IDC School of Design
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Indian Institute of Technology Bombay

Masters' Industrial Design Project 2 | Autumn 2022

Designing a Prayer Aid for Salah

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Guided by **Prof. Sandesh**

Declaration

I declare that this written submission represents my ideas in my own words, and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated, or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been appropriately cited or from whom proper permission has not been taken when needed.

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28th December 2022

Approval Sheet

This B.Des Design Project titled **“Designing a Prayer Aid for Salah”** by Zaid Khuram, Roll Number 18U130030 is approved, in partial fulfilment of the M.Des Industrial Design Degree at the IDC School of Design, Indian Institute of Technology Bombay.

Internal

External

Chair

Guide: **Prof. Sandesh**

Digital Signature
Sandesh R (i07139)
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Acknowledgements

I would firstly like to thank my guide, Prof. Sandesh for his constant guidance and support, and going above and beyond in steering me in the right direction. I also want to graciously thank my jury, Prof. Chakravarthy, Prof. Avinash and Prof. Purba Joshi, for all their valuable feedback.

I would also like to thank all of the users who took time out of their schedule to participate in my research. I am most grateful to my family, who gave me regular feedback on a project so close to home, and my dear friends at IIT Bombay for their support without which this project would not have been possible.

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Section 1:

Background and Research

Introduction

What is Salah?

The Salah is a special form of worship that is the second most important pillar of Islam after the shahada (testimony of faith). It is an obligatory form of prayer performed five times a day as commanded by the Prophet Muhammad (peace be upon him).

The salah involves a number of physical movements – standing, bowing, prostrating, and sitting (shown in figure 1). It also involves the recitation of verses from the Holy Quran in Arabic along with a number of dua (supplications).

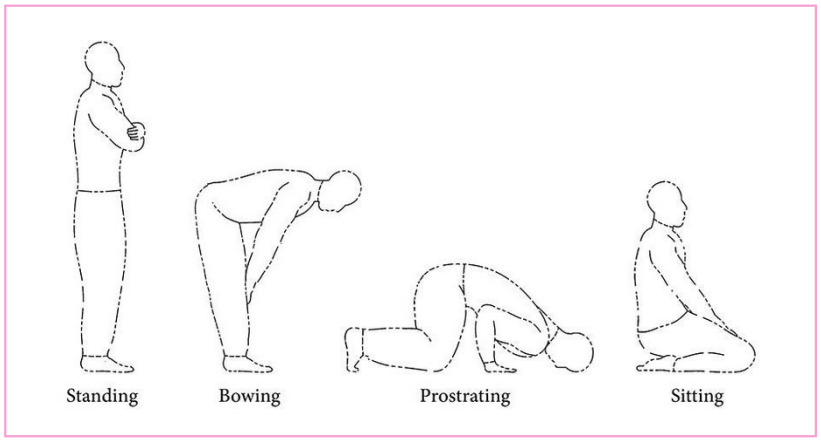


Figure 1: Different positions of Salah

The Muslim will face the direction of the Kaba, the sacred mosque in Makkah, whenever they perform their prayer. These physical movements, recitations, and supplications are all done to show humility and submission to Allah.

When is it prayed?

The Salah is performed by Muslims five times a day. Each of the five prayers have names - Fajr, Zuhr, Asr, Maghrib and Isha, and have prescribed times during which the prayer is performed. Each of these prayers also have a prescribed number of units to be performed during that prayer.

Fajr	Dawn	2 Rak'ahs
Zuhr	Noon	4 Rak'ahs
Asr	Late Afternoon	4 Rak'ahs
Maghrib	After Sunset	3 Rak'ahs
Isha	Dusk	4 Rak'ahs

Table 1:Prescribed time and length of the five daily Salah

How is it prayed?

The required physical movements within Salah - standing, bowing, prostrating, and sitting, are performed in a fixed order to complete *rak'ahs* (units) of prayer.

Each unit starts in the standing position where verses from the Holy Quran are recited before going into the bowing position. Supplications are made before standing back up for a brief supplication and then going into prostration.

After reciting supplications while prostrating, the Muslim will sit for a brief moment before prostrating again. If there are remaining units of prayer to be completed, the unit of prayer is completed and one stands back up to start the next unit of prayer.

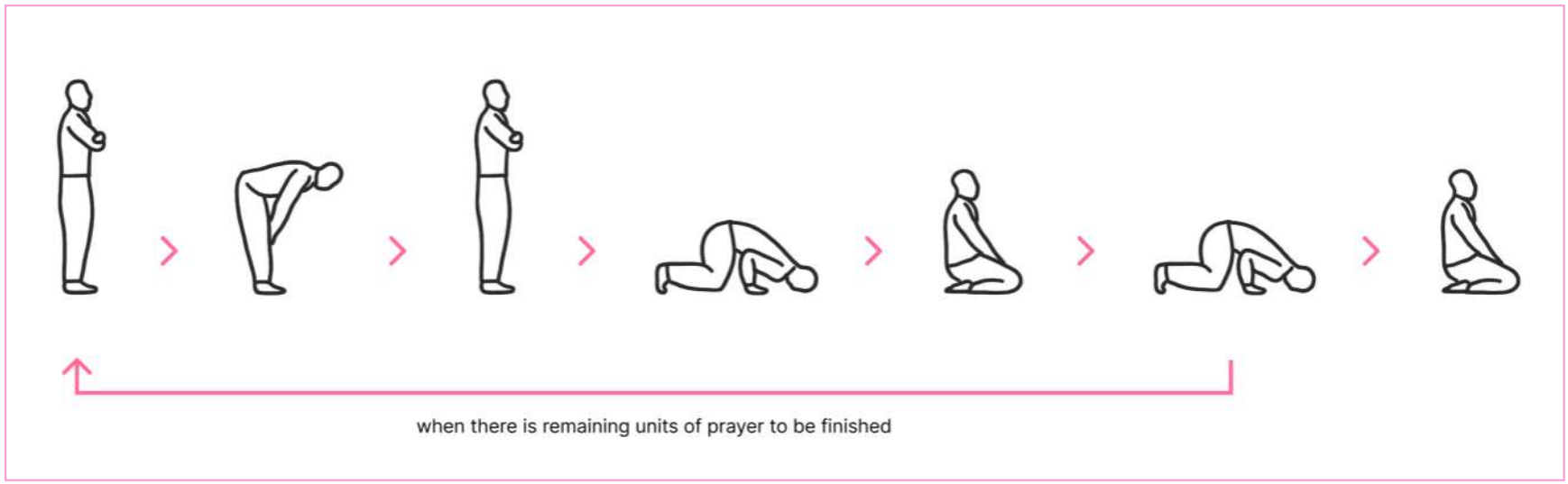


Image 2: The order of positions in which Salah is prayed.

If it is the last unit of prayer, or an even unit of prayer, one will go into the sitting position. If it is an even unit, one will stand back after completing a small supplication. If it is the last unit of prayer, the muslim would complete the prayer in the sitting position.

One unit of prayer, on average, takes about **1-1.5 minutes**, depending on the length of time spent reciting the verses of the Holy Quran in the standing position.

The Problem Space

In Muslim households, children watch elders around them perform Salah and are taught how to do so at an early age. As they grow to become adults, many muslims embrace the meditative nature of the prayers and the connection with the physical movements is only heightened until it cannot be separated from what is their daily routine.

As the same people grow older, the physical body however, cannot keep up. This narration of the Prophet Muhammad (peace be upon him) informs us of how we can continue to perform prayers in spite of physical inconveniences.

I had haemorrhoids so I asked the Prophet (peace be upon him) about praying. He said: "Pray standing up; if you cannot, then pray sitting down; and if you cannot, then pray (lying) on your side."

While sitting on a chair and praying is a very comfortable option for most elderly muslims and those with joint pain, it makes the users feel like they are doing less. After a lifetime of prostrating on the ground, many muslims would be very reluctant to completely switch over to praying on a chair. This can lead to worsening of the physical pain and a sense of spiritual incompleteness.

Secondary Research

Understanding who uses the chair while praying Salah and what exactly they struggled with was the next step.

According to a study done by Daghistani (2016), 50.8% of participants that used the chair struggled with knee problems and 42.7% participants said their problems were because of old age.

"The main reasons for using the chair during prayer are inability to stand during prayer, inability to kneel, inability to prostrate, and inability to sit for the middle or final Tashahhud."

Causes	Number of Cases	Percentage of Cases
Knee Problems	63	50.8%
Aging	53	42.7%
Back problems	44	35.5%
Pregnancy	7	5.6%
Foot Problems	6	4.8%
Disability	5	4.0%
Extra Weight	4	3.2%
Other	15	12.1%

Table 2: Causes of using chairs while praying

In the same study, the author mapped out the usage patterns of the chair to better understand what positions people struggle with and end up using the chair to pray (table 2). Summarising the top three patterns, **63.7% of the participants struggle with prostrating and staying in the sitting position.**

Pattern	No. of cases	Percent	Standing	Bowing	Prostrating	Short Sitting	Long Sitting
1	37	29.8%	x	x	x	x	x
2	28	22.6%			x	x	x
3	14	11.3%		x	x	x	x
4	8	6.5%		x	x		
5	6	4.8%				x	x
6	6	4.8%			x		
7	4	3.2%	x	x	x		
8	3	2.4%	x	x			
9	3	2.4%		x			
10	2	1.6%	x		x	x	x
11	2	1.6%	x		x	x	
12	2	1.6%	x	x			x
13	2	1.6%	x				x
14	2	1.6%			x		x
15	2	1.6%	x				
16	1	0.8%	x	x	x	x	
17	1	0.8%	x		x		x
18	1	0.8%	x		x		

Table 3: The 18 patterns of using chairs, based on the various combinations of praying position(s) where chairs are used

It is important to note that the study above was conducted in a mosque that includes only male participants.

The Dependency Scale

Based on the findings in the research above, and an understanding of Salah from my own experience, I was able to create a dependency scale to map out how dependent users would be on the assistive device (in this case, a chair) while praying Salah.

For the sake of simplicity, I have mapped three main patterns of use — independent of the chair, semi-dependent (uses chair only for prostration and sitting), and fully dependent (uses the chair for all positions).

Image 3: An illustration of how Salah would be prayed when fully dependent on the chair.

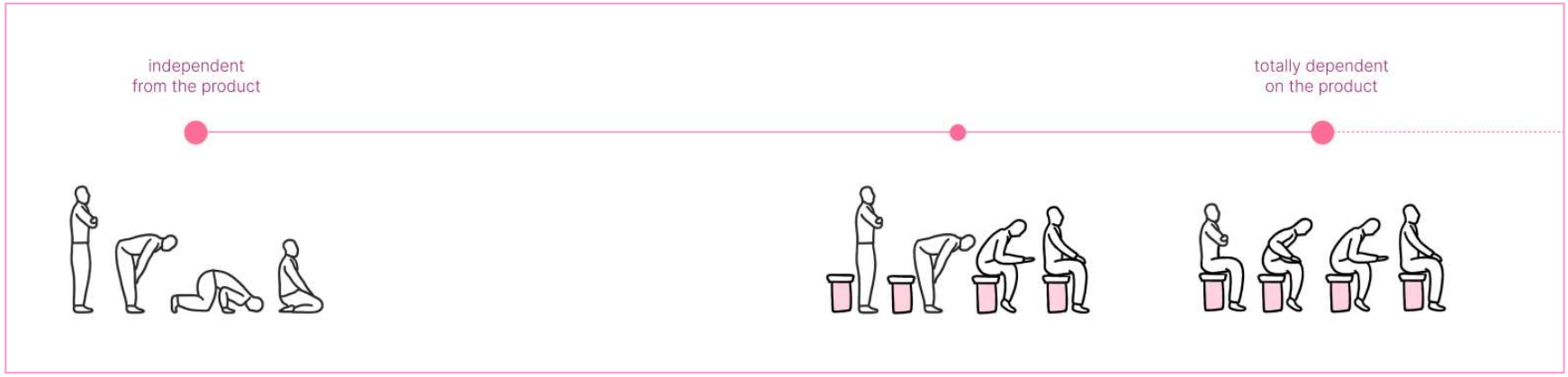


Image 4: The dependency scale

Design Directions

Finding the Gap

Through my own experience and secondary research, I was able to categorise the users that use chairs to pray salah into broad user groups.

1. Lower body joint / muscle pain (temporary - from injury)
2. Lower body joint / muscle pain (long term / chronic - arthritis, old age)
3. Pregnancy (temporary)
4. Increased weight (long term)
5. Full body musculoskeletal weakness (long term - old age)

I then mapped these user groups onto a dependency scale based on the patterns of usage of the chair from the above paper.

By mapping the user groups on this dependency scale, I was able to identify design opportunities where users ended up sitting on the chair to pray Salah even when they didn't need to. Many user groups had higher capabilities to pray in the prescribed positions but had no product or knowledge on how to do so.

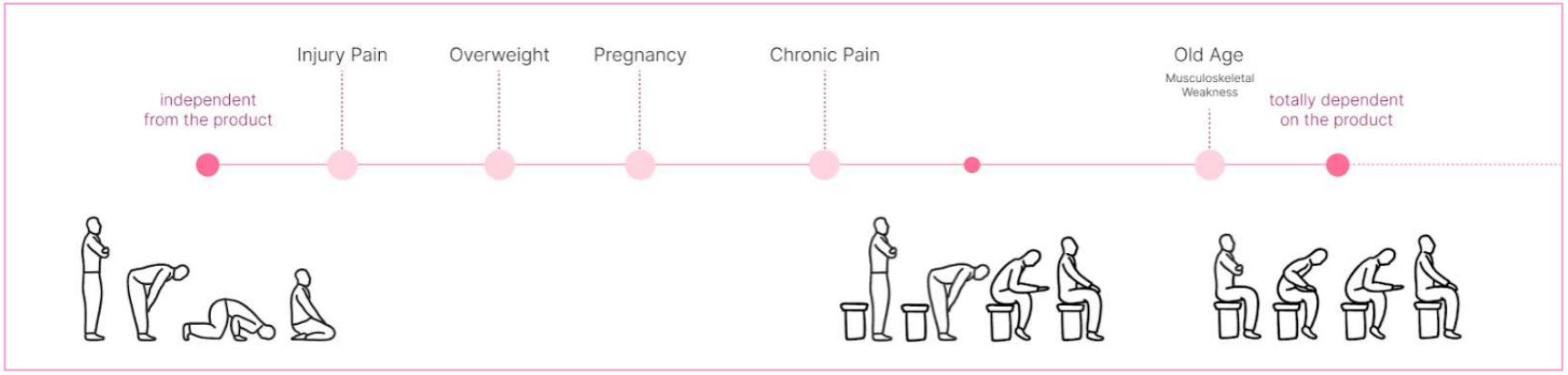


Image 5: User groups mapped on dependency scale

Design Direction 1

*Create an appropriate product solution that users with **minimal physical disabilities** can take advantage of instead of defaulting to praying on a stool/chair.*

This prospective product would be aimed at user groups with less severe physical discomforts. These users would be able to use this product to find ease in praying, but still remain as close to the prescribed positions as possible.

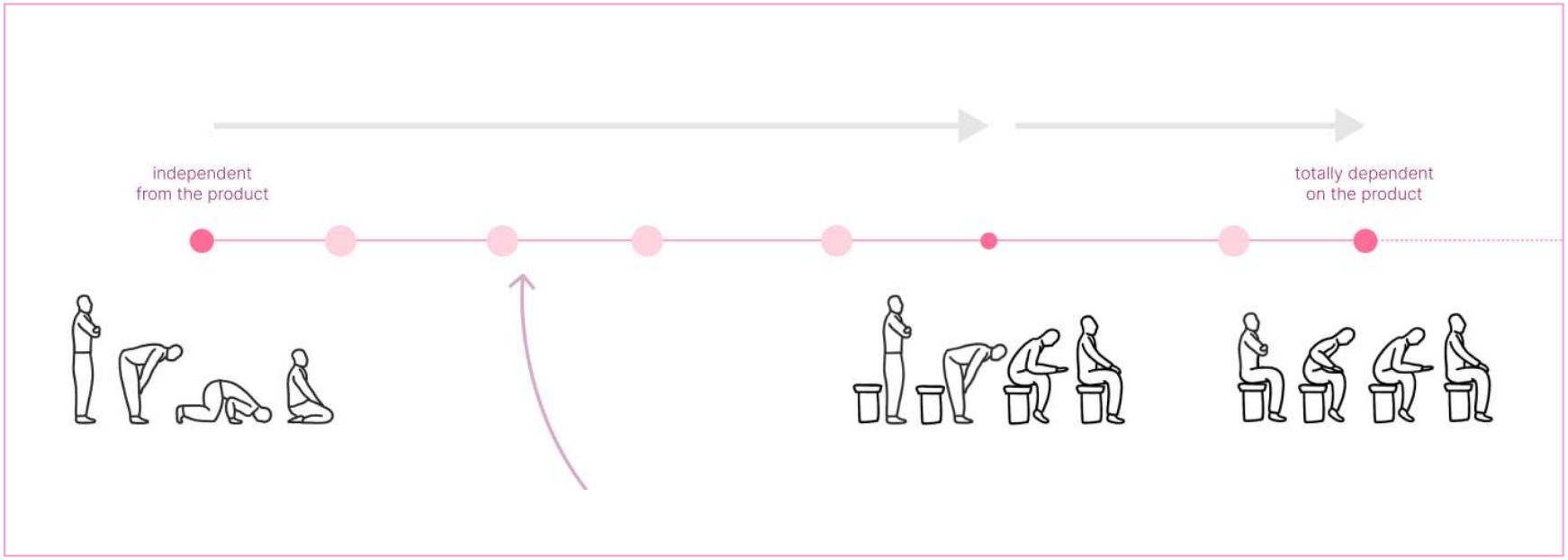


Image 6: Gap for design direction 1 on the dependency scale

Design Direction 2

*Create a product that helps users with **more severe physical disabilities** perform prayers as close to the prescribed method of praying as possible.*

More severe physical disabilities would include the inability to stand while praying. This product would attempt to mimic some form of emotional / spiritual comfort that is achieved by praying in the prescribed positions.

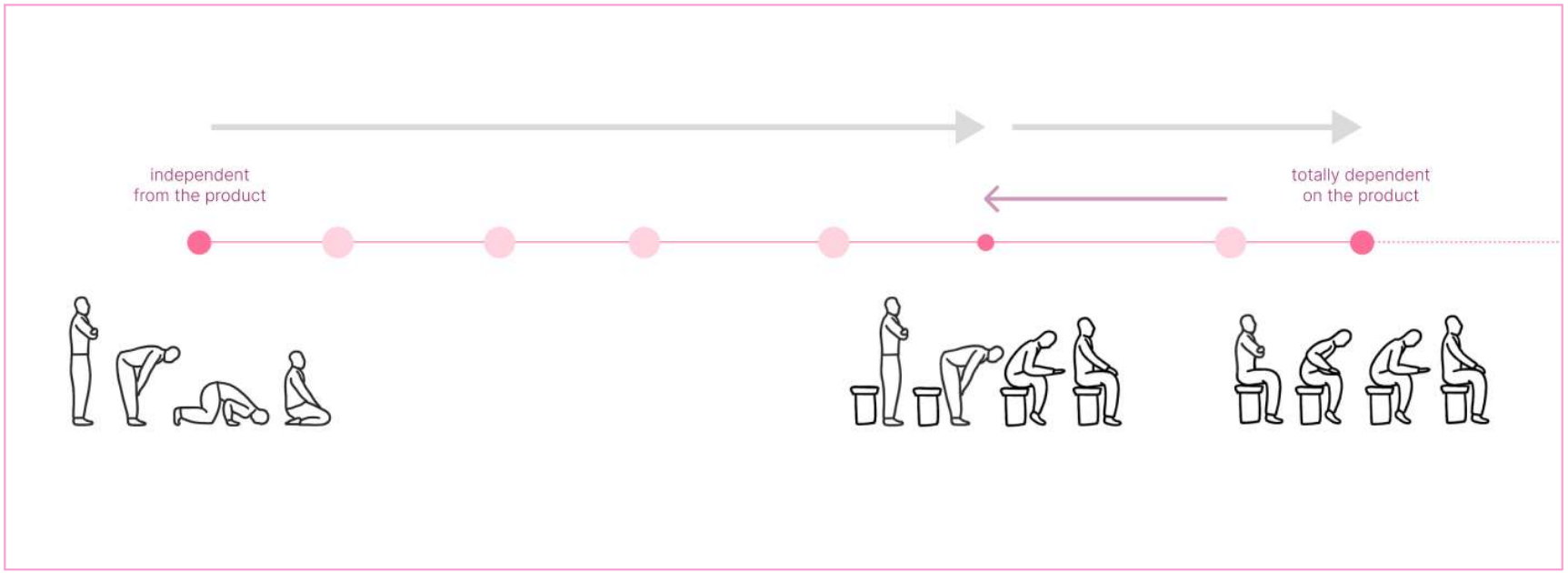


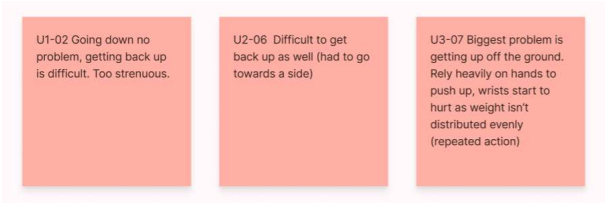
Image 7: Gap for design direction 2 on the dependency scale

Research

Interviews and Insights

I have experienced elders in my own family facing a similar issue. I conducted informal interviews with **four elders**, and **two recently pregnant women** to understand the struggles they face in going through the physical motion of Salah. The key insights are listed below.

1. 3 out of 4 users struggled with getting back up from the lower positions in Salah — sitting and prostrating.



2. 2 out of 4 users suffered from continuous knee pain after sitting for long periods of time.

3. Pregnant users faced difficulty in the prostration position. The weight of the baby puts pressure on the lungs making it difficult to breath comfortably.
4. All users preferred to carry out all the prescribed positions with some pain even if recommended otherwise. Users felt it was only for some time and they would recover quickly enough afterwards.

Market Research

Products in the market to aid in praying Salah are not new. However, most of these products are modified versions of chairs or stools that do not challenge the prescribed default of sitting on an elevated platform to pray.

Image 8: Products in the prayer space in the market today

There is one unique product in the market that aims at solving a key issue I found in my research. The SalatBuddy is a small stool-like product that is placed a little in front of the user while in the standing position of prayer.

Image 9: The SalatBuddy (https://salatbuddy.com/)

This product is used to help the user in the sitting position of Salah. He/She would be able to sit on a raised surface, reducing the strain on the knees by not needing it to bend completely. It will also remove the need to rest one's weight on their ankles, providing a much more comfortable experience.

Image 10: The SalatBuddy in use

Studying the SalatBuddy

My uncle faces difficulty in staying in the sitting position and uses the SalatBuddy. I was able to study the movements while praying Salah with it and without it. (image x) I made key observations from the pictures that I have listed down below.

1. In the standing position, he was required to adopt a wider stance than usual to accommodate for the width of the Salatbuddy. He would need to go around it to get to the lower positions.
2. While lowering himself into the lower positions, he uses his hands to absorb the initial impact, and lower himself down slowly to avoid force on the knees.
3. The position of sitting is very similar with and without the Salatbuddy. While it may be visible when in the standing position, it's near invisible in the sitting position.

From my time spent at my uncle's home, I also noticed some habits that are worth mentioning. While he can do all the positions without the SalatBuddy, he prefers using it as much as he can. He would go as far as to carry it to the mosque in a cloth bag every morning at dawn. However, he does not carry the same product to work everyday.

This shows the need for the product in the user's life that is being limited by its portability.

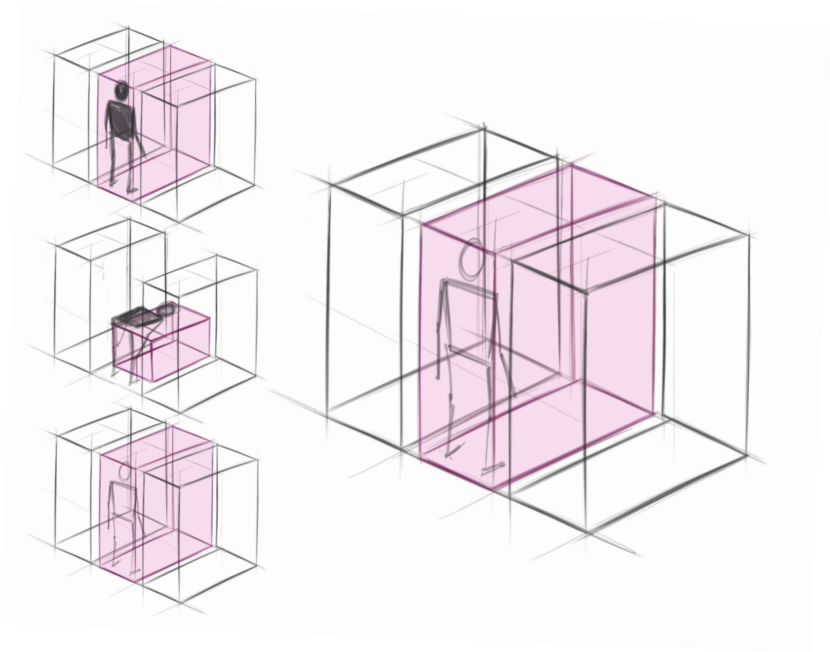
Image 11: My uncle going through the motion of Salah using the SalatBuddy

Details in the Prayer Space

Physical Space required

When praying in the prescribed positions of Salah, one only requires a rectangular space directly in front of them. While the positions of bowing and prostration themselves do not take up a whole lot of space, the motion of the person to get into those positions requires space around them.

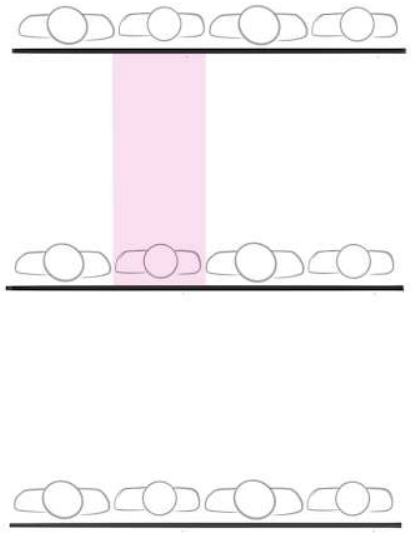
Logically, people with broader shoulders or larger width would require more horizontal space. And those who are taller would require more vertical space on the floor while in prostration.



Praying in Congregation

In congregation, people are expected to stand in neat rows facing the direction of prayer. Praying in congregation means to follow the leader in his recitation and movements in Salah and complete the prayer as one congregation and community.

While each person may take as much horizontal space as needed, each person is expected to not leave any gaps between each other and stay as close to each other as comfortably possible.



During Covid-19, when physical distance was imperative to stop the spread of the virus, this rule of standing as close to each other was dropped. Each person would stand 6 feet apart but continue to follow the congregation in prayer

Design Objective

To create a product that helps people, who's lower body requires assistance, in standing back up while praying Salah.

Design Brief

At the same time, I also worked on creating a design brief that would later help me evaluate my ideas. These were crafted based on the research I had conducted and my own personal experiences with the act of praying Salah.

1. *Should be* **easy to set up and use**

The Salah happens 5 times a day for short durations of time. As prescribed originally, it requires minimum preparation. To keep with the philosophy of making prayer easy, I wanted to make sure a product that users would need should be easy to set up and use.

2. *Should be* **portable**

Salah can be prayed individually or in congregation at the mosque. Salah prayed individually can be performed anywhere on a clean surface, mostly done at home as it is convenient. I aimed to make the product portable so that users would be allowed to carry the product to wherever they wanted.

3. *Should* **not interfere when praying in congregation**

Prayers in congregation require everyone to stand in neat rows facing the qiblah (direction of Makkah). While standing in congregation, one is expected to stay within their space and not disturb or interfere with those around them.

Chairs or stools, which are currently used by those with physical discomfort, end up causing inconvenience for those praying around them and breaking the rows in the congregation.

Section 2:

Ideation and Testing

Exploring Lifting Mechanisms

One of the main problems to solve was helping users get back up from the lower positions in Salah. I explored existing products and their mechanisms to understand how similar problems are solved in different contexts.

Scissor Lift

Could be used to lift a user off the ground if the pressure is enough. Looks visually complex, which could make it uncomfortable to use in the context of prayer.

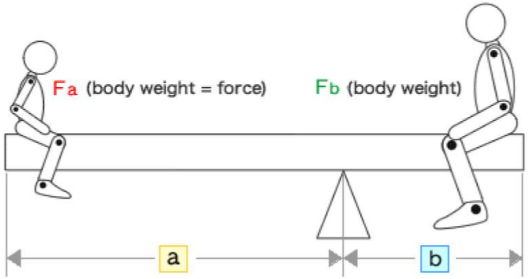
Worm Gear

This mechanism turns rotational movement into vertical movement. A teeth on the gear that is attached to the hand crank interacts with the threads on the worm gear.

An interesting mechanism for precise movement, however, unrealistic in the context of prayer where you require a quick lift multiple times

Seesaw Lift

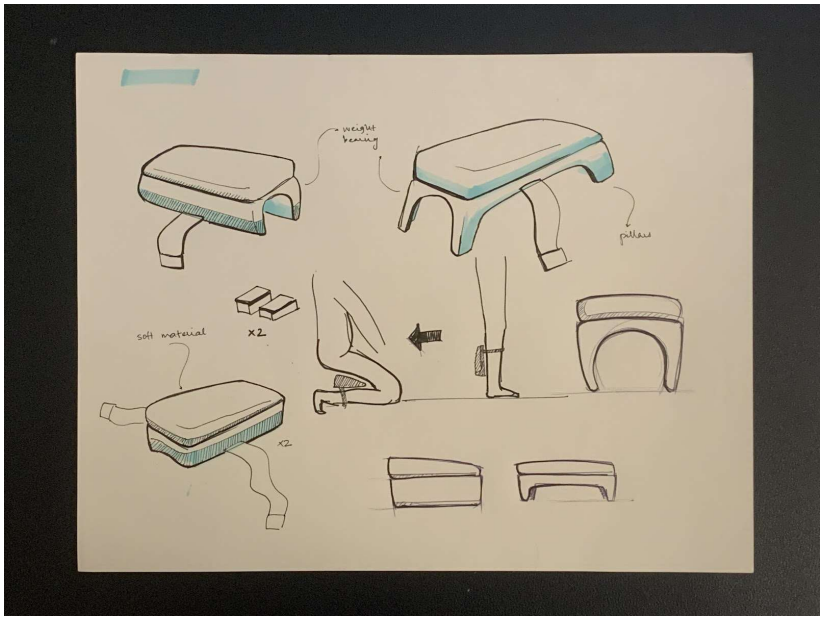
The most simple pivot mechanism where the moment around the pivot in one direction creates the same moment in the opposite direction. This mechanism seemed very plausible as the interaction is fast and simple.

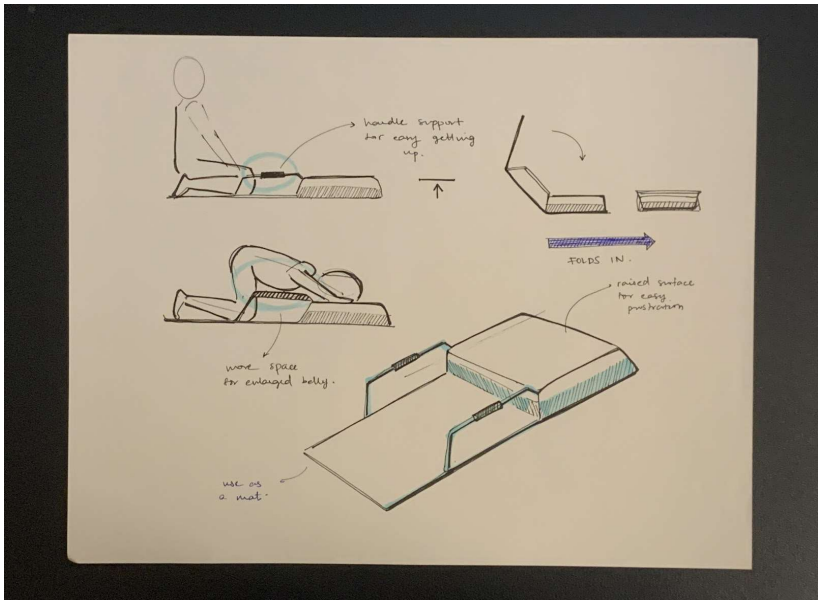


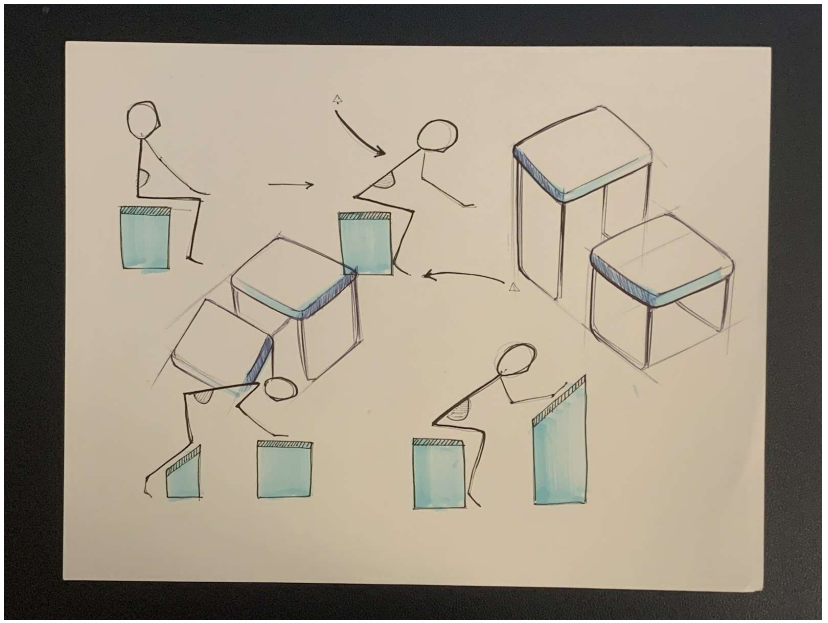
Initial Ideation

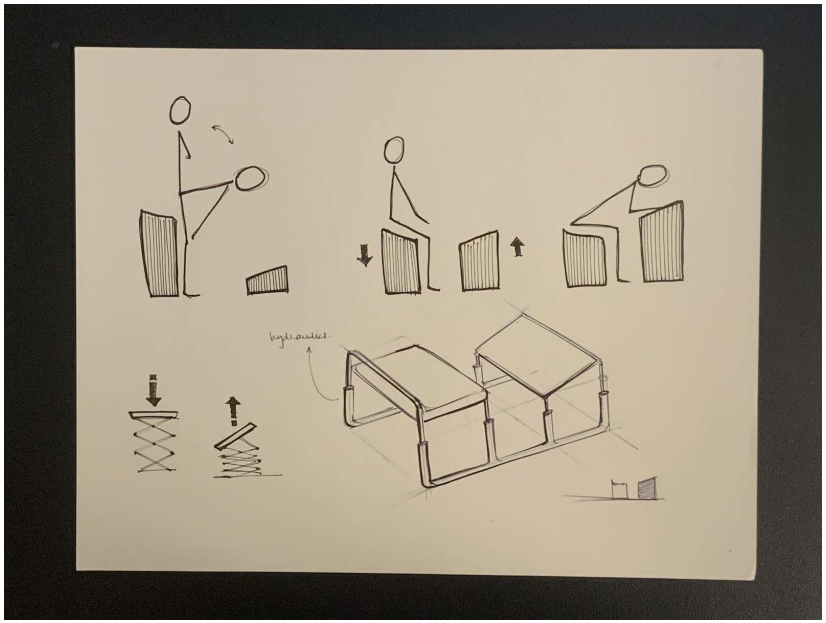
An initial set of explorations helped me think of wild ideas without worrying about constraints. I avoided thinking about likeability, feasibility, willingness to adopt and usability. I focused on just thinking of random ideas that solved the problem.

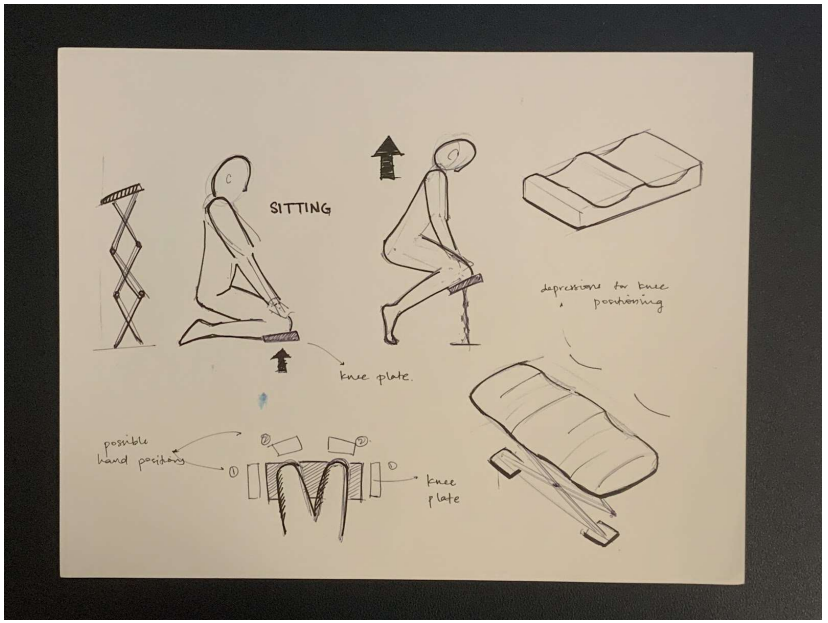
I explored wearable products, stand alone supports (like handlebars and stools) and mechanical aids that would aid in particular movements.

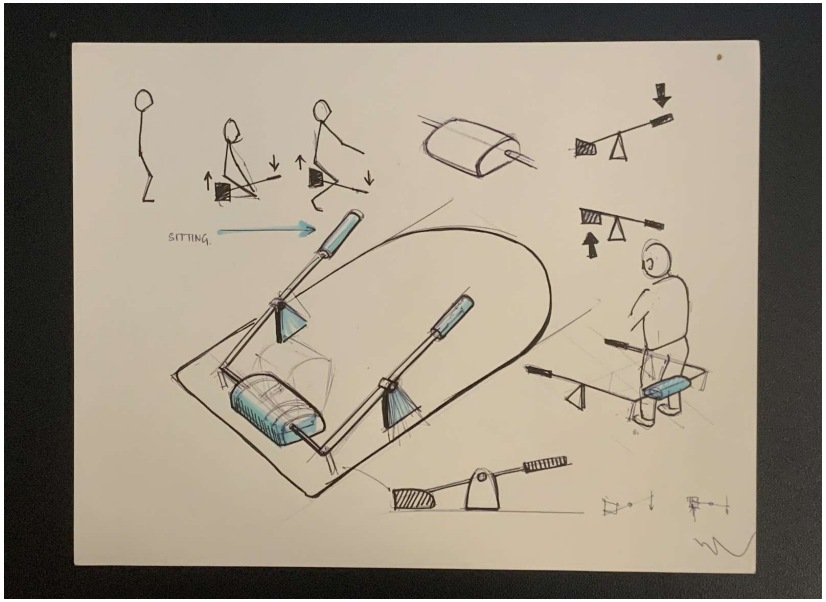







hydraulics


SITTING
knee plate.
depressions for knee positioning
possible hand positions
knee plate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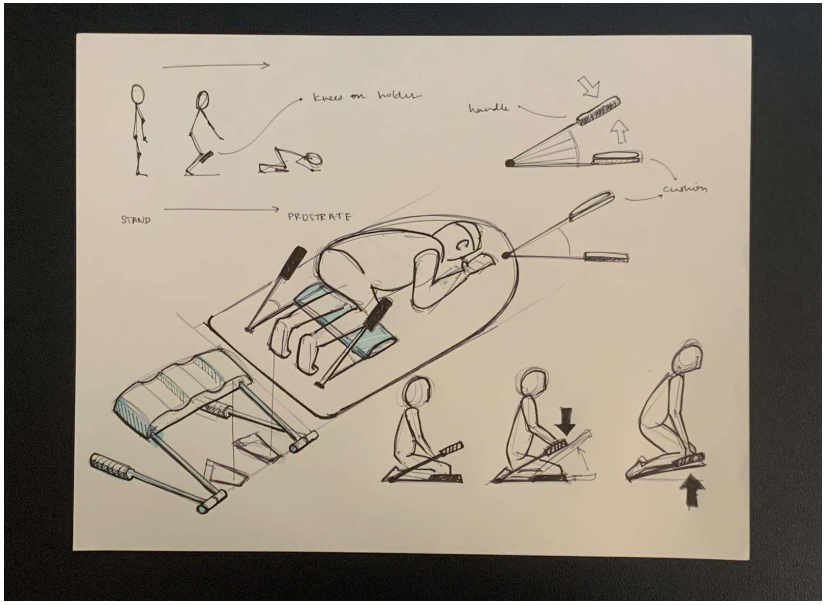
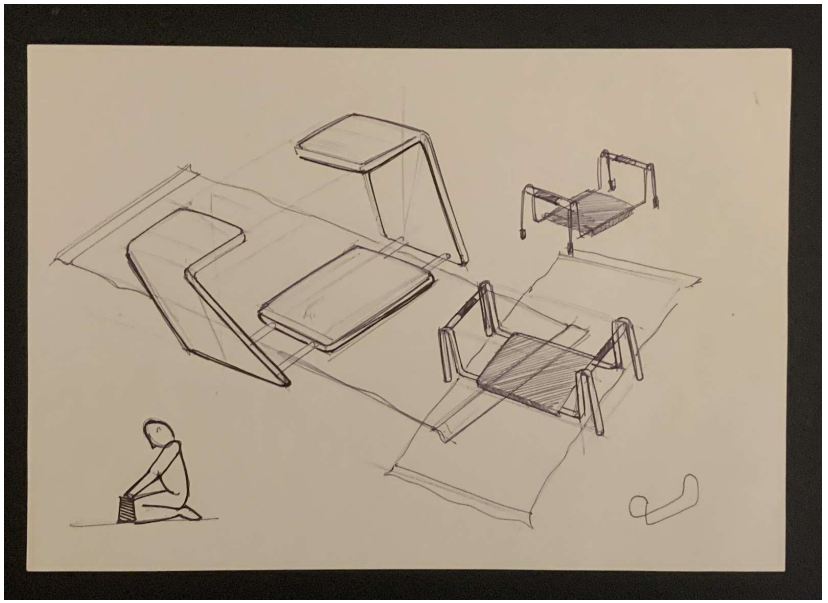
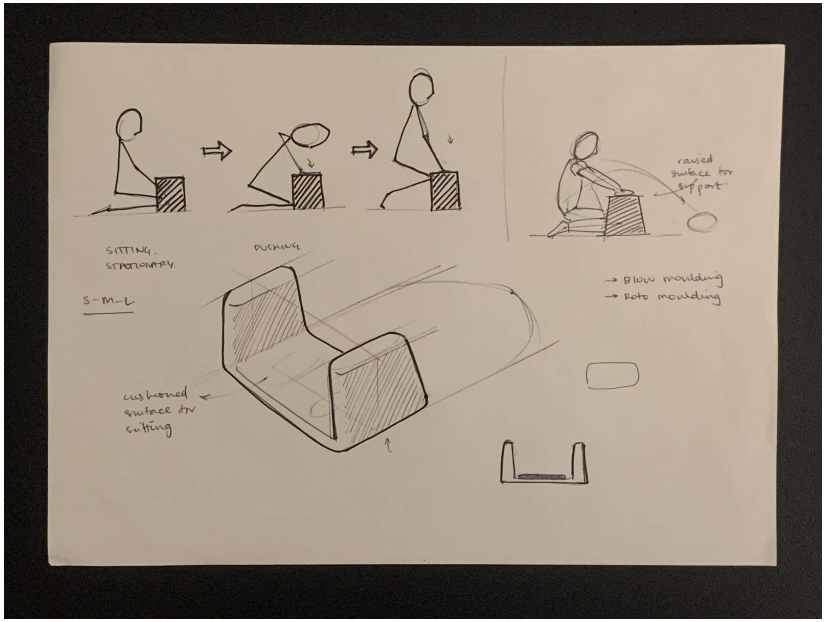

knees on holder
handle
cushion
STAND
PROSTRATE

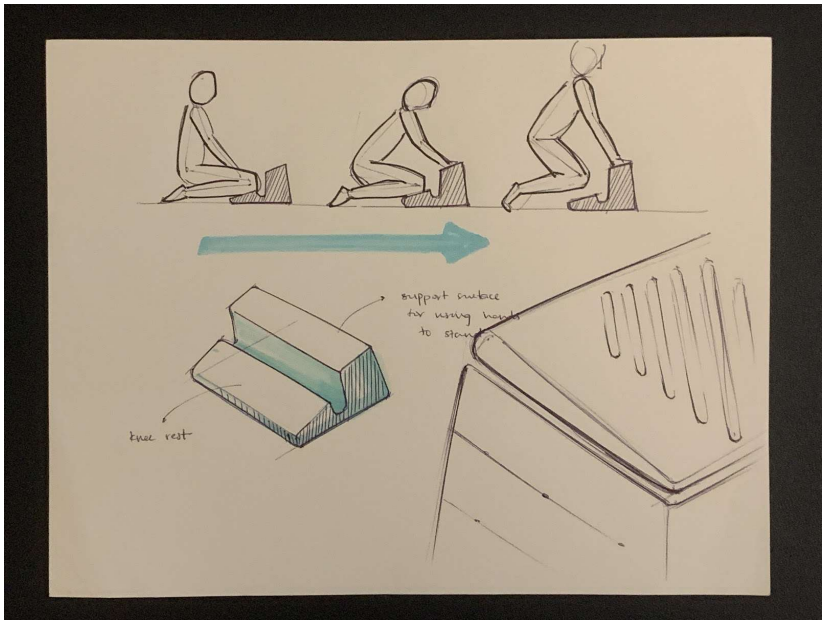
Handlebar Ideation

I chose the handlebar idea to explore further as a solution to help users get back up from the lower positions in Salah, prostrating and sitting, to the standing position.

I studied users to understand the position of the hand people default to while lifting themselves up. Based on this, I explored possible positions for the handlebars.







Testing the Rig — Handlebars

It was essential to know if the idea of creating supportive structures on either side of the user **would actually help them stand up** while in the flow of movement in Salah.

Making the Rig

I created a simple rig out of wood that measured handles of 35 cm tall on either side with a bar of wood measuring 68 cm that joined the two pieces and held them steady. Slits within the wooden pieces were used to hold them together.

Session 1 — Young Muslims

User 1 found the handlebars to be **helpful in reducing the lower body's effort** in standing back up from the lower positions. However, he mentioned that the middle beam (in the rig) made him cautious while going into and coming out of the prostration position.

User 1 also found the flat top of the handlebars to not be ideal. Since the movement of getting back up from the sitting / prostration position requires the user to push backwards, **the handlebars could be angled to make that easier**. The current design puts an unnecessary strain on the shoulder blades.

User 2 pointed out that the handlebars could possibly be too close together. In the prostration position, the elbows flare outwards to give support to the forehead and upper body. The position of the handlebars makes it interfere with this position.

Session 2 — Senior Muslims at the local Mosque

I visited the local mosque to talk to users about their difficulties and asked them if they felt the handlebar product was helping them to stand back up or not.

I was able to interview and test with two users in the mosque. I selected users who had some level of difficulty in standing back up from lower positions. Both users felt the handlebars definitely solved that particular problem.

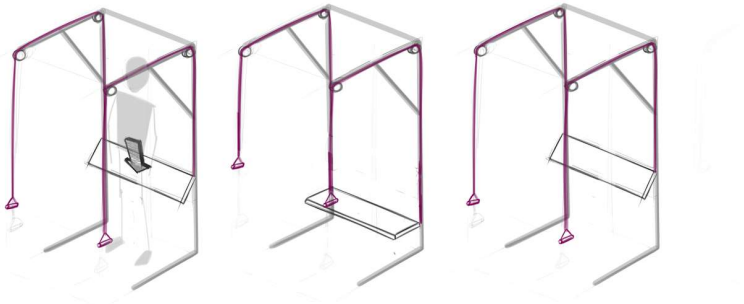
Updated Design Objective

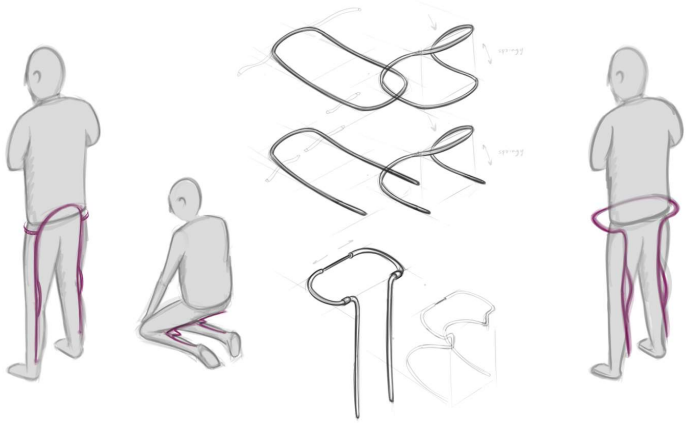
To create a product that helps people, who's lower body requires assistance, in standing back up while praying Salah ***AND helps users stay in the sitting position comfortably for long periods of time.***

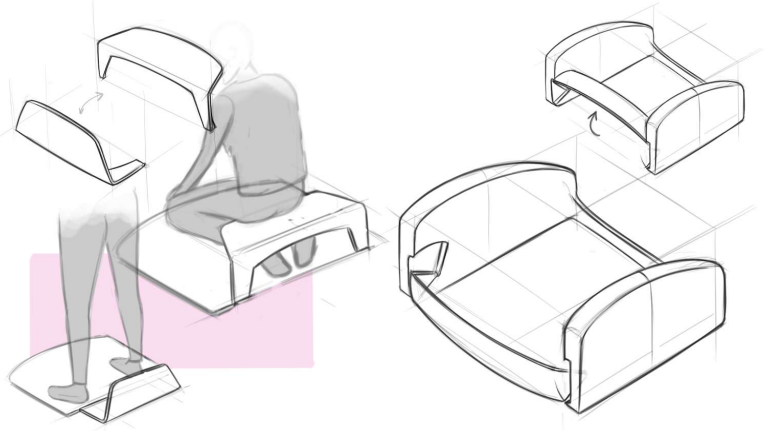
Ideation - Sitting Solutions

After getting feedback from my panel members and my guide, I understood that one problem will seldom exist without the other for the users. Creating a solution for only one product would make an incomplete solution.

I went back to the drawing board to ideate on how I can help users that struggle with sitting for long periods of time, sit comfortably.

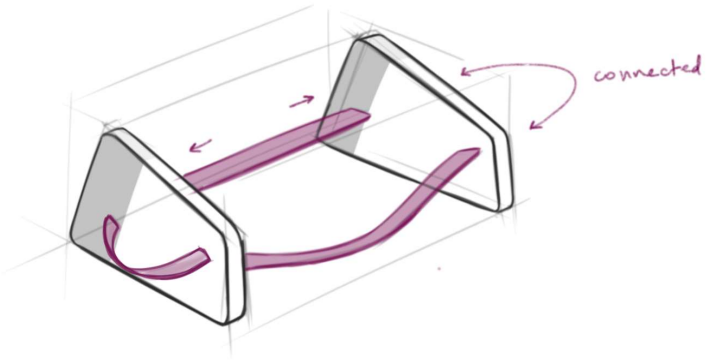




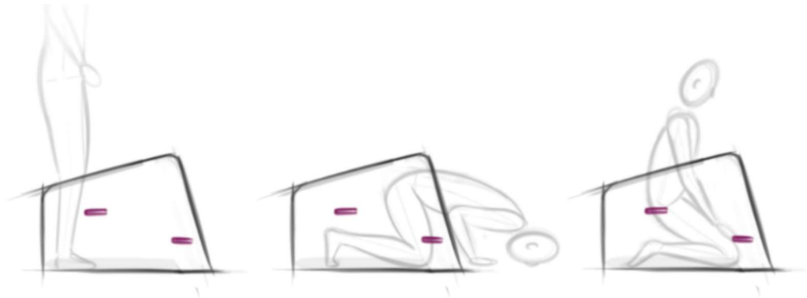


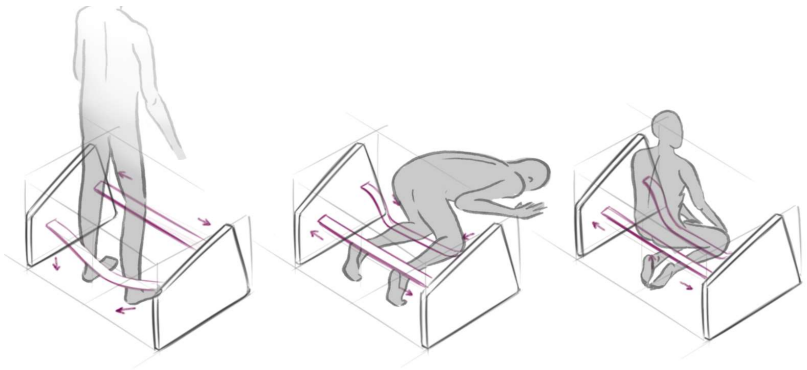
Testing the Rig — Dynamic Belt

Designing the Rig



This mechanism is designed to stay out of the way of the user when not needed and only get activated in the lower positions (sitting and prostrating, when the knees are on the floor).





At the start, the belt looped towards the back is loose, allowing the user to stand comfortably. When the user goes into any of the lower positions, his/her knees would push the forward strip of the belt downwards, pulling the side of the back belt to create a somewhat rigid sitting surface for the user.

Testing the Rig

Before taking it to the local mosque, I tested the rig with a friend of mine to understand better how someone would use it.

The main feedback was negative. The nature of a belt made trusting it to hold up your weight very difficult. He found it very **daunting to even try** it at first.

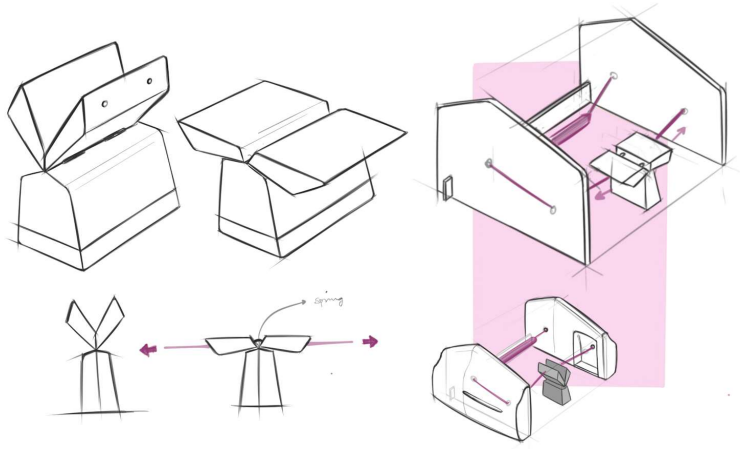
Once I explained the mechanism in the rig, he was a little less reluctant. As seen in image x, he was unsure of his knees holding the belt down, and instead used his hands to secure the belt. Alas, even when the belt was held down, he was very under confident to put all his weight and sit comfortably on the back piece of the belt.

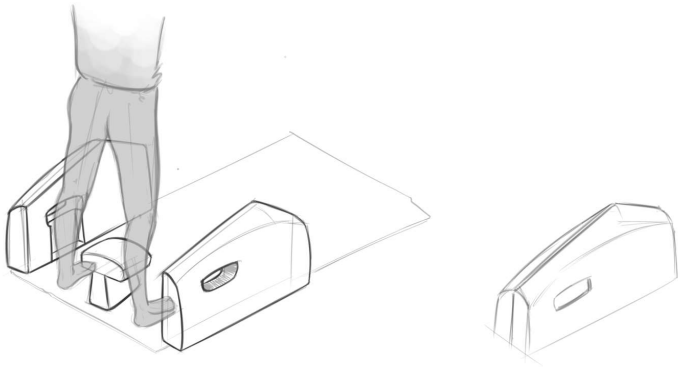
This feedback was essential as it made me realise the role **perception** plays in the adopting of a product. The nature of this rig made a young muslim, who is much more confident of his/her body, also feel reluctant to try. I realised it would **absolutely not work** for anyone who is having any form of physical problem with a product like this to aid them.

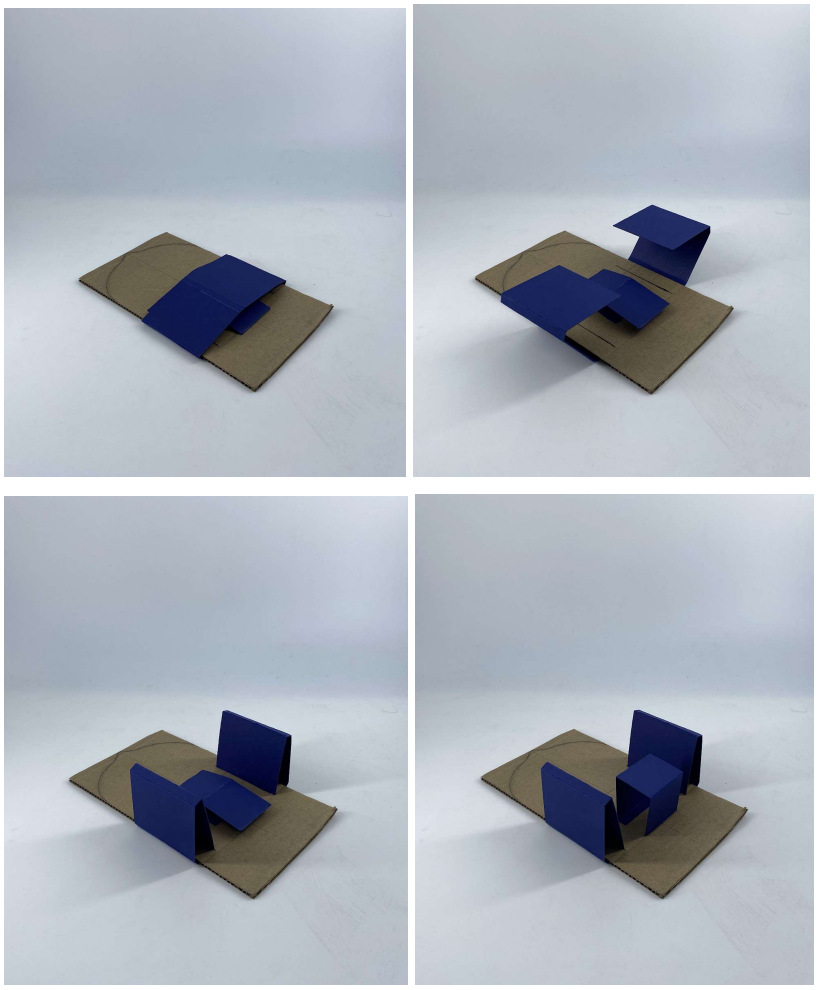
Rethinking the Seating Problem

It was clear at this point that I needed a simple solution for the seating problem. The SalatBuddy was successful in its adoption by the users. I attempted to leverage that concept and ideate on a simple stool-like form that would serve the same purpose while being part of the handlebar product.

More Ideation





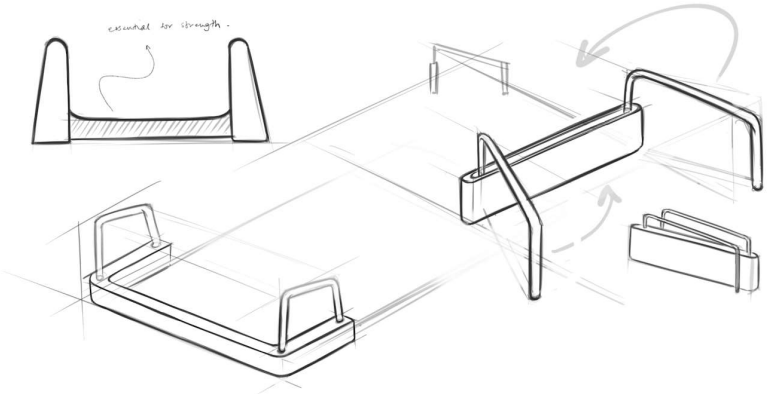


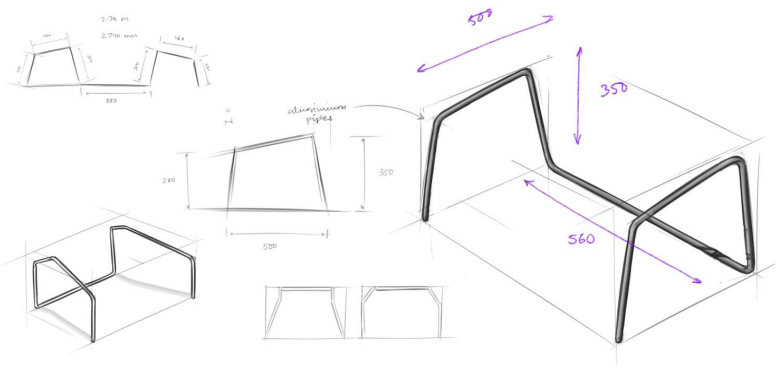
Concepts

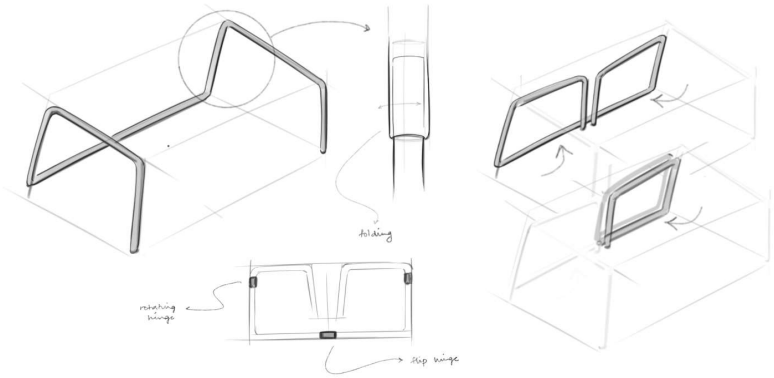
After ideating and testing designs for both the handlebar and the seating, I needed to create a product that would solve both problems. At the same, it would need to be portable, non-invasive, and easy to set-up.

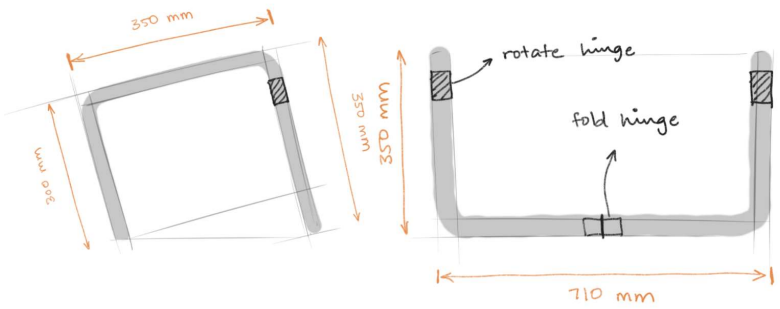
I came up with 3 concepts that were made by picking out pieces from the previous ideation stages. An idea of what material I would use was also suggested at this stage.

1. Separate handlebar and seating that folded and fit into an easy to carry shoulder bag. The product would be made of **bent aluminium / steel pipes.**

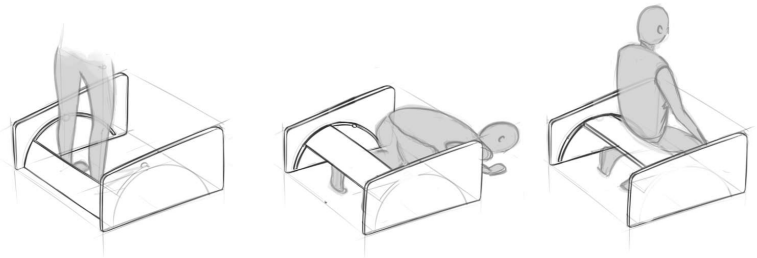


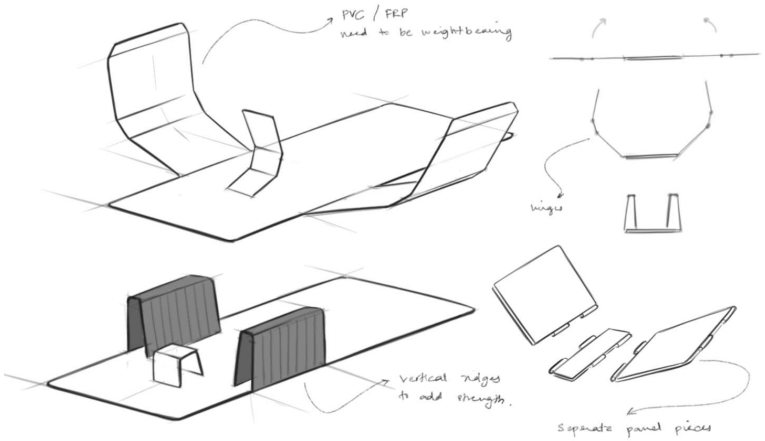




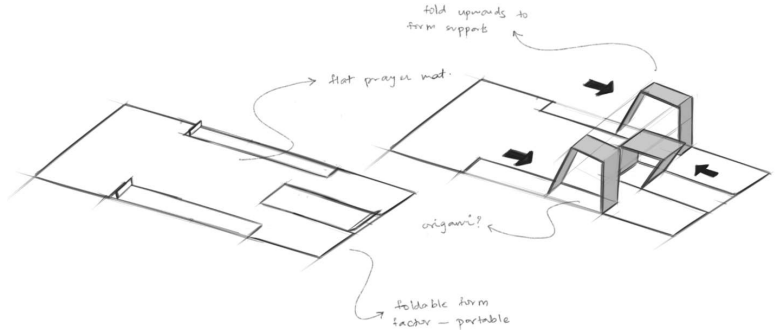


2. An extended handlebar design that ran from the halfway section to the back of the prayer space. It would include a sliding seat that would be pulled forward manually as the user went down to prostrate. This product would be made of **injection moulded plastic.**





3. A prayer mat that folded out to form the support structures. In an origami design, the handlebar and seat would be stored flat and manually set up to create a usable product. This product would be made of **plastic boards wrapped in fabric.**



Fabricating Metal Pipe Concept

Since concept 1 was relatively straightforward, I attempted to prototype it with the help of some experts from Chandivali. I added hinges to allow it to fold inwards and make it more portable.

Concept Evaluation

All the concepts were evaluated based on the three briefs that were finalised early in the project. The product must be:

1. Easy to set up and use
2. Portable
3. Not interfere with the congregation

Concept 1

The setting up of the metal pipe product was simple and relatively straightforward. It also had a design that was almost completely non-invasive to the congregation.

However, after fabricating it, I realised that I didn't expect metal pipes to be this heavy. The product weighed almost 5-7 kgs, making it not easy to carry or move around. It would not be possible to do, especially for older users.

Concept 2

This concept, while unique, had a fundamental flaw that was pointed out to me later on. The product was invasive and required the user to interact with it while praying Salah. This did not make it easy to use and benefit from.

In addition, there was no simple and easy way to make this product portable. With the seating mechanism as is, it would make folding the product to make it portable very tedious.

Concept 3

This idea seemed most plausible and attractive to me. The prayer mat is and has always been an essential part of the Salah. Even in mosques where carpets are in place, many people carry their own prayer mats.

This idea allowed me to join an already established product and build on to that. The foldable handlebars and seat allow it to remain invisible when not in use and stand up when required. I also imagined the product to completely fold down, similar to a prayer mat so that it could be transported easily.

Section 3:

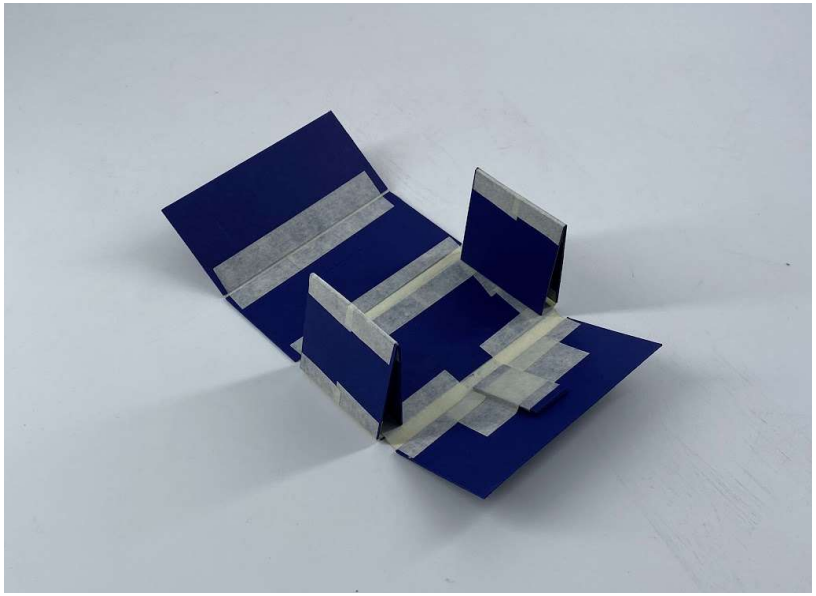
Product Development and Detailing

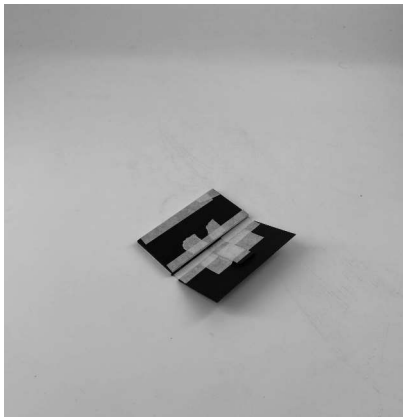
Concept Development

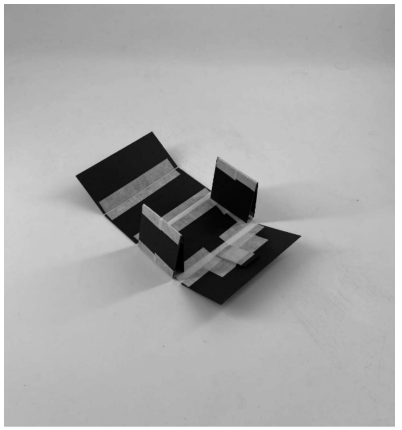
Structure and Positioning

To get an understanding of how the product, as a whole, would work and be used, I created a 1/5th scale paper mock up using tape to recreate hinges.

Since the form of the seat had not been finalised yet, a small piece of paper was stuck on the position to allow for the thickness to remain and recreate the folding ability the product was intended to have.



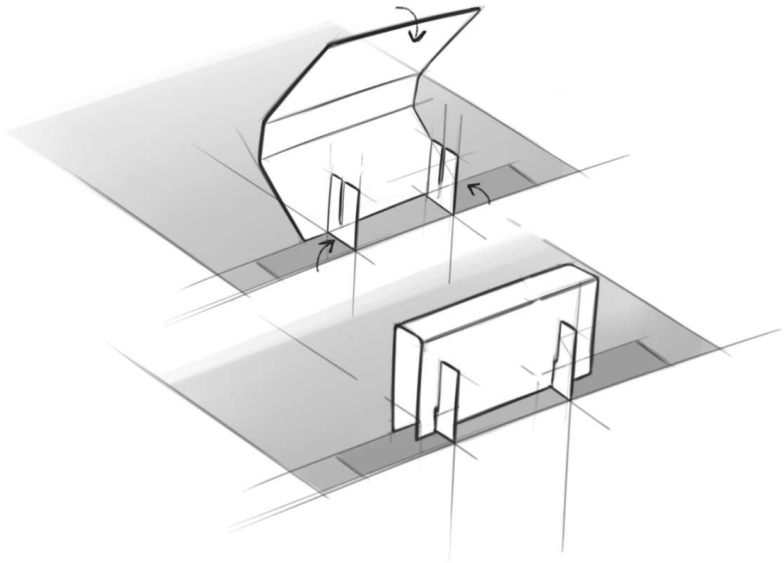


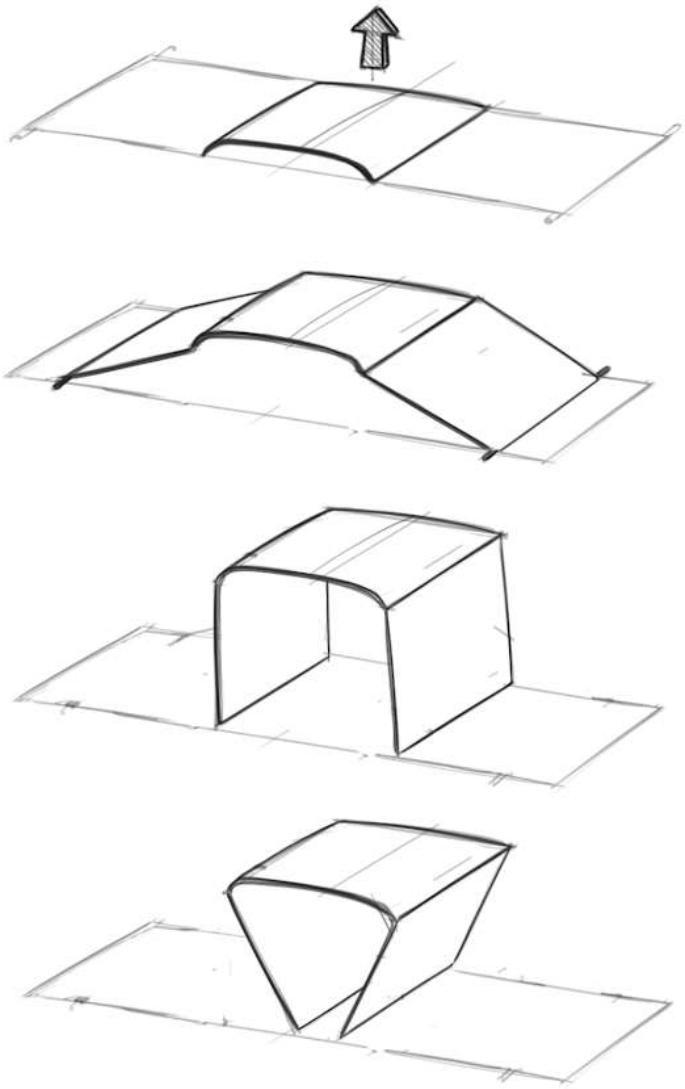


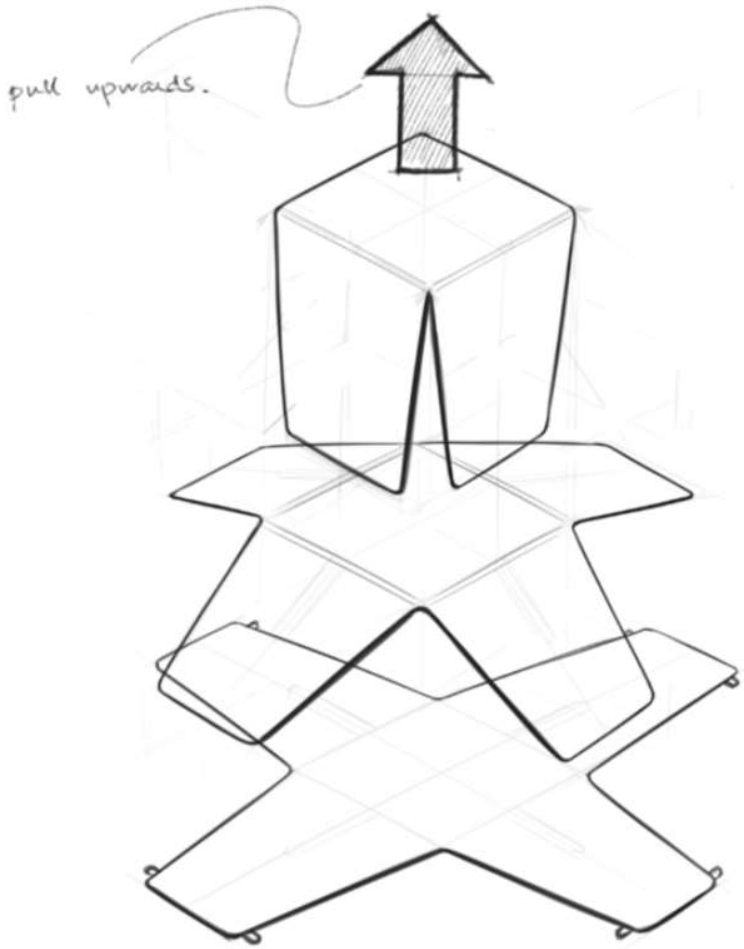
Exploring Origami Solutions

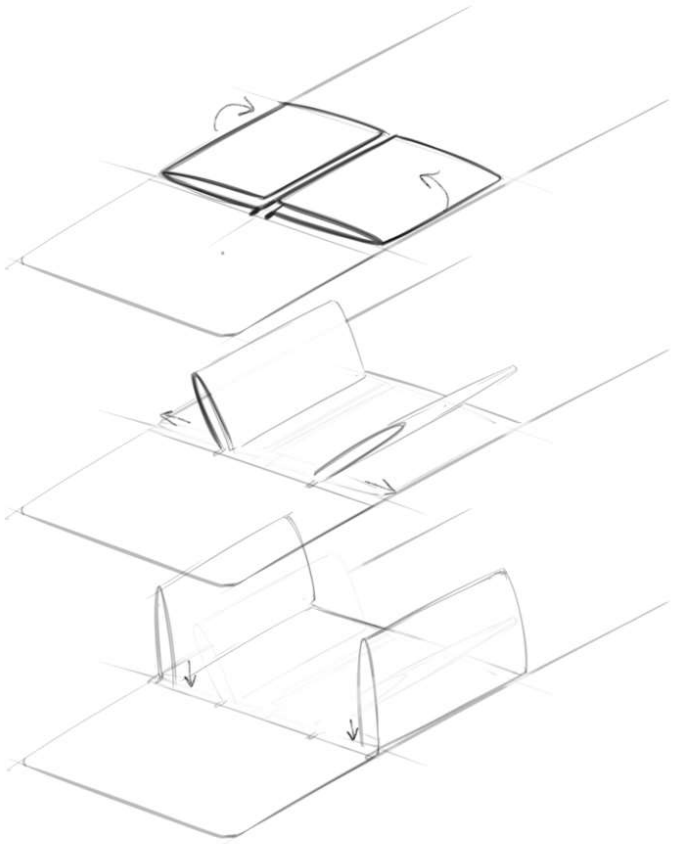
I first explored ideas by sketching them out. Many concepts included rails and grooves to keep the folded panels sturdy when in position, but that would only add to the cost and complexity of manufacturing the products.

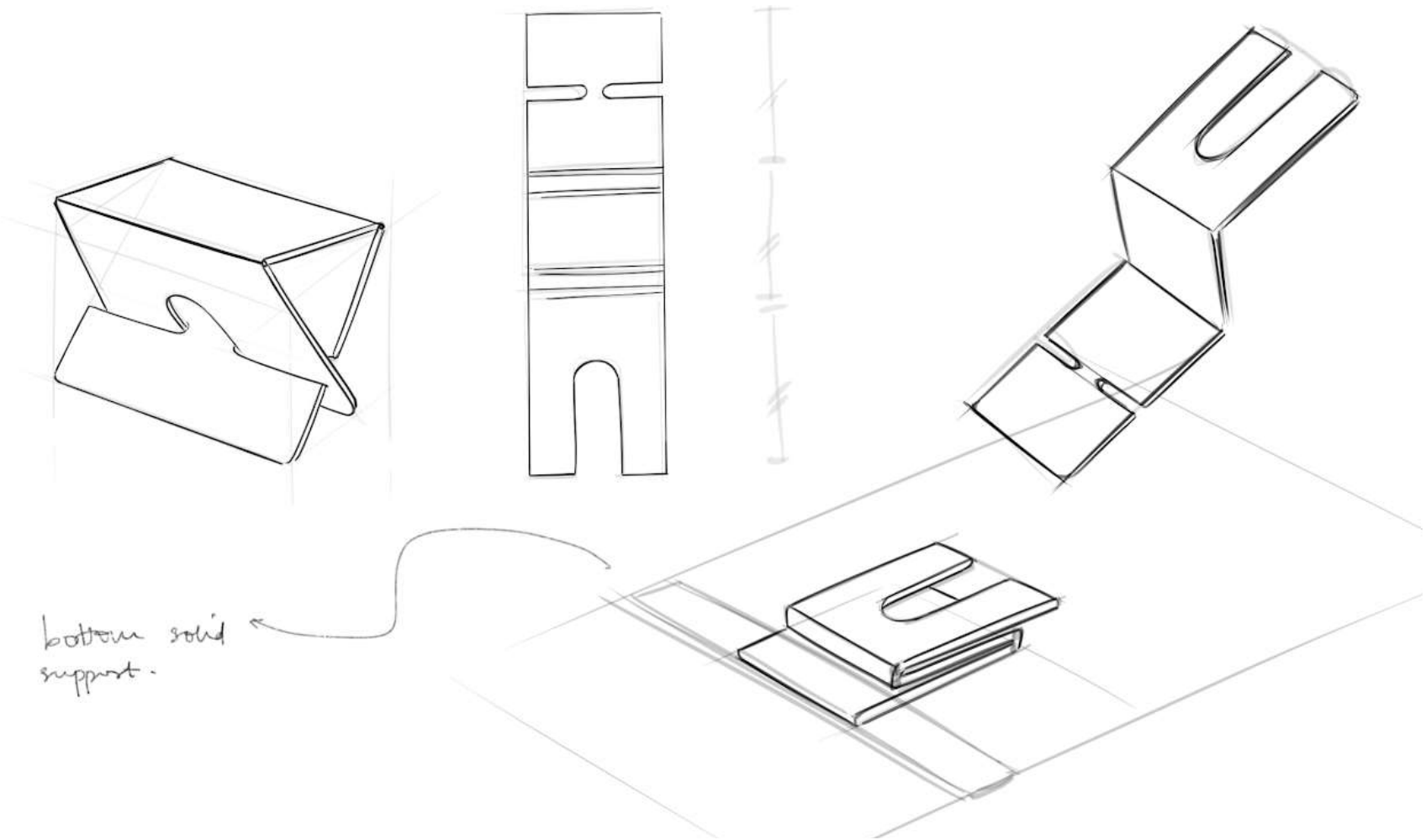
The aim was to create products that were sturdy enough when locked in place and required minimal extra effort or parts to do so.





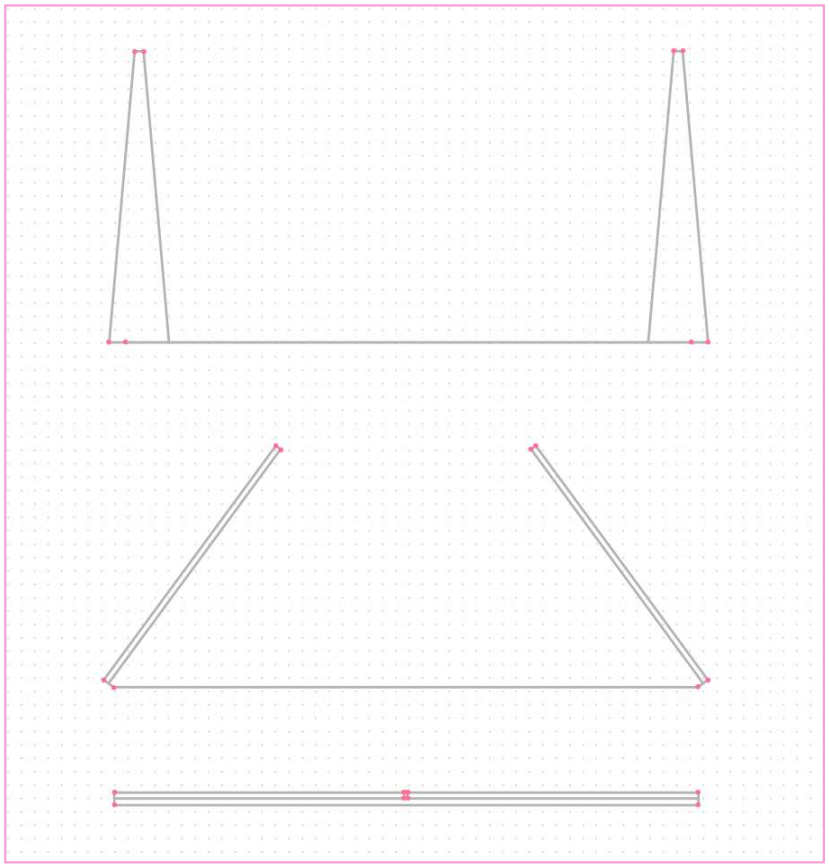

pull upwards.




bottom solid
support.

Making Cardboard Prototypes (Handlebars)

The initial ideas were very straightforward. A long rectangular piece would hinge at points across its length to form the handlebars at approximately 90 degree angles from the floor. The aim was to create **triangular** structures to increase strength in the form.



Adding Supports (Handlebars)

While keeping the set up and folding simple, it was also important to make the handlebars sturdy enough to take the weight of the user. At the same time, the handlebars must also remain in the position rather than slide away and collapse.

Different shapes and forms were explored to create **support pillars** while keeping the triangular structure to retain its strength.

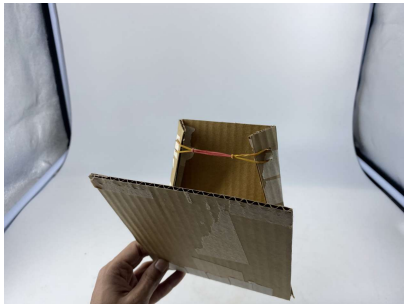
I created flaps on both sides of the internal layer. These would fold inwards and form pillars to keep the two vertical panels apart and provide structural support.

However, there seemed to be a problem with this. There was nothing keeping them held in this position.

Adding Elastic to keep the Structure (Handlebars)

From the outside, the proof of concept looks similar to the previous one. However, when pulled up into position, the pillar supports fold back automatically (because of the elastic in place) and stay in position. This makes sure to keep the triangular structure of the handlebar in place while in use.

To fold it back down, the user would need to pull the two ‘pillar flaps’ outwards, stretching the elastic, and fold the handlebar component down.

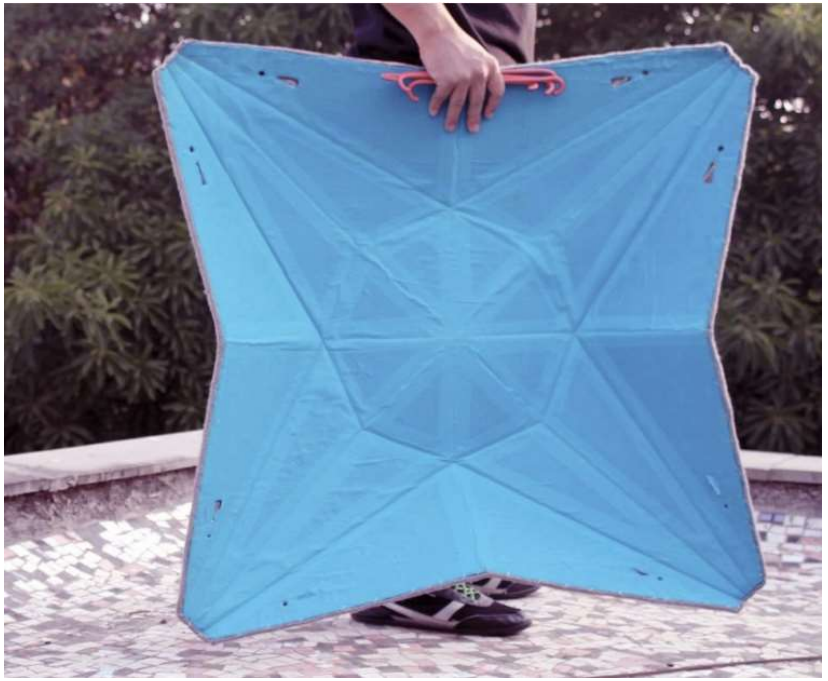


Studying Foldable Products

Creating seating that could fold down flat when not in use was essential to keep the product compact and portable. Inspiration was taken from laptop and tablet stands that require minimum effort to set up and take down.

Moft is an accessory company that uses ‘smart design’ to create easy to use productivity accessories.

This is a folding stool designed by an IDC alumni during her masters' project. Similar to what I want to achieve, the stool folds into a completely flat structure, using the cloth to act as live hinges for the product. This provides a level of softness and comfort in touch and feel, along with providing a homely aesthetic.



This is a prayer mat that folds up to form a backrest. As a basic form, it too folds up to reduce the size of the product to make it portable.

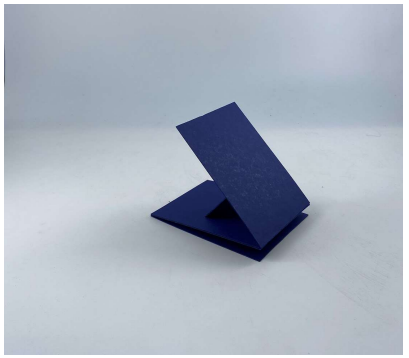
In its design, the soft touch fabric on each of the panels, encloses a stronger material inside to give it strength. This allows for the user to lean back on the supportive element without it bending or cracking. This product serves as **proof of concept** for the folding panels concept shown before, and how it can be executed using strips of cloth to form live hinges.

However, the skeletal material used in this product seems to be MDF which makes it heavy and uncomfortable to carry around.

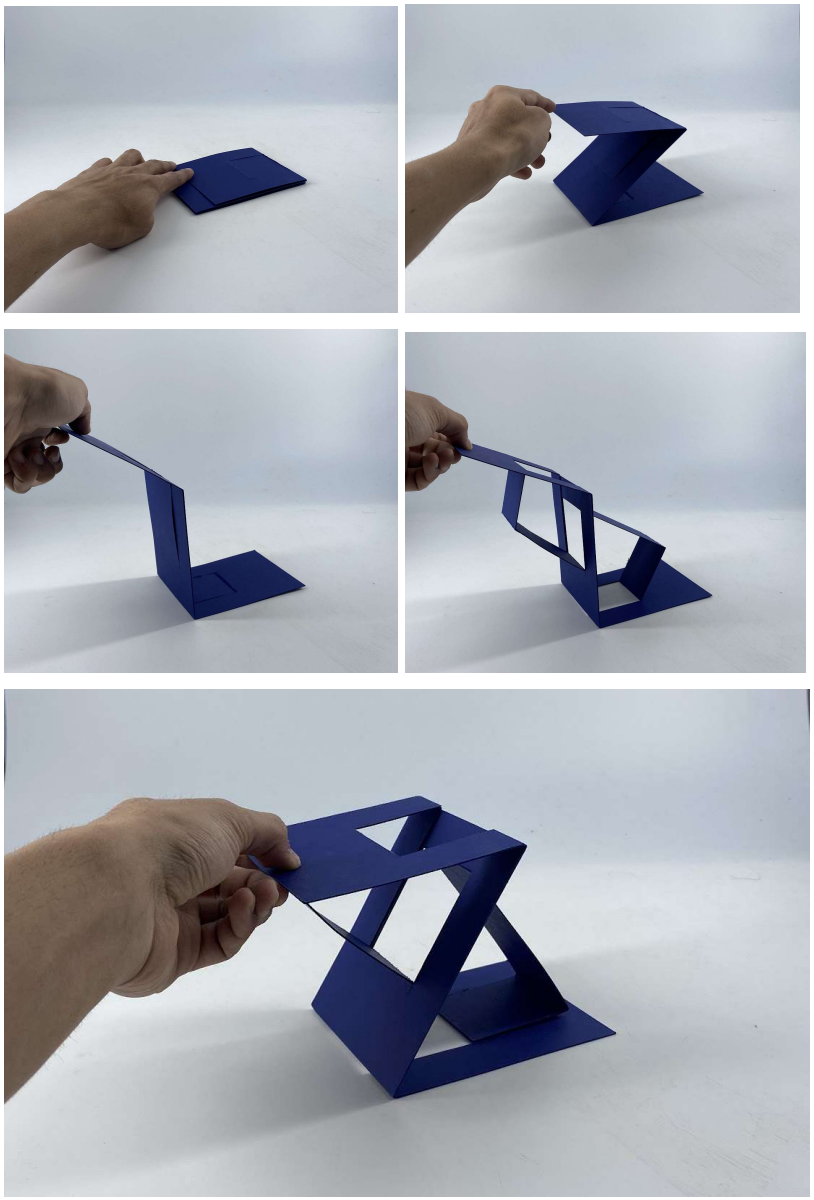
Making Scaled Prototypes in Paper (Seating)

I first explored the use of simple fold and flaps to hold them in place. A cutout from the main surface would split out to form the pillar and be held in place with a flap rising from the floor as seen in the image below.

However, I soon realised that this would remain unstable as the flap is only providing stability if the pillar component is pushed backwards. This idea of seating was disregarded.



This concept was heavily based on one of the Moft products shown above. It seemed the perfect fit because of the triangular structure used to create a rigid form that could bear weight. At the same time, the form was disassemblable so that it could be folded down for easy storage.



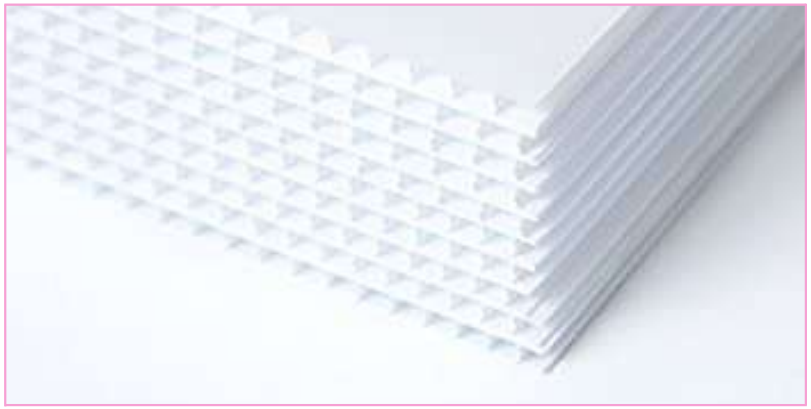
Exploring Materials

The final design requires structural panels inside the fabric that would provide the strength. The fabric would be stitched across panels to form the live hinges.

Structural Panels

Many materials for the inside panels were explored. The main criteria for its selection was its strength on the axis that it would be taking weight along with the weight of the material itself, to make sure the product remained relatively portable.

1. Corrugated Plastic Sheets



Similar to cardboard, corrugated plastic sheets have immensely higher capability to withstand weight on the vertical axis of the corrugation. However, similar to cardboard, the plastic sheets have next to no strength to withstand any force on the horizontal axis. This allowed the sheet to bend very easily.

2. Sun Board

While the sunboard is not inherently known for its strength, I hoped the triangular structures of the weight bearing components would allow the sunboard to work. This didn't end up being the case.

While the sunboard seemed to be sturdy in the scaled models I made, I was certain that the increased size for the actual prototype would not withstand the force required. Other issues were faced later on with its warping when glue was applied as well.

3. Cast Acrylic

While my initial thought about acrylic was that it would be too brittle, 4mm acrylic was thin and strong enough to withstand force. This material was tested out in the form of the handlebars and was able to withstand the force successfully.

However, there was still uncertainty about whether it would work for the structure of the foldable seat and remained to be tested.

Fabric

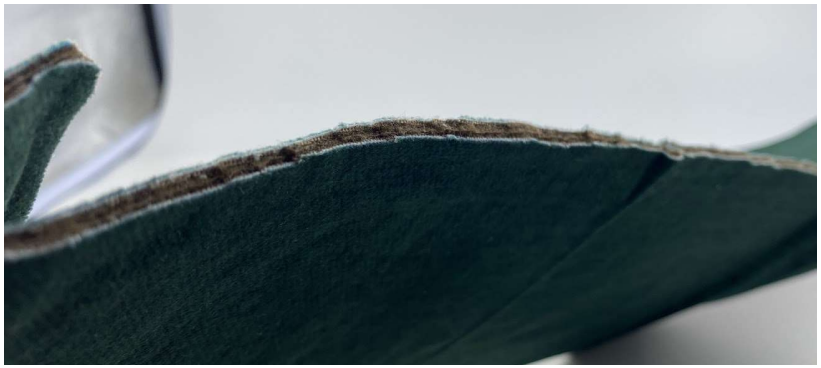
The fabric would be required to have a minimum strength to withstand force and act as a live hinge. Beyond that, it would need to be soft and similar to other prayer mats in texture.

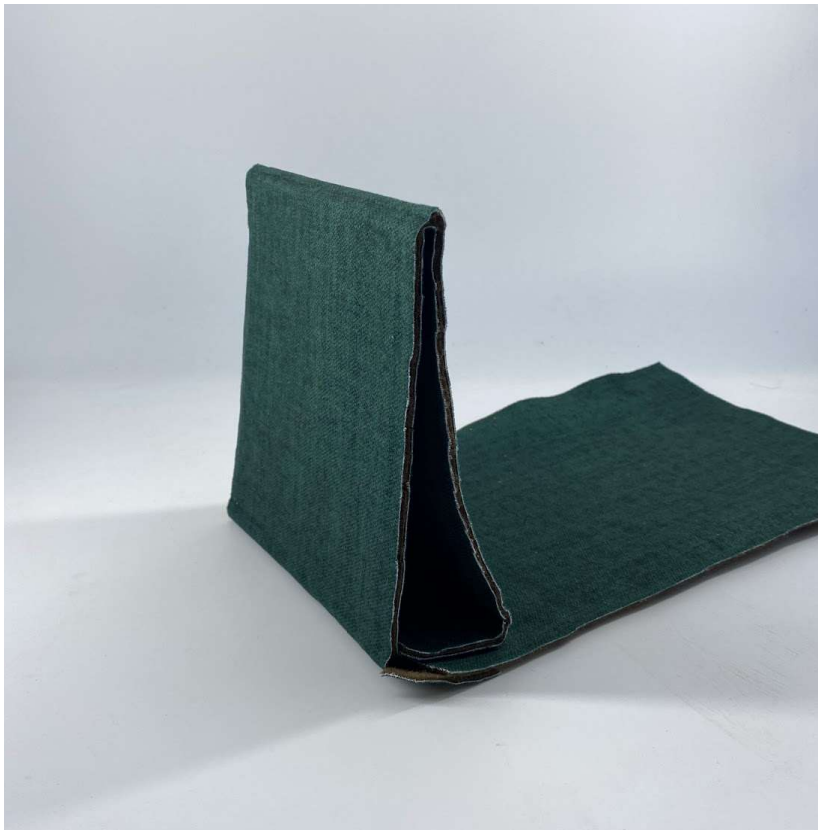
I found sofa fabric to be ideal for this situation. It was thin enough that it is usually stapled onto the structure of the sofa, so it could easily be stitched. Beyond that, it was soft and had a premium feel to it.

Exploring Joining Processes

Glueing the Fabric onto the Panels

The initial idea was to sandwich the structural panes in the fabric and glue them all together. I attempted to stick the sun board to the fabric using peb7 adhesive. While it did work, it left the side of the fabric exposed, looking unfinished and unappealing.

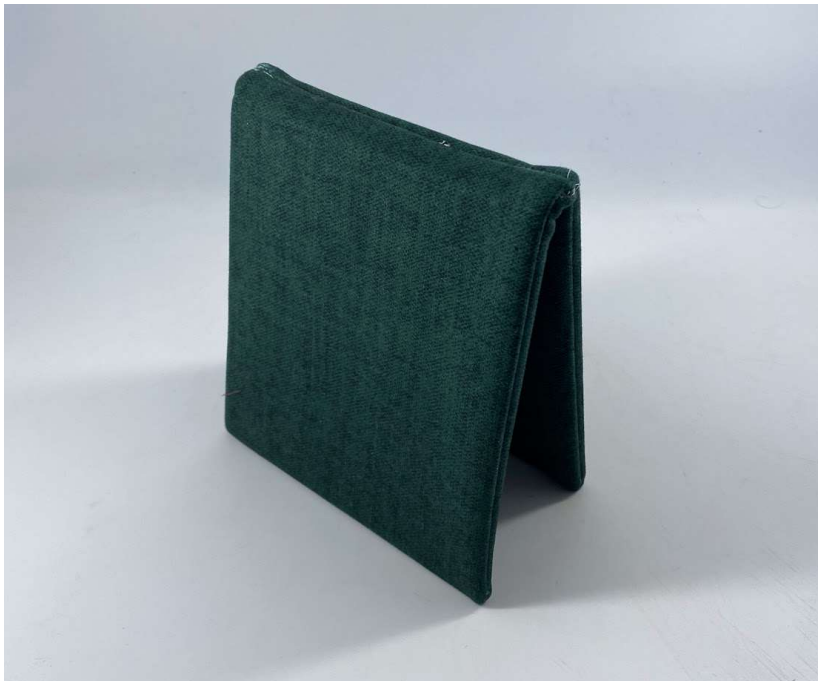




I even attempted to glue it onto the different cut out panels to recreate the handlebar. Here I realised that I would need to precisely measure out the distance between the panels to create a fully functional live hinge.

Trial Stitching for the Live Hinge

The next thought was to stitch the cloth together to create the live hinge. To test out if this method would work, I took the help of an experienced quilter to join two pieces of sun board in a live hinge that would be stitched.

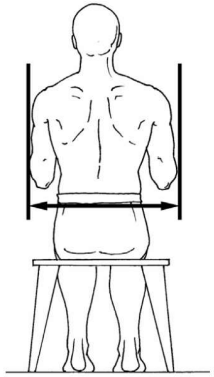


Relevant Anthropometry

Forearm-Forearm Breadth

Forearm-Forearm Breadth

FEMALE N = 2208			MALE N = 1774		
Centimeters		Inches	Centimeters		Inches
46.85	Mean	18.44	54.61	Mean	21.50
3.47	Std Dev	1.36	4.36	Std Dev	1.72
60.90	Maximum	23.98	72.52	Maximum	28.54
37.30	Minimum	14.69	39.90	Minimum	15.71
	Percentiles			Percentiles	
39.42	1st	15.52	45.12	1st	17.76
40.24	2nd	15.84	46.17	2nd	18.18
40.76	3rd	16.05	46.84	3rd	18.44
41.47	5th	16.33	47.74	5th	18.80
42.58	10th	16.76	49.16	10th	19.35
43.33	15th	17.06	50.13	15th	19.74
43.94	20th	17.30	50.91	20th	20.04
44.47	25th	17.51	51.59	25th	20.31
44.94	30th	17.69	52.21	30th	20.56
45.39	35th	17.87	52.79	35th	20.79
45.82	40th	18.04	53.35	40th	21.00
46.24	45th	18.20	53.90	45th	21.22
46.66	50th	18.37	54.45	50th	21.44
47.08	55th	18.54	55.00	55th	21.65
47.52	60th	18.71	55.56	60th	21.88
47.98	65th	18.89	56.16	65th	22.11
48.47	70th	19.08	56.79	70th	22.36
49.01	75th	19.30	57.47	75th	22.63
49.63	80th	19.54	58.25	80th	22.93
50.37	85th	19.83	59.16	85th	23.29
51.33	90th	20.21	60.32	90th	23.75
52.84	95th	20.80	62.06	95th	24.43
53.87	97th	21.21	63.18	97th	24.87
54.66	98th	21.52	64.00	98th	25.20
55.95	99th	22.03	65.27	99th	25.70



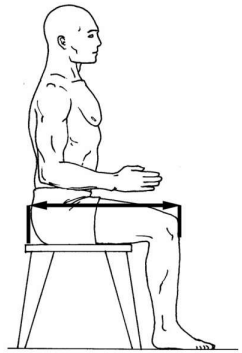
99th percentile (male) = ***65.27 cm***

The space between the two handlebars would need to be a minimum of 66 cm to cater to all possible users. Any distance greater than this could be adopted.

Buttock-Knee Length

Buttock-Knee Length

FEMALE N = 2208			MALE N = 1774		
Centimeters		Inches	Centimeters		Inches
58.89	Mean	23.19	61.64	Mean	24.27
2.96	Std Dev	1.17	2.99	Std Dev	1.18
69.10	Maximum	27.20	72.30	Maximum	28.46
49.10	Minimum	19.33	50.60	Minimum	19.92
	Percentiles			Percentiles	
52.18	1st	20.54	55.07	1st	21.68
53.03	2nd	20.88	55.81	2nd	21.97
53.54	3rd	21.08	56.28	3rd	22.16
54.21	5th	21.34	56.90	5th	22.40
55.20	10th	21.73	57.87	10th	22.78
55.87	15th	22.00	58.54	15th	23.05
56.39	20th	22.20	59.08	20th	23.26
56.85	25th	22.38	59.55	25th	23.45
57.27	30th	22.55	59.98	30th	23.62
27.66	35th	22.70	60.39	35th	23.77
58.04	40th	22.85	60.78	40th	23.93
58.41	45th	23.00	61.16	45th	24.08
58.78	50th	23.14	61.54	50th	24.23
59.15	55th	23.29	61.93	55th	24.38
59.54	60th	23.44	62.32	60th	24.54
59.95	65th	23.60	62.73	65th	24.70
60.38	70th	23.77	63.17	70th	24.87
60.85	75th	23.96	63.65	75th	25.06
61.39	80th	24.17	64.19	80th	25.27
62.01	85th	24.41	64.81	85th	25.52
62.81	90th	24.73	65.60	90th	25.83
63.98	95th	25.19	66.74	95th	26.28
64.72	97th	25.48	67.45	97th	26.56
65.24	98th	25.69	67.95	98th	26.75
66.02	99th	25.99	68.69	99th	27.04



99th percentile (male) = ***68.69 cm***

The sitting position in Salah would require a minimum of 69 cm from the bottom of the prayer mat for the person to be seated comfortably. Some additional distance would need to be added for the feet while the person stands, since the motion of going from the standing position to the sitting position transitions forward, pivoting on the toes.

Seating Height and Form Geometry

The measurements and angles of the triangular structure within the seat would be determined by the seating height. Initially, based on rough estimates, I calculated the seating height to be about 280mm off the ground. I created a cardboard prototype of the exact dimensions to test out its comfort.

I realised that the height was **significantly higher** than expected.

Since the basic seating concept was similar to that of the SalatBuddy product shown earlier in the project, I used the height of that product to determine the rest of the dimensions of the seating. The seating height was decided to be 210mm.

The width of the whole seat was determined to be 200mm, so as to not be too wide where the user would need to widen their stance and not too narrow that the material would not be strong enough to withstand the weight. The internal pillars that popped out to create supports had a width of 78mm with 12mm of tolerance on either side for the stitching of the cloth.

Product Mood Board

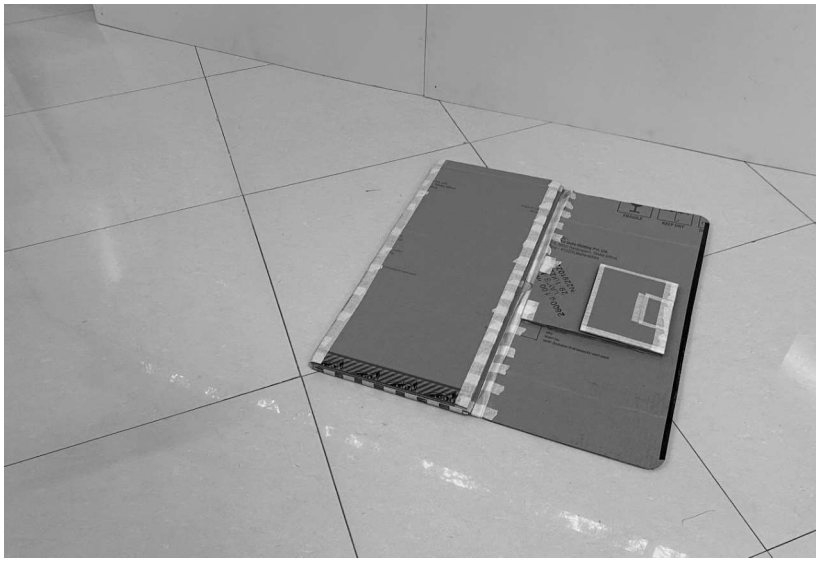
Geometric patterns are central to the islamic aesthetic around the globe. These patterns, mostly seen in holy places like mosques and praying areas, directly relate to the emotion of spirituality and devotedness.

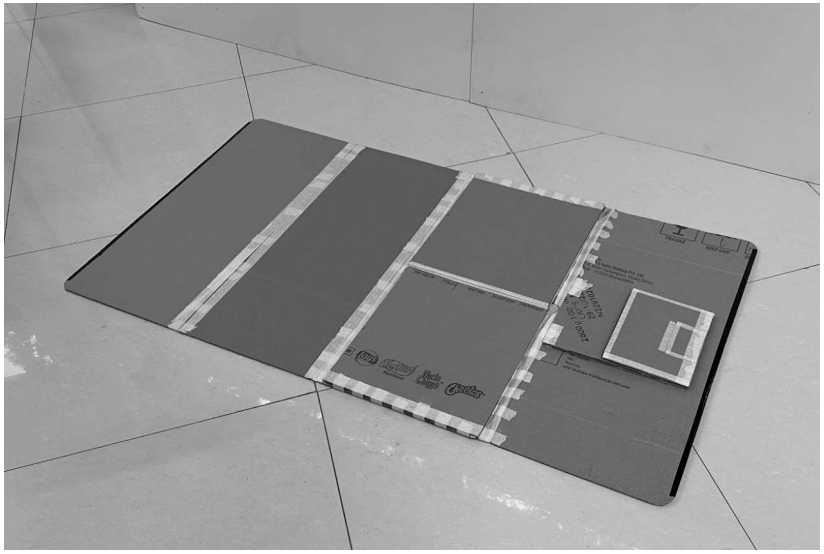
The functional aspects of the product I have designed, has a level of simplicity, similar to the geometric patterns. But for it to be recognised as a prayer mat, it would need visual features that help it be recognised as such, like the geometric woven prints or embroidered edges.

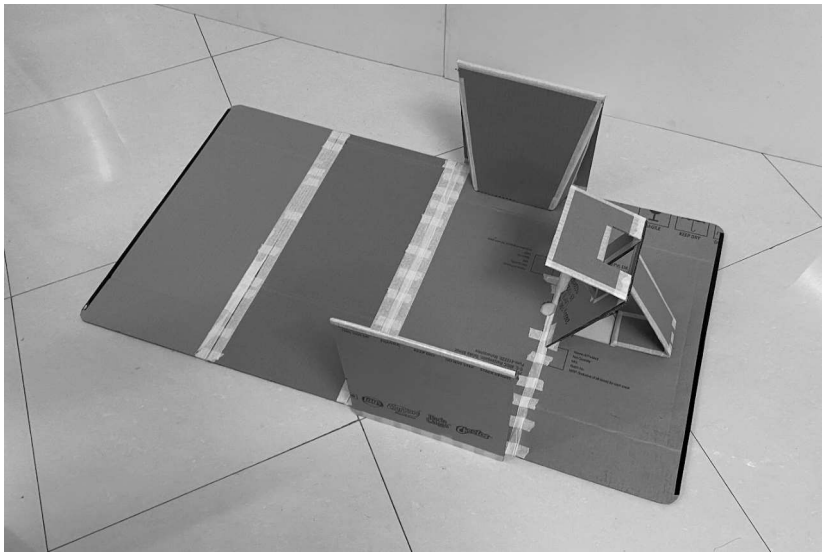
Section 4:

Final Design and Manufacturing

Full Size Cardboard Prototype





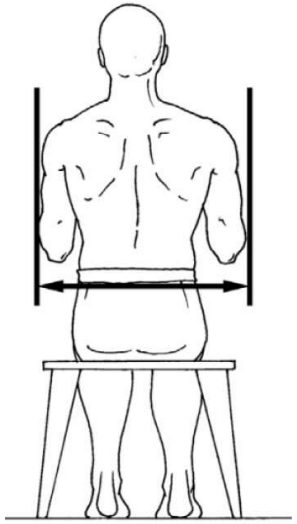


Anthropometric Data

Forearm - Forearm Breadth

The design must allow for every user to comfortably fit within the two handlebars. The 99th percentile was used for this dimension.

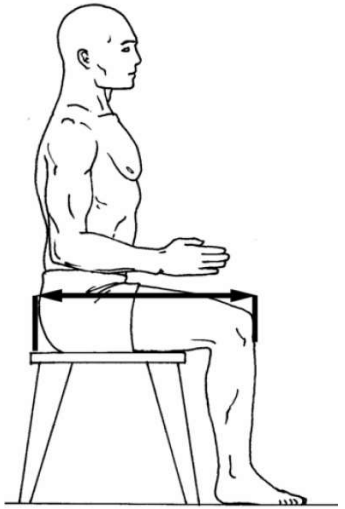
According to Chakrobarty (1997), the 99th percentile for Indian users' forearm - forearm breadth was **65.7cm.**



Buttock - Knee Length

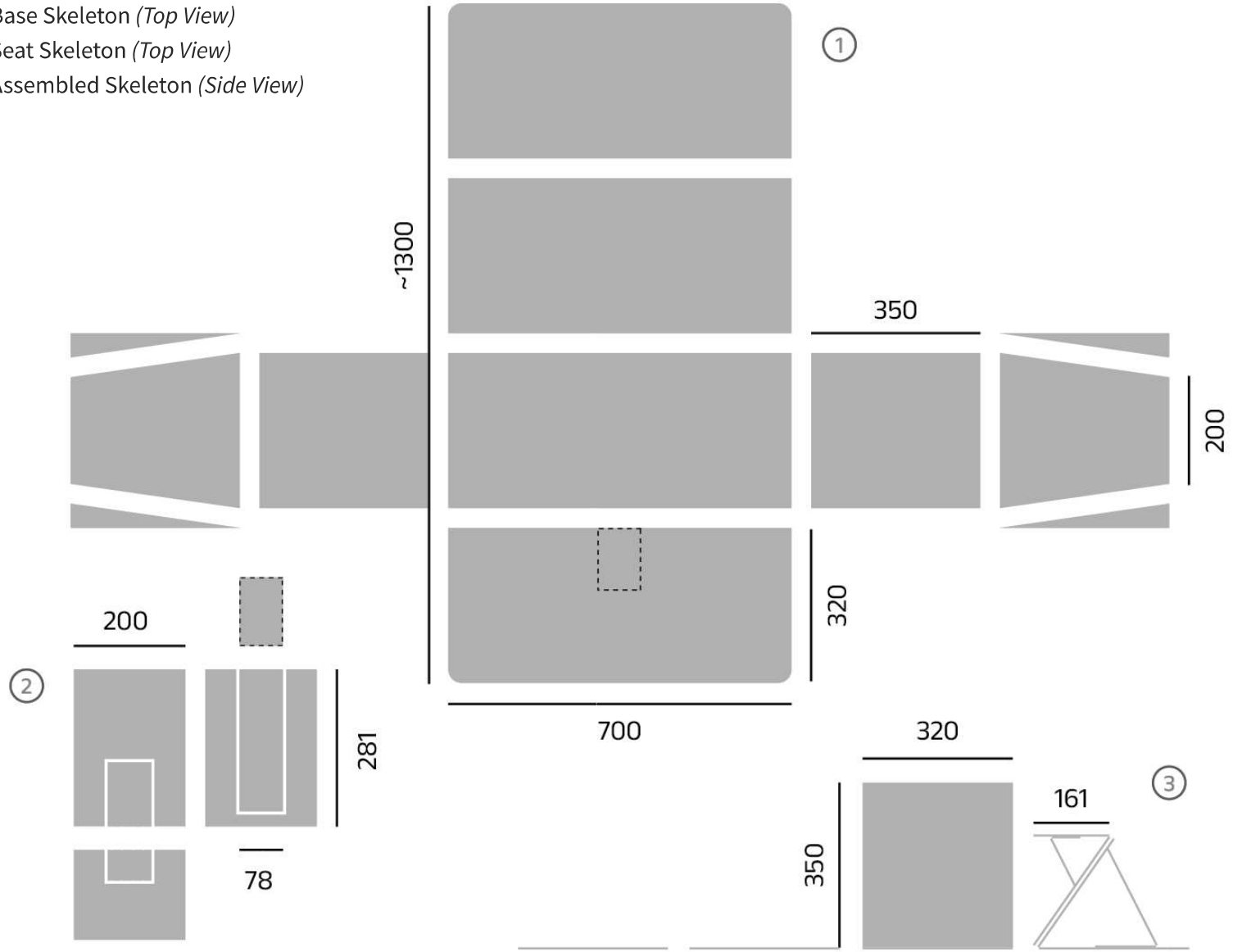
The same logic applies here. Users with shorter length would be able to comfortably use the product, but must account for users with longer buttock - knee length. The 99th percentile was used for this dimension as well.

According to Chakrobarty (1997), the 99th percentile for Indian users' buttock - knee length was **68.7cm.**

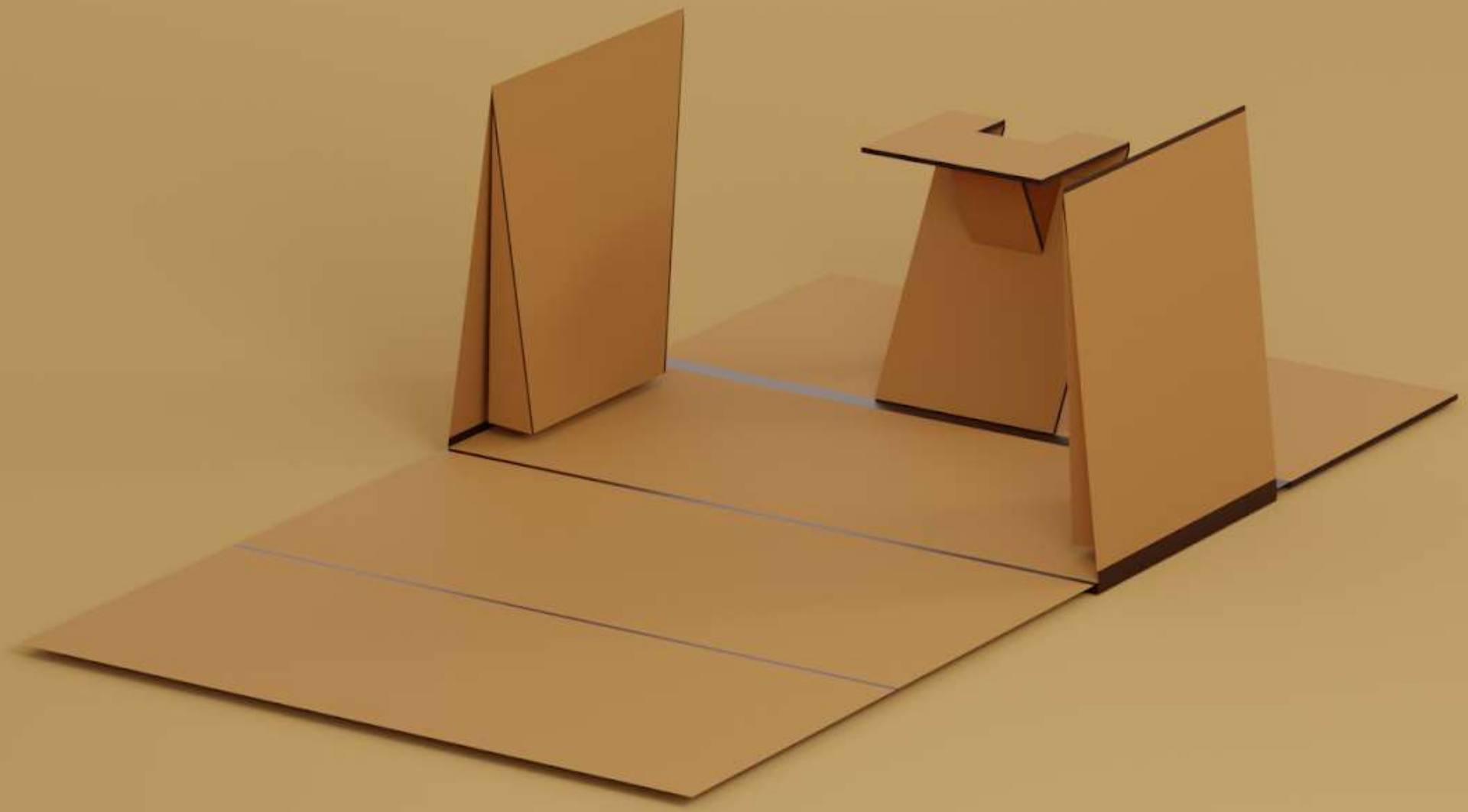


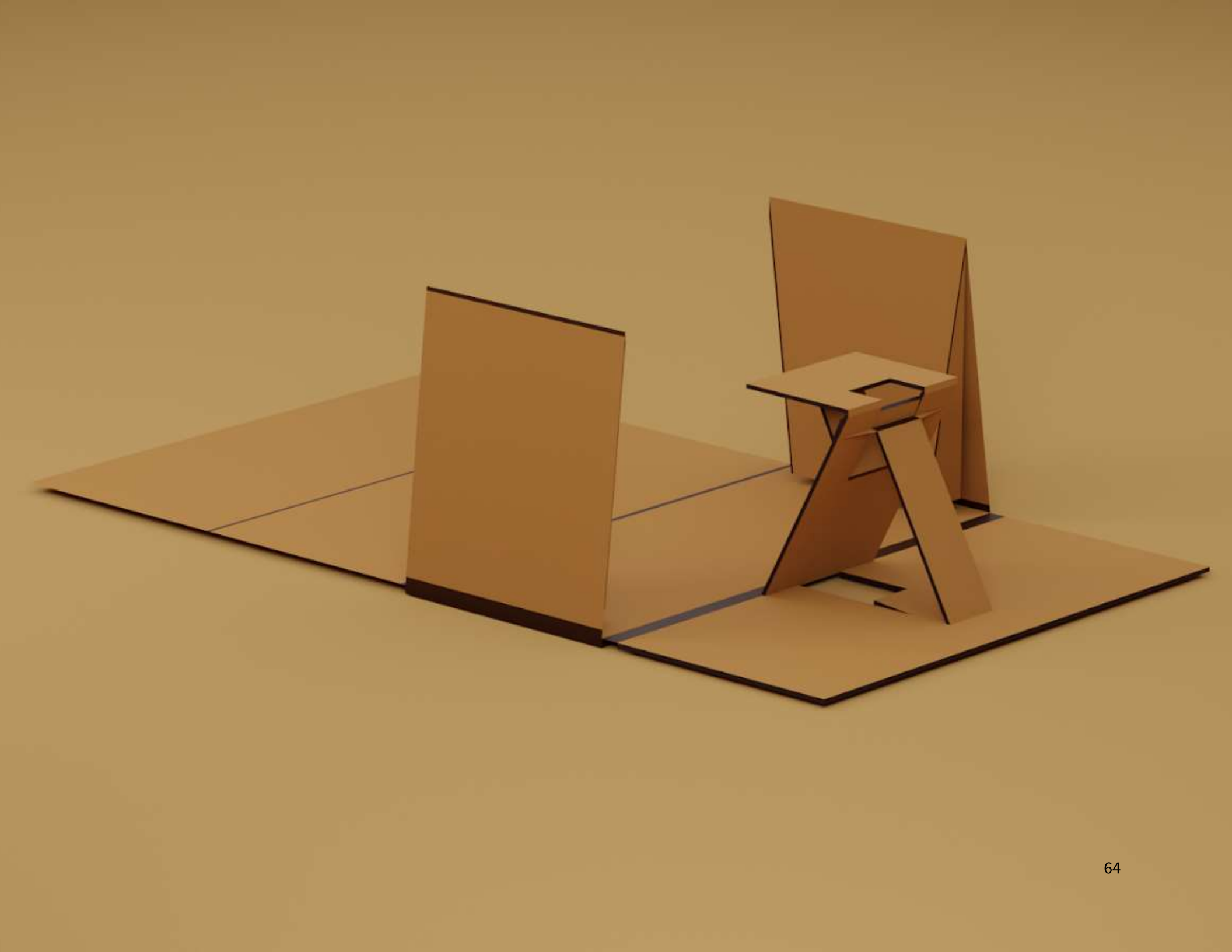
Product Dimensions

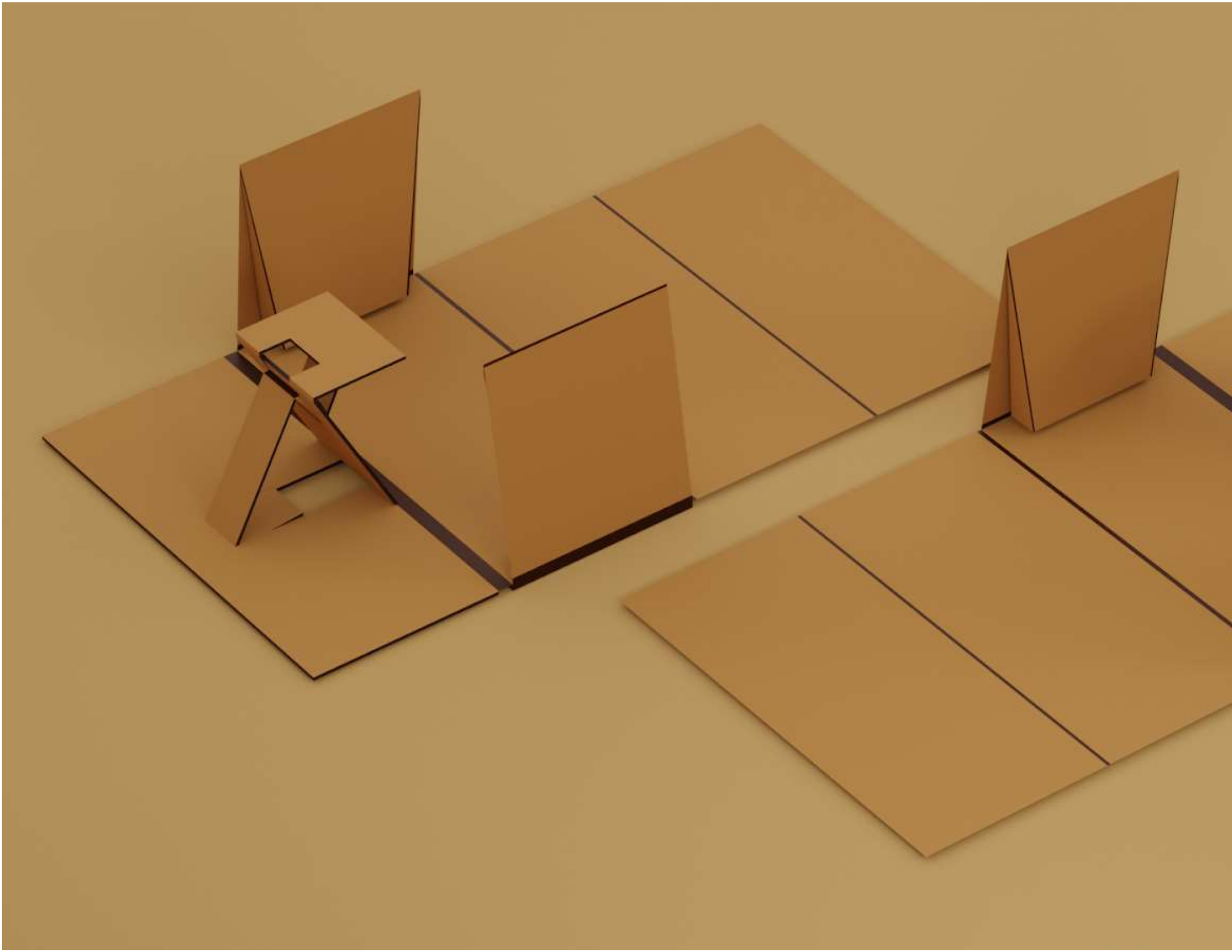
1. Base Skeleton *(Top View)*
2. Seat Skeleton *(Top View)*
3. Assembled Skeleton *(Side View)*

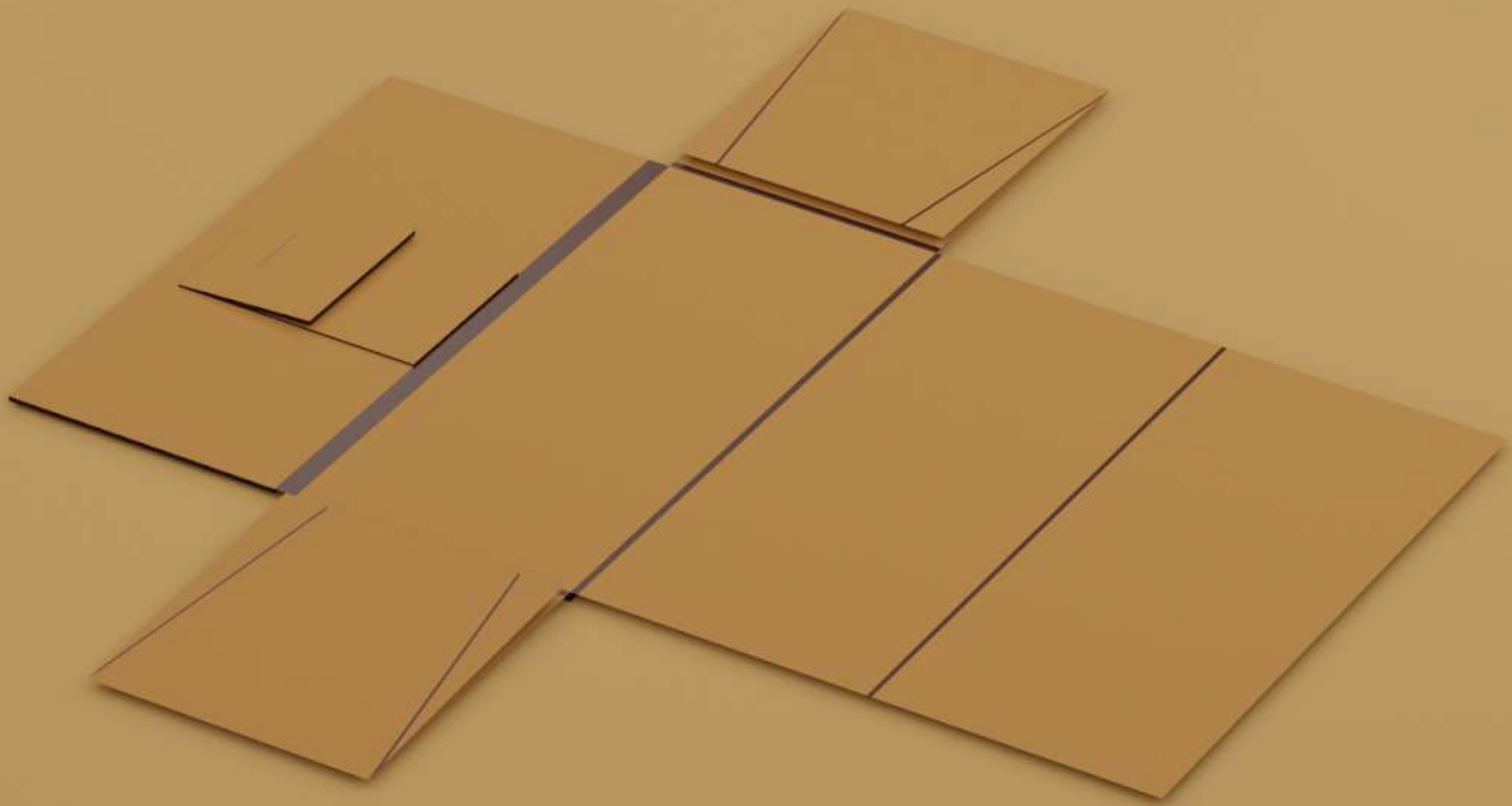


Product Renders









Material Exploration

Internal Structure

3 options were considered for the internal structure that would be weight bearing.

1. Corrugated plastic sheet
2. Sun board
3. Cast acrylic

Cast Acrylic was selected to make the prototype as it was the material that had the right balance of strength and low weight.

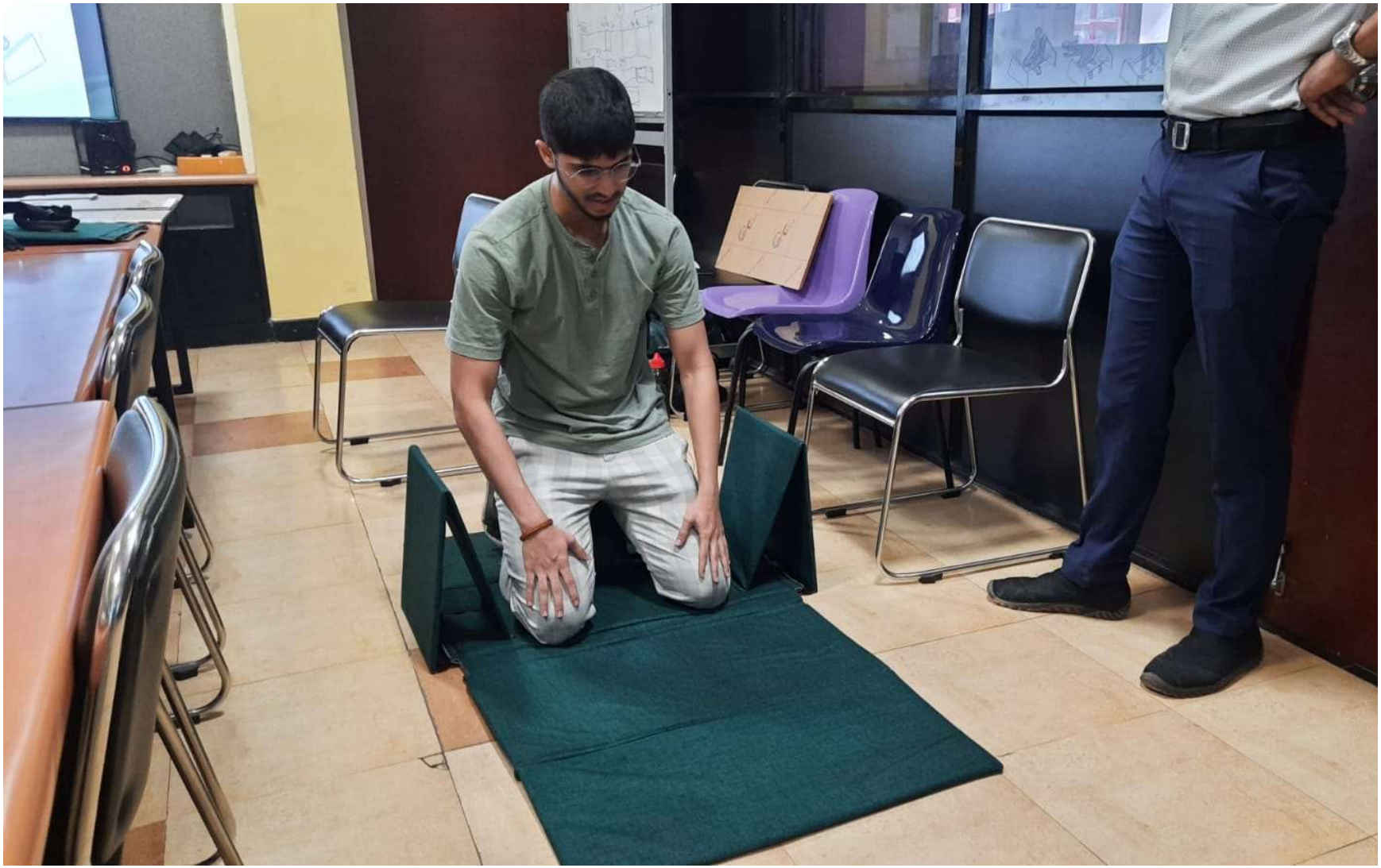
Outer Covering

The fabric chosen was **Sofa Fabric** that had the strength to act as a live hinge connecting to the internal elements.

Glueing the fabric to the acrylic was not ideal as it caused the fabric to warp and not allow any movement.

The fabric was stitched to the exact dimensions of the internal pieces to provide structure and allow the fabric to function as a live hinge as well.

Prototype



Manufacturing

The internal structural pieces would be laser cut. The soft touch cloth covering these pieces would be laser cut as well to the exact dimensions required. Long strips of embroidered cloth would be used at all the edges and at the hinges.

All of these pieces would need to be **manually assembled** by skilled workers.

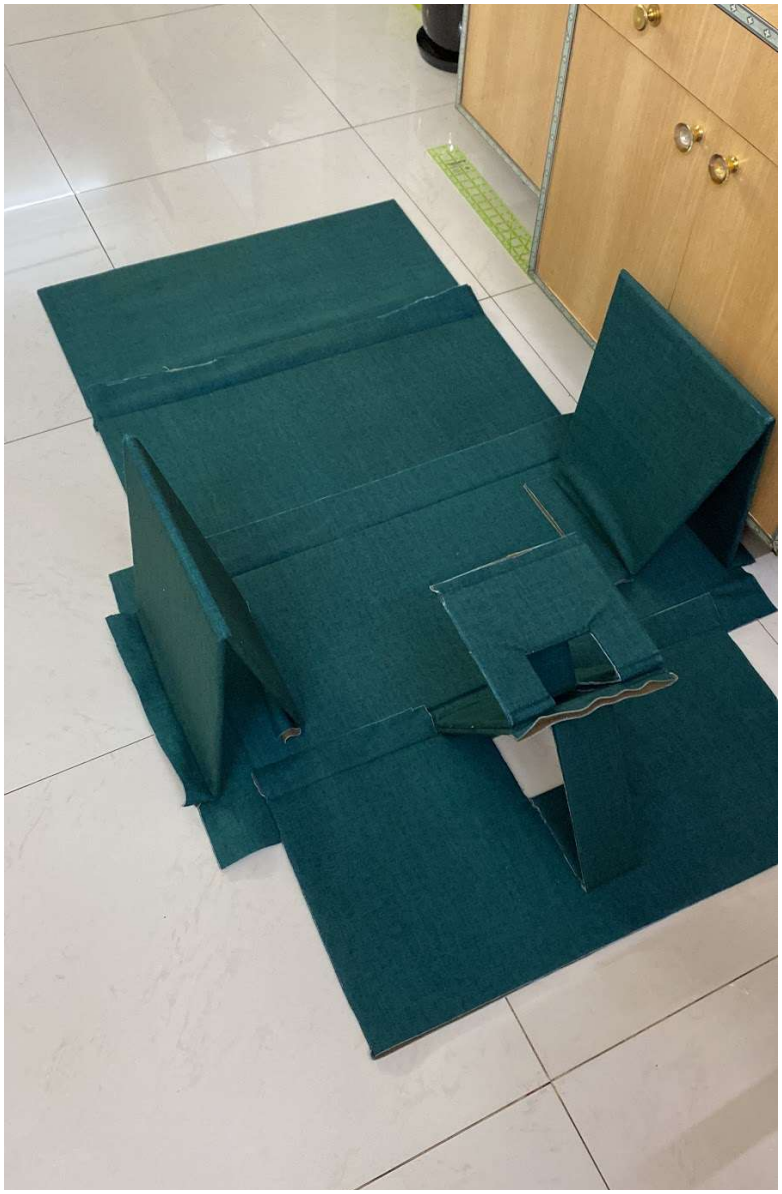
The structural pieces will be sandwiched in soft touch fabric and glued on to make sure they do not slip or move while being used. This will be done for all the panel pieces including the seat.

The strips of cloth will need to be carefully stitched to join these pieces together. This may require extra effort as the pieces being joined will include the weight of the structural pieces. This step will need to be repeated for all the hinges sequentially.

Who Will Manufacture?

There were three possibilities to design for, with regards to manufacturing. It could be manufactured at a large scale by enterprises, it could be made at a relatively smaller scale by Small and Medium scale enterprises (SMSEs) or be handcrafted for users by craftsmen or artisans.

The concept I developed is designed to be manufactured by SMSEs at a semi-automated level.



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