SecuriTray

For stroke survivors and others having only the use of one hand

Client: Ms. Edie Babbitt
Rehabilitation Institute of Chicago (RIC) / Archeworks

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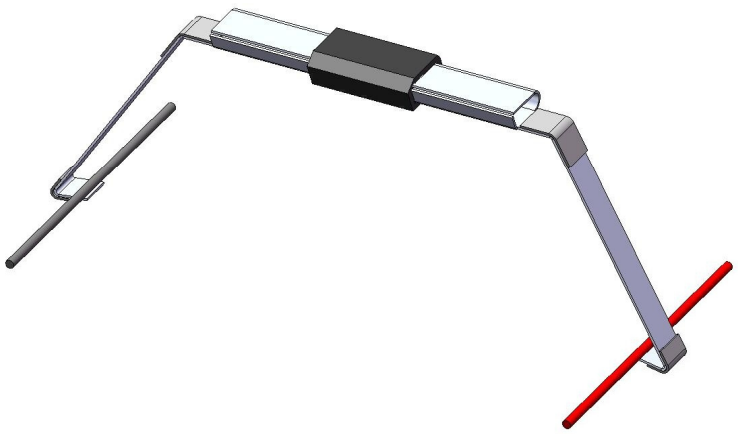

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Table of Contents

List of Figures

List of Tables

Executive Summary

SecuriTray

The SecuriTray was designed to allow stroke survivors with limited use of one arm and with general mobility of the lower limbs to navigate the cafeteria and dining area at the Rehabilitation Institute of Chicago (RIC) with ease.

The basic problem the design addresses is the user's lack of stability when handling a tray with one hand. This problem is amplified due to most users having reduced strength in their functioning arm and an unsteady step due to limited mobility of one or both legs.

Our research narrowed the problem to three categories: self-sufficiency, steadiness, and discreetness. We found that the design must allow the user to be independent while taking advantage of the user's intact and recovering abilities. The device should not require another's assistance to be used successfully.

The primary complaint from users and the client about the current cafeteria trays is that they are too unstable and that drinks tend to spill. This problem is caused by the fact that many stroke survivors are weak in one side of their body and have difficulty balancing. As a consequence, stability of the device became a requirement in order to prevent sliding and spilling. When researching the users' reactions to such devices, we found that one of the most difficult aspects of dealing with a disability is the social barriers that exist in the environment. The device cannot attract attention and should be as invisible as possible in order to allow the user to blend in.

In light of this information, we came up with the following design: the SecuriTray.

The SecuriTray is made to add on to the existing trays at the Rehabilitation Institute of Chicago (RIC) and can be produced from relatively inexpensive parts, providing a cost effective solution. The device is a "self-energizing clamp" that fits onto the tray and increases the force with which it holds on to the tray as the weight on the tray increases. The SecuriTray also features guide wires that fit underneath the lip of the tray to keep the tray from moving back and forth. These wires are coated with a rubber surface to prevent slipping. The design features a soft, comfortable, non-slip handle. A non-slip mat, specifically shaped to fit the trays at RIC, is also part of the package.

These features combine to create a device that is very stable when controlled with only one hand. Once the user knows how to use to the SecuriTray, it is easily attached and detached from the tray. The centered handle and the non-slip mat combine to provide stability while the tray is in motion. The non-slip mat makes it difficult to tip or spill a cup in unexpected situations. Finally, the device is small, containing minimal parts, which addresses the user's desire for a discreet device. The SecuriTray is a simple solution that seamlessly meets several user needs and requirements in a single device.

Introduction

For this project, the client needed a device that would allow stroke survivors with limited use of one arm, and with general mobility of the lower limbs, to obtain, pay for, and enjoy a meal at the cafeteria and dining area at the Rehabilitation Institute of Chicago (RIC) with ease (see Appendix A for project definition). Although these users are able to walk, they still have some degree of difficulty moving smoothly and balancing – especially when carrying a cafeteria tray. Most importantly, the affected arm often lacks the strength and dexterity required to carry a typical cafeteria tray with one hand. These issues make carrying and balancing a cafeteria tray problematic in any environment. RIC currently does not have a cost-effective solution to this problem.

At present, RIC staff members assist stroke survivors in the cafeteria when necessary. Cafeteria workers carry the trays for the stroke survivors and take the food to the dining area for them. However, this presents several problems. First, this solution is expensive, requiring RIC to hire additional workers or risk distracting workers from their primary cafeteria roles. Second, it may be embarrassing for stroke survivors to have to ask for help. The client stated that some survivors choose lightweight, packaged foods or even avoid eating in the cafeteria in order to escape having to depend on the assistance of cafeteria staff. Perhaps the most significant issue is that cafeteria assistance makes it difficult for rehabilitation to extend throughout all aspects of a stroke survivor's life. Ideally, a stroke survivor should be able to be independent in the cafeteria in order to further his or her path to regaining functions lost after a stroke.

The proposed SecuriTray gives users this independence. It allows for stable and comfortable one-handed use and control of the RIC cafeteria tray (as well as other trays of similar shape and size). The design prevents spilling drinks and dropping food items by means of a nonslip surface. It does not require that the current trays be replaced, which maintains cost-effectiveness and simplicity. SecuriTray can be hung on the wall by the trays, allowing for easy access and space-effectiveness. The handles also fit into each other, further compacting Securitray's volume when stored.

This report discusses how our design addresses the difficulties that stroke survivors have in the RIC cafeteria. We explain our process for evaluating the users' needs and how each stage of iterative design attempts to meet those needs. Finally, we present possible next steps for developing the design further in order to help it achieve its full potential.

Design Concept

Overview of the Design

The SecuriTray (Figure 1) is designed to allow persons without the use of one of their hands but with walking mobility to manipulate a tray in the Rehabilitation Institute of

Chicago's (RIC) cafeteria. It can be added to existing trays at the RIC and can be made from relatively inexpensive parts, providing a cost effective solution. It is designed to address three problems – food slipping, difficulty in stabilizing the tray, and drinks spilling.

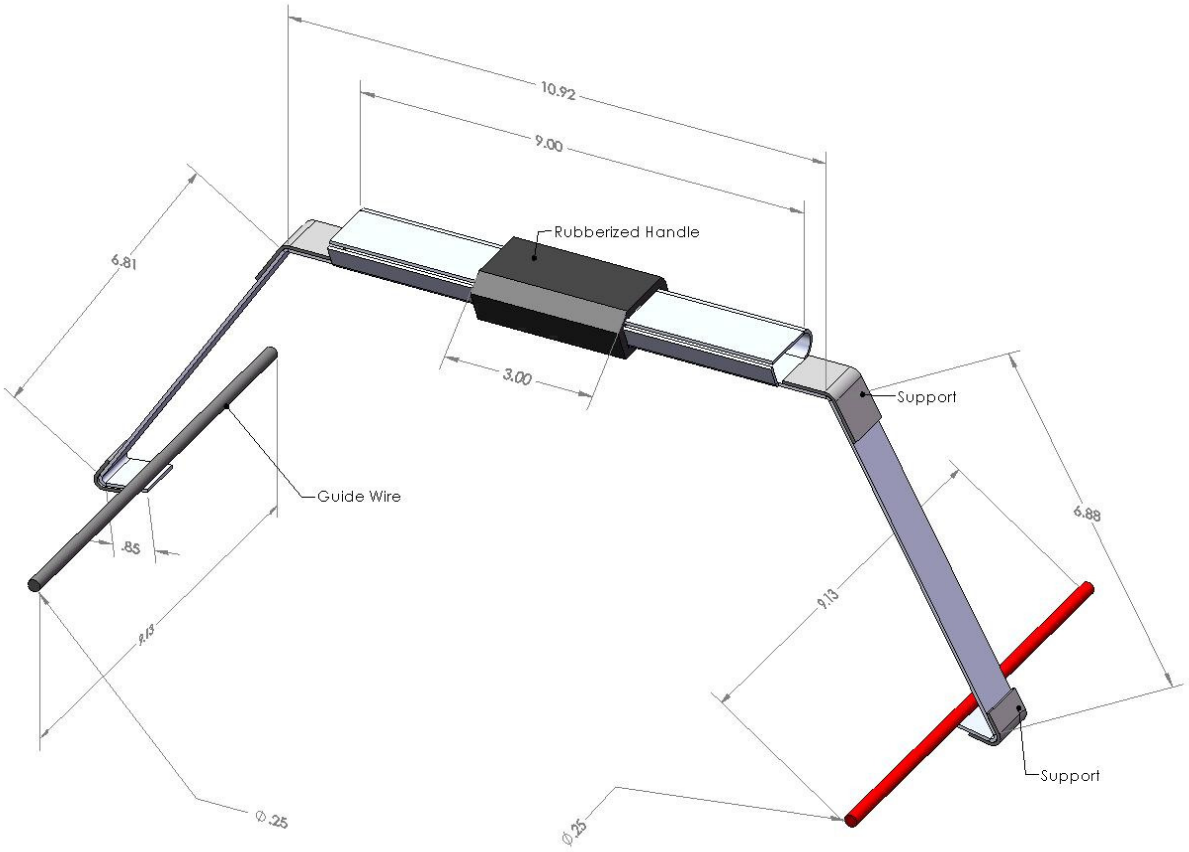

Figure 1: Overview of SecuriTray

It was concluded that one of the reasons that holding the tray was so difficult with one hand was that there was only one point to support the tray. As Figure 2 demonstrates, the SecuriTray addresses this issue by clipping on to two sides of the tray, supporting the tray from two ends rather than one. This lends to greater tray stability. The SecuriTray is a self energizing clamp which securely holds the handle to the tray. The SecuriTray also has a soft, comfortable, non-slip handle. The SecuriTray features guide wires that fit underneath the lip of the tray to keep the device from sliding out of position. A non-slip mat, specifically shaped to fit the trays at RIC, is also part of the package.

The SecuriTray can be easily stored in the RIC cafeteria. Its trapezoidal shape lends to stacking and its legs allow it to be balanced on rods. The device can be placed by the trays so that it is easy to access. Overall, the device costs under $4 in materials to construct with the accompanying mat adding just $5 more. A full cost analysis can be found in Appendix K.

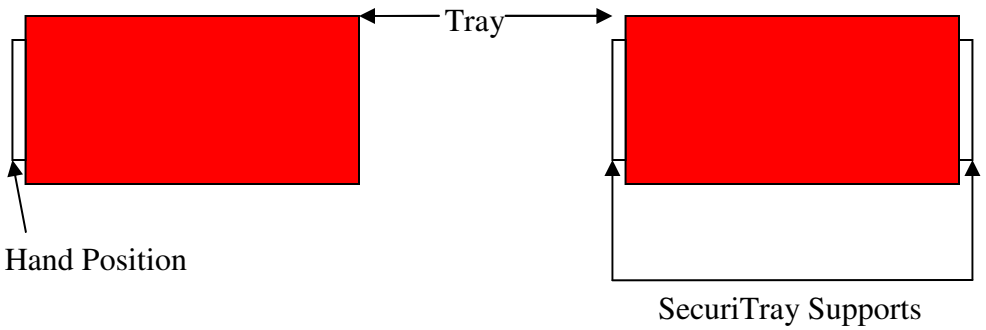

Figure 2: Tray Support: One hand vs. SecuriTray

Features

"Self-Energizing" Clamp

The handle acts as a self-energizing clamp. It is made of a combination of 3003 and 5052 aluminum which act like a spring. The handle is intentionally made 7.10 inches shorter than the tray and the legs are angled approximately 59° so that when the device is stretched to fit the tray, it pushes inward on the tray. The ends of the device are bent inward so that the device can hook into the lip of the tray. As seen in Figure 3, when weight is added to the tray, the tray pushes the legs outward and the device has an increased reaction force (R_f), increasing the tendency to push inward. Testing has shown that the handle can support the weight of the tray and an eight lb. McMaster Carr catalog.

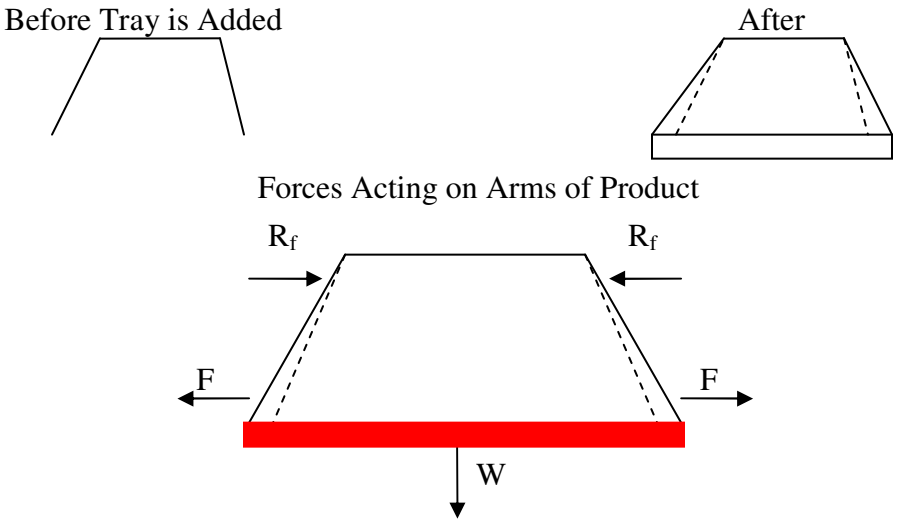

Figure 3: Illustration of the Self-Energizing Concept

Guide Wires

The guide wires fit in the lip formed on the outer edge of the tray, as demonstrated in Figure 4. They are made of Aluminum and have a diameter of .25 inches. The guide wires have a length of 9.1 inches so that they run along the short edge of the tray. They have been coated with a special rubber coating called Plastidip that prevents the tray from slipping on the wires. This helps keep the tray in place. The guide wires are specifically designed for the trays at the Rehabilitation Institute; however, they can be constructed to fit other trays.

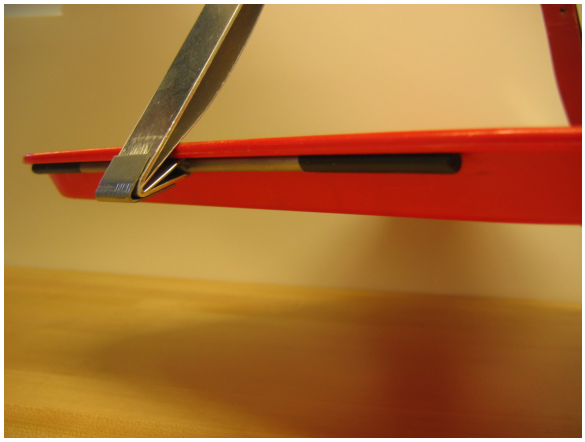

Figure 4: Guide Wire Fitting into RIC Tray

Non-Slip Mat

The non-slip mat is a flat neoprene surface that is intended increase the grip of the tray. It is also supposed to resolve the issue with food slipping and drinks spilling. It's 17.7 by 13.8 inches dimensions are shaped to fit the trays at the Rehabilitation Institute of Chicago, though mats can be shaped for various trays. Informal tests show it takes a 30° angle to cause a filled plastic soda bottle to slip. Figure 4 is a demonstration of the advantage of the mat over the tray by itself. The angles in Figure 5 are the angle before the drink began to slip.

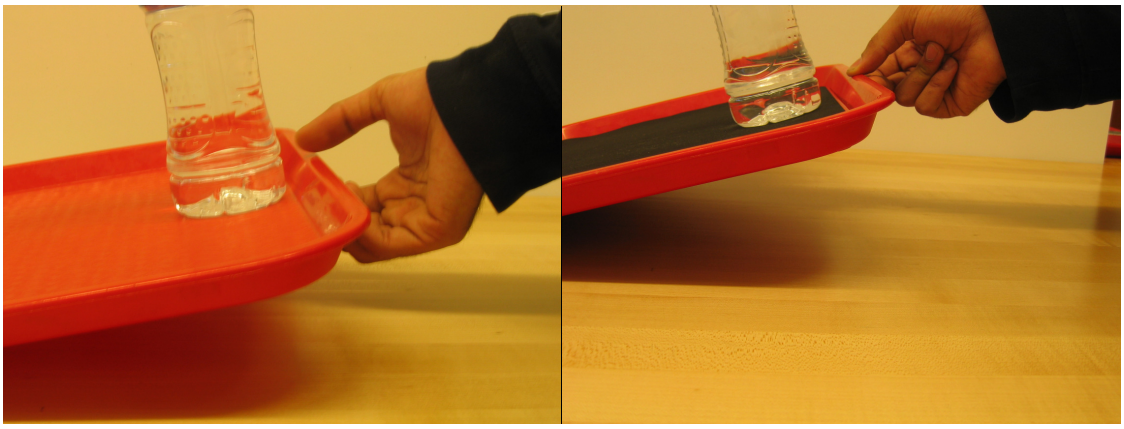

Figure 5: Demonstration of Non-Slip Mat

Methods

We gathered background information about the effects of stroke, safety issues, user and client preferences, and previous attempts to design a device similar to ours from the following sources:

Web research: The *Assistive Technology Journal* and the Functional Solutions catalog present a large number of competitive and model products and their descriptions. WebMD and the Centers for Disease Control discuss materials to for building a device of this kind. (See References.)

Electronic Database: *Microsoft Encarta* provided several articles discussing the effects of stroke and other conditions resulting in the use of only one hand. (See References.)

Text: *The Merck Manual* details the physiological and psychological effects of stroke. (See References.)

Client meeting: On January 8, 2007, we met with Ms. Edie Babbitt from the Rehabilitation Institute of Chicago (RIC). (See Appendix B.)

User observation: On January 17, 2007, we observed two users (one affected by stroke on the left side and the other affected on the right side) at the RIC cafeteria. (See Appendix C.)

Collaborative research with other student groups in our class:

- Group 11-1: The United States Patent and Trademark Office provided two pertinent products to be studied further for ideas. (See References.)
- Group 11-2: Ability Answers sells a competitive product, the One Handed Tray with Fold Down Handle. (See References.)
- Group 11-4: The Disabled Living Foundation of England provides information about adapting to the effects of stroke in a household setting. Nauticalia also sells a model product intended for a different user group. (See References.)

Findings

Physiological/Psychological limitations:

Visual: Stroke survivors may have a reduced peripheral field of vision. Diabetes, a contributing factor to stroke, may also lead to poor vision. Therefore, the device cannot require the manipulation of small, invisible parts.

Cognitive Abilities: Memory, thinking, learning, and attention may be impaired after stroke. The device must be simple and intuitive and require little mental effort. Also, the

user may be affected by aphasia, or "the inability to express oneself through speech or writing" (*Microsoft Encarta Reference Library 2004 DVD Plus)*.

Balance: Dizziness may be a problem for those affected by stroke, in addition to weakness in one side of the body. These issues present difficulty for maintaining balance; consequently, the device must be stable.

Social: The support of family members and friends is crucial for stroke rehabilitation. As a result, the device should not alienate the user but allow him or her to easily sit at the same table as unimpaired persons. This is a functional limitation in that the device should not physically impede a typical seating arrangement. This is also a psychological limitation in the sense that the device cannot broadcast the individual's handicap.

Psychological: Stroke may result in depression and anger or frustration. Survivors often are upset by their inability to perform tasks that were easy or automatic before the stroke (*The Merck Manual of Medical Information: Second Home Edition*). The device needs to feel intuitive and allow the user to be successful at the targeted task.

Strength: If people lose mobility in half of their body, the other half, while usable, may still be weakened. The total weight of the device and food stressing the user should be around two pounds. (Appendix B.) Users can be classified in three categories: (1) Those who recently had a stroke and cannot eat without assistance, (2) those who have recovered some function but still rely on a walker or wheelchair for mobility, and (3) those who are able to move on their own but still have some difficulty balancing and carrying objects with one hand. This third group would benefit most from an assistive device because their physical limitations are fewest and are most easily augmented to achieve "normal" function.

User Preferences:

Discreetness: Users want a design that does not look "handicapped." In other words, it should not stand out and draw attention to the user's disability (Appendix B.)

Stability: The users are primarily concerned with spilling drinks, so the design must address this issue. Also, other food items should secure from slipping. (Appendix C.)

Client Preferences:

Independence: The client wants a design that will allow users to be independent in the cafeteria; in effect, the client would like to reduce patients' dependence on RIC staff in the cafeteria. (Appendix B.)

Universality: The design of the device should fit in many different situations, and ideally it will pertain to many different user groups. It may be a personal device (individual to the user) or common (shared by many users). (Appendix B.)

Cost Effectiveness: The device should be compatible with the existing trays in order to keep costs down. An alternative to the tray is acceptable if it is cost-effective. (Appendix B.)

Safety Concerns:

Allergens: Metals such as nickel, cobalt, and gold should be avoided because of skin interactions ("Top 10 Causes of Skin Allergy"). Latex and other rubber products are also problematic ("NIOSH/latex alert").

Cleaning: Because bleach is frequently used to clean devices quickly and efficiently, the device must be resistant to damage by bleach ("Cleaning to Control Asthma and Allergies"). The design should also be easy to clean and resistant to mildew growth.

Existing Products:

Canvas Bag: A potential user created this solution for herself. She would place the tray in the bottom of the bag and then place the food on the tray. Although this may work for one person, it proves unwieldy in crowded quarters. Also, it does not address the issue of stability and preventing spills. (Appendix B.)

Airline Trays: As a model product, these trays are designed to avoid spilling and sliding with the use of a friction surface and special "bowls" that complement each others' shapes on the tray. This loosely interlocking design minimizes open areas that promote sliding.

One Handed Tray with Fold Down Handle: This competitive product has a high friction surface to reduce spillage and a low center of gravity for stability. However, it is limited in its ability to be raised and lowered by the strength of the user. Also, it is most stable in the direction of the hinge's free motion. (Appendix D.)

One Handed Tray: This model product was designed more as a novelty for those interested in sea travel. However, it demonstrates a way in which items on a tray can remain stable despite dynamic and unstable motions. (Appendix D.)

Beanbag Tray: This model product was designed for wheelchair users (which are a potential user group for this project). The beanbag conforms to the lap so that it does not slip.

Implications for Alternatives

The research raised several important design issues that guided our generation of alternative concepts.

Self-sufficiency: RIC, as a rehabilitative institute, aims to maximize a patient's functional independence and promote his or her reintegration into a community. Therefore, the

design must allow the user to be independent while taking advantage of the user's intact and recovering abilities. The device should not require another's assistance to be successfully used.

Steadiness: The primary complaint from users and the client about the current cafeteria trays is that they are too unstable and that drinks tend to spill. This problem is magnified by the fact that many stroke survivors are weak in one side of their body and also have difficulty balancing. The design must be stable to prevent sliding and spilling.

Discreetness: One of the most difficult parts of dealing with a disability is the social barriers that exist in the environment. The device cannot attract attention and should be as invisible as possible in order to allow the user to blend in. Camouflaging and disguising the device should not be ignored as design options.

Alternatives

Concepts

Introduction

From our brainstorming session (see Appendix E), we selectively incorporated the best ideas into four alternative concepts and chose to build variations of the best two (see Appendix F). These alternatives were intended to answer the following questions:

1. How will the user hold the device?
   The user must be able to use the device with only one hand. The two mockups presented the user with different methods of controlling the device.

2. Will the device be balanced and stable?
   Each mockup addressed the issue of stability with a different mechanism.

3. How will the device hold drinks and prevent them from spilling?
   We created several styles of cup holders to mix and match with each mockup during testing to find the optimal solution.

4. How will the device hold food in place?
   As with the cup holders, we mixed and matched three surfaces of varying degrees of grip with each mockup to find the best option.

5. Is the device as discreet as possible for use in social situations?
   The two concepts had different levels of discreetness and different methods of camouflage to test this requirement's importance to users.

6. How will the device be stored?
   Varying methods of compacting the device addressed the issue of feasible storage.

7. Will the device be comfortable?
   We used different materials and attachment methods for each mockup to make the apparatus as comfortable as possible for the user.

Concept Descriptions

Alternative 1 – "Handle Tray"

This concept consists of a handle, cup holder, and high friction surface attached to the tray currently used at RIC (see Appendix G, Figure 5). The cup holder is attached to the handle, and the entire apparatus clips onto the tray. The high friction surface is a rubber mat that the user places on the tray. When the user wants to remove the handle, he or she merely unclips it from the tray. Another variation (see Appendix G, Figure 6) allows the handle to fold down into the tray.

This alternative was designed to answer these questions (as well as the ones in the introduction):

- Is the folding handle sturdy?
- What is an optimal design for the shape and thickness of the handle?
- Where should the cup holder be placed for optimal balance?
- Is this concept a feasible solution for users with canes or walkers?
- Can the user lift and lower the device with ease?

Alternative 2 – "Strapped Arm Support (SAS)"

This concept is a flat surface with a lip that allows the user to support a cafeteria tray with the weakened arm (See Appendix G, Figure 7). The surface attaches to the arms with tightening Velcro straps, which are also easily removed. An edge on the side prevents the tray from falling off the support, and a rubber mat on the surface grips the tray. Another rubber mat is also placed on the tray for holding drinks and food items in place.

This alternative was designed to answer these questions (as well as the ones in the introduction):

- Do different surface lengths provide a better fit for each user?
- Do different surface lengths affect the stability of the supported tray?
- What proportions of the user group have enough strength to support the tray using SAS?
- Do the users value discreetness over stability?

Testing

In the first phase of testing, we examined a number of variations to our alternatives over two days of testing. In phase two of testing we focused on improving our primary design.

Methods
Our first day of testing took place in the lobby of the Ford building on February 3, 2007. We had one user evaluate the feasibility of two variations of two alternatives: the Fold Down Handle Tray with rope handles, Fold Down Handle Tray with metal handle, Strapped Arm Support short, and Strapped Arm Support long. The user also compared the relative strengths and weaknesses of each design. We also tested the cup holders and the position of the cup holders. Since we were not in a cafeteria, we simulated one with tables and asked the user to perform several tasks (see Appendices H and I). For food we used a bag of potato chips and Pop Tarts, and we used a cup filled with water to evaluate the cup holder. We asked the user to first put on the device and to judge its ease and stability. Next we asked them to get a drink and to use the cup holder. The user then simulated taking an entrée and proceeded to pay for the food. Finally, we asked the user to find a seat and to sit down with the food. A summary of findings for Day 1 can be found in Table 1.

We also conducted a second day of testing with three users at the Rehabilitation Institute of Chicago on February 8, 2007. These tests were designed to evaluate the feasibility of two alternatives, the Fold Down Handle Tray and Strapped Arm Support, and also to compare the relative strengths and weaknesses of each design. Due to time constraints (having to share the users with other groups), we were only able to perform one round of testing with each user. We asked the users to simulate the entire process of obtaining and eating a full meal at the RIC cafeteria (see Appendices H and I). We asked the users to first put on the device and to judge their ability to understand the design and its stability. Next we asked them to get a drink and to use the cup holder. Then we asked them to simulate taking an entrée and to proceed to pay for the food. Finally, we asked the users to find a seat and sit down with the food. A summary of the day's findings can be found in Table 2.

These tasks allowed us to:

- Determine overall suitability of the alternatives to the average user
- Narrow the user group for our potential final design
- Determine the best way to carry the food
- Observe how easily users were able to understand and put on the device
- Determine the proper size, shape, and height for a cup holder
- Determine the best high friction surface
- Observe the tray's balance while in motion
- Determine how easily the user could maneuver each mockup

Findings

Table 1: Day 1 Key Findings

Model	Users' Comments	Users' Suggestions
Fold Down Handle Tray (bungee cord)	Handles do not lend stability	Make handles wider
Fold Down Handle Tray (Wire)	Did not like at all, was too unstable	
Strapped Arm Support (Long)	More stable than short version	
Strapped Arm Support (Short)	Difficult to use for people with stroke	Simplify strap system

Table 2: Day 2 Key Findings

Model	Users' Comments	Users' Suggestions
Fold Down Handle Tray (foamcore)	Difficult to reach food because handle is in the way Handle uncomfortable and unstable Tray feels unstable	Handle needs to be able to fold down Make handle thicker, add a grip Control tray against body
Strapped Arm Support (Short)	Rubber surface helped to stabilize tray Device is uncomfortable: thumb works better Needs to frequently adjust support Straps come out of slots	Secure straps so they will not slide out of loops

See Appendix I for full summary of findings.

Evaluation

Based on user test results from Phase 1, we decided to focus on the fold-down handle tray design, or at least a solution using some form of handle attached to a tray. The decision matrix (Table 3) and the discussion following it show how we arrived at that decision.

Table 3: Decision Matrix

	User Testing 1 (Feb. 3)			User Testing 2 (Feb. 8)	
	Fold-Down Handle (wire)	Fold-Down Handle (bungee cord)	Strapped Arm Support (short)	Fold-Down Handle (foamcore)	Strapped Arm Support (short)
Easy to figure out use	-	+	+	+	+
Accessibility of cup holder	N/A	+	N/A	+	N/A
Balance of tray with drink	N/A	-	N/A	+	N/A
Fit of cup holder	N/A	-	N/A	+	N/A
Maintain balance with food	-	+	++	+	-
Easy to pay	-	-	+	+	N/A
Easy to pick up tray after paying	-	+	++	+	N/A
Maneuver through busy hallway	-	+	++	+	-
Navigate around tables and chairs	N/A	N/A	N/A	+	N/A
Put tray down on table	-	N/A	++	++	N/A
Balance while raising/lowering tray	-	N/A	++	++	N/A
TOTAL	7-	2+	12+	13+	1+

KEY
- \- = does not satisfy criterion
- \+ = satisfies criterion
- ++ = satisfies criterion extremely well
- N/A = Not Applicable (or did not get to test)

In our first user testing, the short version of Strapped Arm Support had a much higher total score than the other two options for trays with handles (12 to 2 and -7). However, the user had significant mobility and strength in the weakened arm, and is therefore not the typical user that would be in our target group.

In the second user testing, the fold-down handle tray had a higher total score than the short version of Strapped Arm Support (13 to 1). In addition, the fold-down handle tray is easier to both balance the food and navigate the tray throughout the cafeteria.

The users provided useful suggestions that eventually enabled us to improve the design of the fold-down handle tray in the aspects of flexibility of the cup holder and ease of eating with the tray. These suggestions included expanding the cup holder and possibly allowing it to fit drinks of various shapes and sizes and making the handle either fold-down or clip-on.

The fold-down handle tray design allowed us to target a specific user group: those who are mobile but have limited use of one arm. Narrowing down our user group enabled us to better assist these users with the operation of a cafeteria tray and to allow them to regain independence in a cafeteria setting.

Testing (Second Phase)

Methods

In the second phase of testing we focused on examining the differences between two variations of a tray controlled by a handle: one with a folding handle and another using a detachable handle

Our third and final day of testing took place in a conference room at the Ford building on February 17, 2007. One user tested the SecuriTray and the cup holder on the Fold-down Handle Tray. We asked the user to give us her immediate impressions of the devices, followed by her independent attempts to operate them. When needed, we provided assistance in the form of information about the operation of the device. Again, since we were not in a cafeteria, we simulated one with tables and asked the user to perform several tasks (see Appendices H and I). For food we used a bag of potato chips and Pop Tarts. A cup filled with water was used to evaluate the cup holder. We asked the user to first put on the device and to judge its ease and stability. Next she selected a drink and used the cup holder. We then asked her to simulate taking an entrée and then proceed to pay for the food. Finally, we directed the user to find a seat and sit down with the food. A summary of the findings can be found in Table 4.

Findings

Table 4: Day 3 Key Findings

Model	Users' Comments	Users' Suggestions	Our Suggestions
SecuriTray	Cup holder outside edge of tray will interfere Handle moves when set tray down, no longer centered Feels stable Cannot figure out how to take handle off tray	Place cup holder on tray Perhaps cup holder is unnecessary Provide instructions, or tell someone competent in cafeteria how it works Make the edges not sharp	Make the height of the folded section of metal the same as the height of the tray – everything lies flush with the table when set down
Fold-down Handle Tray (cup holder)	Handle needs to be over cup holder Rubber rim is easy to use compared to cardboard cup holders		Find a way to place cup holder on the tray without obstructing it

See Appendix I for full summary of findings.

Evaluation

This round of user testing confirmed our proposed design direction. We chose to focus on the SecuriTray design, utilizing a detachable handle, a nonskid surface, and the current RIC cafeteria tray. Several design problems still needed to be addressed, but the SecuriTray proved to be a functional and feasible solution for our intended user group.

General points that the user testing addressed include the following:

1. User will hold the device with a handle that clips onto the tray
2. Device is balanced by built-in supports on the handle
3. A cup holder is not necessary to hold drinks; the device is stable enough to prevent them from spilling
4. A nonskid surface will hold food in place

5. The device is discreet because it does not protrude past the length and width of the tray
6. The device will likely be stored on a shelf or on hooks by the current trays; they may be designed so they can stack on top of one another
7. A rubber handle addresses the issue of comfort – ideal size has yet to be determined

Lab Testing

Test 1
Methods

This test was conducted to choose a rubber mat that would best meet the users' needs.

We tested the ability of each of the nonskid surfaces (rubber mats) to keep a block of wood (3" x 6") in place on the RIC cafeteria tray as the tray was tilted. We measured the angle at which the wood block began to slip downwards. The results are summarized in Table 5.

Findings

Table 5: Rubber Slip-Angle Testing

Rubber mat type	Angle
Pillows	43.85
Flat	42.65
Honeycomb	43.45

Evaluation

From the results of the lab testing, we concluded that all three mats provide similar levels of grip. However, from a practical viewpoint, the flat rubber mat is the best choice. This is because it has no crevices or openings in which food can be caught. Also, its simplicity contributes to a high level of durability.

Test 2
Methods

We wished to test the durability of the final product. We put the heaviest object we could find (that would fit) on the tray. The item we used was a McMaster Carr catalog. The device was then attached to the tray and the tray was lifted up. Afterwards, we found the weight of the catalog, which was 8 lbs.

Findings
The test found that our product was able to securely support the catalog without substantial warping. Ironically, the tray was all that bent under the weight of the catalog.

Evaluation
The device is able to easily support 8 lbs of weight on the tray. This is significantly larger than the weight of a typical meal. The handle is more than strong enough for a meal at the RIC cafeteria.

Next Steps

The SecuriTray with rubber mat has proven itself to be effective through both lab and user testings. The device is easy to attach and provides good stability and balance. The apparatus is also cost-effective and simple enough that it is feasible for RIC to stock it.

Nonetheless, the design reviews by show that the device could use further development in the following areas:

User Friendliness

The device is not intuitive to use, and can cause food or drinks to spill or fall off the tray if not used properly. Questions to investigate include:

Can the proper usage of the device be made clearer?
Can the design guide the user to prevent mishandling of the device?

Durability

The device is held in place by the spring force of the aluminum bars, which may lose their tension over time. Questions in this category include:

Can the corners of the device be prevented from bending without complicating the device?
Would a different material better hold the shape of the device while still allowing the arms to flex?

Attaching a Cupholder

Although the current device is functional without a cupholder, it would still benefit some users to have one. Attaching this cupholder may create difficulties in maintaining the basic functionality of the device.

What kind of cupholder should be used?
Where can the cupholder be placed on the device?
Can the cupholder be connected to the device?

Manufacturing the Device

The current device relies on customized parts that may not be commonly available in its construction, such as the filler rods, plastidip, and foam handle. It is also built to fit only the RIC tray, and works for trays that very slightly from the size of the RIC tray.

Can the components of the device be standardized for easier mass production?
Could a single Securitray work on trays of a range of sizes?

This device does an excellent job of addressing the problem for the specified user group (stroke survivors with mobility of the legs but limited use of one arm). However, we believe that it could be easier to use, more intuitive, and more durable. This warrants further development to polish the current design in order to maximize its user friendliness.

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Appendix A – Project Definition

Project name: One-Handed Cafeteria Tray

Client: Ms. Edie Babbitt, RIC - Archeworks

Team members: Ankur Bakshi, Jean Chia, Mathew Lowes, Alexander Sheu

Date: February 11, 2007

Version: Four

Mission Statement: Design a device that will allow stroke survivors to obtain food and drink, pay, and dine with ease in a cafeteria. The targeted users are those with general mobility but limited use of one arm.

Constraints

- Have final prototype on March 6, 2006.

Users and Stakeholders

- Stroke survivors with restricted use of one arm
- Others with restricted use of one side of their body
- Caregivers and family members of end users
- Cafeteria staff, including those responsible for cleaning and distributing the product
- Other RIC or Northwestern Memorial Hospital patrons
- RIC – Archeworks

Requirements/Needs		**Specifications**
<u>Safety</u> • Hot liquids must not spill • Device should be non-allergenic • Device should not interfere with medical equipment • Device must not harm the user in any way		• Device must have no components, such as magnets, that would interfere with medical equipment • Material is not to exceed 30°C regardless of temperature of carried food and/or drinks • Device does not have areas where fingers or other body parts can be caught
<u>Comfort</u> • Device is comfortable to use • Device can be worn for an extended period of time, up to 10 minutes • User does not feel embarrassed using device	{	• Device must weigh less than 2 pounds with load (food and drink) • Device must not irritate skin (indicated by redness) • User does not complain of excess pressure
Ease of Operation • Device is simple, quick, and convenient • Device must be adaptable to other cafeterias	{	• A user must be able to put on the device in less than 20 seconds (in a busy cafeteria, people will not want to wait for extended periods of time for user to set up device) • On first attempt, the user must be able to understand how to use the device with less than 1 minute of instruction

<u>Stability and Balance</u> • Device must have a way to secure drinks in order to prevent spills • Items should not slip • Device must be easy to maneuver in crowded areas • Device must be stable	}	• The device should must be able to prevent plates and cups from slipping at up to 20° of rotation (past 20°, full cup will spill) • Device should not protrude more than 2 feet in any direction from point of interaction with user
<u>Maintenance</u> • Device should be easy to clean • Device should not collect food in hard to clean areas	}	• Device must be cleanable using standard methods, such as a dishwasher or washing machine OR device must require minimal cleaning
<u>Storage</u> • Device should be easy to store • Device should be easy to extract from storage • Device should be easy to return	}	• Device needs to collapse or fold into a size both concealable and easy to move by user, less than 2’ x 2’ x 6” • Device needs to be able to be stored or removed from storage in less than 20 seconds by one person with no additional tools (in addition to 20 seconds to prepare for use). • Device should be stored within 10 feet of cafeteria trays

Appendix B – Client Interview

Date of Interview: January 8, 2007
Time of Interview: 6:00 – 7:00 PM
Client: Ms. Babbitt, Edie
Location of Interview: Ford Motor Company Engineering Design Center, Room G201
Attendees: Entire team (Alex, Ankur, Jean, Mat)
Project Name: One-Handed Cafeteria Tray

This appendix contains the responses from the client interview on January 8, 2007. The purpose of the interview was to define the design problem and learn about the needs and requirements of the user. Questions regarding the problems with the usage of the current cafeteria tray at RIC were addressed. The client elaborated on certain requirements and features that needed to be taken into consideration. General information was given about the present conditions of the trays, as well as the cafeteria environment.

I. Problems with current cafeteria tray
   a. Targeted towards stroke survivors or people with the loss of use of one hand
   b. Moving within the cafeteria while balancing a tray is the main problem
   c. Goal: independence in the cafeteria
   d. Current solution
      i. Staff at RIC help carry trays to tables
      ii. There often aren't enough staff to carry all of the trays
      iii. Some individuals refuse to be helped
   e. Negative consequences arise from these problems
      i. People do not buy, and consequently, eat, as much as they used to
      ii. People do not buy drinks
      iii. People would rather choose to skip meals

II. Considerations, requirements, features, constraints, and other designs
   a. Looking for a design that is universal
      i. A design that can fit in many different situations
      ii. Broader appeal if it pertains to more user groups
      iii. May either market as personal for individual's use or common (i.e. supplied in cafeteria)
   b. If people lose mobility in half of their body, the other half of the body may also be weak
      i. A belt or sling is a possibility if there is use of a shoulder
      ii. Approximate weight of two pounds
   c. People tend to grasp trays at the edges because they cannot get their hands under the tray
   d. Trays must be stable; many people have balance problems
   e. Many people have walkers, canes (approximately 25%), or wheelchairs
   f. Ideally want something already available
      i. A design that can be attached or used with existing trays

ii. Keep costs down
iii. Redesigning of tray is acceptable if it is cost-effective

g. Aesthetics - do not want it to look “handicapped”

III. General Information
a. Trays are standard solid trays (plastic or thick cardboard)
b. Trays are stacked by garbage for staff to collect
c. Disposable plastic utensils, Styrofoam plates, etc. are used
d. Standard metal ledges to place and slide trays
e. Diets vary significantly among patients
f. Cafeteria is crowded at mealtimes
g. Some patients devise their own methods
i. One woman placed food in a large canvas bag and carried the bag by the handles
ii. Some people use the baskets on wheelchairs

IV. Observations and visiting RIC
a. Shadowing is permitted
i. Obtain contact information of users
ii. Perhaps interview the woman who devised the canvas bag solution
b. Cafeteria is open 7 a.m. – 8 p.m. and weekends
c. Groups for stroke and aphasia meet Tuesday and Thursday afternoons
d. Schedule observations on Martin Luther King Jr. Day (January 15)

Appendix C – User Observation Data

Introduction

User observations were conducted on Monday, January 15, 2007 by Alex and Mat, while user interviews were conducted on Wednesday, January 17, 2007 by Ankur and Jean. The users were observed following a set observation plan which divided the task into two parts, when the user is in the cafeteria and when the user is in the dining hall. The interviews were conducted with two potential users and were organized by Ms. Babbitt. The goal of the interviews and observations was to get an idea of the features necessary for any device to properly address the problem of carrying a food with one hand.

Summary of Findings

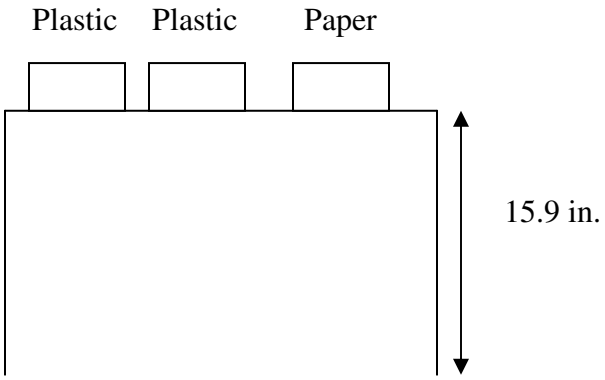
Observations	Opportunities	Follow-Up
Ledges are not connected	Make it easier to move through the cafeteria.	Connect ledges.
Users have difficulty reaching food that is placed farther away (salad bar, drink area and fruit)	Make it easier to reach objects in the back of the food holding areas.	Slide-out shelves.
User has difficulty placing drink. Drink in upright position will slide and fall. Drink lying on its side is awkward to hold and still slides.	Keep the drink in place.	Drink/cup holders or surface that prevents slipping (like that found in airplanes).
User has to stand in line at the register if the line gets too long.	Share the load of the weight to make it easier for user to hold for prolonged times.	A support structure to brace/distribute the weight.
Tables are randomly spaced, leaving few straight paths.	Remove obstructions and create more free space.	Optimize space to make it easier to navigate.
Some users are unable to return tray.	Facilitate the throwing of trash.	Move trash bins so that they are in the dining halls and out of high traffic areas.
Some users have difficulty pushing trash into the garbage can.	Simplify process of using garbage can.	Use a food pedal to open the lid/
Users have difficulty maintaining balance.	Prevent the tray from tipping over.	Tray or apparatus to keep the tray level even if user wobbles a little bit.

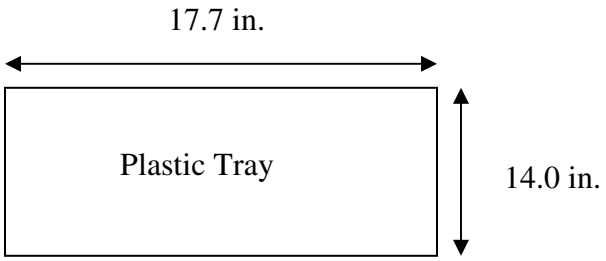
User Observations

Cafeteria in the process of purchasing food

a. User enters cafeteria
   - From cafeteria, very close
   - High traffic area (near elevator)

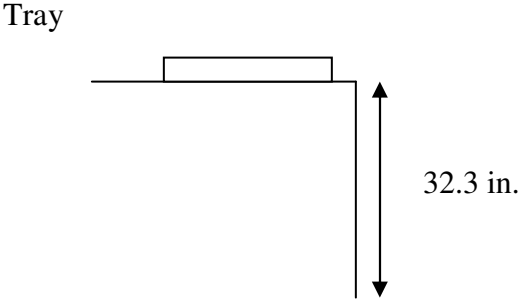
b. User obtains cafeteria tray
   - Wheelchair put in lap
   - Disposable tray has poor weight distribution, is flimsy





c. User approaches lunch line
   - Fairly openly spaced
   - Was not busy at time of observation but when it is busy it can be chaotic

d. User places tray on ledge



e. User slides tray along ledge
   - Ledges are not connected

f. User obtains food
   - Food may be higher (shoulder level) or lower (lower than knee)
   - Sections:
     1) Drinks (fountains and express)
     2) Deli
     3) Grill
     4) Entrée
     5) Salad
     6) register

g. User picks up tray (important to note how user compensates with the extra weight and the ability of the plate to slide)
   - Currently need helpers

h. User obtains drink (important to note how use compensates with the weight, the cups ability to slide and the contents ability to splash)
   - Cups have lids or bottled drinks
   - Put drink in center or put drink close to usable hand

i. User approaches register
   - Same counter height as food ledges

j. User waits in line to pay (important to note how user compensates the weight while standing still, whether tray begins slipping, etc.)
   - Register have counters for placing tray but if line is too long, no place to put tray

k. User sets down food and pays at register
   - Pay with cards

To and In Dining Hall

a. User picks up tray
   - Counter in middle with condiments
   - Takes time to put money away, get tray

b. User leaves register
   - Walk across hallway – very busy (elevators)

c. User searches for a seat
   - Tables are spaced randomly, no straight paths
   - Some chairs pushed to middle to make room for wheelchairs

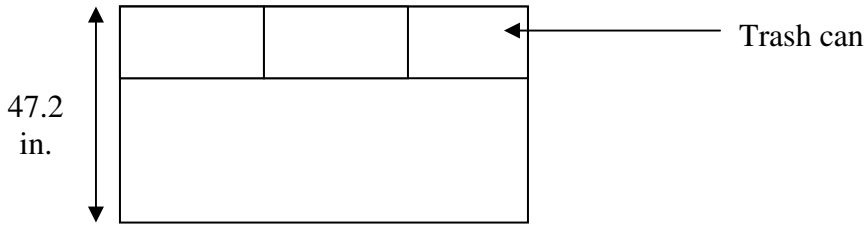
d. User places tray on table
   - Need tray above level of table

e. User eats
   - Tray needs to be usable for eating

f. User gets up and picks up tray
   - Some people in wheelchairs left food on table (they were alone)

g. User disposes of cups/plates
   - Push into bin, like fast food restaurant bins
   - Need to open lid and empty trash

h. User disposes/returns tray
   - Leave on top of trash cans

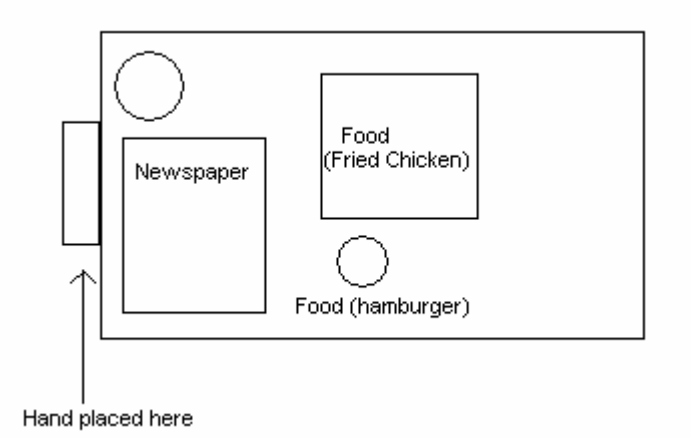


User Interview
First User: Shawn Luera

1. How old are you and when did you have your stroke?
   - 38 years old, had stroke in March of 2003
2. Which hand was your dominant hand before your stroke and which one can you use now?
   - Leftie before, can still use left hand
3. Do you eat at the RIC cafeteria often?
   - 2 times a week
4. Do you prefer to use the plastic tray or the cardboard tray? Why do you prefer one over another?
   - Plastic tray. Cardboard tray is not sturdy enough.
5. What is a typical meal?
   - A hamburger or sandwich, hot food (like fries), bottled soda or water
6. What do you have the most difficulty with when carrying your tray?
   - Walking with the tray (left foot and left hand causes bobbing)
7. What other difficulties do you experience?
   - The drinks slide off

- If drink is held upright, slips off quite easily, if drink is held on its edge, tray is awkward to hold

8. What features would you like to see in a tray or device for the tray?
    - Cup holder
9. Can you simulate a typical meal for us?
    - Gets newspaper
    - Holds tray with left hand on edge
    - Picks up hamburger and fried chicken then pudding and then brownie
    - Rests plate on counter to the right of the register, puts drink upright close to left edge, holds tray on edge



Second User: Nancy Brewer

1. How old are you?
    - 54 years old
2. Which hand was your dominant hand before your stroke and which one can you use now?
    - Left hand was dominant, stroke affected left side (uses right hand)
3. Do you eat at the RIC cafeteria often?
    - 2 times a week
4. Do you prefer to use the plastic tray or the cardboard tray? Why do you prefer one over another?
    - Has caregiver to get food, caregiver uses plastic tray
5. What is a typical meal?
    - Salad and non carbonated fountain drink
6. What features would you like to see in a tray or device for the tray?
    - Something to balance on Left Arm (arm that can not be used)
    - Cup holder useful

Appendix D – Competitive and Model Products

Product Name:	Image:
One Handed Tray with Fold Down Handle	 Source: Ability Answers (http://www.tekability.com/catalog/item218.htm)
One Handed Tray	 Source: Nauticalia (http://nauticalia.com/uk-info/our_favourites/one_handed_tray/96421.html)

Appendix E - Brainstorming

Holding food in place

1. Rubber base
2. High friction surface
3. Compartments
4. Rubber "grommets"
5. Conforming pins
6. Car cupholder arms
7. Plate built into tray
8. Sticky-tack/putty
9. Tray with cup and dish holders
10. Tray with clamps
11. Non-Tipping, Weighted Dishes
12. Tray with Pullout Holders
13. Magnetized Tray and Dishes
14. Velcro Tray and Dishes
15. Ping-pong Paddle Rubber

Transporting food with the user

1. Bank money tubes
2. Cart
3. Fat/skinny rolling cart
4. Hinged cart with swivel
5. Layered rolling tray
6. Walker tray with swivel
7. Walker tray with slide
8. Plain walker "taxi" tray

Attaching to the user

1. Vest
2. Basket
3. Utility Belt
4. Wrist Belt

Preventing drink spills

1. Separate drink carrier
2. Tupperware top (Tilt OK)
3. Movie theater carrier (i.e. the holder with drink compartments)
4. Foam-can holder that is built into tray
5. Foam-can holder that is removable from the tray
6. Have a hold in the tray to place items through
7. Have a memory foam surface on the tray
8. Camelback system-backpack with a tube/straw coming around to the front
9. Drink hat
10. Have cups with wide bases for stability

11. Beanbags for wheelchair

Allowing the user to balance with food

1. Ballast by hand position
2. Shoulder strap carry
3. Front pack/Child carrier
4. Ballpark vendor trays
5. Food that is stackable
6. Gino's clamp
7. Stabilize with gyroscopes

Allowing the user to hold the tray

1. Handle in center
2. Chin/ear Prop
3. Shoulder rest on bottom of tray
4. "Bag sides" around tray
5. Strap tray to arm
6. Velcro strap to arm
7. Glove groove
8. Handle across top
9. Strap to neck
10. Suction cup lifter
11. 3-M hooks
12. Tray that conforms to hip
13. Over-shoulder "drummer boy" harness – with locking mechanism

Raising and lowering the tray

1. Hydraulic lift
2. Telescoping legs
3. Folding legs
4. Adjustable height tray holder on user
5. Tray becomes cart – spring loaded legs
6. Roller converter
7. Magnets to align tray with surface
8. Pedal operated lifts for ledges

Trash Lid Problem

1. Button-Automated Lid
2. Sensors in trash cans
3. Foot pedal pusher
4. Detachable fabric lid
5. Open trash can—no lid
6. Lock/unlock mechanized lid
7. "Snap-out bottom" tray
8. Tray with extension arm for longer reach (limping start)

“Freestyle” solutions – eliminated due to problems of cost, feasibility, safety, etc.

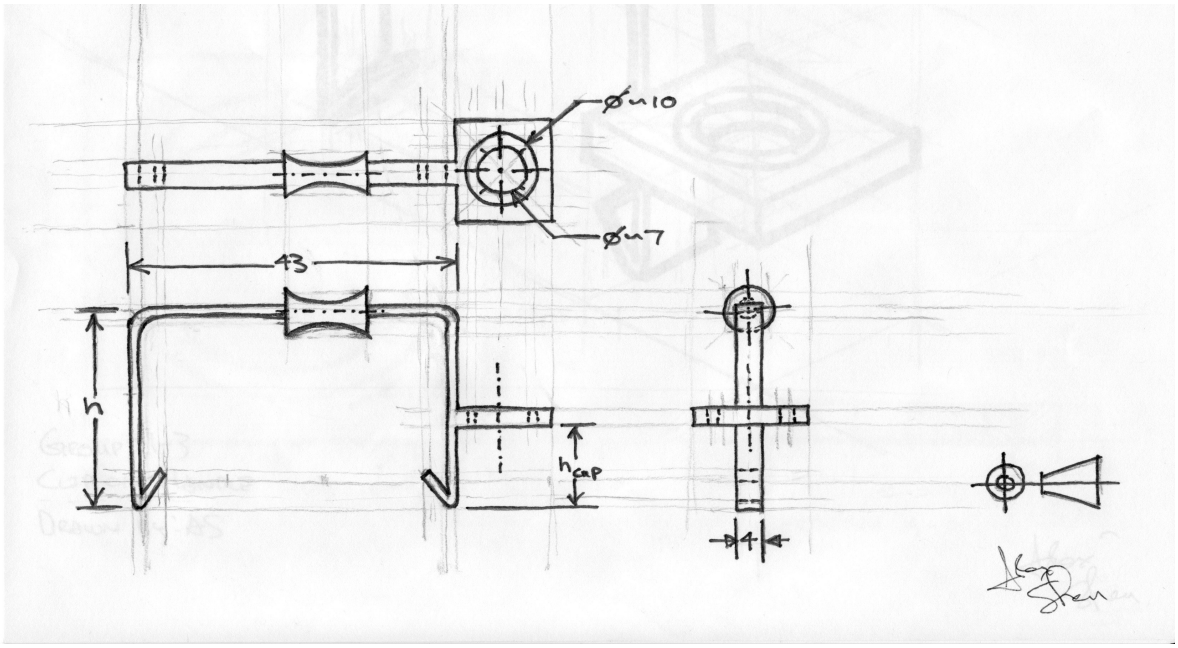
1. Gravity vortex trays
2. Dogs carry tray
3. Trained monkeys
4. Robots carry tray
5. Freeze-dried food: rehydrate at table
6. Harpoon your food/Kebab
7. Invisible assist-device-magnet
8. The Force
9. Segway
10. Food shows up on table (Star Trek)
11. Transformer tray
12. Servers
13. Jell-o / edible tray / “bread bowl” tray
14. Mind control
15. Remote/autonomous wheel chair with tray
16. Soylent green food
17. Milkshake meal
18. Lotion food
19. Meal pill
20. Wheeled tray - adjustable height (ambulance)
21. Hot air balloon tray
22. Chair lift assembly line tray
23. Drink dispensers at table
24. Magnetic field delivery system
25. ESP system (psychic tray)
26. Little person in can or dinosaur
27. Astroturf
28. Hoverboard
29. Roomba Vac carries tray
30. Duct Tape Tray/Holder
31. 2-sided tape
32. Velcro
33. Suction/vacuum tray
34. Silly Putty Bottomed Dishes
35. (Liquid) pool tray with “sailboat” dishes
36. Magnetic base on disks
37. Remote control
38. Overhead tracks support tray
39. Hovercraft tray
40. Magnetic field supports tray
41. Wi-Fi/ Radio control
42. Electric field
43. Clicker/ whistle
44. Ultrasonic
45. Conveyor belts carry food by tables

46. Leash – drag tray on ground
47. Sushi tray solution (counter comes to tray)
48. Eat at counter
49. Flypaper
50. Freeze drinks so that they don't spill (thaw at table later)
51. Smoothie – lunch
52. Pour drinks into trays
53. Use "sippy cups"
54. Carry on head
55. "Yoga" ball
56. Electronic stability control tray
57. Sensing "smart" tray – self adjusting/beeping
58. Chin claw
59. Seat lifting mechanism on bottom of the tray
60. Raise/lower the carrier (ledge)
61. Roller on edge of tray
62. Stepstools
63. Touch screen tray
64. Key ring of cards
65. Speakerphone E-tray
66. Advanced ordering
67. Have a "jelly" surface on the tray
68. Magnetic can + dishes
69. Beanbag lap tray
70. Laser sensing lid
71. "Saran" removable wrap lid
72. Remote control tray
73. Wheelchair with hydraulics
74. Static lift off
75. Hydraulic pusher

Appendix F – Alternatives Matrix

Name	Attaching to user	Balance/ Stability	Hold Drink in Place	Discreetness	Hold Food in Place	Portability	Storage Method	Comfort
Drummer Boy Harness	Held over shoulders by curved supports	Crossing metal bars to hold tray	Cupholder attached to side of tray holder (metal clamp style)	Thin, flat materials	Ping-pong paddle rubber (insert on tray)	Lightweight materials, do not hit/obstruct legs (tray at waist level)	Foldable	Padding, ergonomically shaped
Fold Down Handle Tray	Handle, hold at side	Low center of gravity	Cupholder by attachment point to tray (plastic ring)	Thin, flat materials	Compartments	Lightweight	Foldable	Handle comforts to grip (gel like material)
Walker	Held with hands	Wheels and frame	Cupholder by attachment point to tray	Not discreet, but can make thin or with clear materials	Plastic sheet (insert on tray) forming indentations	Wheels	Foldable	Do not hit/obstruct legs
Strapped Arm Support	Support straps to forearm of unusable arm.	Able to use both hands to carry	Rubber sheet for increased friction	Only small straps are visible	Rubber sheet for increased friction	Lightweight	Storable in any backpack	Padding on straps

Appendix G – Graphics



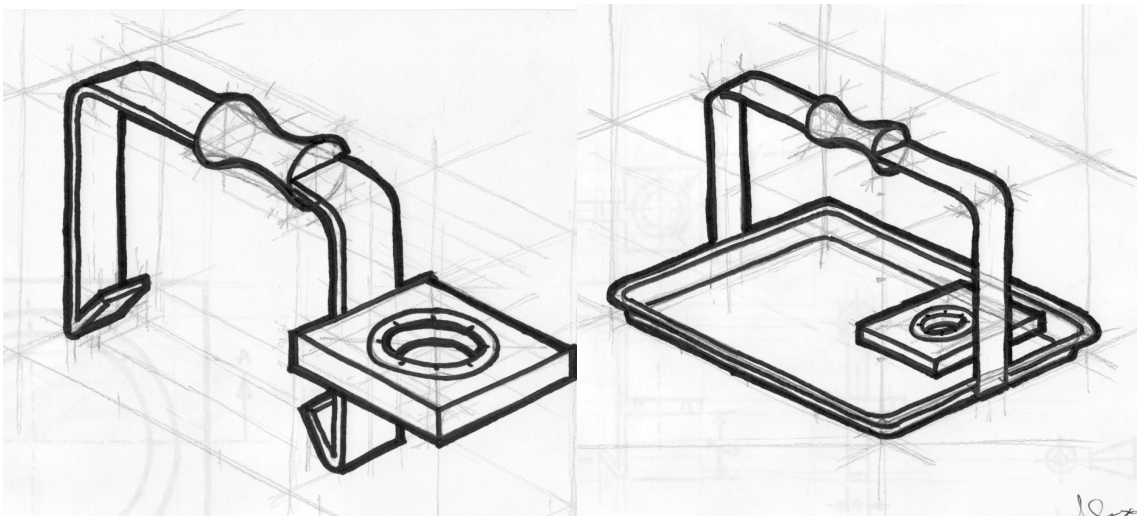


Figure 6: Clip-on Handle
Source: freehand sketches by Alexander Sheu

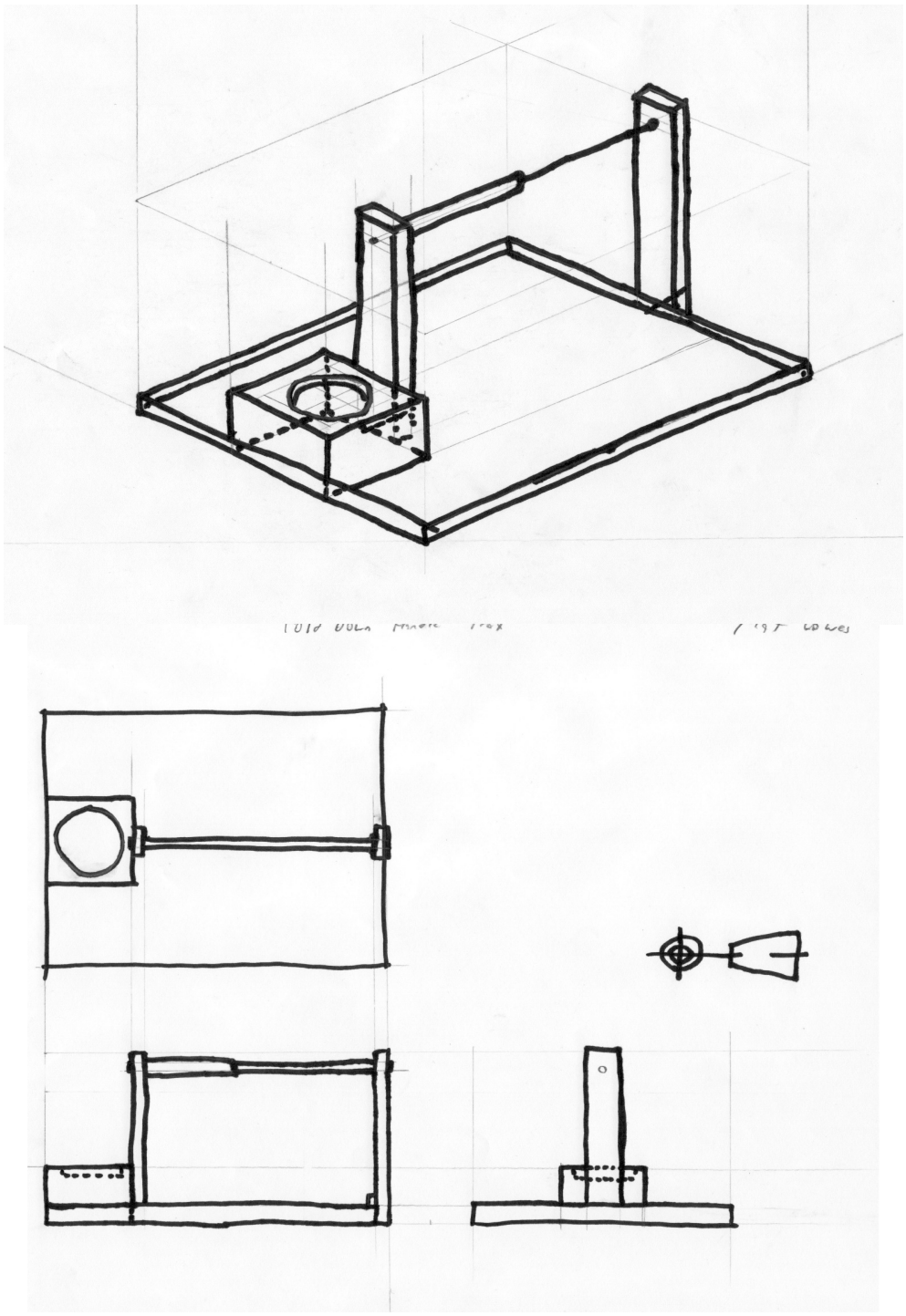


Figure 7: Fold-down Handle Tray
Source: freehand sketches by Mathew Lowes

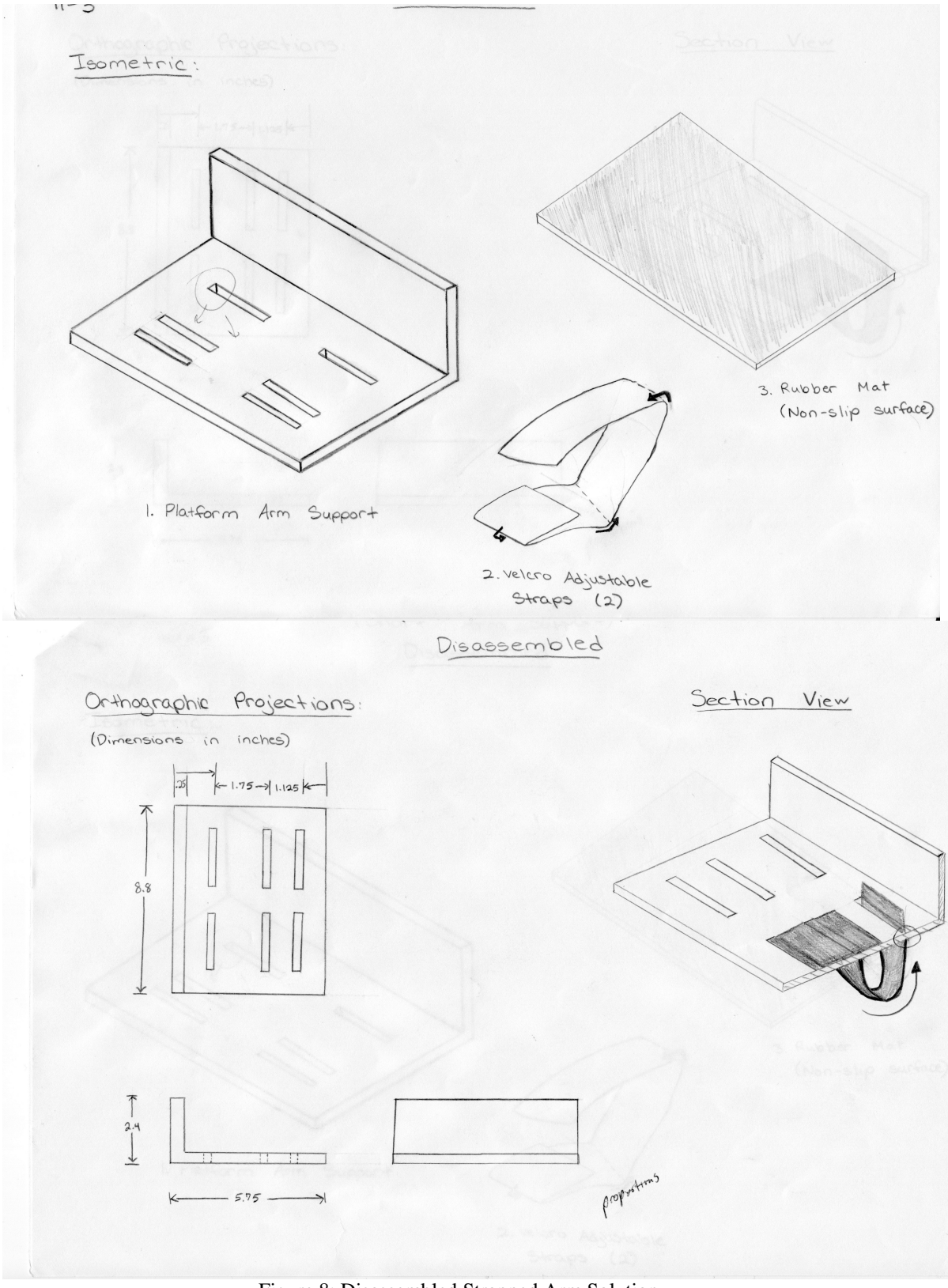


Figure 8: Disassembled Strapped Arm Solution
Source: freehand sketches by Jean Chia

Appendix H – User Testing Plan

A brief overview:

Our project is to design a cafeteria tray for people with only the use of one hand. We will describe a scenario, have you perform a set of tasks, and ask a few questions about each completed task.

Please feel free to give comments and to ask questions at any time.

Scenario:

You are having lunch in the cafeteria at the Rehabilitation Institute of Chicago (RIC). It is about noon, which means the serving area is extremely crowded. You have plenty of time to get your food and to eat. There are three stations that you need to visit: Entrée, Drinks, and Cashier. After visiting the stations, you may sit down and eat.

Tasks:

Perform tasks with: (upon completion of 1. repeat tasks with 2., then 3.)

1. Fold Down Handle Tray
2. Mat's Sweet Solution (short)
3. Mat's Sweet Solution (long)

<u>In the Serving Area</u>:

Task 1: Obtain a tray.

Questions

- What are your first impressions?

Task 2: Put on the device (if you are using the Fold Down Handle Tray, skip to Task 3).

Questions

- Did you find it easy to figure out how to use the mockup? Please give a rating for how easy it was to use on a scale of 1 to 10 (1 hardest, 10 easiest).
  _____ _____ _____
- Do you have any suggestions to make the device more intuitive?

Task 3: Walk in a straight line to Drink Station; wait 30 seconds before setting tray down on Drink Station.

Task 4: Place a drink in the cupholder, then proceed to Entrée Station.

Questions

- How accessible was the cupholder? Please rate on a scale of 1 to 10 (1 hard to reach, 10 most accessible). _____ _____ _____

- Please rate how balanced you felt the tray was after the drink was placed in the cupholder on a scale of 1 to 10 (1 unbalanced, 10 very balanced). _____ _____ _____
- How well do you think the cupholder fit your tray? Please rate on a scale of 1 to 10 (1 very bad fit, 10 snug fit). _____ _____ _____
- Do you have any suggestions to improve the cupholder?

Task 5: Set the tray down on Entrée Station, then put a plate on the tray.

Task 6: Proceed to the Cashier. Set the tray down on the Cashier, then pay for your meal by giving the cashier your money.

Questions

- How easy was it for you to maintain balance once food was on the tray? Please rate on a scale of 1 to 10 (1 hardest, 10 easiest). _____ _____ _____
- Did the mockup make it difficult for you to pay? Rate the difficulty on a scale of 1 to 10 (1 hardest, 10 easiest). _____ _____ _____

<u>In the Dining Hall</u>:

Task 1: User picks up tray after paying for food.

Questions:

- How easy was it to pick up the tray on a scale of 1 to 10 (1 hardest, 10 easiest)? _____ _____ _____
- Do you have any suggestions for making this step easier?

Task 2: User leaves register, and walks into a busy hallway.

Questions

- How easy was it to maneuver the tray on a scale of 1 to 10 (1 hardest, 10 easiest)? _____ _____ _____
- Did you ever feel the contents of the tray were in danger of slipping?
- Which mockup is easier to balance while walking?

Task 3: Having made it to the seating area, you now must search for a seat.

Questions

- How easy was it to navigate the tray over and around tables and chairs on a scale of 1 to 10 (1 hardest, 10 easiest)? _____ _____ _____

Task 4: Now that you have found a seat, you put the tray down on the table.

Questions

- How easy was it to put the tray down on a scale of 1 to 10 (1 hardest, 10 easiest)? _____ _____ _____
- How do you rate the balance of the tray when raising or lowering it to the table on a scale of 1 to 10 (with 1 as the least balance, 10 as the best)? _____ _____ _____
- (Mat's Sweet Solution) Did you have any trouble when removing the non-dominant arm support?
- Do you have any suggestions for making this step easier?

Task 5: Having found a seat, you are able to eat your food.

Questions

- Do you see any difficulties when eating with this tray?
- What would you recommend for improving this process?

Task 6: Now that you have finished your meal, you go to dispose of the cups and plates, and return the tray.

Questions

- How easy was it to dispose of the contents of the tray on a scale of 1 to 10 (1 hardest, 10 easiest)? _____ _____ _____
- Do you have any suggestions to make this step easier?

Overall Questions about Mockups:

1. What do you like about each mockup?
2. What do you dislike about each mockup?
3. Which mockup would you prefer to use in the cafeteria? Why?

Appendix I - User Interview/Observation Summary

Feb. 3, 2007 (Day 1)

Day 1 Findings

Model	Users' Comments	Users' Suggestions
Fold Down Handle Tray (bungee cord)	Cup Holder not high enough Rubber Cup Holder was the best Handles do not lend stability People put wallet on tray	Raise the cup holder Use rubber cup holder Make handles wider Make top left corner accessible
Fold Down Handle Tray (Wire)	Did not like at all, was too unstable	
Strapped Arm Support (Long)	More stable than short version	
Strapped Arm Support (Short)	Difficult to use for people with stroke	Simplify strap system

User Name: Tom
Age: Not Given
Gender: Male
Location: Ford Building

**1 is worst, 10 is best

In Serving Area

Task 2: How easy is it to figure out mock-up?

	Mockups			
	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	6	4	7	

Task 4: How accessible was the cupholder?

	Mockups			
	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	6			

Task 4: How balanced was the tray with a drink?

	Mockups			
	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	5			

Task 4: How well did the cupholder fit?

Mockups

	Rope Handle	Comments
Tom	5	If the cupholder was higher, it would get a 10

Task 6: How easy was it to maintain balance once food was on the tray?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	6	4	10	

Task 6: How easy was it to pay?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	4	5	6	

<u>In Dining Hall</u>

Task 1: How easy was it to pick up tray after paying?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	6	4	10	

Task 2: How easy was it to manuever tray through hallway?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	7	4	10	

Task 3: How easy was it to navigate tray around tables and chairs?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	-	-	-	

Task 4: How easy was it to put down the tray?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	-	4	10	

Task 4: How would you rate the balance of the tray when raising and lowering it?

Mockups

	Rope Handle	Metal Handle	Arm Support Short	Comments
Tom	-	3	10	

Feb. 8, 2007 (Day 2)

Day 2 Findings

Model	Users' Comments	Users' Suggestions
Fold Down Handle Tray (foamcore)	Handle not obvious enough	Limit where handle can be grasped
	Square milk cartons do not fit	Make larger cup holders, alter shape
	Hard to get drinks out of cup holder (too tight)	^^
	Difficult to reach food because handle is in the way	Handle needs to be able to fold down
	Cup holder not obvious enough	
	Handle uncomfortable and unstable	Make handle thicker, add a grip
	Tray feels unstable	Control tray against body
Strapped Arm Support (Short)	Rubber surface helped to stabilize tray	
	Device is uncomfortable: thumb works better	
	Edge is too short	
	Needs to frequently adjust support	
	Straps get stuck on clothing	Make straps longer so they can fit over clothes
	Straps come out of slots	Secure straps so they will not slide out of loops

User Names: Chuck,
Jan, Andy
Ages: 58, 49, 56
Gender: Male, Female, Male
Location: RIC

**1 is worst, 10 is best

In Serving Area

Task 2: How easy is it to figure out mock-up?

Mockups

	Handle	Arm Support	Comments
Chuck	5		Make it more clear where to grab
Jan		8	Feels weird, prefers rubber pad
Andy	10		

Task 4: How accessible was the cupholder?

Mockups

	Handle	Arm Support	Comments
Chuck	7		Hard to get drinks out of cupholder
Jan		-	
Andy	5		

Task 4: How balanced was the tray with a drink?

Mockups

	Handle	Arm Support	Comments
Chuck	7		
Jan		-	
Andy	8		

Task 4: How well did the cupholder fit?

Mockups

	Handle	Arm Support	Comments
Chuck	5		Only fits some drinks - change shape
Jan		-	
Andy	8		Needs to be looser

Task 6: How easy was it to maintain balance once food was on the tray?

Mockups

	Handle	Arm Support	Comments
Chuck	6		
Jan		1	
Andy	5		

Task 6: How easy was it to pay?

Mockups

	Handle	Arm Support	Comments
Chuck	6		
Jan		-	
Andy	10		

In Dining Hall

Task 1: How easy was it to pick up tray after paying?

	Mockups		
	Handle	Arm Support	Comments
Chuck	5		
Jan		-	
Andy	8		

Task 2: How easy was it to manuever tray through hallway?

	Mockups		
	Handle	Arm Support	Comments
Chuck	3		Tray could hit people, Feels easy to slip or tip
Jan		2	
Andy	8		

Task 3: How easy was it to navigate tray around tables and chairs?

	Mockups		
	Handle	Arm Support	Comments
Chuck	-		
Jan		-	
Andy	8		

Task 4: How easy was it to put down the tray?

	Mockups		
	Handle	Arm Support	Comments
Chuck	9		
Jan		-	
Andy	8		

Task 4: How would you rate the balance of the tray when raising and lowering it?

	Mockups		
	Handle	Arm Support	Comments
Chuck	9		
Jan		-	
Andy	8		

Day 3 Findings

Model	Users' Comments	Users' Suggestions	Our Suggestions
SecuriTray	Cup holder outside edge of tray will interfere Handle moves when set tray down, no longer centered Feels stable Likes nonskid surface Cannot figure out how to take handle off tray Handle is sharp on some edges Likes feel of handle	Place cup holder on tray Perhaps cup holder is unnecessary Provide instructions, or tell someone competent in cafeteria how it works Make the edges not sharp	Make the height of the folded section of metal the same as the height of the tray – everything lies flush with the table when set down
Fold-down Handle Tray (cup holder)	Handle needs to be over cup holder Likes solid feeling of high edge of cup holder Rubber rim is easy to use compared to cardboard cup holders		Find a way to place cup holder on the tray without obstructing it

Appendix J – Design Review Summary

This appendix contains the feedback from the two design reviews conducted on February 15 and February 20, 2007. The purpose of the design review was to ask for suggestions and to obtain different perspectives on our mock-up designs from fellow teams. The first design review primarily compared the Fold-Down Handle Tray and SecuriTray designs. Ideas were obtained to further strengthen the handle and cupholder. The purpose of the second design review was to troubleshoot the SecuriTray mock-up, which needs to provide a stable, sturdy, yet flexible handle and to question the importance of stackability.

Design Review 1
Team 11-3: Ankur Bakshi, Jean Chia, Mathew Lowes, Alexander Sheu
Date: February 15, 2007

General Feedback:
Reviewers preferring Fold Down Handle Tray: 1
Reviewers preferring SecuriTray: 10

Fold Down Handle Tray with Fold Down Handle
Reviewer Likes:

- Folding handle is easy to get out of the way
- Cup holder is effective
- The pad on the handle
- Compactness and ease of use
- Simple

Reviewers' Suggestions for handle:

- A spring-loaded "button" to hold handle up
- A track that does not allow the handle to fold when lifted
- Add finger holes to the grip
- A locking mechanism similar to a doorknob
- Expand handle across whole base

Reviewers' Suggestions for cup holder:

- Spring loaded sides
- Collapsible for easier stacking
- Make it a bit smaller
- Move it to long side to be out of way of handle

Other General Suggestions:

- Cut segments out to allow for easier cleaning, and no trapped food/drinks

Clip On Handle Tray

Reviewer Likes:

- Fewer moving parts
- Adaptable to existing trays
- Simplicity
- Fast and easy
- Compact
- Low maintenance

Reviewers' Suggestions to better hold tray:

- Rubber coating
- Magnetic rods
- Add hooks
- Self-energizing spring

Reviewers' Suggestions to strengthen area where metal is bent:

- Cross-bracing
- Stronger metal (stainless steel)
- Springs at the corners
- Replaceable rubber bands

Reviewers' suggestions for attaching a cup holder:

- Rivets
- Weld
- Screw
- Don't attach one

Other general suggestions:

- Bend metal around handle to make it more stable
- Screw a rubber support on to the metal handle
- User needs a place, usually a flat surface, to clip handle to tray
- Provide clues for how to use the device in the design

Design Review 2
Team 11-3: Ankur Bakshi, Jean Chia, Mathew Lowes, Alexander Sheu
Date: February 20, 2007

SecuriTray

Reviewers' Suggestions for preventing handle from moving when tray is set down and picked up:

- High friction handle grips
- Add two short sides to the dowel
- Larger dowels
- Clips on one or both sides of tray

- Rubber wheels
- Add two small obstructions so dowel can only go in one place
- Make rods out of a material that grips

Reviewers' Suggestions for softening sharp edges:

- Rounded edges
- Electrical tape
- Rubber
- Coat with lacquer
- Foam coverings

Reviewers' Input for proposed cupholder:

- Could throw tray off balance, but is "inevitable"
- If cupholder swivels, sturdiness and balance may become an issue
- May not be necessary with non-slip surface

Reviewers' Opinion on the importance of stackability:

Reviewers favoring importance of stackability: 0

Reviewers believing that stackability is not important: 9

- Handles may be stored either hanging from wall or in a box
- Design is compact enough as is
- Storage is not an issue unless there are many (more than expected 10-20) handles

Other general suggestions or comments:

- Design with bended wire (instead of dowel) looks like it holds better
- Space between aluminum sheets may trap food – single sheet or sealing may reduce flex
- Do not need to make handle easier to stack, hanging is better
- Thinner sheets of stainless or spring steel
- Several bends in clamp to create a handle that angles outward

Appendix K – Bill of Materials

Item	Catalog #	Dimensions	Price	Quantity Used	Cost
4140 Alloy Steel Rods	8927K21	¼" dia, 6 ft long	$2.63	(2) rods, 9.13" ea.	$0.67
Zinc-Galvanized Carbon Steel Sheet	8943K15	0.024" thick, 24" x 48" sheet	$12.43	(2) 0.875" x 1.5"	$0.03
				(2) 0.875" x 2"	$0.04
Standard Blind Rivets (Plain Steel)	97519A020	⅛" dia, Hole size: 0.126"-0.187", 500 pkg.	$8.54	(8) rivets	$0.14
Natural Gum Foam Rubber	8601K12	36" wide, 0.1875" thick, 1 ft long	$5.08	(1) 3" x 10" sheet	$0.35
Alloy 3003 Aluminum Sheet	8973K67	0.063" thick, 24" x 36" sheet	$33.58	51.29 $in.^2$	$1.99
	8973K64	0.032" thick, 24" x 36" sheet	$24.00	26.54 $in.^2$	$0.74
				Subtotal (Handle only):	**$3.96**
Grip-ALL Textured Neoprene Rubber	8445K22	0.0625" thick, 12" x 24" sheet	$6.80	(1) 17.7 x 14.0 in sheet	$5.85
				Total:	**$9.81**

*Prices for all items are taken from McMaster-Carr Catalog 109