GNG 2101 – Intro. to Product Development and Management for Engineers

Deliverable C- Conceptual Design and Project Plan

Team 11

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Introduction

After having established our client's needs and then determined their products' functional requirements, our team began the ideation phase of our shower seat project. First, our group applied the functional decomposition technique, to divide the shower seat project into simpler sub-tasks. Then, each group member created 3 conceptual designs, resulting in a total of 18 designs. Each concept was evaluated, ranked and scored based on the client's target specifications (from PD-B). Our team integrated the highest-ranking concepts into a final design using computer aided software. A visual representation of our preliminary design has been provided, along with a brief description that outlines the benefits and drawbacks of each associated sub-system. We are confident in our preliminary design and believe it is a feasible, effective and reliable solution for our client.

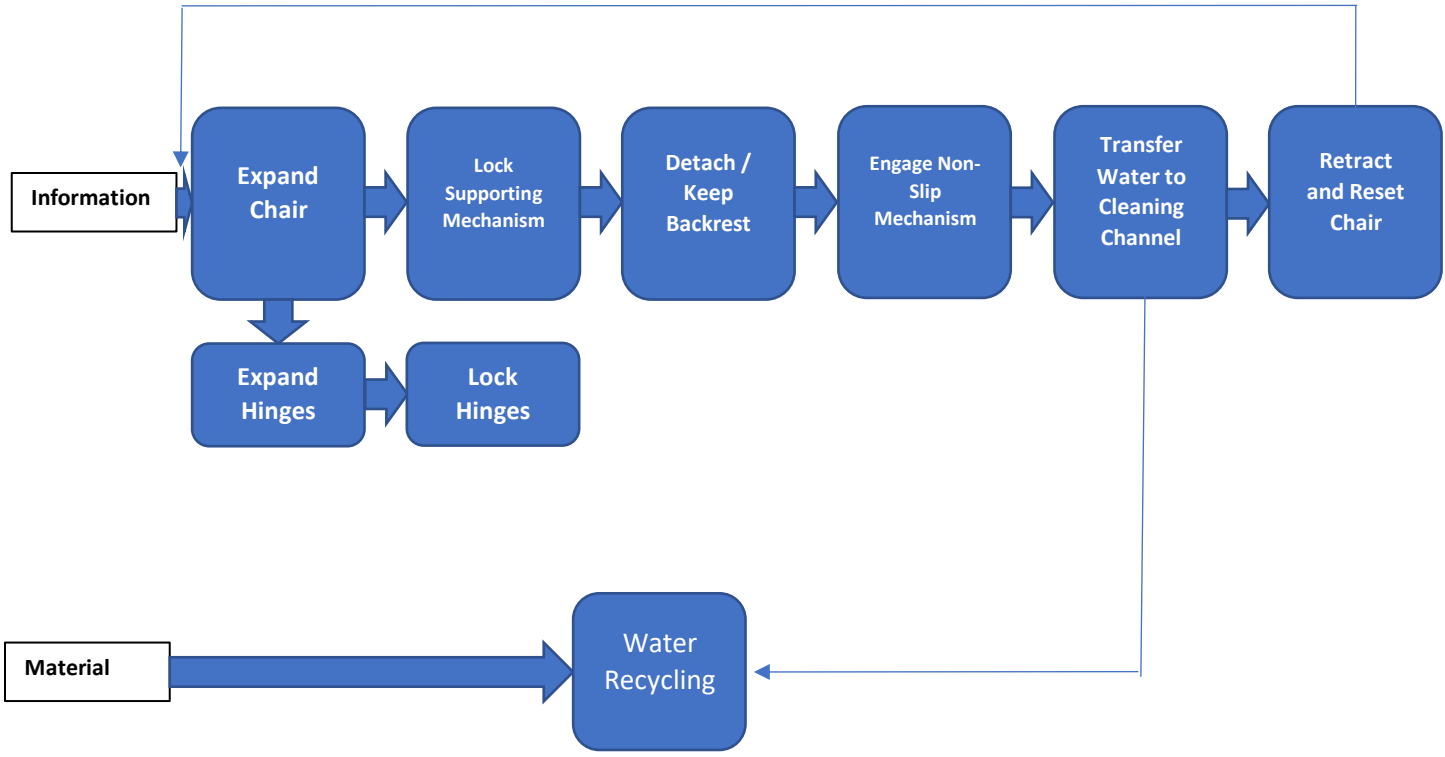
1. Functional decomposition

Table # Summarizing the Client's Focused Interpreted Needs & their Respective Functions & Subfunctions

Interpreted Need	Function	Sub-Functions (If applicable)	Sub-System
Withstand the user's weight	Can support over 250 lbs. of weight		Legs & Seat
Designed for a tub shower	Fits in a tub shower	1. Can accommodate round bottomed bathtubs	Legs & Seat
Allows water to flow freely	Water does not pool inside the chair	1. Drain system so no water pools in the chair	Seat
Comfortable cushion	Waterproof cushion for comfort		Seat
Cleaning channel	Have a channel in the middle of the chair to allow easier access for cleaning		Seat
Slip-resistant	Feet of the chair do not slip	1. Durable incasing material to prevent puncturing of the chair leg through the slip resistant incasing	Legs & Feet
Detachable backrest preferred	Backrest can come off and can be put back on	1. Detaches 2. Attaches and locks into place	Back Rest
Deployable and retractable	Can be converted into a compact form	1. Folds up 2. Stays folded up for transport 3. Unfolds for use	Legs, Seat and Backrest

Figure 1.1 High-Level Functional Decomposition of Shower Chair

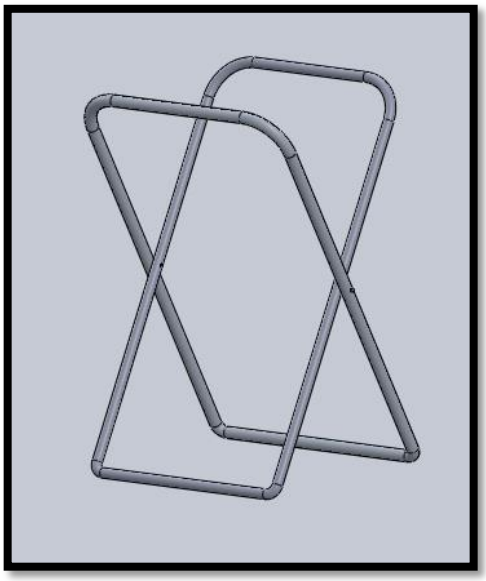
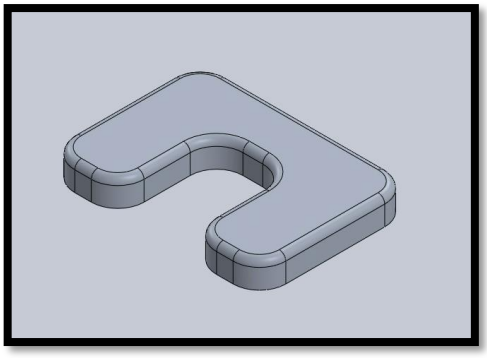
Figure 1.2 Detailed Functional Decomposition of Shower Chair


Information
Expand Chair
Lock Supporting Mechanism
Detach / Keep Backrest
Engage Non-Slip Mechanism
Transfer Water to Cleaning Channel
Retract and Reset Chair
Expand Hinges
Lock Hinges
Material
Water Recycling

2. Product Concepts

2.1 Amelia's Concepts

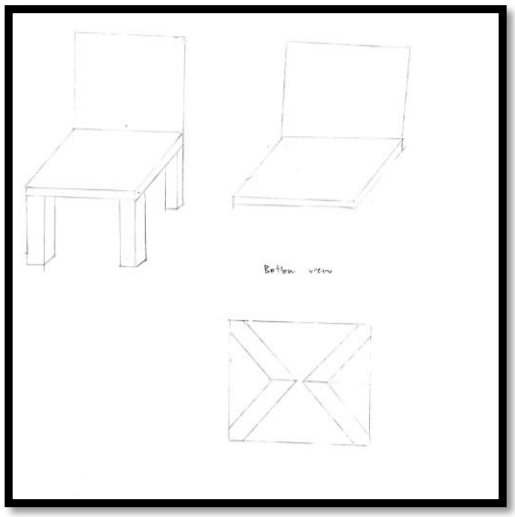
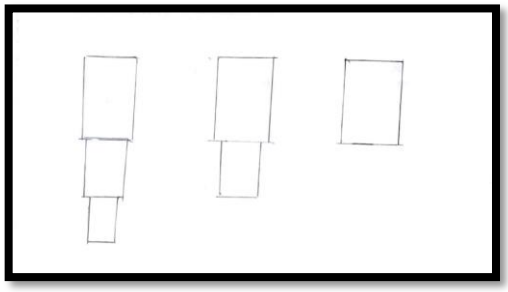
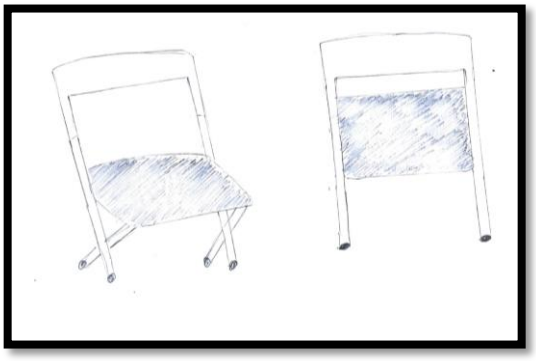
Table 1: Concepts by Amelia

Concept 1	 *Figure 1: Amelia's Concept 1*	This concept is to support the functions of compactibility, fitting in any size tub, and supporting 250Ibs of weight. This concept has the legs opening and closing converting it to a compact form. Since the legs can open and close this design could fit in any size tub. This design should support 250Ibs because of how the weight distributes.
Concept 2	 *Figure 2: Amelia's Concept 2*	This concept supports the functions of a waterproof cushion for comfort and a channel to allow easier cleaning. The cushioning is made of polyethylene foam sheets, it is a lightweight, durable, and waterproof material. There is a cutout in the middle that allows for cleaning.

Concept 3	 *Figure 3: Amelia's Concept 3*	This concept includes using suction cups at the bottom of the chair to establish a strong seal on the tub to prevent the chair from sliding. This option is easily replaceable and cost effective.

2.2 David's Concepts

Table 2: Concepts by David

Concept 1	 *Figure 4: David's Concept 1*	The first design is the folding mechanism for the backrest, seat and legs of the shower seat. The seat folds in half, by a hinge/lock system located in the middle of the seat. In addition, the legs fold at a 45-degree angle with the same hinge/lock system to be compact and fit into carry-on luggage.
Concept 2	 *Figure 5: David's Concept 2*	The second concept is for the shower seat legs. They are to be shortened and extended using a hollow cylindrical system, like a telescope. The cylinder diameters decrease as the leg becomes longer and the bottom two cylinders slide into the top. They are to be assembled using a locking pin-slot on each slot and a rubber pad is located at the bottom to prevent slipping.
Concept 3	 *Figure 6: David's Concept 3*	The last concept is like a folding chair, where the seat folds clockwise by means of locking pivot pins. The pivot pins are located on the legs and seat of the chair. In the folded position, the seat and back rest become parallel to one another.

2.3 Ethan's Concepts

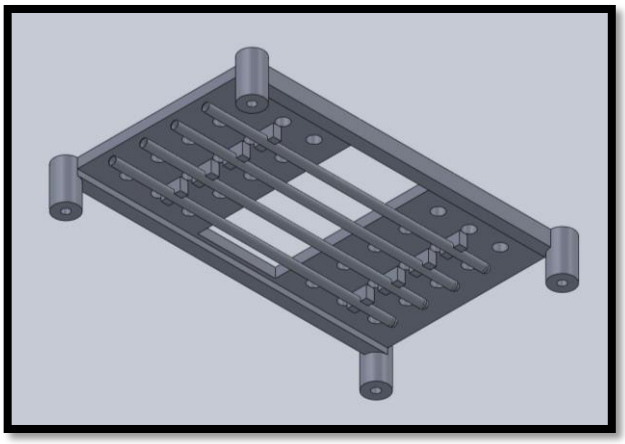
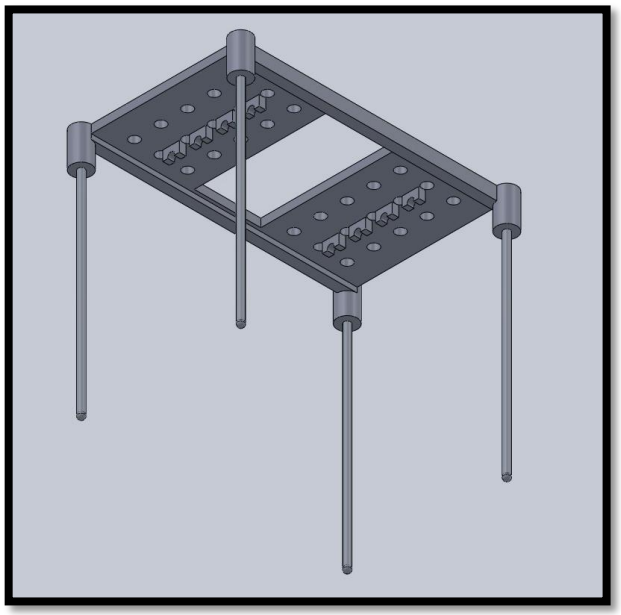
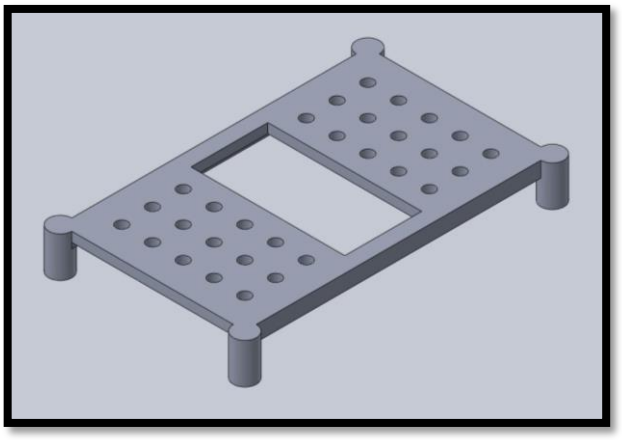
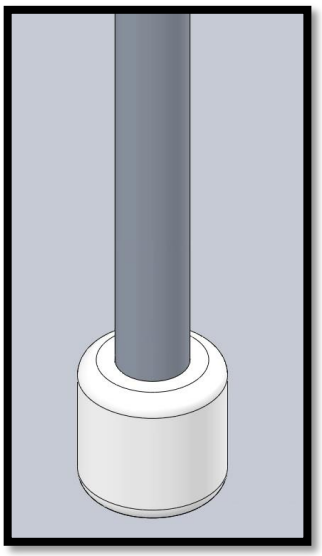
Concept 1	 *Figure 7: Ethan's Concept 1*	This concept is for the disassembly of the shower chair. In this concept the legs would be removed and attached to the underside of the seat with clips that are built into the seat.
Concept 1	 *Figure 8: Ethan's Concept 1*	This concept is for the assembly of the shower chair. In this concept the legs would be attached to the seat by putting them into holes on each corner of the chair.
Concept 2		This is a concept for the seat of the shower chair and more specifically the drainage system of the chair. This design includes a hard plastic seat with a series of holes so that water doesn't pool on the seat.

	Figure 9: Ethan's Concept 2	
Concept 3	 *Figure 10: Ethan's Concept 3*	This is concept for the feet of the shower chair. The idea is to have a swishy material. This material would squish against the bottom of the bathtub and hold on to improve the stability. This is meant to solve the issue of unstable shower chairs.

2.4 Omar's Concepts

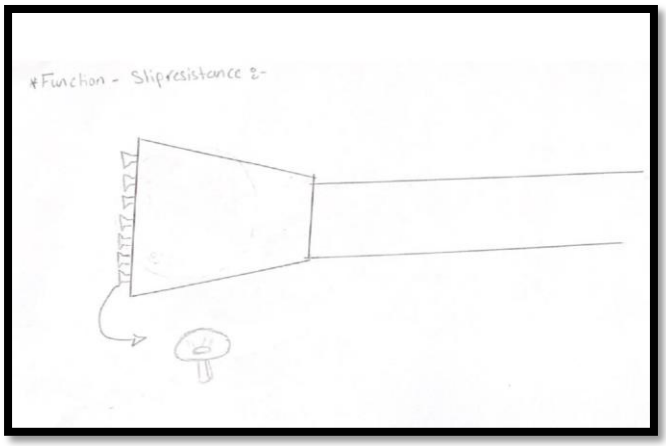
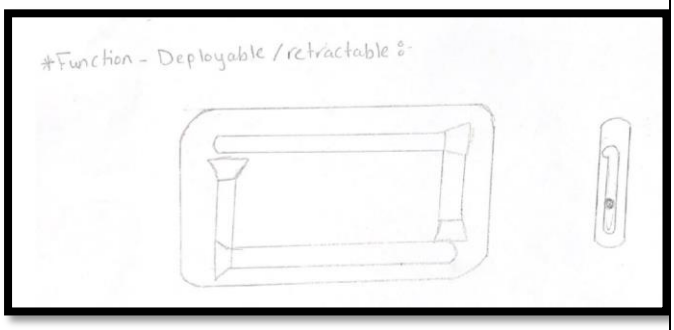
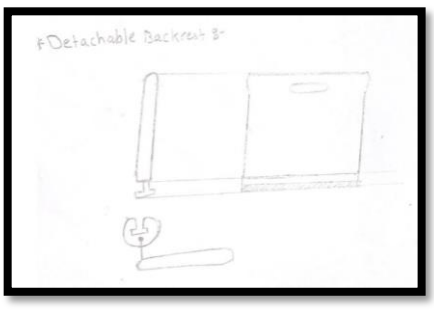
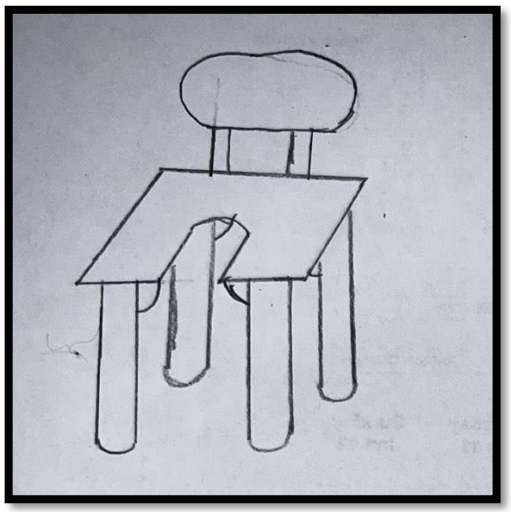
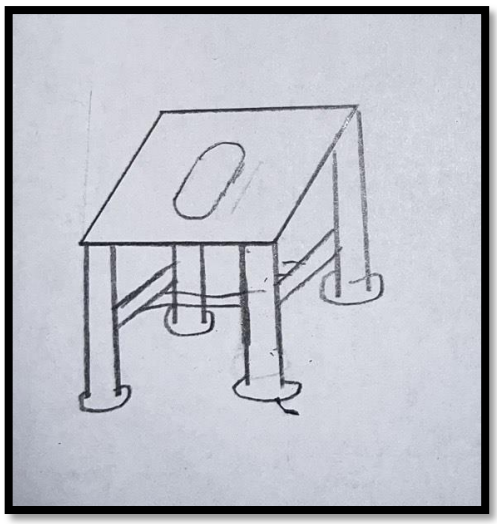
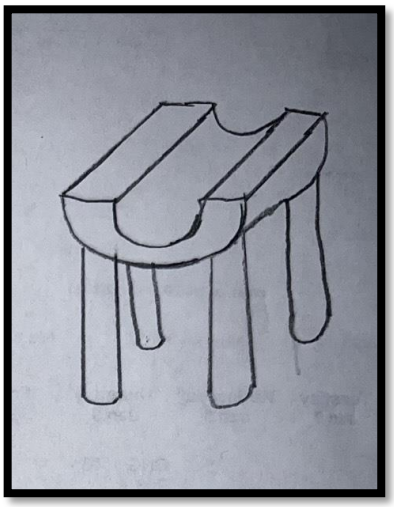
Concept 1	 *Figure 11: Omar's Concept 1*	This concept addresses the Slip Resistance function. The concept involves using a rubber copolymer, namely Nitrile, as an incasing for the chair leg. Nitrile was chosen since it has a very high static friction coefficient, as well as high tensile strength which will offer high puncture resistance. The concept also involves using multiple mini suction cups at the bottom of each chair leg. This will offer an extra safeguard against slipping and increase the overall stability of the chair.
Concept 2	 *Figure 12: Omar's Concept 2*	This concept addresses the deployment from compact size and retraction function. The main idea behind this concept is to have as low assembly time as possible and to avoid having the user to use tools of any sort to assemble the chair. The concept illustrates force deployment which will involve the user holding the chair from the back handle and rocking it forward to deploy. This can be achieved using mechanical slot linkages for each of the chair legs; which will automatically lock in place when the legs expand from compact position.
Concept 3		This concept addresses the detachable backrest function. The concept basically involves having a slide slot at the back edge of the chair seat where the backrest can easily slide into when desired.

	Figure 13: Omar's Concept 3	

2.5 Owen's Concepts

Concept 1	 *Figure 14: Owen's Concept 1*	This concept involves a U-shaped cutout on a thinner seat. The legs are adjustable in height and have a folding and locking hinge. This design also has a removeable backrest that slots into the base of the chair.
Concept 2	 *Figure 15: Owen's Concept 2*	This concept has a thicker and larger seat with a full-length cutout. The legs in this design are solid and slot into the base. The backrest also slots into the base and has a rectangular shape.
Concept 3		This concept is the most different of the three. This concept uses mostly PVC pipes which are all detachable for transport. The seat is made of thin plastic with a small cutout to maintain rigidity and support.

	 *Figure 16: Owen's Concept 3*	

2.6 Samuel's Concepts

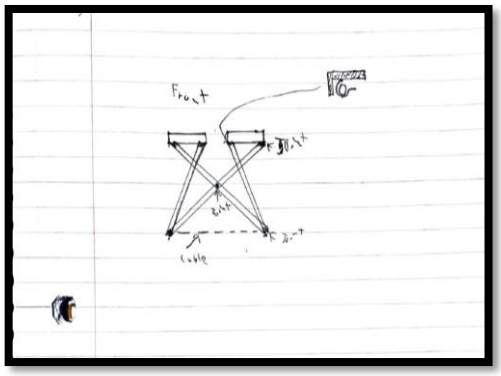
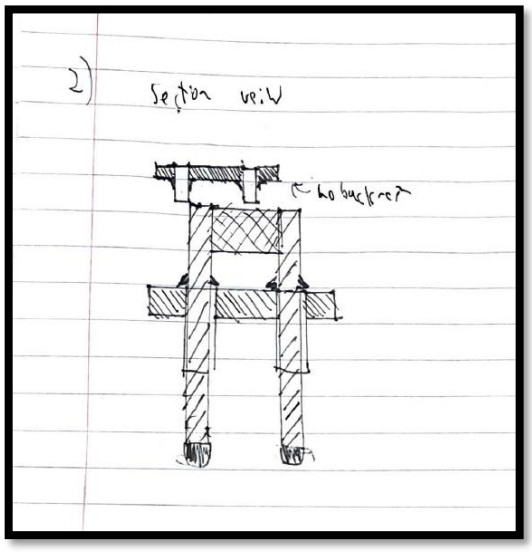
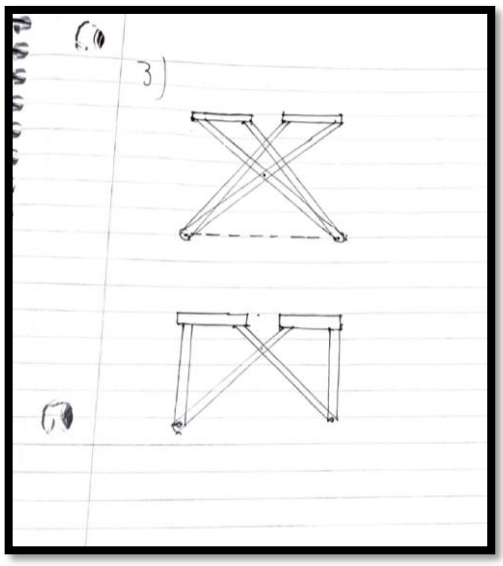
Concept 1	 *Figure 17: Samuel's Concept 1*	The first design uses a scissor-like system to easily fold and unfold the double-padded seats. A rotating pin is in the center, attached to each seat and it allows the system to fold in half. The separated seats provide a cleaning channel, and compact design.
Concept 2	 *Figure 18: Samuel's Concept 2*	The second design concept analyzes the structural mechanics of the back rest. The back rest is attached to two main rods which are molded into the shower seat. It closely resembles a luggage handle, which slides vertically along its perpendicular metal bars.
Concept 3		Here is a reiteration of *Concept 1*, where the scissor brackets have been arranged to provide additional durability. This 90-degree angle will make the shower seat more stable.

	Figure 19: Samuel's Concept 3	

3. Concept Analysis

This section of our report analyzes the feasibility of each sub-assembly using a weighted matrix system. Each team member's designs are scored based on the technical requirements established in PD-B. The rating scale ranges from 1 to 5, where 1 poorly satisfies our technical requirements and 5 completely satisfies the technical requirements. In addition, the weighting factor has been established based on our customer's prioritized needs from PD-B.

Table 3.1: Weighted Matrix of Leg Sub-Assembly

Concepts	Slip-resistant		Lightweight		Low-cost		Durable		Fits into luggage		Aesthetically Pleasing		Total
Weighting factor	16%		16%		16%		8%		40%		4%		%100
Amelia- 3	4.5	0.72	5	0.8	4	0.72	4	0.32	5	2	4	0.16	4.72
Ethan- 3	4.5	0.72	4	0.72	4	0.72	3	0.24	5	2	5	0.2	4.6
David- 2	3	0.48	3	0.78	3	0.48	1	0.08	5	2	4	0.16	3.98
Omar- 1	5	0.8	4	0.72	3	0.48	4	0.32	5	2	4	0.16	4.48

The results for the shower seat legs are: 4.72, 4.6, 3.98, and 4.48 for Amelia, Ethan, David and Omar's designs respectively. Amelia has the highest-ranking design with a value of 4.72.

Table 3.2: Weighted Matrix of Seat Sub-Assembly

Concepts	Waterproof		Durable		Low-cost		Lightweight		Fits into luggage		Drain System		Cleaning channel		Detachable Backrest		Aesthetically Pleasing		Total
Weighting factor	20%		10%		10%		12%		20%		10%		8%		8%		2%		100%
Amelia - 2	5	1	4	0.4	5	0.5	3.5	0.42	4	0.8	5	0.5	2.5	0.2	2.5	0.2	4	0.08	4.1

Ethan-3	4	0.8	4	0.4	4.5	0.45	5	0.6	2.5	0.5	2.5	0.25	2.5	0.2	2.5	0.2	4	0.08	3.48
Owen-1	2.5	0.5	3.5	0.35	4	0.4	2	0.24	4	0.8	4	0.4	2.5	0.2	2.5	0.2	3.5	0.07	3.16
Owen-2	4	0.8	3.5	0.35	4	0.4	2	0.24	4	0.8	4	0.4	5	0.4	5	0.4	3.5	0.07	3.86
Owen-3	2.5	0.5	3.5	0.35	5	0.5	3	0.36	4	0.8	4	0.4	5	0.4	2.5	0.2	3.5	0.07	3.58
Samuel- 1	2.5	0.5	3.5	0.35	4	0.4	3.5	0.42	4	0.8	4	0.4	2.5	0.2	5	0.4	3.5	0.07	3.57

Table 3.3: Weighted Matrix of Folding Mechanisms

Concepts	Lasts 10 years		Low-cost		Lightweight		Fits into luggage		Fast to assemble		Aesthetically Pleasing		Total
Weighting factor	8%		20%		20%		36%		12%		4%		100%
Amelia- 1	3.5	0.28	4	0.8	4	0.8	4	1.44	5	0.6	5	0.2	3.2
Ethan- 1	4	0.32	3	0.6	4	0.8	5	1.8	4	0.48	4	0.16	4.16
David- 1	3	0.24	3	0.6	4	0.8	4	1.44	5	0.6	4	0.16	3.84
David- 3	4	0.32	3	0.6	3	0.6	4	1.44	5	0.6	4	0.16	3.72
Omar- 2	3	0.24	2.5	0.5	3	0.6	4	1.44	5	0.6	5	0.2	3.58
Samuel-1	3.5	0.28	4	0.8	3.5	0.7	4	1.44	5	0.6	5	0.2	4.02
Samuel-3	3.5	0.28	4	0.8	4	0.8	4	1.44	5	0.6	4	0.16	4.08
Owen- 1	3	0.24	4	0.8	4	0.8	4	1.44	5	0.6	4	0.16	4.04

Ethan has the highest-ranking design concept.

4. Selected solutions

The main aspects of the highest-ranking design are to be implemented into the preliminary design, and the top three solutions are to be combined based on the sub-task scores and our team's expertise. For the shower chair, the highest-ranking solutions and chosen concepts are Ethan's rubber stoppers and straight legs with suction cups from Amelia's concepts. The shower seat will be a combination of Amelia's shower seat with the channel combined with drainage holes from Ethan's concepts. Our team's folding mechanism will be from Ethan's concept of attaching and detaching the legs to the seat.

5. Group Design Concept

Our team's preliminary design is based on the highest-ranking concepts in each sub-assembly. Therefore, it incorporates Amelia's leg suction cups and seat designs, as well as Ethan's folding mechanism. It is important to note that various features from the second and third best design concepts have been implemented into our product. First, we will be focused on the suction-cup slip-resistant leg design (See *figure 3*). This concept scored the highest by our weighted matrix and the team members confidently believe it will perform well. The suction cups are to be made from clear and flexible plastic, while their legs are to be cylindrical poles. Currently, we believe that aluminum would be the most appropriate material, and our team will test its material properties later in the engineering design process. Secondly, we have the seat design, which is a combination of Amelia and Ethan's ideas (see *figure 2* and *figure 7*). We settled on a U-shaped seat, which will provide a useful cleaning channel for our customer. A series of holes will be drilled within the seat along with large fillets to act as a water drainage system. Lastly, we compared the folding mechanisms of each group member. Our analysis showed that although the scissor and hinge-based mechanisms were the most compact, they were the least practical. Thus, our team decided to use Ethan's first concept (See *Figure 7*). This folding mechanism is the most feasible and cost-effective; it consists of holes located on the bottom corners of the seat and four legs which may be screwed and unscrewed from their respective holes. Moreover, the seat will contain easy-to-use clips that hold the legs while the seat is in the disassembled position. After deliberately selecting and combining the most effective concepts, our team looks to design the shower seat using Solidworks Computer-aided (CAD) software.

6. Visual Representation

This section of our design report provides several 3-dimensional views of our portable shower seat. We created this design using Solidworks CAD software. It contains 9 parts and 3 sub-assemblies.

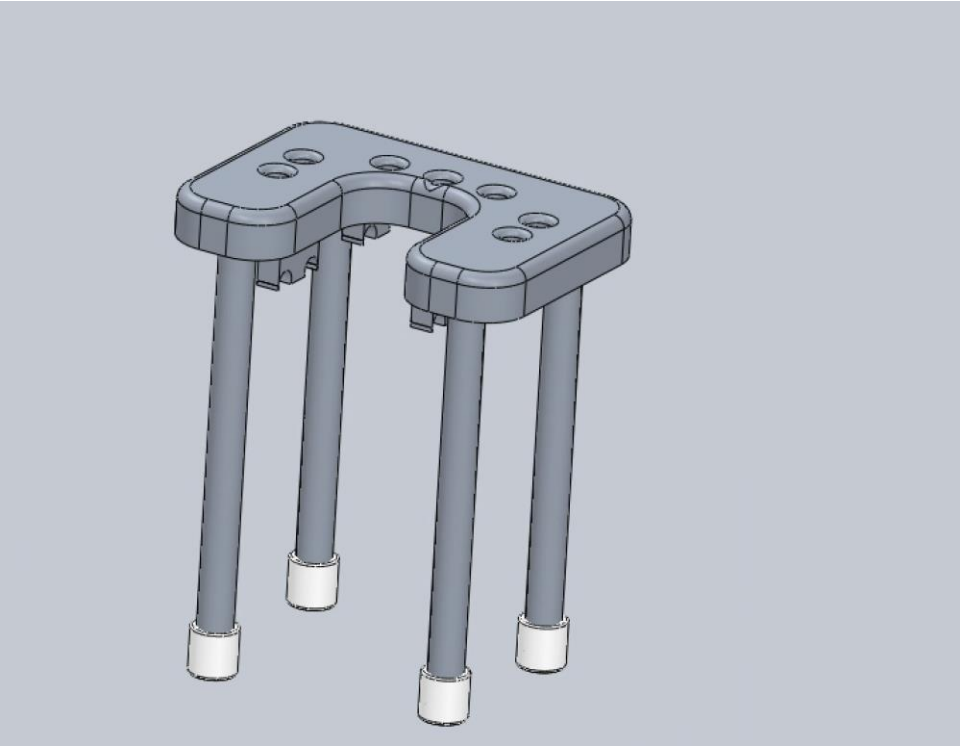


Figure 20: The above figure is a screenshot of our shower seat in an isometric view, and in its assembled state. The top of the seat, with its drainage holes and safety fillets may be seen.

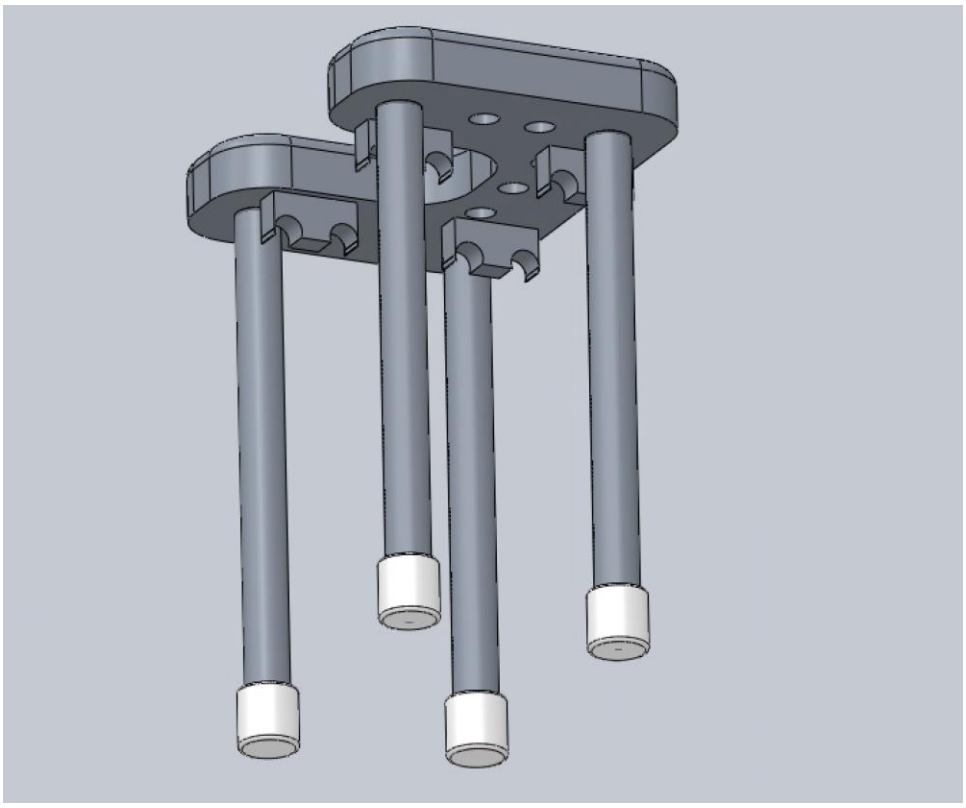


Figure 21: Here is another screenshot of the shower seat in the isometric and assembled state, except now the bottom of the shower state may be seen.

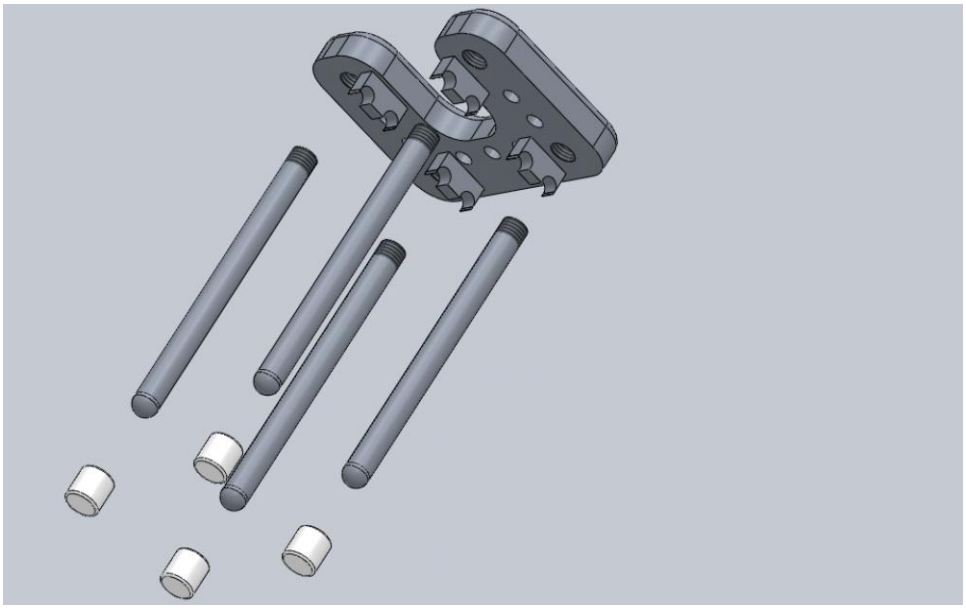


Figure 22: The above figure displays our portable shower seat in the exploded view, where all 9 parts may be easily viewed.

7. Concept Description

The chair has been designed to accommodate the client's needs; it will contain the same dimensions and a similar cleaning channel as his current shower seat at home. In order to prevent the shower seat from slipping, the legs will be fitted with slip-resistant suction cups or rubber casing. It has detachable legs, that allow the chair to be disassembled into a compact shape. The seat base is a major factor to be considered when creating the shower seat, as its large size will determine whether it will fit into carry-on luggage. Moreover, the shower seat must be below 5 pounds, to provide additional weight for our client's personal belongings. The shower seat does not include a backrest, but our team looks to implement one in the future prototype. The shape of the seat has a semicircle cut out to facilitate cleaning and provide comfort for the customer. The seat also includes holes to prevent "sloshing" and water build-up in the seat. The shower seat contains a simple curved geometry, which requires minimal precision during the manufacturing process, which will increase production and require simpler manufacturing skills.

Table 7.1 Advantages and Disadvantages of Current Concept

Advantages	Disadvantages
• Easy to assemble for the user • Slip resistant and low-cost legs • Durable materials and mechanism • Easy to fabricate by the producer • Simple, safe geometry, with low degree of precision	• The current design does not include a backrest, which is less convenient for the user • Thick seat may exceed carry-on capacity • Clips may be difficult to produce

8. Conclusion

Our team entered the ideation phase with a focus on creativity, through motivation and hands-on expertise. Each member produced 3 concepts in the form of hand sketches or CAD designs, resulting in 18 total concepts. In the analysis phase, our team used a 5-point grading system and a calculated weighting factor, to establish the most appropriate and effective design concepts. These 3 designs, along with various new features were subsequently implemented into the preliminary product design. Our group provided a detailed description of our CAD model and analyzed its potential benefits and drawbacks. After completing the first round of the ideation process, our team looks to follow-up with Darcy to ensure that we are solving the real problem at hand, and catering to his true needs.