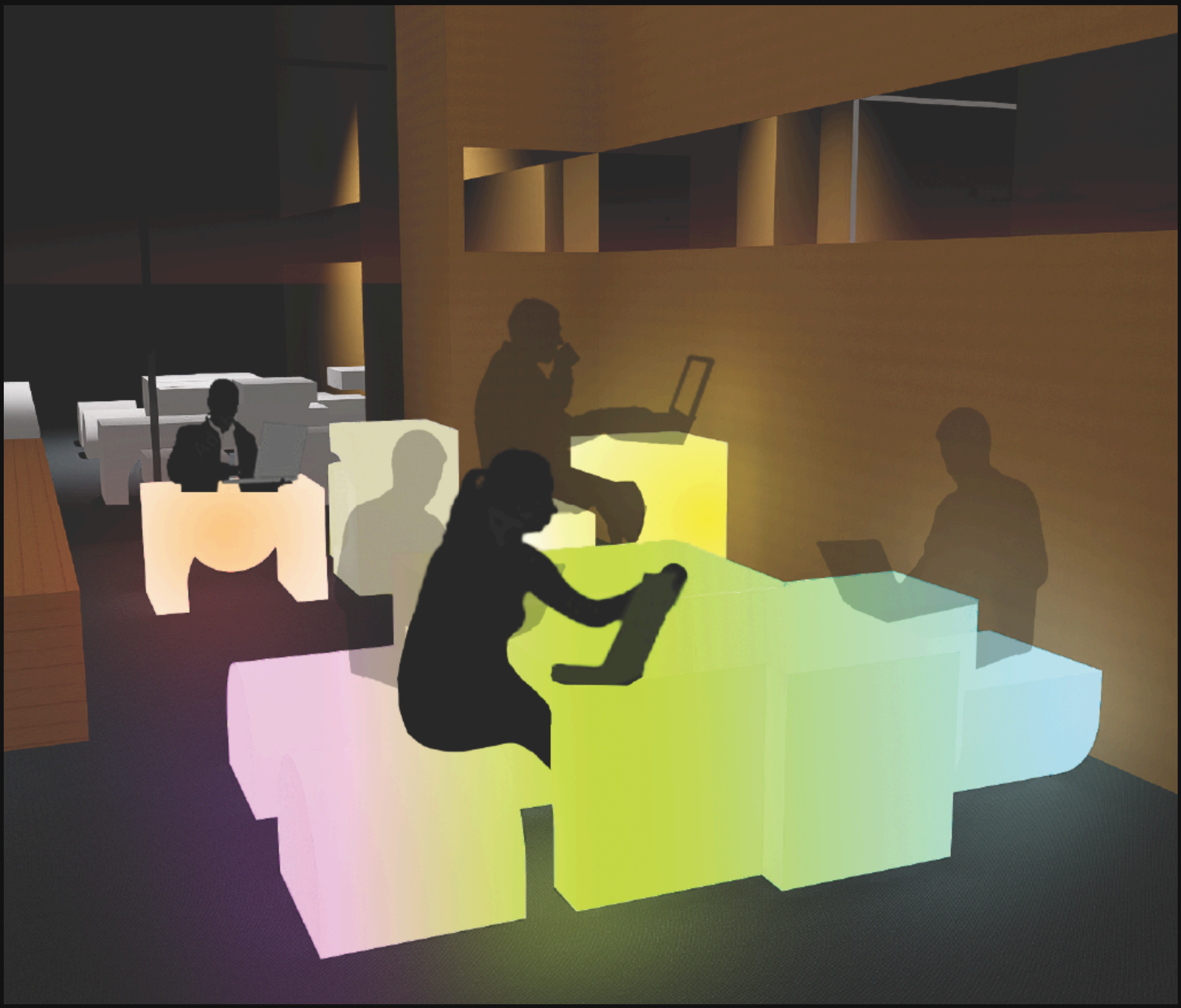
Background Information

BBTL presents to you a way to make workspaces more interesting. We have created a modular box that can take on many forms and adapt to any kind of workspaces that you need.

Our design, named REM, stands out due to its innovative integration of lighting and modularity, which **enhances adaptability** and **interaction between people** within the workspace. Notably, being able to change the modes of our product provides customisable functions, catering to the diverse needs of our target audience. This design embodies a thoughtful convergence of form and function, making it not only a visually captivating piece but also a breakthrough in the industry.



Inspirations

Our initiative was sparked by a scarcity of preferred study spaces within the hostel. We uncovered that students were gravitating towards certain types of workspaces. It became apparent that their activities fluctuated between **deep-focused study sessions and group study sessions**. This revelation was the cornerstone for our project and to resolve this we aimed at developing an adaptable workspace solution tailored to the fluctuating rhythms of student life. The main inspiration was taken from an exhibition at the Art Science Museum where they utilised lights to promote interactions and convey emotions between people. We also drew inspiration from Bauhaus-style modular furniture that creates a minimalistic and clean look to homes.

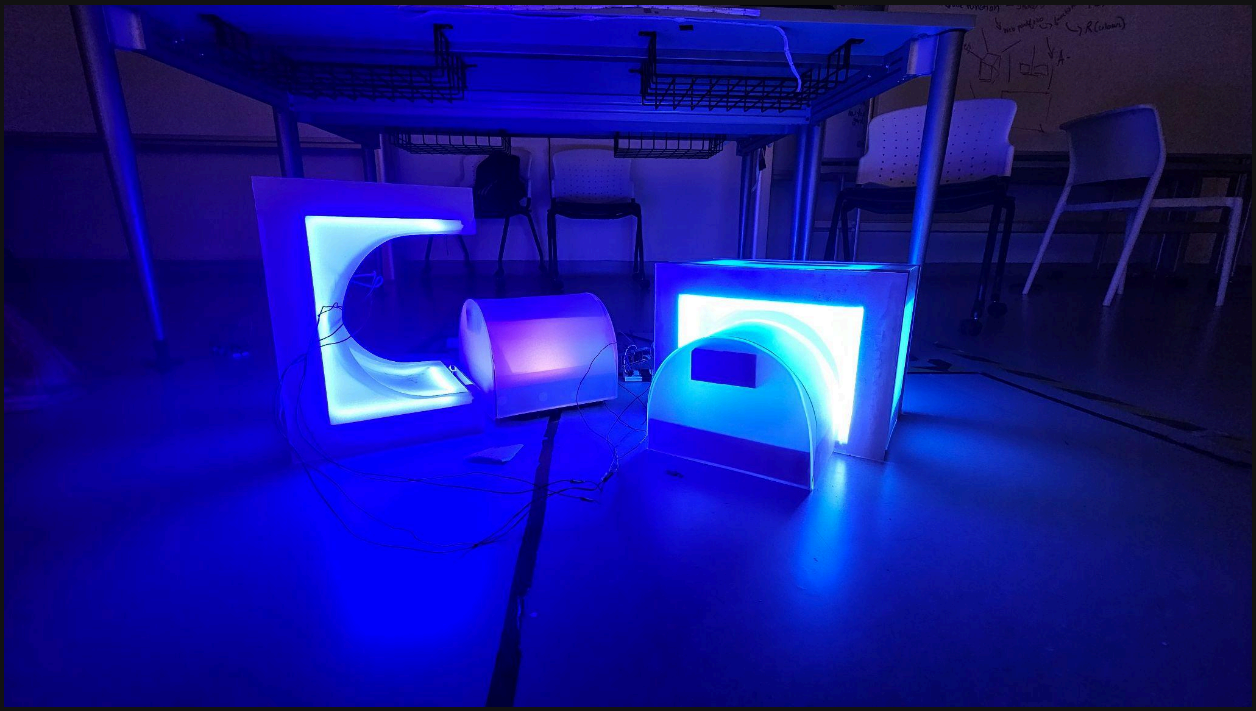
Interactive Lights at The Art Science Museum

Modular Bed

A student studying with a table lamp

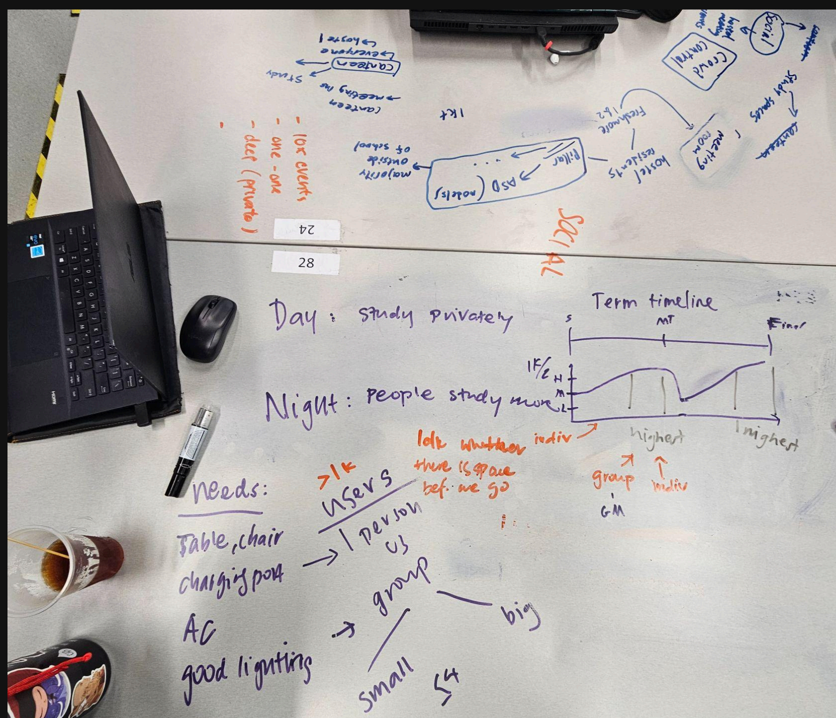
Setup with Philips Hue Lights

Image of static prototype



Our Journey

Ideation Process: We began with an in-depth refinement of our problem statement, achieved through internal interviews and a thorough site analysis that helped crystallize the objectives of our project. Collaboratively, we had multiple brainstorming sessions, utilizing mind mapping techniques to expand upon our ideas. These concepts were then organised and evaluated for viability. Through a collective decision-making process, we merged several concepts and ultimately distilled our vision into one singular, focused idea poised for development.

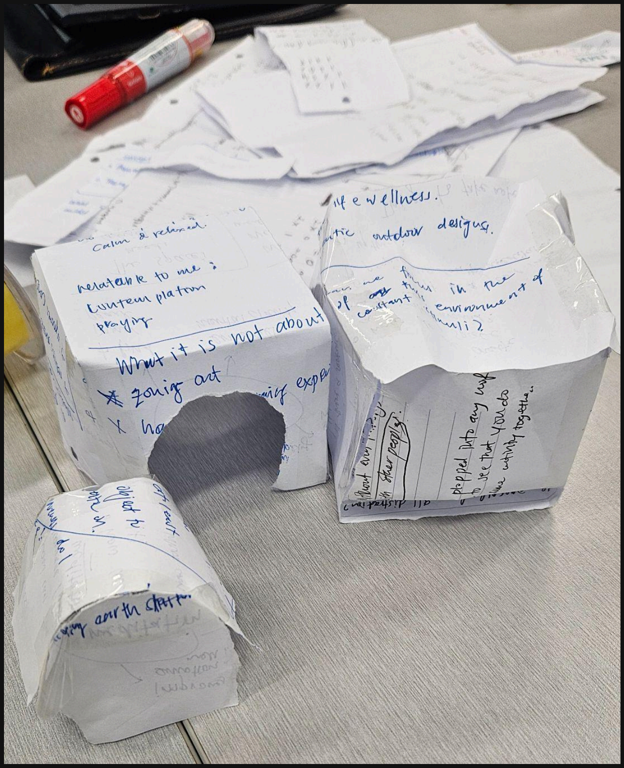


Defining problem statement and finding pain points

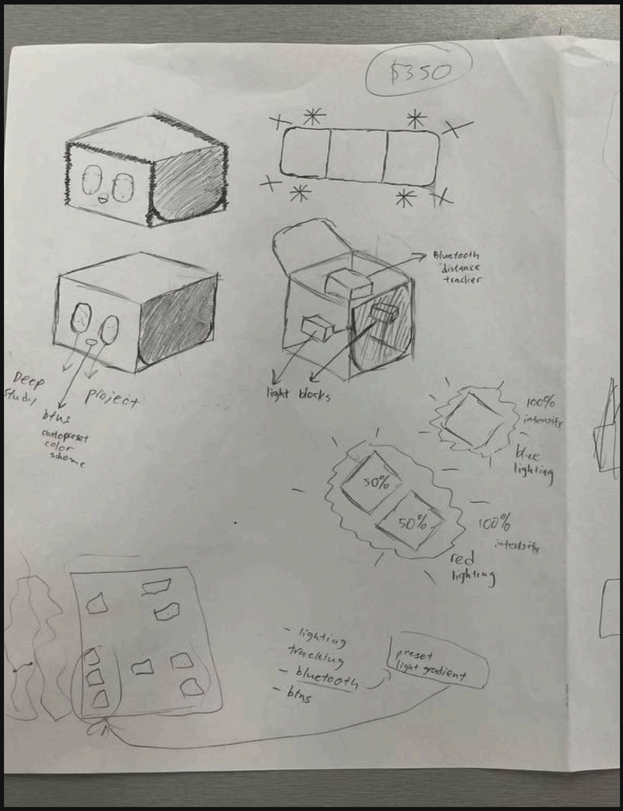
Prototyping Process: The development of our prototype involved a dynamic, iterative process, beginning with rudimentary paper models to conceptualise the physical form. Significant effort was invested in perfecting our design, particularly in programming the LED lights to achieve the desired functionality. Through persistent testing and refinement, we ensured our prototype not only met but surpassed our initial expectations in terms of aesthetics and functionality.

Our process was Planning -> Developing -> Executing. We wrote down our ideas and planned out the next steps before we actually ordered and started developing our product.. Execution came to play when we tested our products and went through rounds of optimisation and refining.

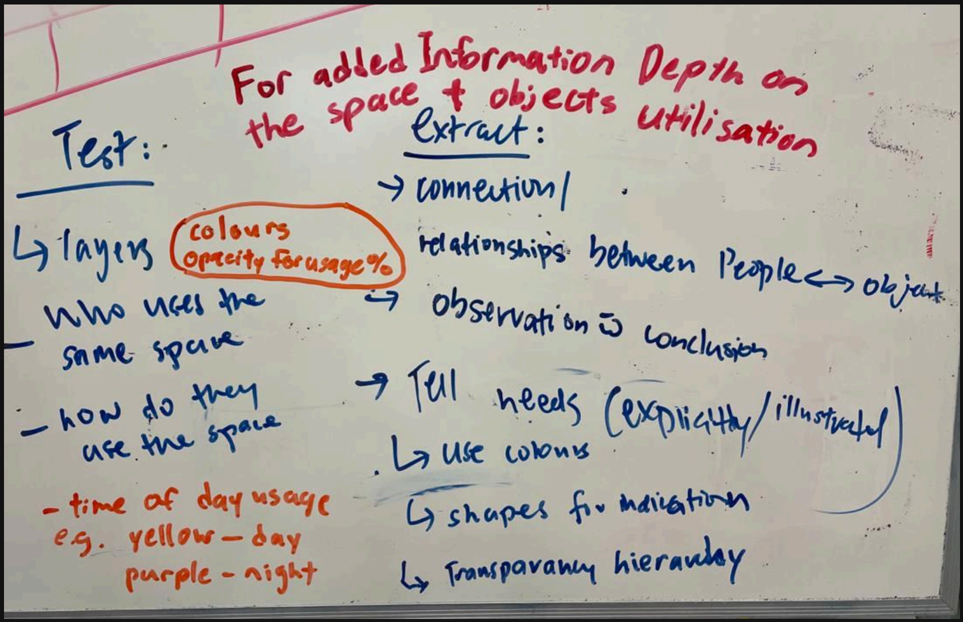
PLANNING



Mock-up with paper

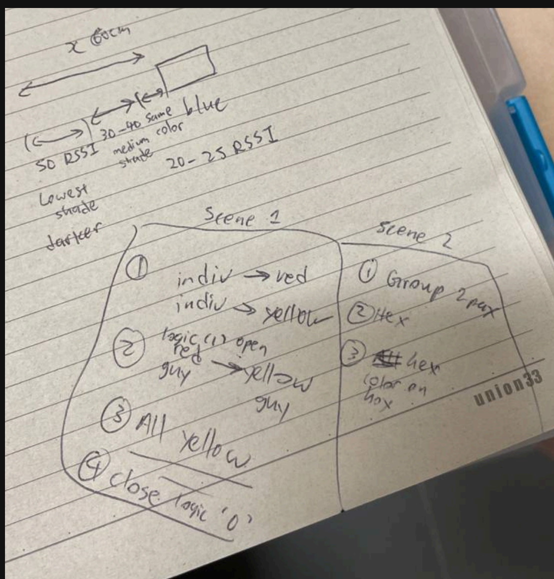


Rough sketch of product

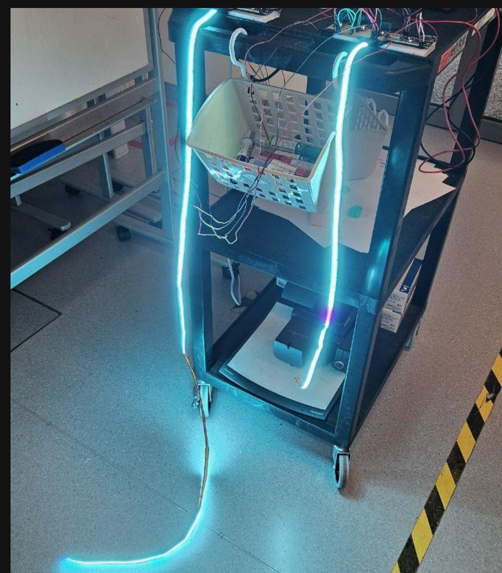


AEIOU planning

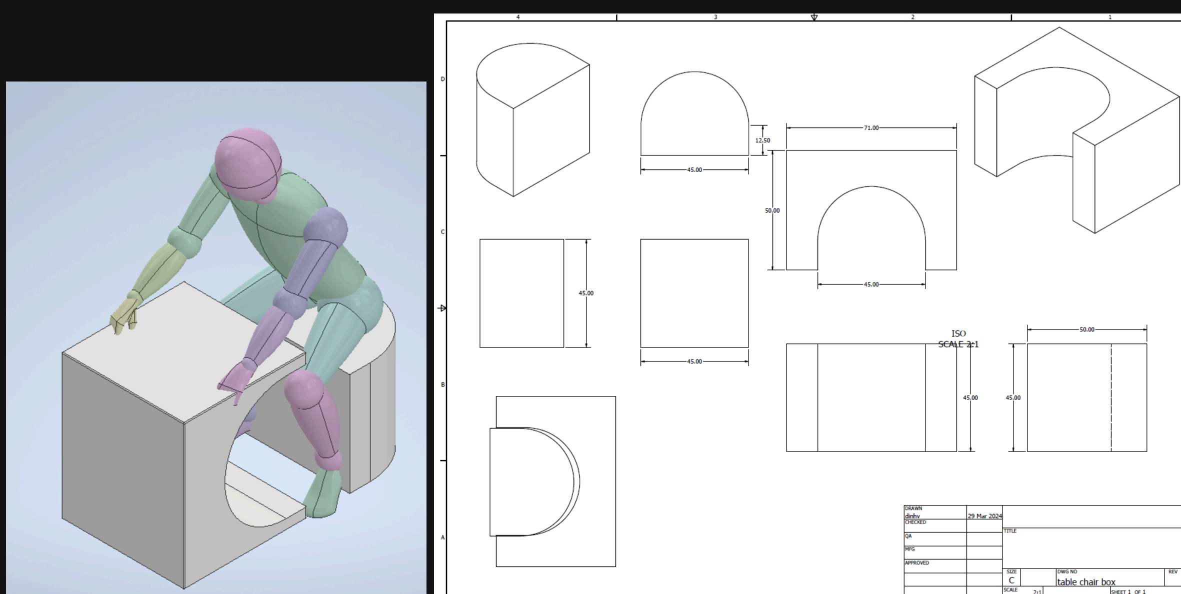
DEVELOPING



Rough programming logic of the prototype

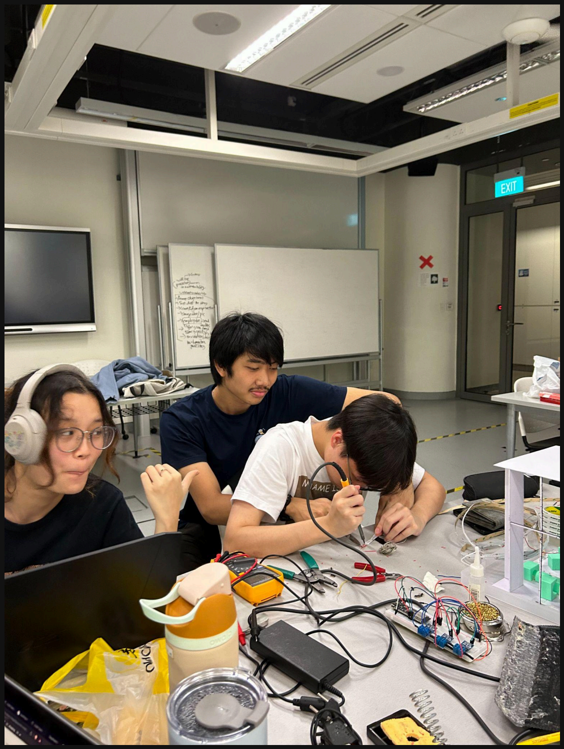


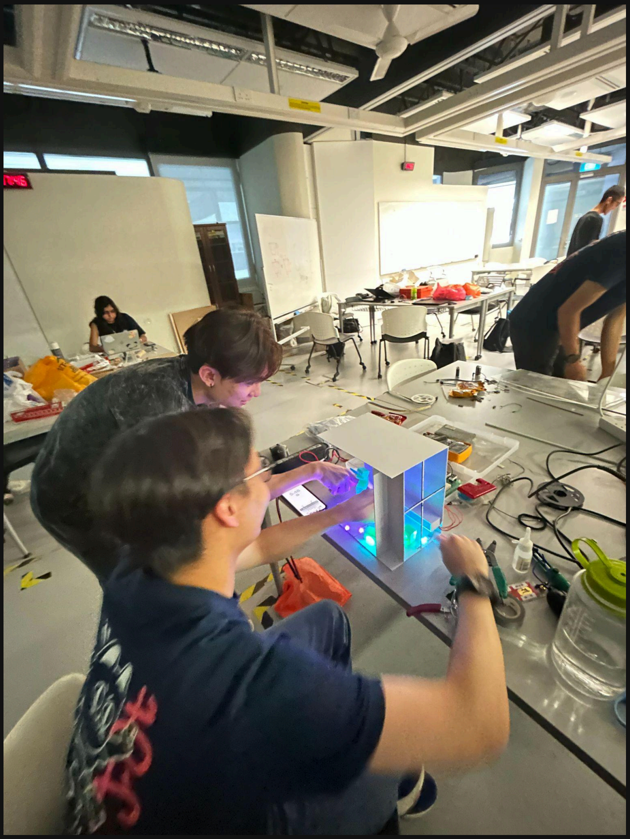
Testing LED-strip

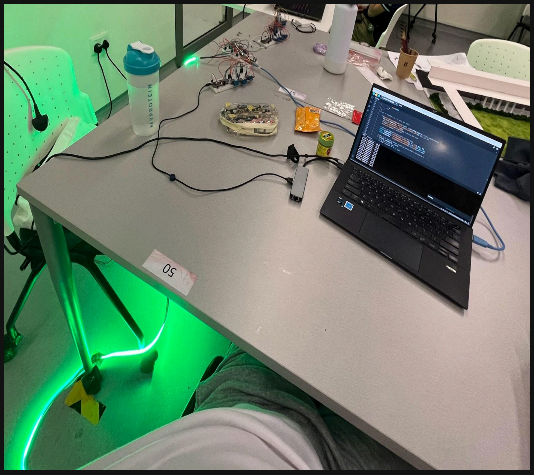


Actual product’s 3D CAD and dimension (scaled down for prototype)

EXECUTING



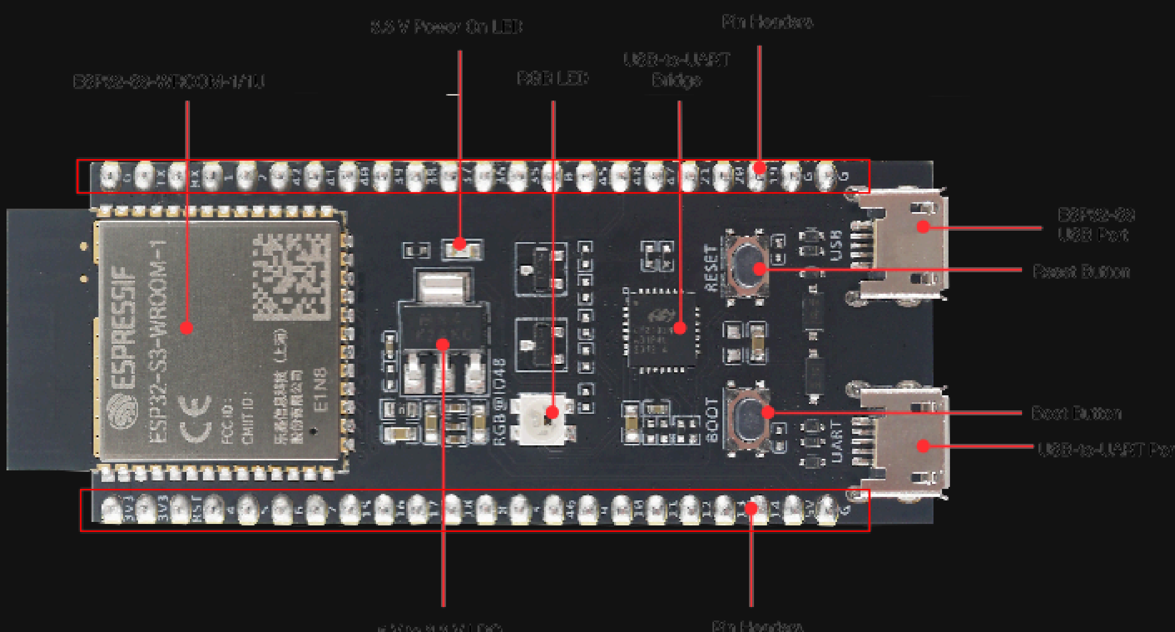




Documentation:

Specifications and dimensions

Dimensions (table): 71cm (length) x 45cm (breadth) x 50cm (height)
Dimensions (chair): 45cm (width) x 50cm (height)



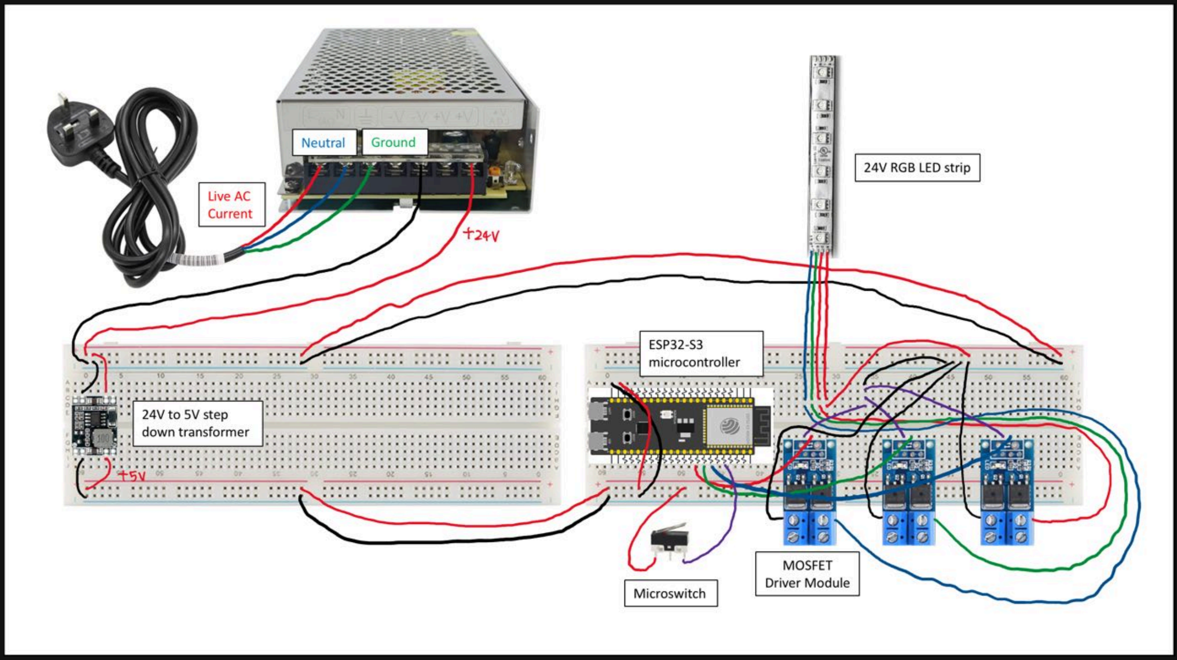
ESP32 Module
Dimensions: 62.74mm (length) x 25.40mm (breadth)

Software

- **Architecture Flowchart**
- **Code Snippets**

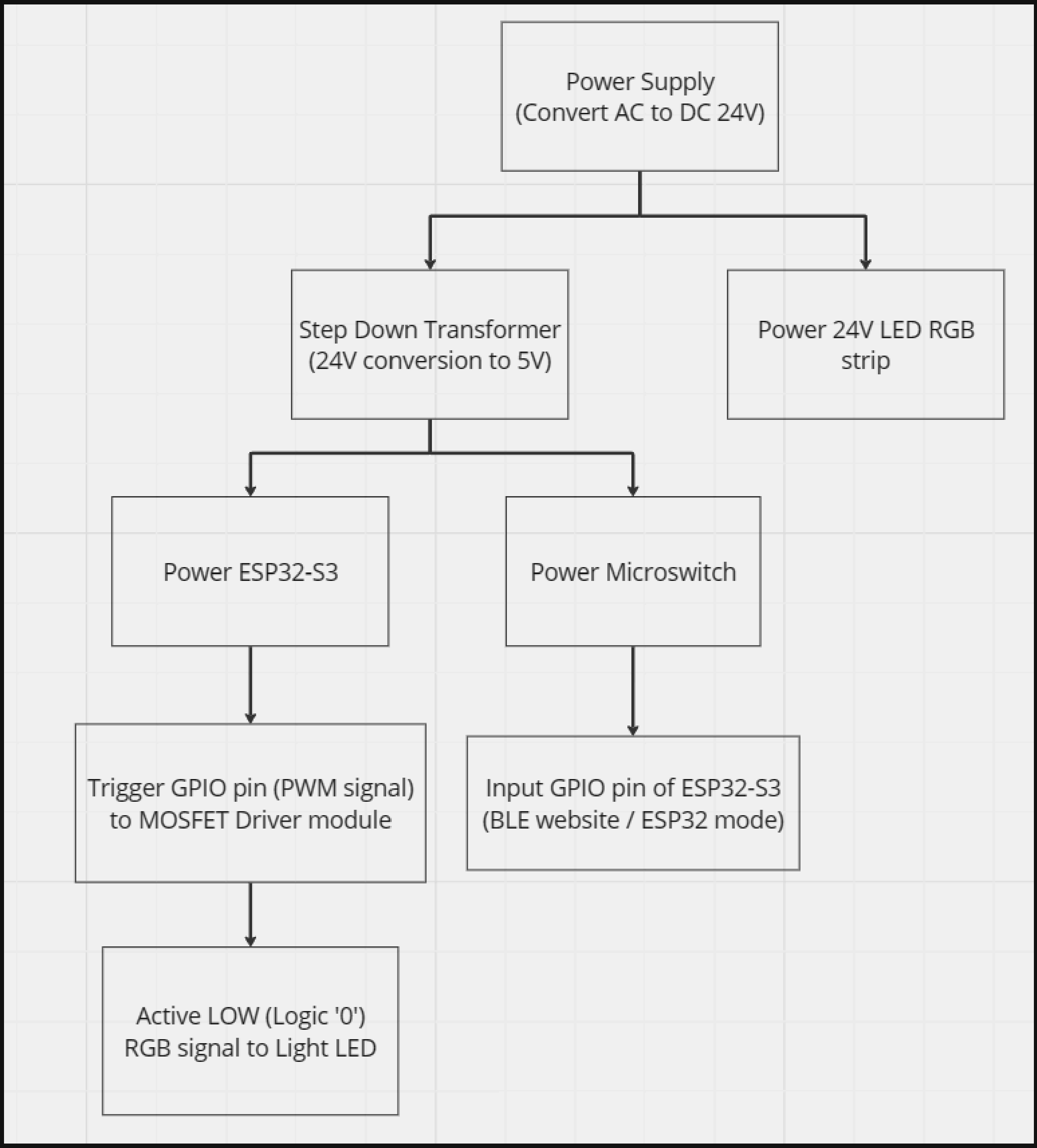
Electrical

- **Schematic Diagram**



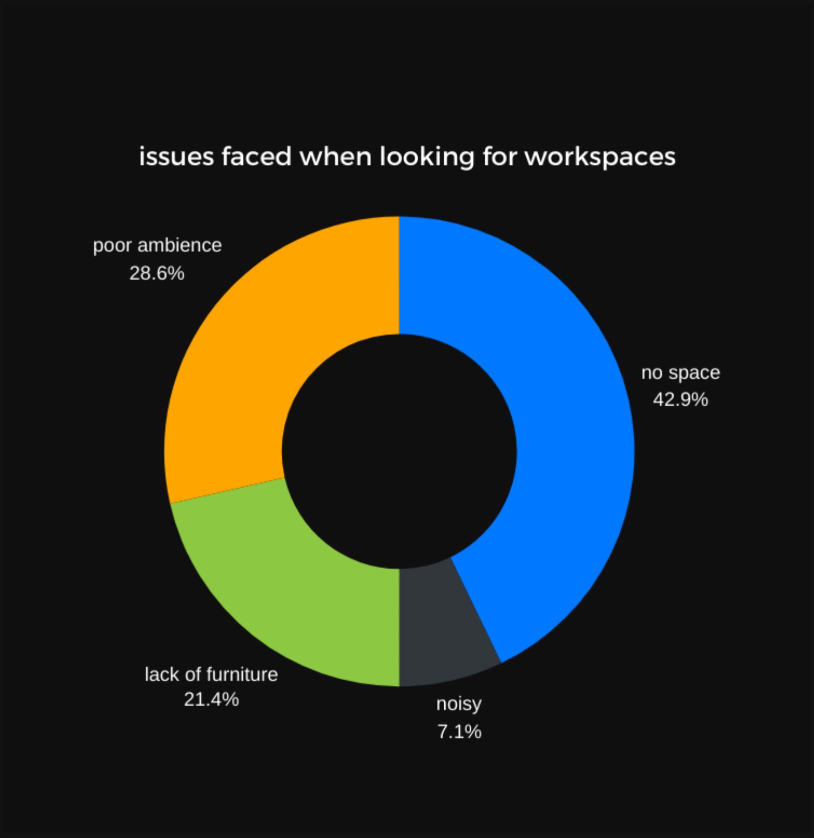
The above illustrated figure is the schematic diagram of 1 product component

- **Circuit Flowchart**



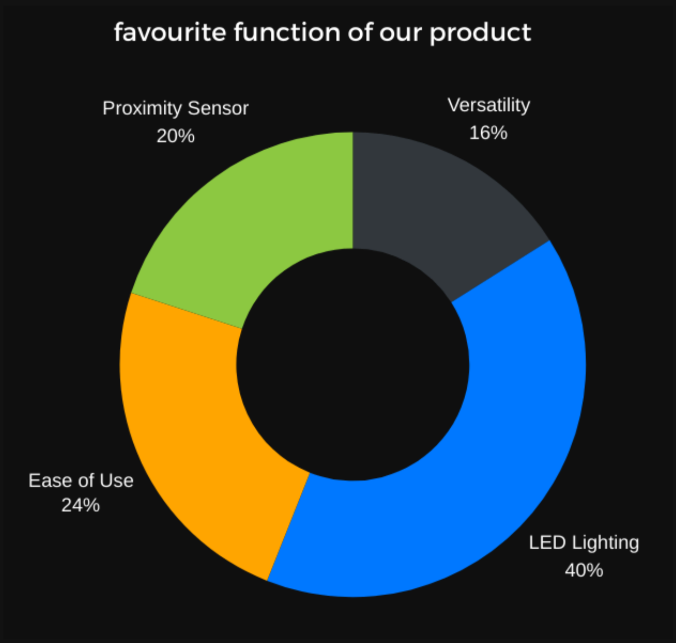
Data & Feedback

We conducted BOTH qualitative surveys and verbal interviews

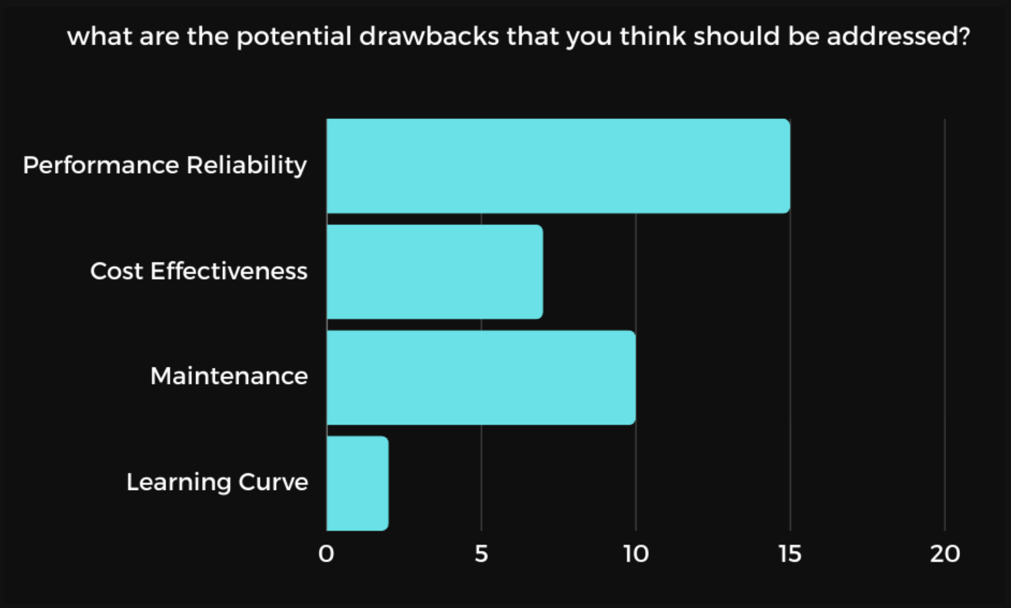


We identified **key issues** that were faced by students that support our problem statement to ensure we were on the right track.

An astonishing 80% of people were willing to give our product a shot.



We conducted a survey to find out what people love most about our design.



Verbal interview for potential improvements that we should look at.

Video

https://youtu.be/_FS3sQ58yWw

Additional Communication Details

Keywords & Tags
ADAPTABILITY, SOCIAL INTERACTIONS, ESP32, MODULARITY, LED STRIPS

Interaction / Flow / Operation
When users use our website, they are able to select between Solo or Group studying, from there they can also choose their colours from a wide variety of options. If they move closer to one another, the colours become interactive as well, allowing them to switch between study modes seamlessly.

Location
School Workspaces

Project Abstract
The inception of REM was driven by a need to address workspace usage. Our investigative approach involved user behaviour studies, aiming to deeply understand how people use respective workspaces. The objective was to create a solution that not only meets but exceeds the expectations and needs of students.

Utilising qualitative interviews, quantitative data analysis and design thinking processes, we crafted a series of prototypes, each refined through iterations based on feedback and performance metrics.

The results were transformative, leading to a product that reduces waste, enhances user engagement and overall looks cool. Insights gained from this project highlight the potential impact of REM in a public setting, expanding the scope of the impact to a larger audience. This project not only meets the contemporary demands of the market but also sets a new benchmark for future developments in light and social interactions.

Creative Challenge
The hardest part of the design activity was striking a balance between creative aspiration and the practical constraints of technology and production. We wanted to push for functionality while making our product as aesthetically-pleasing as possible. Externally, we contended with regulatory standards and the availability of technology, which dictated our approach to materials and processes. Internally, the team had to align diverse perspectives and expertise to forge a path forward. Overcoming these hurdles was a testament to our adaptability and collaborative spirit.

2D Posters

REM

HOW MIGHT WE design adaptive workspaces that dynamically transition between promoting social interactions and supporting deep study sessions, accomodating to different phases of the term?

Overall Analysis:

Life Cycle Assessment (LCA):
Silicon and Copper are highlighted as energy-intensive, while Acrylic and Plywood significantly affect water resources, marking these as critical areas for efficiency improvements. During end-of-life processing, recycling is vital for materials like PVC, Acrylic, and Plywood, significantly lowering their environmental impact. Combustion reveals that PVC and Acrylic release considerable emissions, emphasizing the need for prioritising recycling to reduce environmental harm. CO2-equivalent emissions analysis identifies PVC and Copper as major contributors due to their energy-intensive production, targeting them for urgent emission reductions.

Technology Improvements:
Focusing on efficiency metrics, significant technological innovations in the production of Silicon, Aluminium, and Plywood have led to reductions in energy usage by up to 10% and water usage by 30%. Enhancements in recycling technologies for PVC and Acrylic have also notably increased recycling efficiency. These improvements are not only pivotal for achieving environmental objectives but also for driving cost efficiencies.

Benchmarking:
Comparative benchmarking across companies illuminates variances in energy and water use, waste management, and CO2 emissions, allowing for the identification of industry leaders in sustainable practices. This benchmarking is instrumental in pinpointing companies that excel in environmental stewardship and those that need substantial improvement, providing a clear roadmap for industry-wide enhancement.

Recycle Parts:
By sorting and recycling materials like metals and plastics, we can turn the components into raw materials for new products, reducing resource use and energy consumption. We can dismantle and reuse parts to extend their life and minimize environmental impact. Our other school or personal projects can benefit from repurposed electronic boards and mechanical parts, promoting resource conservation and innovation.

Donate or Sell Reusable Parts:
Donating or selling reusable parts helps prevent waste and supports community resources. Functional components such as sensors or switches can be invaluable to educational institutions and DIY enthusiasts, we can use the money we get back to buy parts for another project, promoting economic and environmental sustainability.

1. Copper

Very durable: Copper is corrosion-resistant, making it long-lasting. Copper demonstrates excellent corrosion resistance in a multitude of different environments.
High conductivity: Pure copper has the highest electrical conductivity of any commercial metal. This property makes it the preferred material for power cables, circuit board conductors and a variety of other electrical applications.

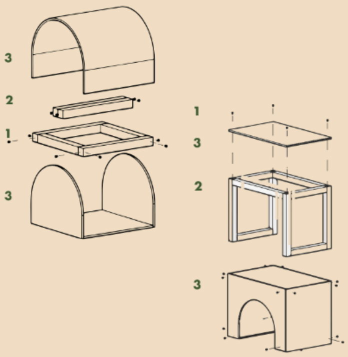
Environmental Impact
Sea pollution: excess copper in the water has adverse effects on aquatic life, with damage to freshwater organisms such as fish. Copper damages the kidneys, nervous systems, and livers of most water creatures.
Habitat destruction: Copper mining has a significant environmental impact, destroying habitats. Conservationists suggests that forest has been severely affected by mining-caused deforestation that began decades ago.

End-of-Life Analysis
Recycling: Copper is highly recyclable and can be recycled indefinitely without losing its properties. Recycling copper uses much less energy than producing new copper from ore. By recycling copper, we reduce CO2 emissions and save about 85% of the energy required for primary production. Moreover, the European Circular Economy Stakeholder Platform notes that using copper scrap can lower CO2 emissions by 65% compared to using virgin materials.

Incineration: Not applicable, as copper does not burn. However, copper can contaminate the fly ash if other materials are incinerated with it.

Landfill: Copper in landfills does not degrade, but it can potentially leach into the soil and groundwater, which can be toxic to wildlife and plants.

How we made it sustainable
By using recycled copper, we can save costs and lower our environmental footprint. Recycled copper reduces the need for mining, lowering the associated land and water use, and it consumes up to 85-90% less energy than normal copper production.



2. Plywood

Easy to Handle: Plywood's lightweight quality simplifies transport and handling. Its ease of shaping allows it to be customised into various unique forms and sizes to our specific requirements.
Cost-Effective: Plywood production allows for more sheets to be created from a single tree compared to solid wood, enhancing efficiency and conservation of resources. The increased availability of plywood makes it a cost-effective option for both residential and commercial use.
Dimensional Stability: plywood has amazing dimensional stability, allowing it to maintain its shape and size even when exposed to moisture, heat, or cold which is highly relevant since our product can be exposed to the elements.

Environmental Impact
Plywood has a relatively low carbon footprint due to carbon sequestration in the wood. The adhesives used in plywood often contain formaldehyde, which can off-gas volatile organic compounds (VOCs) into the environment, posing health risks and contributing to indoor air pollution.

End-of-Life Analysis
Recycling: Plywood can be recycled into wood chips or fibers for other products, though the presence of adhesives can complicate the process.

Incineration: Plywood can be utilized for energy recovery through incineration. This process not only reduces the volume of waste but also harnesses the energy contained within the wood to generate electricity. However, the efficiency and environmental impact of this method can vary based on the technology used and the composition of the plywood, such as the type of wood and any treatments it may have undergone.

Landfill: Plywood is biodegradable, especially if it is not treated with preservatives. However, degradation can release methane, a potent greenhouse gas, and chemicals from adhesives can leach into the environment.

How we made it sustainable
Our design incorporates a combination of plywood and other reclaimed wood materials for the frame construction. While plywood remains the predominant material—reflected in our LCA analysis—integrating other wood types allows us to minimise waste and make use of existing resources.

3. Polyvinyl Chloride (PVC)

Durability: PVC is resistant to weathering, chemical rotting, corrosion, shock, and abrasion. It is the preferred choice for many long-life and outdoor products. About 60% of PVC manufactured has a service life of between 15-100 years.
Amazing mechanical properties:
PVC (plasticised) is less tough while having high impact strength and is easy to extrude or mould. It has lower temperature resistance and usually lower tensile strength that allows for easy manipulation.

Environmental Impact
Production releases organic pollutants: dioxins, furans, polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB)
Vinyl chloride is identified as a carcinogen with links to liver, lung, brain cancers, lymphoma, and leukemia. Any exposure carries risk, with high levels potentially causing severe symptoms or death.
PVC production can lead to harmful substances like phthalates and vinyl chloride leaching into tap water, posing health risks.

End-of-Life Analysis
Recycling: PVC can be recycled, and there are two main types — mechanical recycling where the material is melted and remolded, and feedstock recycling where it is broken down into its chemical components. However, recycling rates for PVC are relatively low compared to other plastics.

Incineration: When incinerated, PVC can release toxic chemicals, including dioxins, which are harmful to human health and the environment. This makes energy recovery from PVC less desirable.

Landfill: PVC is non-biodegradable, and when placed in landfills, it can take a very long time to break down. The presence of additives can also lead to potential leaching issues.

How we made it sustainable
Design for Disassembly: Our PVC-based products that can be swiftly and easily taken apart. This facilitates efficient recycling processes, ensuring that each component can be properly sorted and reused, thus reducing the environmental impact and promoting a circular economy.

4. Acrylic

Innate property: Highly transparent, transmitting up to 92% of visible light, more than glass, while being malleable and sturdy and not brittle.
Low maintenance: It maintains its optical clarity and doesn't yellow with age, making it a great choice since our product can be used for prolonged periods without needing much maintenance, saving costs over time as well.

Environmental Impact
Dangerous and harmful to humans and wildlife: production of acrylic fabric involves volatile processes and the use of toxic substances, posing explosion risks at manufacturing plants and potential ecological harm if mishandled. Legislation mandates that the harmful gases from acrylonitrile production be filtered in a controlled environment to prevent environmental and health hazards.

End-of-Life Analysis
Recycling: Acrylic can be recycled, but the process is not as straightforward as with other plastics. It often requires chemical recycling to break it down into its monomers.

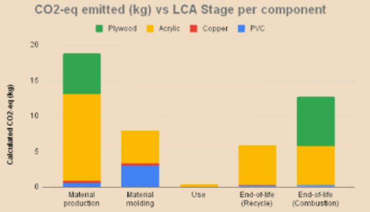
Incineration: When burned, acrylic can release toxic fumes including carbon monoxide and formaldehyde.

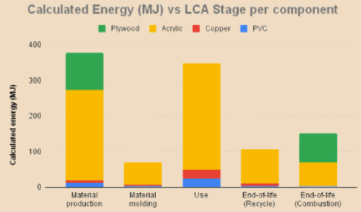
Landfill: Acrylic is non-biodegradable and can last for many years in a landfill. It does not leach toxic substances but does contribute to the volume of waste. Acrylics contribute to landfill volume due to their non-biodegradable nature. In 2018 U.S. landfills received 27 million tons of plastics, which accounted for 18.5% of all municipal solid waste landfilled that year.

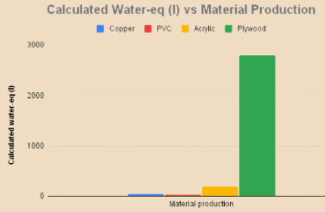
How we made it sustainable
We used bio-based acrylic that transitions away from conventional petroleum-derived acrylic, actively reducing our reliance on finite non-renewable resources. Bio-based materials can reduce carbon emissions by up to 75% compared to their petroleum-based counterparts. Additionally, the biodegradable nature of bio-based acrylic could potentially decrease plastic waste in landfills by a substantial margin.

Conclusion:

This journey of product creation has made us more aware on the materials that go into our everyday products and how sustainable they are towards the environment. Our choice of materials was paramount in ensuring our product worked as intended while minimising harm to the environment. We can use environmentally-friendly material while maintaining functionality. Through this journey, we've delved into the lifecycle of products, from raw material extraction to end-of-life disposal, ensuring each step aligns with our environmental ethics. This deep dive into the ecological aspects of production has informed every decision, reinforcing our resolve to employ materials that support the planet's health. We've emerged with a greater appreciation for material sciences and a refined approach to sustainable innovation, crafting a product that stands as a testament to what can be achieved when environmental responsibility is placed at the heart of design.







LCA / References / Assumptions

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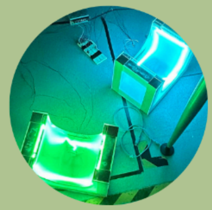
1007824 Darren Goh Xin Yang
1008239 Beatriz Acosta Ong
1007519 Tan Tian Kovan
1005088 Khoo Li Cheng Dylan

REM

EXPERIMENT DATA



HOW MIGHT WE DESIGN ADAPTIVE WORKSPACES THAT DYNAMICALLY TRANSITION BETWEEN PROMOTING SOCIAL INTERACTIONS AND SUPPORTING DEEP STUDY SESSIONS, ACCOMODATING TO DIFFERENT PHASES OF THE TERM?

IMPROVEMENTS

Incorporate safety features that deactivate electrical components if structural integrity is compromised, such as breakaway connectors or circuit breakers sensitive to physical deformation. Equipped with detachable connectors and sensitive circuit breakers, these systems preemptively avoid electrical risks, enhancing user safety and product reliability.

Protective coatings and laminates will be applied to the surfaces to improve resistance to scratches, impacts, and weathering. These enhancements will maintain the product's appearance and structural strength over extended use.

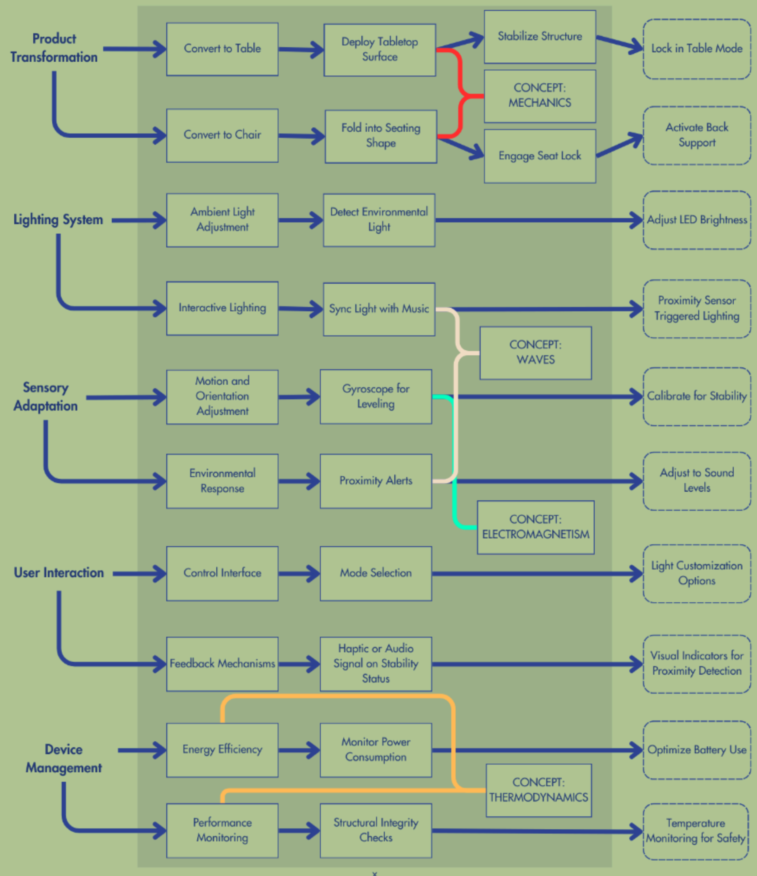
Conduct extensive load testing for all possible configurations to identify weak points and certify the maximum safe load. Protective coatings and laminates will be applied to the furniture surfaces to improve resistance to scratches, impacts, and weathering. These enhancements will maintain the product's appearance and structural strength over extended use.

LIMITATIONS

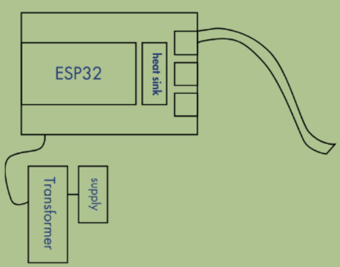
Material durability, the materials used (e.g., plywood, acrylic) might be prone to scratches, impacts, or weathering, which could limit its longevity or aesthetic appeal. Furthermore, when the materials become more worn out, it could be dangerous to use as there are a lot of electrical wiring insides in the event the product collapses.

There might be limitations on how much weight the box can support in its various configurations, affecting its functionality as a piece of furniture. A table will have less support when the 2nd component of the box is removed from below.

FUNCTIONAL DIAGRAM



EXPERIMENT 1



Experiment 1: Finding out how temperature of circuitry components affect resistance, power loss and hence cost of running our product. Relation between temperature and resistance is given:

$$R = R_{ref}\,[1 + \alpha(T - T_{ref})]$$

Where,

R = Conductor resistance at temperature "T"

R_{ref} = Conductor resistance at reference temperature T_{ref}, usually 20°C, but sometimes 0°C.

α = Temperature coefficient of resistance for conductor material.

T = Conductor temperature in degrees Celcius.

T_{ref} = Reference temperature that α is specified at for the conductor material

How it works:

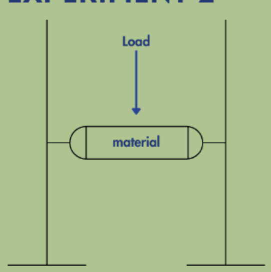
To calculate power loss and hence cost, we will set up a similar circuit to the one we are using for our product. Voltage is kept at a constant 24V through the transformer, initial resistance was gauged using a multimeter.

There are 2 parts to the experiment, with and without a heat sink. We then proceeded with temperature recording over specific intervals, with one trial including a heat sink and another without, to measure the impact on resistance. Power Loss = V^2/R, where V is the constant voltage and R is the calculated resistance, was monitored under both conditions. The outcomes of the experiment will guide optimizations in circuit design to help us enhance energy efficiency and thermal management.

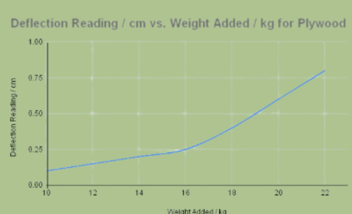
Experiment Results

Experiment 1: The incorporation of a heat sink substantively reduced the temperature within the circuitry, leading to a decrease in power loss. This suggests that the heat sink is highly effective in managing thermal load, which is a crucial factor for product's life span and safety. However, only small amounts of power is needed to power our product so the difference in power loss did not make a huge difference in the costs. In scenarios where multiple units operate continuously, the cumulative effect on power consumption and thus costs will then become significant.

EXPERIMENT 2

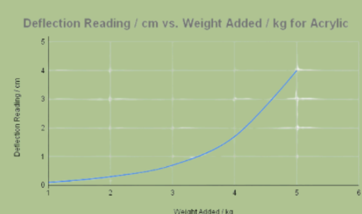


Experiment 2: Determining the maximum load the product can handle.



How it works:

To conduct this load experiment on both Acrylic and Plywood which are the materials for the main frame of the product and where users will be in contact with most. By incrementally applying weights to each material, we simulate the stress they would encounter in everyday use. This systematic approach allows us to determine the load-bearing threshold where the materials begin to warp or sustain damage. Deflection is measured from an unloaded state to maximum load, noting any point of permanent bend or fracture. By understanding the limits of Acrylic and Plywood, we can make informed decisions about the product design, ensuring that it can withstand the typical forces exerted by users without compromising on form or function.



Experiment Results

Experiment 2: Plywood can withstand more weight than acrylic, which matches with our frame being made out of majority plywood. Having pinpointed the weight threshold at which failure occurs, we've implemented targeted reinforcements. This has not only increased the product's load-bearing capacity but also its longevity. Now, even under varied weight distributions that come with different user interactions—whether it's being used as a table or a chair—our product maintains its integrity. This ensures that we our product is reliable, safe, and user-friendly without compromising on the elegant design our customers value.

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1007824 Darren Goh Xin Yang
1008239 Beatriz Acosta Ong
1007519 Tan Tian Kovan
1005088 Khoo Li Cheng Dylan

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