ComforTable

Your Comfort Matters

20
ENGINEER 1P03
“The Ladies at Table 2”
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1. Introduction

1.1 Background Information

"The Ladies at Table Two" are clients from St. Peter's Residence at Chedokee. Most of the residents at St. Peter's are wheelchair-bound. Each wheelchair differs in size and height, which affects the resident's ability to sit comfortably at a standard dining table. Meals are very important, for residents to gain proper nutrition and fluids. Dining is innately social, and the client would like to preserve this, while keeping the residents independent. The social aspect of meal times is disrupted by the use of standard tables, which do not allow easy access for wheelchairs of varying heights/sizes.

1.2 Refined Problem Statement

The problem presented to the team involves wheelchair bound residents at St. Peter's Residence. The residents eat meals at cafeteria tables. Because the wheelchairs and people are of different sizes, they cannot all fit comfortably at one table. Sometimes the wheelchairs cannot fit under the table. The prevents the residents from socializing and eating independently. The device must allow up to 4 wheelchairs bound residents to eat at the table, at the same time, in relative comfort. optimally, the users should be able to operate the device without staff assistance.

1.3 Objectives and Constraints

We developed four main objective to our design challenge using an objective tree; they are: inexpensive, safe, accessible, and comfortable. The final product had to be affordable for the residence, and so it was important to keep costs within a decided metric.

The second objective was safety. The final device must meet RHA standards, be stable, and reliable. When working with wheelchair-bound users, physical ability must be taken into consideration, and additional safety measures must be put in place. Additionally, in Ontario there is a piece of legislature called the Retirement Homes Act, which dictates that a retirement home or permanent residence must be "operated so that it is a place where residents live with dignity, respect, privacy and autonomy, in security, safety and comfort and can make informed choices about their care options" [12]. In order to make sure that the device was suitable to be used in a residence, the RHA guidelines and standards were followed.

The third objective was accessibility. The device had to be independently useable and accessible by people in all different types of wheelchairs, not just for one specific model. The current tables at St. Peter's Residence are not accessible to all wheelchair models, so the entire purpose of the device is to amend that.

The final objective was to maintain a comfortable dining experience. This was done by minimizing the interaction between the wheelchair and the table-mechanism. Another aspect of comfort that was taken into consideration was social comfort. As stated in the initial problem statement, it was imperative to maintain the social aspect of dining.

1.4 Prior Art:

1.4A Patents

The main objective of this project is to design a table that enables four people to eat together, regardless of the size and mobility of their wheelchairs. There are few complete products available on the market that fulfill this need,

thus, a new product is required to fulfill the gap in the market. This product will need to have a vertical component, to adjust the height of the table surface for each user, as well as a horizontal component to ensure that the legs and support system of the table do not interfere with the wheelchairs.

The first aspect of the project is how to adjust the height of the surface of the table to assist with ease of eating. This can be done through the use of a hydraulic lift system [1]. This system uses a pair of scissor lifts that pivot to raise and lower the tables to the desired height. This system allows the user to customize the height of the table surface to suit their individual needs.

The user can adjust the mechanism through the use of hydraulics [2]. Using a hydraulic system, the vertical movement of the tray is smooth and uniform, which can prevent spills. To use the system, the user pushes on a plunger, which in turn raises the table surface. The further the plunger is pushed, the higher to table rises, until it reaches its maximum height. Similarly, if the plunger is pulled on, the surface will lower until it reaches its minimum height

The second aspect of the project is adjusting the horizontal position of the table surface for comfortable eating and ideal wheelchair position. A method of doing this is an expandable table [3], which allows wheelchairs to glide under without disrupting the table's legs and support system. Additionally, this enables the user to move the surface of the table until it has reached his/her desired distance from them-self. This model is composed of a circular table divided into 8 sections. When a piece of the table is pulled on outwardly, it glides along a rail into the desired position to expand the size of the table. Each piece moves individually of the others, allowing each user to position the table exactly where they want it to go.

The user can adjust the mechanism by pulling outward (toward them) on the piece of the table that they are sitting at. The distance the edge of the table is from the person can be adjusted by pulling further outward or pushing inward, while the piece glides over a track into position. The further the piece is pulled out, the further the edge of the table is from the support system, and it is less likely that the table legs will disrupt the wheelchair’s movement. The moving piece is still connected to the main frame by the track, ensuring that it is still stable and sturdy, even when pulled outward from the main support.

1.4B Injuries and Disabilities

Types of Injuries/Disabilities Affected: In general, residents with movement and leg related injuries and disabilities are the main group affected by this problem. Specifically, wheelchair users have a problem eating together with other residents as they would need the height of the table to be adjusted. As mentioned in the original problem statement, there is an issue with sliding the wheelchair under the table due to its height. Moreover, wheelchair users have limited movement at the table, even if they were to be properly seated. The variations in height within the wheelchairs themselves would result in varying comfort for the user at the table. Furthermore, wheelchair users still have to maintain a proper position in the chair while being seated at the table as it could cause discomfort if they were to break this position as a result of an issue with the table [4]. Additionally, it is also possible that residents in wheelchairs will also have problems in their upper body resulting in increased difficulty at the dining table. These residents may have spinal injuries, neuromuscular impairments or

other disabilities related to one's posture which would lead them to have a conflict with the height of the table as their disability could make it harder for them to reach the food. The ability to independently sit upright in such residents, can also be categorized into further levels based on the amount of assistance required from their hands [5]. Overall, the varying heights of the residents and their wheelchairs, in addition to their personal injuries and disabilities, detail the problems that a solution should address.

How the product Addresses the Problem: At present, it is possible to adjust the height of the tables used at St. Peters . However, the adjustability of these tables only serve to make general height adjustments for all residents at the dining table. In comparison, the product must match the requirements of all 4-5 residents at the dining table. Therefore, the product must address this issue by allowing the users to make their own personal adjustments to the height of the table based on their injury/disability. The product should also accomplish this task while essentially allowing the residents to eat at together at the same table. Currently, residents may also require assistance with being seated at the table. This issue must also be addressed through the product as it should allow the residents to conduct the dining process on their own. The wheelchair should also not be a hindrance to the residents. Largely, this product should allow wheelchair-bound residents to ignore the existence of their wheelchair and treat it as just another chair at a dining table. After all, having to conduct the act of eating together at a table with difficulty, could lead to emotional distress for the resident [6].

1.4C Existing Commercial Products

Abstract: The project task is designing a table that allows four people with different sized wheelchairs to eat together. Because powered wheelchairs are a recent invention, this modular table problem has not had enough time to be fully addressed. Therefore, there are few innovations that solve the problem. This provides an exciting frontier where many original ideas for the problem can be explored.

Discussion: The most obvious solution to the problem is placing four separate modular tables together, as shown below. Each table is adjusted, depending on the person sitting there. Many companies sell small modular tables. The most common type are standing desks. Standing desks are tables with telescopic legs. These legs can expand and be locked at different positions. RDM Industrial Products sells a variety of adjustable tables. Using a hand crank, a person can raise and lower the table. The hand crank connects to a rack and pinion system that expands and contracts the telescopic legs. The RDM Model i-107P Ergonomic Table is a specific product that can be used exactly for St. Peter’s purpose. This solution does solve the project problem. However, there are a few reasons it is not ideal. Buying four small modular tables is significantly more expensive than buying one large modular table, that St. Peter’s currently uses. Additionally, residents sitting at the table are not very close to each other. This might be an issue, since the residents are probably hard of hearing. Because of the hand crank, it would be difficult for residents to raise and lower the table independently. ComforTek sells a table specifically for St. Peter’s purpose. The ComforTek Butterfly has four separate adjustable sections. Each section of the table can be raised, lowered, moved in, and moved out. The table

is adjusted manually The ComforTek Butterfly allows wheelchair bound residents of St. Peters to eat together. Residents can eat close to one another and in relative comfort. Unfortunately, the tables retail for $2260.60 USD[11]. It is not feasible for St. Peter's to provide accessible tables to all the residence's occupants at this price. Residents would be unable to manually adjust both of the mentioned products independently. A caretaker would need to adjust all of the tables beforehand. After adjustment, residents should be able to eat at the tables by themselves.

Analysis: Clearly, there are some effective commercial products for St. Peter's table problem. The biggest issue with the existing solutions is that they are too expensive for St. Peter's Residence. Additionally, the St. Peter's residents cannot adjust the existing product tables without assistance. Considering the previous solutions, below is one better design alternative for the St. Peter's table problem. It is much cheaper to build an adjustable tray than an adjustable table. This is a design for a tray that can move up and down based on the user's needs. There is a cupholder as well. The tray can clamp onto any kitchen table using a winged bolt system. The tray moves up and down using a motor winch system. Residents can activate the motor using a wireless button.

1.4D Useful Materials

The main function of our device will be to enhance or adjust the table so that it no longer interferes with the variety of wheelchairs and custom assistive devices that some of the residents, at St. Peters, use to maintain their regular daily life. The function of a dinner table is to support weight and create a stable plane for people to eat at. Therefore our table adjustment device must almost fulfill a similar purpose of support and stability. Knowing this, an ideal material for us would be one that is strong, cheap and easy to manipulate. Some properties that are not very important in our build material are weight, heat resistance, electrical conductivity.

Woods; Hardwoods vs. Softwoods: In general hardwoods are stronger and more dense then softwoods [7], because of their high density hardwoods are more difficult to work with, meaning softwoods would be much easier to prototype with, allowing us to prototype more often and produce a much better final product. Also softwoods are cheaper than hardwoods, in fact, 80% of lumber around the world is made from softwood [7] of its characteristics of being relatively strong compared to its price and weight. Another advantage of woods is that they work very well with glues, such as carpenters glue, drills, and screws.

Metals; Advantages and Disadvantages of metallic properties in our device: Metals are the strongest material we have access to, as well as the heaviest. Metals are significantly more expensive than woods [8]. Metals are also extremely difficult to manipulate due to their strength. If we decided to use metals in our design, we would have to commit heavily to our preliminary design as it would take a lot of time to develop a metallic prototype at the student workshop. The weight disadvantages caused by metals would be fairly small, as the table does not need to portable or light. Metals are difficult to drill, and do not glue very well [10], meaning we may need to solder or weld them together in order to connect metal parts.

Useful Plastics and Classification of Plastics: There is an extremely large variety of plastics, differing on a wide variety of properties, such as thermal

resistance, toxicity, and strength. Although this is a dinner table, which will come in contact with food, our device will not be in direct contact with food or plates, therefore toxicity of plastics, should not be a constraint in selecting a plastic to use. Plastics are easy to morph into complex shapes due to their flexibility [10], this is very useful for more intricate parts of our design, however plastic would not be optimum for the stronger support sections of our design. Of the 7 classifications of Plastics, according to SPI codes [9] (Classification system of plastics), I would recommend the use of PVC plastics, under SPI code 3, which are very useful for industrial work due to their high strength [9].

2. Conceptual Design

2.1 Brainstorming

The team started brainstorming by breaking off into pairs and creating morph charts based on the information given in lecture. Each pairing was responsible for coming up with 3 means for each of 4 functions. After this was completed, we viewed our morph charts as a team, and decided what the best means for the functions would be. We fully discussed and analyzed each pairing to decide what the best design would be.

2.2 Design Alternatives

2.2A Preliminary Alternatives:

The basis of this design was 2 components: a tray an a support clip (Appendix B - Figure 1, Preliminary Alternative (conceptual)). The system slides onto/over the arms of a wheelchair, and 2 spring clips are secured into place, to attach the tray system to the wheelchair. The side supports and tray are made out of galvanized sheet metal, and welded together for strength. The system can be moved to different distances along the wheelchair arm to accommodate each person's desired eating distance. Additionally, the support system is adjustable for different-sized wheel chair arms (width/depth). The final bill of materials for this design was ____ (Appendix A - Figure 1, Preliminary Alternative Bill of Materials)

2.2B Secondary Alternatives:

The design must allow up to four wheelchair bound people to eat at a dinner table together. The design must meet RHA and ORCA standards [12]. The design should be inexpensive, safe, reliable, easy to use, socially acceptable, and comfortable. This design allows the ladies of St. Peter's Residence to eat dinner together. This design is for an adjustable tray for wheelchair-bound people. It is much cheaper to build an adjustable tray than an adjustable table. Each table can have four of these trays clamped to it. The tray can swing up and down using a parallel arm linkage system. This allows the staff members to adjust the tray in the vertical and horizontal directions. The tray is locked in place using a pin and hole system. The pin is big enough to be adjusted easily. The tray can clamp onto tables, even if the table is thick in width. The tray is clamped by tightening a bolt. The bolt can be easily tightening because of the shape of it. (Appendix B - Figure 2, Secondary Alternative (conceptual)). The sketch meets the objectives well. The cost of our device is $36.74 (Appendix A - table 2), which is a 7 according to the metrics.

2.3 Design Evaluation

The main points of importance when we were designing our final device were expense, stability, reliability, ease of use, adjustability, and level of physical comfort. For expense, we gave ranges of cost, and evaluated how that cost would score out of 10. If the device cost less that $25 to produce, it was scored a 10/10. On the opposing end of the scale, if the device cost more than $75, it was given a 1/10. Stability was measured in terms of how much weight the device could support. Supporting a weight less than 25kg scored a 1/10, while supporting between 75-100kg earned a 10/10. Reliability can be measured by using a focus group, and evaluating the satisfaction of the members of the group. The focus group would be asked to rate the

reliability of the device, with a 10 being amazing, and a 0 being completely unreliable. Ease of use would also be measured with the help of a focus group. The focus group would rate the device from 0-10, with a 10 being very simple to use, and a 0 being extremely difficult. Adjustability would be scored according to the change in vertical height that the device is capable of. If it can move 40-50 cm from top to bottom, then a score of 10/10 would be given. alternately, if it can only move 0-20 cm, a score o 1/10 would be earned. Lastly, physical comfort would be evaluated using a focus group. The focus group would be asked to test the device during a meal-time setting to see how comfortable they are eating at it, and then to rate the device from 0-10, using a similar scale as mentioned above. (Appendix A - Figure 4, Metrics)

3. Final Design

3.1 Description

The design must allow up to four wheelchair-bound people to eat at a table together. the design must meet RHA and ORCA standards. The design should be inexpensive, safe, reliable, easy to use, socially acceptable, and comfortable. This design allows the ladies at St. Peter's Residence (as well as other residents) to eat dinner together. We have designed an adjustable tray for the wheelchair-bound residents. It is much less expensive to build an adjustable tray than an adjustable table. Each table at St. Peter's Residence can have four of these device's clamped to it. The tray can pivot up and down using a parallel arm linkage system (Appendix B - Figure 4, Final Design (conceptual)). This enables the staff members to adjust the tray in both the horizontal and vertical directions. The tray can be locked in position using a pin and hole system. The pin is big enough to be adjusted easily. The tray can be clamped onto tables, regardless of the thickness of the table's edge. The tray is clamped by tightening a bolt. It is easy to tighten, due to the shape of the shaft. The sketch meets our objectives very well. The cost of our design is $34.68, which is a 7 according to the metrics scheme (Appendix A - Figure 4, Metrics).

3.2 User:

The device can be used by the residents after the initial setup. The device is first attached to the desk by properly aligning it and tightening the three screws located at the lower back end. Once this is complete, the resident can approach the device with his/her wheelchair and adjust it to their preferred height. This can be done by simply loosening the screws on both ends of the device and then lifting or lowering the device as needed. Additional assistance may be required during this initial step depending on the hand dexterity of the resident. After this is done, the resident can easily use the device on future occasions as it will remain at their preferred height.

This device is very capable of withstanding the weight of a resident's dining plate and food as the base has strong wooden construction. Once attached to the desk, the clamping screws should also be able to withstand weights of common foods and items. If the resident wants to place a drink on the device, there is a cut-out cup holder on the device that can hold regular-sized plastic cups. The device can easily be kept underneath the tables when not in use. However, the device is ideally made to serve as a long-term attachment to the table in order to accommodate a specific resident's dining height. Overall, the features in the device have a clear focus of providing more comfort for the residents to enhance their dining experience.

3.3 Construction

The device uses parts and materials that can be found at any local hardware store, such as Home Hardware or Home Depot. The design will be fulfilled using machines, such as a drill press, mill, bandsaw, and various other hand tools. This process involved cutting, drilling, and taping aluminum pieces. The main frame of the mechanism is built using sheet metal, square aluminum tubing, with 1/4 20 bolts to hold the pieces together. Cotter pins and brass wing nuts are used to secure the height of the device after it has been adjusted to the user's preferences / their wheelchair height. All of the rough edges on the metal were grinded down to ensure safety of the user, and a wood top was fixed in place using screws. Additionally, a 2.5 inch hole was cut from the tray top, to allow for a cup to stay securely on the mechanism. (Appendix B - Figure 3, Final Design (images))

3.4 Safety

During the design process of this device, it was made known that safety was of utmost importance. While it is crucial that the device fulfills the needs of the user, it must also be safe for them to use independently. This was accomplished by putting a cup holder on the surface of the tray, so that, should it be accidentally nudged or bumped, the user's drink would not be spilt on them. Secondly, when choosing a surface for the tray, coefficient of friction was taken into consideration, to ensure that plates and cutlery would stay in place. However, traditional surfaces such as wood can cause splintering, so it was understood that the wood would need to be sanded down and sealed to minimize risk of injury to the user. Finally, the structure of the device was amended to ensure that the shape was conscious of the user's legs and wheelchair frame, thus promoting stability and minimizing risk of the user interacting with the frame.

3.5 Description of Prototype

3.5 A Process

During the prototyping stage of the project, various aspects of the design of the ComforTable changed. We initially used clear, sturdy plastic as the tray on the device, however the screws used to hold it in place cause the material to crack and splinter. Plastic also proved to be a poor surface for holding plates/ utensils, as the coefficient of friction was not great enough to prevent them from sliding if the table was nudged. We replaced the plastic surface with ply-wood, which proved to be more resilient to cracking, but still had some faults. Unfinished wood can cause painful splinters, and isn't aesthetically pleasing for a comfortable dining experience. Thus, we further improved on the tray by replacing the plywood with a sanded and finished wood surface. This fulfilled our design criteria and solved all of the earlier problems.

3.5 B How Changes Occurred

Changes occurred simply by taking apart and fixing our initial prototype. We used high-quality materials from the beginning, which enabled us to replace the problematic parts piece-by-piece, rather than starting from scratch each time. Changes to the prototype occurred each week, following the tutorial, after we were given feedback or new information. In the end we altered our prototype 3-5 times, over the course of the project. This process allowed us to see and test which aspects worked, and alter them to make the best product possible for the residents at St. Peter's.

3.5 C Discussion and Feedback

Each week we discussed our product, and how we were progressing towards a finished product. This led to us giving each other feedback and having an open discussion about the prototype at each level of its refinement and construction.

3.6 Design Review Feedback:

At our first design review day we presented our product 'ComforTable' to a design review board of Biology students. The Intention being to have a fresh view at our product in order to identify any issues with the current model of out device. The benefit of this review being their expertise in knowing what the residents at St. Peter's

and Chedoke might struggle with, relevant to our design. The first prototype that we presented was not fully functional, as we had not yet implemented the locking mechanism needed to secure our device at varying heights. Some of the concerns brought up by the review board included, improving upon the ruggedness of the device, including some protruding screws, sharp edges and the cracked acrylic eating surface. As well the design review board questioned whether the stability of the device was adequate to safely support food and/or a hot beverage. This lack of stability was mostly due to a lack of a locking mechanism which allows the user to tighten the joints to prevent movement, which was improved upon in our second prototype. Secondly, we improved upon the rugged design by replacing the protruding screws with better fitting s crews and bolts, and the acrylic cover was replaced with a wooden board which is not prone to cracking.

At the second design review day we present an updated version of 'ComforTable' with a wooden finish and a completed locking mechanism. The review board was impressed with our design and said it was very well thought out, however they had some objections with the surface size as well as wondering if the residents would have the tactile strength to be able to adjust the table attachment on their own. Although we understood the independence of the residence is ideal, we had been given project goals of a device that could be easily adjusted by the St. Peters staff, which is what we had attained with our current design, satisfying our project requirements. (Appendix C - Figure 1, Tutorial 10 Design Review)

4. Conclusions

In conclusion

5. References

[1] L. Johansson, “Hydraulic Lifting Table,” US Patent 4 753 419, Jun. 28, 1988.

[2] J. R. Conley, A. D. Rudisill, “Expandable Table,” US Patent 6 994 032, Feb. 7, 2006

[3] L. Johansson, Side View of Hydraulic Lift Table. 1988

[4] Good Shepherd Rehabilitation, “Posture, Proper Wheelchair Fit and Seating“, unpublished

[5] Jean, Minkel. (2000, July). Seating and Mobility Considerations for People With Spinal ... (dsd ed.) [Online]. Available: ptjournal.apta.org/content/80/7/701

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[11] ComforTek. Butterfly Table[Online]. Available:http://comfortek.com/seating/assisted-living/overview/ [Accessed: 20- Oct- 2016]

[12] Province of Ontario. (2010, Jun. 10). *1*, *Retirement Homes Act (RHA)*. [Online]. Available: https://www.ontario.ca/laws/statute/10r11#BK11Province of Ontario. Accessed: Nov. 29, 2016

6. Appendices

Appendix A:

Figure 1 - Preliminary Alternatives Bill of Materials

Material:	Source of Material:	Cost ($)
spring clips	Home Depot	2 x $16.99
galvanized sheet metal	Home Depot	$8.46
	Total Cost:	$42.44

Figure 2 - Secondary Alternatives Bill of Materials

Material	Source of Material	Cost
Galvanized Sheet Metal	Home Depot	$13.28
1/4 20 Bolts	Home Depot	10 x $0.12
Square Aluminum Tubing	Home Depot	$17.98
Cotter Pin	Home Depot	2 x $1.34
Brass Wing Nut + Bolt	Home Depot	2 x $0.60
	Total Cost:	$36.74

Figure 3 - Final Prototype Bill of Materials

Material	Source of Material	Cost
Galvanized Sheet Metal	Home Depot	$13.28
1/4 20 Bolts	Home Depot	10 x $0.12
Square Aluminum Tubing	Home Depot	$17.98
Thumb Screw	Home Depot	2 x $1.34
Knurled Screw	JHE Shop	2 x $0.25
	Total Cost:	$34.68

Figure 4 - Metrics

Objective	Inexpensive	
Metric	Cost ($) 0 - 25 25 - 50 50 - 75 75 +	Score (out of 10) 10 7 5 1

Objective:	Stable	
Metric:	Weight (kg) 0-25 25-50 50-75 75-100	Score (out of 10) 1 5 7 10

Objective:	Reliable
Metric:	Using a focus group, the mechanism will be tested. The focus group will rate the reliability of the device (10 - consistently reliable, 0 - completely unreliable)

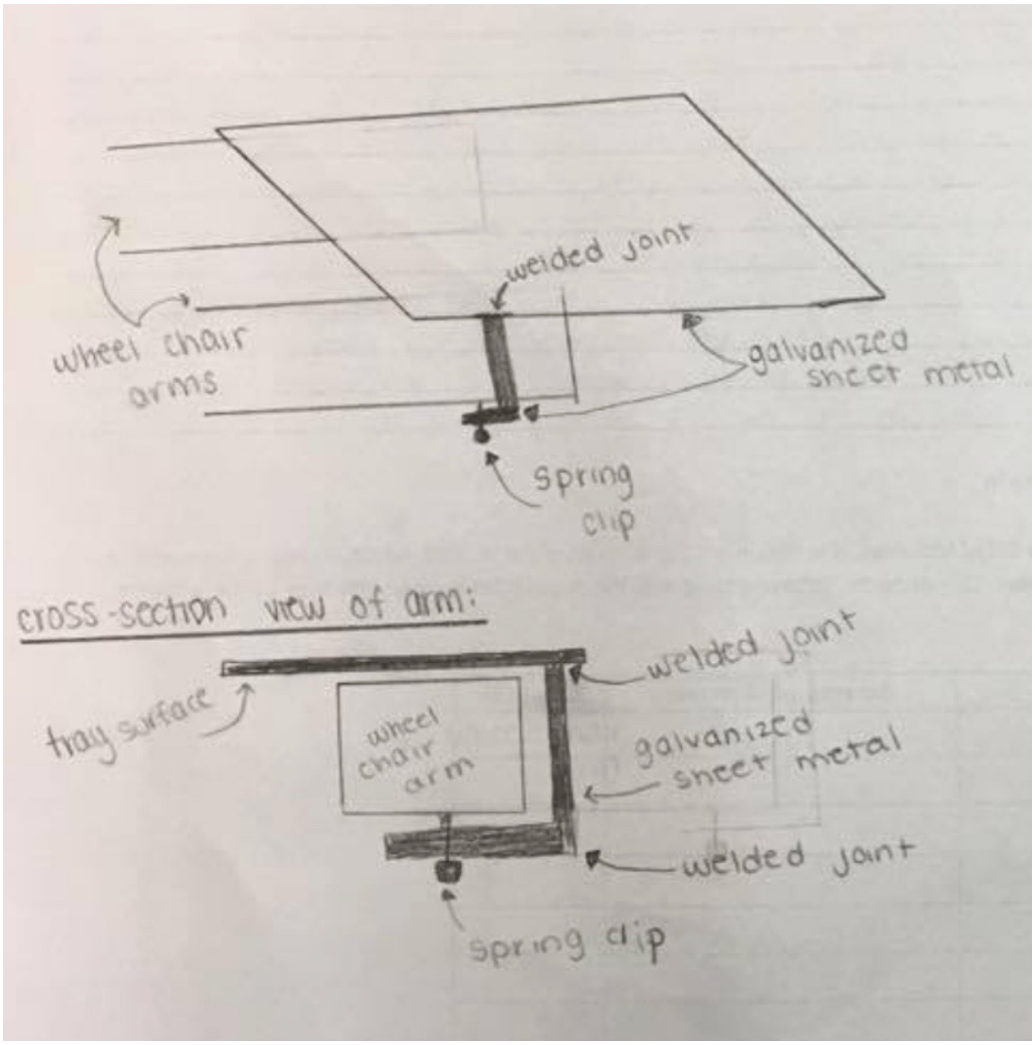
Objective:	Easy of Use
Metric:	Using a focus group, the mechanism will be testing subjectively. The focus group will rate how easy the device was to use (10 - very simple, 0 - extremely difficult)

Objective:	Adjustable	
Metric	Vertical Height (cm) 0-20 20-40 40-50	Score (out of 10) 1 5 10

Objective:	Physically Comfortable
Metric:	Using a focus group, the mechanism will be tested for physical comfort. The focus group will rate their comfort level while using the device. (10 - very comfortable, 0 - extremely uncomfortable)

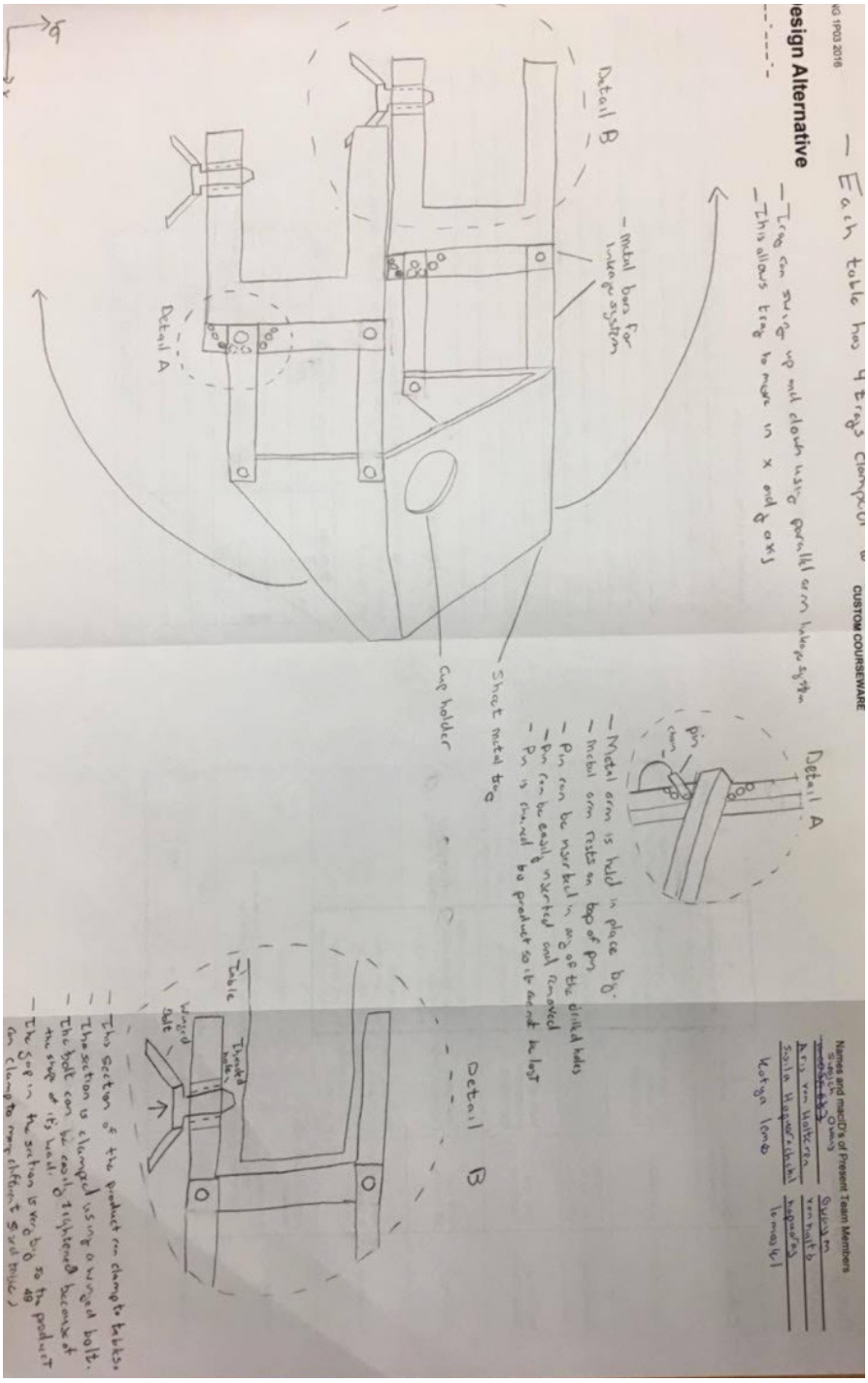
Appendix B:

Figure 1 - Preliminary Alternatives (conceptual)



This diagram shows a potential design for a solution to the problem. It consists of a tray that is clipped to the arms of a wheelchair, completely eliminating the need for a dining table, while maintaining the resident's independence and social nature.

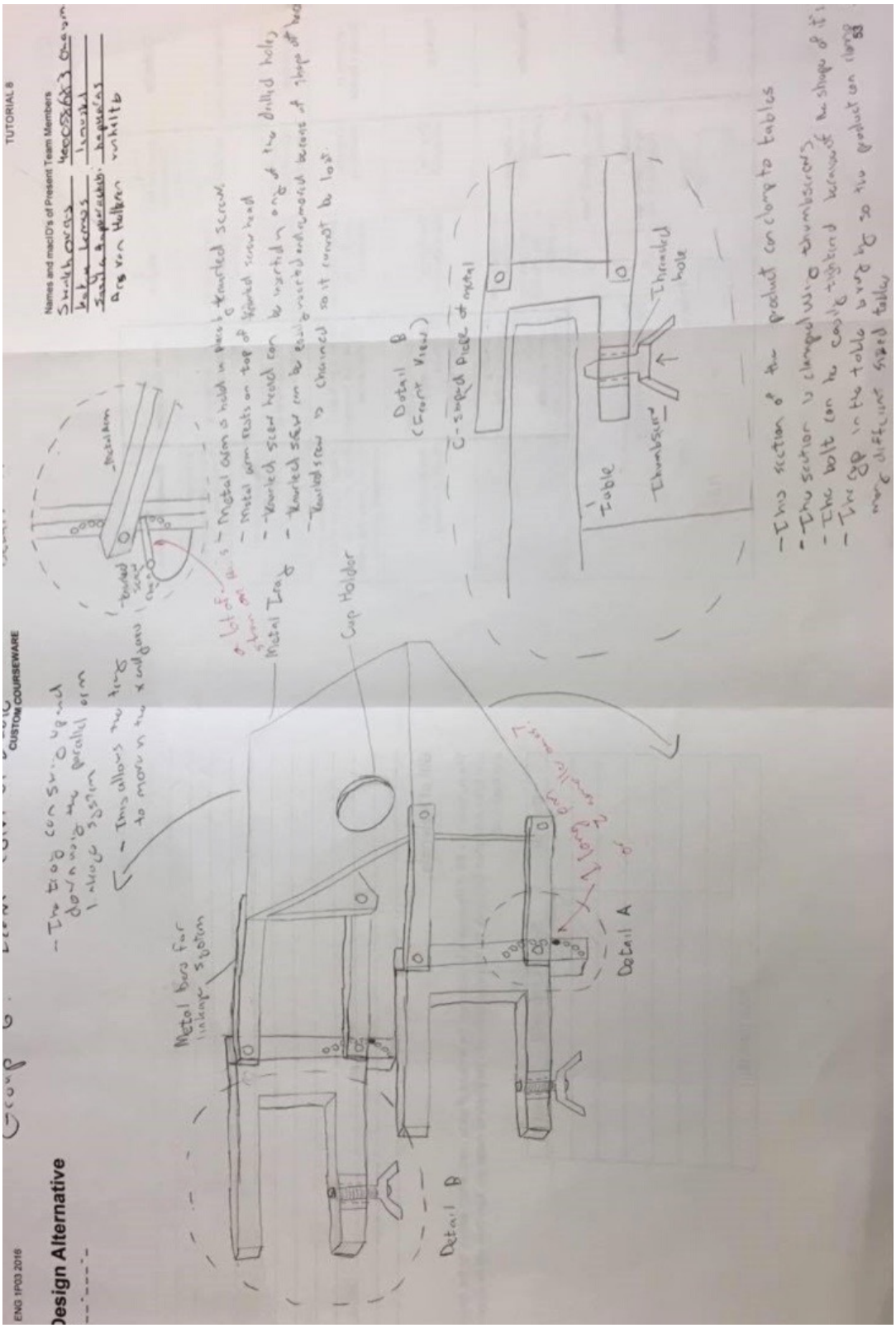
Figure 2 - Secondary Alternatives (conceptual)



The diagram above shows our secondary conceptual prototype design. It is a tray with a parallel pivot system that clamps onto a table for easy meal times for people in wheelchairs.

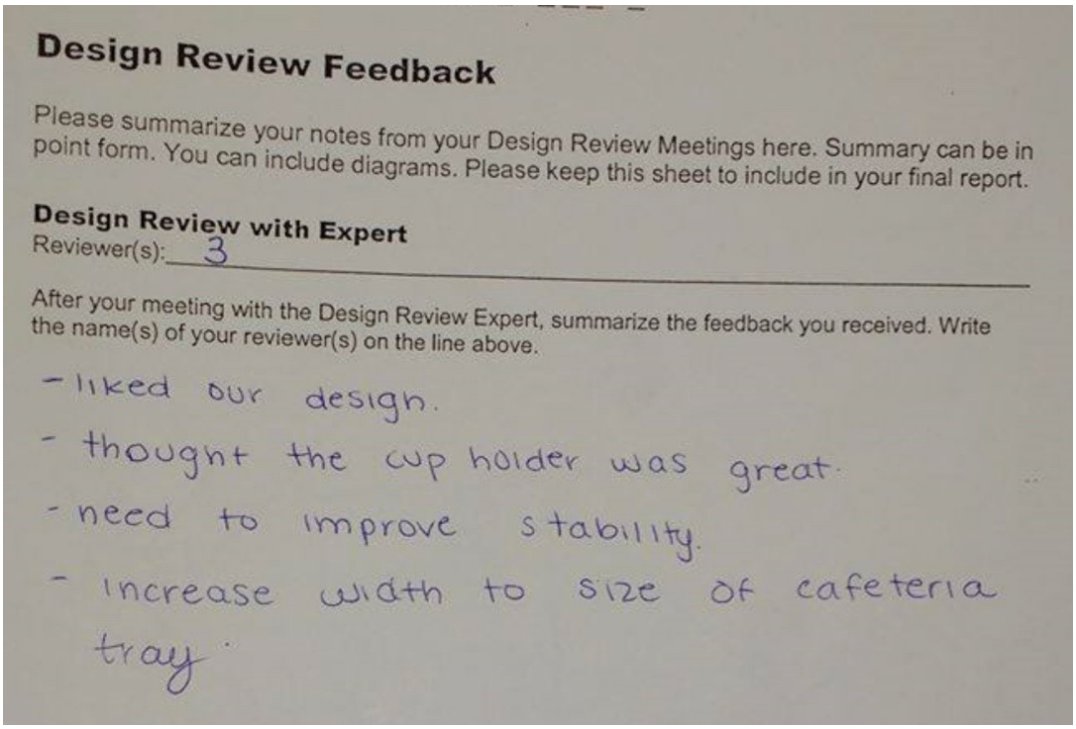
Figure 3 - Final Design

Figure 4 - Final Design (conceptual)



Appendix C

Figure 1 - Tutorial 10 Design Review



Design Review Feedback

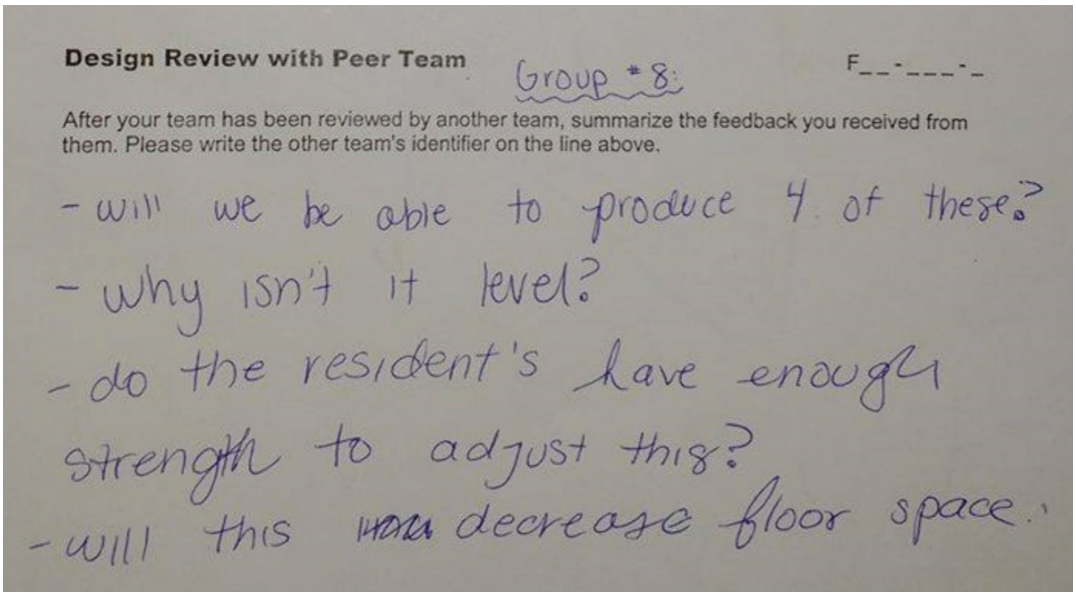
Please summarize your notes from your Design Review Meetings here. Summary can be in point form. You can include diagrams. Please keep this sheet to include in your final report.

Design Review with Expert

Reviewer(s): 3

After your meeting with the Design Review Expert, summarize the feedback you received. Write the name(s) of your reviewer(s) on the line above.

- liked our design.
- thought the cup holder was great.
- need to improve stability.
- increase width to size of cafeteria tray.



Design Review with Peer Team Group #8: F__-___-_

After your team has been reviewed by another team, summarize the feedback you received from them. Please write the other team's identifier on the line above.

- will we be able to produce 4 of these?
- why isn't it level?
- do the resident's have enough strength to adjust this?
- will this decrease floor space.