



uOttawa

Deliverable C: Conceptual Design and Project Plan

Group 2.1

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1. Introduction

The goal of this deliverable is to highlight the important factors to be included in the designs, and to create designs that can satisfy the customer's needs. The designs will be compared to the target specifications previously outlined in Deliverable B and compared to one another to identify the best concepts to further develop moving forward. A final group design will be developed, which will then be presented to the client during the next planned client meeting. This deliverable will highlight creativity, teamwork, and decision-making.

2. Functional Decomposition

The client, [REDACTED], has highlighted some key needs for the clothing rack. The three main needs stated were durability, accessibility, and adaptability. Due to their importance, those three aspects were chosen to be the three main subsystems, as can be seen in Figure 1. As a continuation, aspects of the products that could be used to achieve those needs were brainstormed and developed into smaller subsystems.

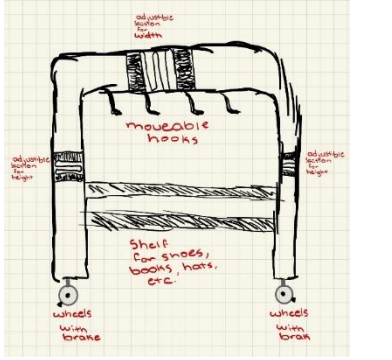
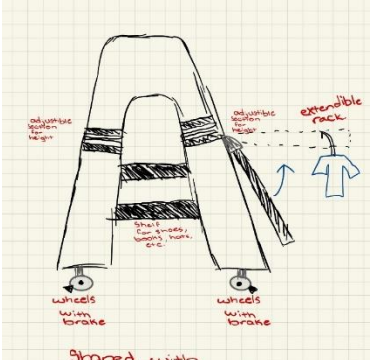
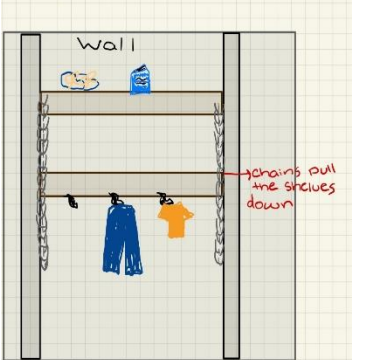
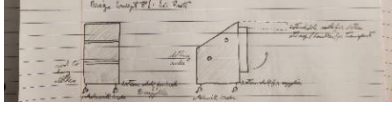
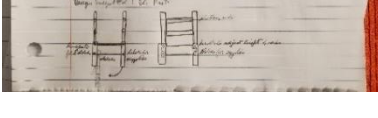
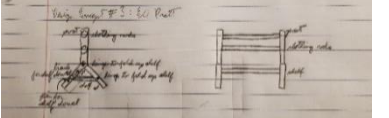
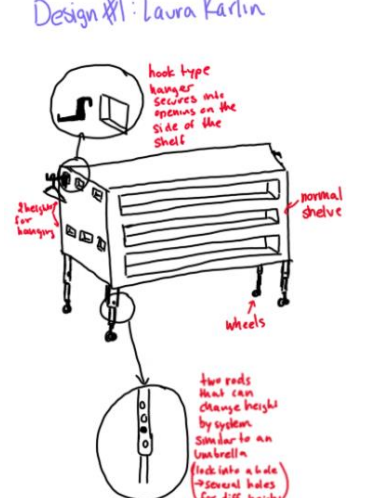
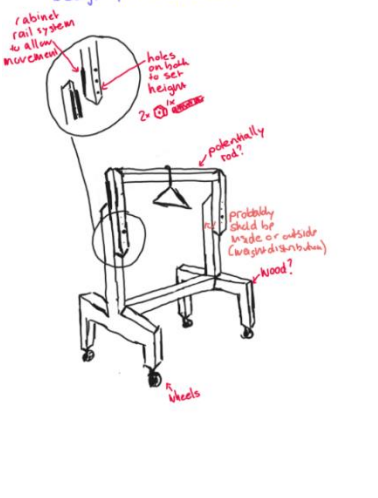
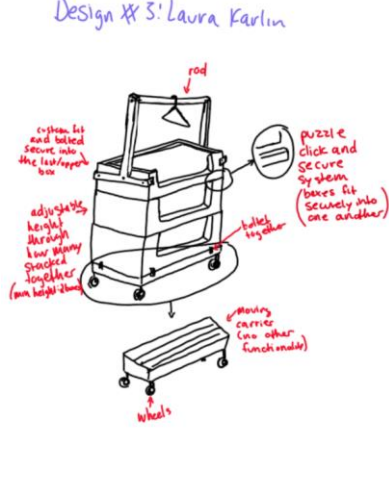
Figure 1: Functional Decomposition of Collapsible Storage Rack



3. Product Conceptual Designs

During the Conceptual design stage, each member of Group 2.1 designed three global product concepts for the entire subsystem, as can be seen in Table 1. Furthermore, each design incorporated ideas for the smaller subsystems outlined in Section 2, as is annotated in words on the designs themselves.

Table 1: Global Concepts Developed by Group 2.1 for the Collapsible Storage Rack

<p>Design Concept #1: Hanna Curry</p>  <p>adjustable system for height movable hooks Shelf for shoes, books, hats, etc. wheels with brake wheels with brake</p>	<p>Design Concept #2: Hanna Curry</p>  <p>adjustable system for height extendable rack Shelf for shoes, books, hats, etc. wheels with brake wheels with brake Shaped with sturdy base</p>	<p>Design Concept #3: Hanna Curry</p>  <p>Wall chains pull the shelves down</p>
		
<p>Design #1: Laura Karlin</p>  <p>hook type hanger secures into openings on the side of the shelf normal shelf wheels two rods that can change height by system similar to an umbrella (fit into a hole -> several holes for diff. heights)</p>	<p>Design #2: Laura Karlin</p>  <p>cabinet rail system to allow movement holes on back to set height potentially rot? probably should be inside or outside (w/adjustment) Wood? wheels</p>	<p>Design #3: Laura Karlin</p>  <p>rod puzzle click and secure system (boxes fit securely into one another) adjustable height through four sliding squares together (can height 2mm) custom fit and locked secure into the top/support box locking carrier (no other functions) wheels</p>

<p>Design Concept #1: Jacob Miller</p>	<p>Design Concept #2: Jacob Miller</p>	<p>Design Concept #3: Jacob Miller</p>
<p>Design Concept #1</p> <p>Paige Petroskie</p>	<p>Design Concept #2</p> <p>Paige Petroskie</p>	<p>Design Concept #3:</p> <p>side 1 side 2 side 3 side 4</p> <p>Paige Petroskie</p>

4. Analyzation and Comparison of Conceptual Designs

For the analyzation and comparison of conceptual designs, each member's design was broken down into how well they met each of the client's criteria. Each design seen in section 3 examined as could be seen in Table 2.

Table 2: Explanations of Global Concept Designs for the Collapsible Storage Rack

<p>Design Concept #1: Hanna Curry [1]</p> <ul style="list-style-type: none"> - Not collapsible - Not enough space for items (hanging, and only 2 shelves) - Adjustable in size - Appears to be stable - Has the potential to be heavy, depending on the material used. - Should be easy to transport and move - With adjustments to the design, has the potential to be collapsible. 	<p>Design Concept #2: Hanna Curry [2]</p> <ul style="list-style-type: none"> - Abnormally shaped - Appears to be bulky - Not a lot of hanging space, but a lot of shelving space - Will be very stable - Has adjustable arms - Will be difficult to transport - Cannot be collapsible 	<p>Design Concept #3: Hanna Curry [3]</p> <ul style="list-style-type: none"> - Will be very accessible - Must be mounted on a wall, and cannot be transported - A lot of space for shelves and hanging clothes. - Moveable in height but cannot be adjusted in width.
<p>Design Concept #1: Eli Pratt [4]</p>	<p>Design Concept #2: Eli Pratt [5]</p>	<p>Design Concept #3: Eli Pratt [6]</p>

<ul style="list-style-type: none"> - Not collapsible - Not very easily adjustable - Bulky - Limited storage capacity before interference with clothes hangers - Should be sturdy and stable 	<ul style="list-style-type: none"> - The design is collapsible - The design is large and awkward to carry - Limited storage of supplies on space between clothing racks - Design is not very adjustable 	<ul style="list-style-type: none"> - Design has potential to jam when collapsing - Very limited storage capacity for supplies - Limited capacity for clothing - Pin to support wooden dowel can break or otherwise fail
<p>Design Concept #1: Laura Karlin [7]</p> <ul style="list-style-type: none"> - Not collapsible - Minimally adjustable in height - Good movability - Shelf should be pretty stable - Bulky - Not too much hanging space (depending on how long the hangers are) - Not a lot of adjustability in height - Depending on the material used, prone to being heavy 	<p>Design Concept #2: Laura Karlin [8]</p> <ul style="list-style-type: none"> - Not collapsible - Should be stable - Height can be greatly adjusted - Good movability - Shouldn't be too heavy depending on the material 	<p>Design Concept #3: Laura Karlin [9]</p> <ul style="list-style-type: none"> - Not collapsible (but can be taken apart) - Adjustable in height (minimal height is the height of 2 boxes plus the rod adjustment) - Can only be adjusted in height in larger differences - Good movability - Should be easily assembled and disassembled - Individual pieces may be a bit bulky
<p>Design Concept #1: Jacob Miller [10]</p> <ul style="list-style-type: none"> - Collapsible - Can adjust in height depending on the clothes needed to be hung. - Has wheels for easy movement around the store. - Not very much room for hanging clothes. - Maybe add extra bars for more hanging room. - Can easily fold up for easy storage due to the limited number of parts. - Depending on material used, can be very lightweight. 	<p>Design Concept #2: Jacob Miller [11]</p> <ul style="list-style-type: none"> - Very bulky - Non-collapsible - Has 5 storage compartments for physical items such as books and electronics. - Has a hanging bar for clothing display. - Has wheels for easy transport throughout the store. - Is relatively heavy since it may store some heavier objects in the shelves. - Maybe add some bars/hooks on either end to add more clothing display space. 	<p>Design Concept #3: Jacob Miller [12]</p> <ul style="list-style-type: none"> - Non-collapsible - Relatively bulky - Has a platform on the bottom for storage of some bigger items that may come into the free store. - Can adjust in height depending on the size of the objects on the bottom. - Has three hanging racks for optimal clothing display. - Has good moveability due to the wheels. - Wheels can lock. - Depending on the material used, could

	- Non-adjustable height.	potentially be used for displaying items outside to withstand certain outdoor elements such as rain.
<p>Design Concept #1: Paige Petroskie</p> <ul style="list-style-type: none"> - Collapsible - Stable, will not easily fall - Lockable wheels can easily be moved around campus/the free store and lock very easily. - Not very adjustable (not as accessible as required) - Can easily be stored, collapsed to a thinner clothes rack. - Has the potential to become flimsy - Could not endure heavy winds/outdoor conditions 	<p>Design Concept #2: Paige Petroskie [14]</p> <ul style="list-style-type: none"> - Very accessible - Very stable - Could become costly due to the moving feature - Not as adjustable due to the wall component - Multiple racks that rotate - Does not collapse - Feature to rotate items for accessibility/aesthetics - Would not be used outdoors - Not as adjustable as needed 	<p>Design Concept #3: Paige Petroskie [15]</p> <ul style="list-style-type: none"> - Collapsible - Stable, will not easily be knocked down - Lockable wheels can easily be moved around campus (placed at different locations)/the free store and lock very easily. - Very adjustable - Stored easily through collapsing the cubes. - Could be stored outside - Lightweight - Cost-efficient - Set-up time may need improvement.

Additionally, the client’s criteria were ranked on a scale of 1-5 on how important it was that the needs were met; each design concept was given a score, located in Table 3, which indicates how well it meets all of the client’s needs.

Table 3: A Matrix Representing how the Global Concepts Meet all of the Client’s Criteria

#	Criteria	Weight* (1-5)	Concept**														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Moveability/ Able to transport	4	3	3	1	3	1	2	3	3	3	3	3	3	3	1	3
2	Quick set-up time/Collapsibility	4	3	2	1	1	3	3	1	2	2	3	1	1	3	1	2
3	Stability/Durability	5	2	3	3	3	2	2	2	2	3	1	3	2	2	3	3
4	Bulkiness	3	3	2	3	1	3	3	1	3	2	3	1	2	3	3	3
5	Easy/Optimal storage	2	3	2	3	1	2	2	1	3	3	3	2	2	3	1	3
6	Able to withstand outdoor conditions	4	3	3	1	3	3	2	3	2	3	1	2	2	1	1	3

7	Adjustable	5	3	2	2	2	2	1	2	3	2	3	1	2	3	1	3
8	Cost	4	2	3	1	1	2	2	1	3	2	2	1	2	1	1	3
9	Aesthetic appeal	1	3	2	2	1	3	3	3	3	3	2	3	2	3	3	3
10	Accessible	5	3	3	3	1	2	2	2	3	2	3	3	3	3	3	3
Total			102	96	73	68	82	77	70	98	90	88	73	79	90	65	107

*5 for the most important designs, 1 for the least important designs

**3 meets the criteria the best, 1 meets the criteria the least

5. Conceptual Design Decision

While analyzing each of the member’s concept designs in Section 4, a few promising solutions were found to appear repeatedly, or were noted to be unique and to be considered for the final design. The individual designs were specifically analyzed according to the Target specifications outlined in Deliverable B: Performance – Travel, whether the Clothes Rack could be moved easily to different locations on campus; Service Life of the clothes rack, whether the design for the clothes rack promised enough stability and durability to withstand at least 10 years of continuous usage; Aesthetic, whether the design appeared to have a clean appearance for the clothes rack; Material, whether the material to be used could potentially withstand indoor and outdoor conditions; Set-Up, whether the clothes rack could be set up easily and quickly by one person; Performance – Locking Wheels, whether a locking mechanism existed to secure the clothes rack in place; and Accessibility, whether the clothes rack could be adjusted in height to make it more accessible for wheelchair users.

One of the designs that was seen repeatedly used throughout multiple member’s concept designs was a sliding mechanism within the rack, to allow adjustment in height and/or width in order to accommodate the accessibility portion of the client needs and target specifications. As can be seen in designs 1, 8, and 10, the idea was heavily favoured in early development and two distinct mechanisms were proposed. The first mechanism which was proposed was that of two hollow metal rods that would fit into one another to enable movement, and which would be locked through some type of ‘to be determined’ mechanism to lock into place. It was even noted throughout the group discussion that using this mechanism to change the width wouldn’t even require a locking mechanism and a simple curtain rod could be used. The second mechanism that was proposed, as is most notably seen in design 8, was the use of two thin and long wooden pieces that were connected via a cabinet hanging rail system for movement and could be locked into place using a bolt that fit through holes on both pieces, preventing further movement and setting a specific height in place. While the ideas were greatly favoured, the only issue seen was that the sliding mechanism would only allow collapsibility to a certain degree, potentially making the product more difficult to store in the small space available in the free store.

On the other hand, an idea that was seen as very unique and could potentially be developed further was design 12, which used the same sliding mechanism to adjust the height of the clothes rack, but most notably also added a platform at the base. The platform would not only add more security and stability to the whole design due to its even weight distribution, it would also create more space to place other items on display other than just clothes. In this regard, the previously mentioned sliding mechanism rack designs were not able to store anything other than clothes. The design also featured wheels for

increased movability and include the opportunity for locking wheels to meet target specifications. The design, as was designed by Jacob Miller, was seen to be a bit bulky, which was described as a drawback; however, the group discussion settled on the potential of the overall design if it could be developed further, and the bulkiness could be mitigated through the addition of other design ideas.

Similarly, designs 5 and 6, created by Eli Pratt, demonstrated unique ideas on how the clothes rack could be made collapsible to save storage space when not in use. The designs used a mechanism which included a rotating axis to allow the whole design to fold into itself but were also simple enough that set-up should be easy for one person, at most two. The designs also offered the opportunity to save on material and make the overall product lighter, which would aid in easy setup and movability. The only drawbacks seen during the group discussion were that the designs couldn't be adjusted to varying heights as easily, and they weren't as stable as they may need to be to handle rough handling by the workers of the free store.

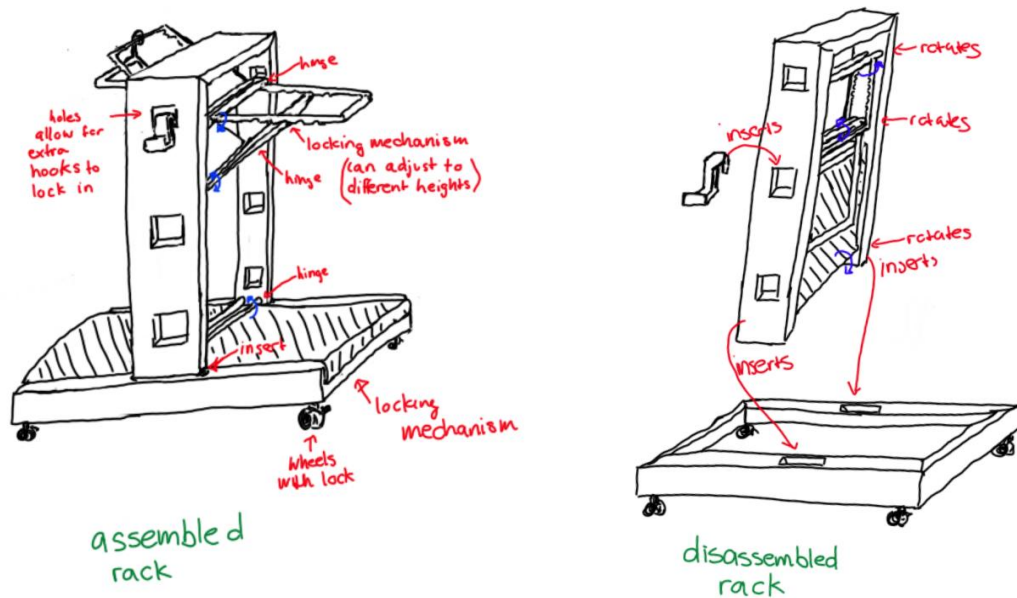
Overall, the group discussion concluded that to create a group design concept that best fit all the target specifications of the client, several different ideas would need to be implemented from several concepts designs of the individual group members. Specifically, the collapsible designs of design 5 and 6, as well as the stable design of design 12 were determined to be especially promising and were chosen as the inspiration for the base of the final concept design.

6. Group Design Concept

The final design concept was chosen to be a combination of several concept designs made by different members to meet as many design criteria put forth by the client as possible. The final design concept involves elements of design 3 by Jacob Miller, with the base of the rack being a platform for supplies and a clothing rack to hand clothes being on top; design concept 1 by Laura Karlin, with hooks that can insert into holes on the side; design concept 2 by Hannah Curry, with the clothing racks being foldable and collapsible; and design concept 5 by Eli Pratt, with the hinges that allow the shelves to rotate and collapse. It was decided to incorporate the aforementioned design elements into the project to not only ensure that the clothing rack was collapsible, but also to ensure that the rack could tolerate bearing weight and has ample storage space for both clothes and miscellaneous items while remaining flexible. The individual elements were combined in one design to meet the customer needs and target specifications better than the individual design concepts by each member could have.

As can be seen in Figure 2, the final group design is made up of two pieces to minimize the space the product will take up when stored. The two pieces fit into one another for easy assembly, and the bottom piece maintains the stability of the whole design while also providing movability through wheels that can lock. The upper piece contains holes on the side to enable the user to lock in extra hooks for hanging up more items. Moreover, on the bottom of the upper piece are two planks that turn into opposite direction via a hinge attachment, and also lock into the bottom piece at the ends for further security of the whole design. On the inside of the top of the upper piece are two clothing rods that are also attached via hinges and can rotate upwards on opposite sides. The same mechanism applies to two planks located in the middle of the upper piece. Ridges along the side of the upper clothing rod allow the middle plank to lock the rod into place and prevent it from falling back down; hence, the rod is able to support the weight of several articles of clothing being hung from it, while also being adjustable in height depending on which ridge the plank was locked into.

Figure 2: Group Design for the Collapsible Rack in Both an Assembled and Disassembled View



7. Relating our Design Concept to our Target Specifications

The target specifications were developed in Deliverable B and did not evolve since. The final design was created to accommodate all the target specifications as best as possible. The concept relates to the target specifications as follows:

Performance – Travel: The conceptual design not only has wheels to make it easier to move around campus, but it is also collapsible and can be disassembled into 2 individual pieces, which makes the entire design smaller and easier to transport. On the other hand, due to the multitude of features given to each of the two pieces and depending on the material used, the design has the potential to be too heavy and thereby potentially cumbersome for just one person to carry it alone.

Service Life of the Clothes Rack: Due to the compact design of the conceptual design, its final design should be easy to store in small spaces which would extend its service life as it would not be bothered when not in use. Furthermore, the design is balanced and sturdy, which should make the overall design very durable. On the other hand, the material used for the design could greatly impact its service life; for example, if the frame were to be made of wood, as would appear to be the easiest solution, it has the potential to bend and warp if unsealed or made with non-pressure-treated wood. Moreover, the design has many moving pieces, such as the hinged, which could become a weak point over time if not treated carefully.

Aesthetic: With a minimalist design and potential to hang uplifting or motivational quotes on the frame itself, the conceptual design has the potential to be very aesthetically pleasing.

Material: If the frame is made of wood, the design has the potential to not fare well in the rain if exposed continuously or left unsealed; however, wear on the frame from movement will be minimal. The client also expressed how the rack will most likely only be used indoors, which would decrease wear.

on the material as well. Otherwise, the material used is not fully decided as of yet as the next client meeting and material demand will determine what will be used.

Set-up: Given the collapsible design and the minimal number of individual parts, the design allows for an easy to understand, intuitive, quick, and simple set-up, even for one person. The connection between the two individual parts is fairly self-explanatory, even though it will still be explained, as are the rotating pieces and the locking mechanisms. Moreover, there is no risk of losing any of the pieces which could inhibit the set-up, and therefore the set-up should meet all demands.

Performance – Working Wheels: Given the customer’s need for working, locking wheels, the design and assembly team will be sure to include these in the final assembly, as can be seen is accommodated for in the lower piece of the two-piece design. The wheels will enhance transportation even while the rack is loaded, and the lock on the wheels will serve as a security measure to prevent accidents.

Accessibility: Given the adjustable nature of the clothing rack and the fact that the bottom shelf sits on supports low to the ground, accessibility to the rack would be easy for those in wheelchairs. Furthermore, the hooks on the side can also be adjusted to three different heights for better accessibility. The only drawback that may occur would be if the bottom platform is too close to the ground which may make it harder to access, though this issue will be addressed during development.

8. Client Meeting Preparation

For the second client meeting, the focus is to show examples of the concepts developed and to grasp what the client feels. They can acknowledge the final concept and ask questions about the design, as well as answer questions about their ideal product. If the client is in favour of the design, the team can move forward and further develop the collapsible clothes rack. If the client is unsure of the design or has some changes they would like for the product, the team will go back to the drawing board and continue the design process. At this stage, information on specifics such as the preferred material and further requirements can be identified, and the product can be developed further.

With the questions and concepts discussed with the client, the team can identify if constraints have been satisfied, needs are prioritized, and refine ideas.

The client meeting will be held through zoom and a slideshow will be used to present the design seen in section 6 to the client. The presentation will be held by Paige Petroskie while the other members of the team take notes on the client expression and feedback. After the presentation, the following questions will be asked of the client for clarification purposes:

- Do you think this is accessible enough?
- What range of heights for the clothing rack would you prefer to have?
- Is there a specific width you would like the clothing rack to have?
- Are there any materials you would advise against using due to past experiences?
- Are there any materials you would encourage us to use due to past experiences?
- Do you have any concerns about the ease of set-up of the design?

- Do the volunteers have experience with using multiple product components to set up a clothes rack?
- What is the ideal time frame you would like to keep the clothes rack for?
- Is there a specification of the wheels you would like (sizing wise)?
- How does our idea compare to your idea of an ideal clothes rack?
- What is the main component you like about the design we have created?
- What is the main component you dislike about the design we have created?

After the presentation, if the client has any questions concerning the design, questions will be answered by all members of the team to encourage further discussion. While one member speaks, the other members will continue to take notes throughout the meeting.

9. Conclusion

In conclusion, after multiple concepts were generated by the various team members, the concepts were compared and analyzed. After each concept was analyzed and compared against one another, the concepts were ranked on a scale of 3 to 1 on whether they met the weighted design criteria, with 3 representing they did. The criteria that the concepts had to meet were the following: moveability/ability to transport, quick set-up time, stability/durability, bulkiness, easy storage, ability to withstand outdoor conditions, adjustability, cost, aesthetic appeal, and accessibility. Out of a possible 108, the top three designs were determined to be concepts 1, 8 and 15. Concept 1 achieved a score of 102/108, concept 8 achieved 98/108, and concept 15 achieved 107/108. The best three designs were discussed a group to realize what made them score so high. Moreover, the rest of the designs were also further analyzed, and the best ideas were combined for the final group design. The final design was meant to meet all the criteria set out by the client in a way that was better and more efficient than each of the individual members concept designs were able to. After combining multiple design concepts and creating a group design concept, the specifications were defined and preparations for the second client meet took place to continue to develop further design aspects.