Senior Design Report: Workstation for Paige Librandi

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Senior Design Report
Work Station for Paige Librandi

by

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Abstract

This project intends to design a wheelchair accessible work station desk to improve the workspace for Paige Librandi and enhance her independence. It aims to incorporate multi-tasking features with organizational tools to make efficient use of space for Paige’s ease of access. The project will take raw materials to create a custom built desk from scratch to best meet Paige’s needs and specifications.

Paige is diagnosed with cerebral palsy that affects her vision and speech so that she is nonverbal and has limited kinesis in her limbs so she uses on an electric wheelchair for mobility. She is highly independent and intelligent; she goes to school, work, and maneuvers in and out of her house on her own as well as customizes many of her gadgets for communication. Her current work spaces for using her devices and doing school work is the kitchen countertop and old desk in her room that do not meet her current needs of accessibility. She is constantly dropping items and relies on others to retrieve them, inhibiting her independence.

With the design and building of a new workstation for Paige, it will incorporate features that allow her to use many of her devices simultaneously and customize their positioning and access. The main features that will implement this are the desk shape, a rotating surface, and a sliding bookcase shelf. These were all considered with three different alternative designs in order to select the optimal design. In design consideration, realistic and safety constraints were addressed to shape the selection of the optimal design from the alternative ones. The desk shape accommodates to her dominant, left-hand side to provide space for Paige to easily access all her materials as well as room for her to efficiently maneuver around it in with her wheelchair. The rotating table surface, located close to desk edge for comfortable reach extension, should provide two electronic device workstations for Paige to rotate and lock in place to easily alternate between workspace positions. The sliding bookcase shelves extend and retract easily for Paige to access books, DVDs, and miscellaneous items. A gliding platform component will act as a second workspace to provide Paige with a simultaneous workstation. These components will provide an optimal workspace specific to Paige to best accomplish her tasks.

The projected budget for this project is about $170 for our team. A timeline of tasks to be carried out was created in order to efficiently complete the project in steps. Each of the team members was assigned various tasks to aid in the completion of the project.
1. Introduction

1.1 Background

Paige is a 20 year old woman who lives with cerebral palsy. Cerebral palsy is a disorder which involves the brain and nervous system and affects movement, posture, and speech [1]. In Paige’s case, she has many of the symptoms of the most common type of cerebral palsy, spastic so that her muscles are tight, weak, and inelastic which prevents her from supporting herself. Her symptoms have affected her right arm with loss of movement or paralysis. For her, brain and nervous symptoms have resulted in speech (nonverbal) and vision problems. However, she is very intelligent and uses a Dynavox VMaxx augmentative device which she has set up and programmed to her liking to communicate. Paige has an electric wheelchair she uses for mobility and is able to perform many tasks independently. Paige is a student of the Milford public school district and attends the Step Forward (21 year) Program at Gateway Community College. In addition, 2 days a week she is in an internship at the Government Center in Milford and assists with childcare at a local Methodist church. Her family has modified their home with automatic door openers so she can come in and out of the house on her own.

With all her workload and programs, Paige is very busy yet, has no organized way of accessing her items in her current work space located on a countertop in the kitchen area. The desk in her room also does not meet her current needs of organizing and accessing items. Because she is in a wheelchair and has limited mobility, she is not able to lean, reach, or grip so is restricted to the desk’s front area which reduces her available workspace. It is challenging for her to access all her devices (laptop computer, Dynavox, ipad) as well as multiple books and schoolwork items in the same area. Her things often fall off from the work space onto the floor, where she cannot retrieve them independently and is constantly relying on others to attend to her.

1.2 Purpose of the Project

The purpose of this project is to create a new desk as a work station for Paige in her room that will accommodate all her electronic devices, books, paper, and miscellaneous items she needs for daily communication and schoolwork. It will replace the kitchen countertop and desk in her room that currently cannot meet her organization and accessibility needs. With the new design, it will accommodate to her dominant, left-hand side to provide space for Paige to easily access all her materials as well as room for her to efficiently maneuver around it in with her wheelchair. It will incorporate different features to create a multi-tasking workspace area for Paige to use all her resources simultaneously and access them with little force motility. Paige is a hard user with all her belongings as she will wear them down with repetitive use. So, the goal is have a sturdy structure that will endure and with tools that prevents her items from falling off onto the floor.

1.3 Previous Work

1.3.1 Products
Very few work stations or desks in the market are intended for persons with incapacities. National Science Foundation (NSF) is a major supporter of the expansion of specifically designing products for them. NSF has published several journals over the years on engineering senior design projects to aid persons with disabilities.

In 2005, a group of students from Duke University’s school of engineering created a rotational work station for a six year client with TAR syndrome [2]. The custom computer station, depicted in Figure 1, was designed with a rotating surface that provided access to a magnetic writing stand and a wireless keyboard, both with adjustable incline. A foot petal was connected so that when released, it locked the rotating surface in the desired position.

The rotating surface was made from a circular piece of ¾” pine, 2’ in diameter, to which a commercial Lazy Susan bearing was attached. A magnetic writing surface was glued to a clipboard which was attached to an adjustable easel which was in turn fastened to the rotating surface. A locking mechanism was implemented to prevent the Lazy Susan from rotating while one of the two stations was in use. A spring pin was positioned under the desk, and two holes drilled into the bottom surface of the Lazy Susan, according to the desired positions of the keyboard and writing surface. A drum pedal was connected to the pin by a bike cable so that when depressed, would disengage the pin while rotating the surface to an alternate position. The cost of parts for the device was approximately $550.

The ABLEDATA company GPK, produces the only accessible workstation in the market with a rotating top. Their products are originally designed as assistive technology for people with quadriplegia [3]. The QuadDesk, seen in Figure 2, is a height-adjustable desk designed for wheelchair users who cannot lean and reach or lack grip strength [4]. It has standard large rotating desktop as well as a rotating carousel for book placement at eye level. The desk has one or two extensions, each of which adds more than 2.6 square feet of additional work space. It is highly wheelchair accessible by incorporating only two legs and no crossbeams. The height can be adjusted to the client’s needs either manually or as an option, motorized.
1.3.1 Patent Search Results

In 1994 Michael McGrath et al filed a patent for an upper torso support for workstations for businesses to accommodate persons with disabilities to make their workstations [5]. It was an ergonomically comfortable approach as the design provided a sturdy workstation support with wide ranges of movement. It was comprised of an adjustable, sturdy upper body support system for keyboard operators with a pair of adjustable arm rests mounted on a rigid frame which could be incorporated into a standalone system or into a desk workstation system.

In 2004, Glen H. Besterfield et al filed a patent for a collapsible computer workstation designed with applications for people with disabilities as well as anyone with a computer at their desk [6]. The present invention comprises a retracting lift mechanism for a keyboard and monitor platform to allow increased work surface. The apparatus retracted and deployed with the push of a button.

1.4 Map for Rest of the Report

The rest of the final report will outline the design components and process for Paige’s workstation. This will include a short description of the teams’ alternative designs and a comparison between leading to the optimal design choice. In this section, a detailed description of the optimal design, its objective, and each of subunits with its composed parts will be provided. This section will give a thorough inspection at each major element of workstation and the components that provide its function to result in a multi-tasking workspace. In the subsequent sections, the realistic constraints, safety concerns, impact of engineering solutions, and life-long learning will be evaluated. It elaborates on the issues that need to be taken into account for Paige’s benefit so that her workstation is accessible to her needs and busy schedule and the purpose of designing this project for her in a global sense. Then, the report will provide a chart detailing the budget and timeline for the completion of the project tasks. Next, a brief overview of each team member’s contribution will be given as well as the goals for the following semester work. Finally, the report will end with a conclusion section that will review the project’s objective, goals, and progress made during this semester in the design process.

2. Project Design

2.1 Introduction

This team design project will construct a new desk as a workstation for our client, Paige, in her room. The workstation will be built by scratch to be custom fit to Paige’s needs. The purpose of this desk project will give Paige, a 20-year woman with cerebral palsy, more independence by creating an easily accessible, multi-tasking workspace with organizational tools. The major features of the desk will be the designs of several key components: its shape, rotating surface, shelving, and the choice of electronic or manual for adjustable elements. The key components will be further discussed in the overview of the subunits that detail specific design elements to each major part. These features should produce a sturdy structure that will endure and with apparatuses that prevent her items from falling off onto the floor. Also, for Paige’s benefit, a main priority in the optimal design in is safety with detail of protective features.
2.1.1 Alternative Designs

The three previous alternative designs were considered and compared for the project. The main differences between them were related to the desk construction and shape and rotating surface mechanism, as well as what additional storage components would be implemented. Engineering standards with respect to constraints were taken into account as well as specifications to select the optimal design features.

2.1.1.1 Alternative Design 1

This workstation for Paige will have a semicircular shape design [7] similar to Fig. 3 for Paige to enter her wheelchair into an open lip space in the center and rotate around in. It will also have four manually adjustable height legs at each corner. The legs will have holes in the sides and a locking pin that can be pressed in while simultaneously changing the table height to the position of a specific hole where the pin will then slide out from to lock. The legs will adjust from a minimum to maximum height of 32 to 37 inches to match the adjustable heights from the floor to the tray table of Paige's wheelchair. The maximum dimensions of the open space will be 82 inches wide and 45 inch depth so that her wheelchair can enter in and rotate a full 180 degrees from side to side.

![Figure 3. Semicircle desk shape](image)

On the left-hand, front edge side of the desk, a Lazy Susan with a minimum 18 inch diameter will be attached onto the surface [8]. In order to keep the Lazy Susan stationary, while one half of the surface station is in use, a locking mechanism will be implemented. It will consist of a junior size drum pedal (Fig. 4) with protective foam covering to be used by her hand [9]. The drum beater portion of the pedal is connected by a bike cable to a spring pin positioned under the desk below the Lazy Susan. Two drilled holes on the bottom surface of the Lazy Susan in the desk will be the position for the pin to lock into. When the hand drum pedal is depressed it will pull back the beater, disengage the pin, and rotate the surface to the alternate position.

![Figure 4. Junior drum pedal](image)
The design will include a shelving unit on the center space of the semicircle table surface. It will consist of two shelves with a minimum 12 inch height separation between them to provide room for a computer device in the upright position. The shelves will be modified drawers so that it only uses the bottom part of the drawer as a platform for holding devices. The bottom shelf will store Paige’s books and DVDs. It will glide forward close to the desk surface on a full extension ball bearing slide. The upper shelf will come forward at face height that will support a smart screen device. Latches will be attached underneath the platform drawers so that Paige can manually pull it out and push it in.

2.1.1.2 Alternative Design 2:

This second alternative design will have a work station with a corner desk L-shape design similar to the surface layout of the desk in Fig. 5 except with a curved inner corner using a fillet [10]. It will have a three cylinder tube legs in order to provide the maximum amount of allowable space for Paige’s wheelchair. The minimum desk height, width, and depth will be 30 inches, 60 inches, and 80 inches, respectively. The left extended side area is 30 inches or greater to support a 2 foot diameter rotating circular surface.

At the corner surface, on the left-hand side, a rotating surface will be attached on top. The rotating surface will be made by cutting out a 2 foot diameter circular piece from a ¾ inch thick softwood veneer sheet to which a commercial Lazy Susan bearing (Fig. 6) will be attached with screws underneath [8]. This will be attached to a wooden base and affixed to the desk surface. The locking mechanism to be implemented will consist of push buttons connected to a spring pin underneath that lies in between the circular rotating and desk surfaces. On the desk surface on the left-hand side, will be a rubber stopper under the push button location for the spring pin to lock into. In this case, instead of a hand pedal, two buttons will be placed on top of the rotating surface on opposite sides of the circular perimeter. The locking mechanism will work similar to a pen clicker. Paige can rotate it by depressing the left-most button to her that will disengage the pin (raise it up out of the stopper). She can then rotate it to the alternate position and depress the other button to engage the pin into the stopper to lock it in place. This will allow for Paige to use solely one hand to rotate the surface for a reasonable amount at which her left-arm can extend.
This design will include a bookcase on the left hand side on the desk to house Paige’s books and DVDs. It will be composed of two shelves with a minimum 15 inch gap in between. The bottom shelf will store her heavier books and the upper shelf, her lighter DVDs. The bookcase will have roller wheels on the bottom to run on a track. A handle will be attached to the bottom shelf that Paige can grip to slide the unit towards her to access her items. A swiveling monitor stand will be constructed next to it to support a touchscreen device at face height.

2.1.1.3 Alternative Design 3:

Finally, this workstation design will be a rectangular U-shaped desk similar to the arrangement of the QuadDesk [4] seen in Fig. 7. It will have open center space for Paige to enter her wheelchair into with a minimum of 30 inch width and 40 inch depth. This desk will be electric for all its adjustable components and be operated by a motor. It will stand on two electrically adjustable height T-beam legs.

Figure 7. QuadDesk wheelchair workstation

As shown in Fig. 7, on the top left-hand corner, a motorized circular rotating surface is integrated. The position of this surface will be adjustable with a motor control located on the desk’s surface left-hand side. The motor will rotate and stop/lock the circular surface in the Paige’s desired position with the press of button.

An electric motorized shelving unit will be part of the design. It will be constructed in the center space of the desk area. It will consist of one shelf. The shelf will be a modified drawer so that it only uses the bottom part of the drawer as a platform for holding devices. The shelf will roll out forward at face height using a full extension electric ball bearing slide and slide back into the unit. An additional button specific to this feature element will be wired to the motor control box.

2.1.2 Optimal Design Selection Reasoning

The optimal desk shape chosen was a corner desk L-shaped design. This design was chosen in order to maximize the available left-area workspace for Paige’s dominant side and was her family’s preference. Since it would be difficult to obtain one with all the specific features needed, the team will build it. The semicircular and the rectangular, U-shaped desks in the first and third alternative designs would not provide as much accessible working area as the optimal, and would not fit well in the space provided for the desk in Paige’s room. The third design was eliminated for budget reasons, since the desk adjustability and all its features would be electric. The optimal design for the rotating surface feature will be a circular board with Lazy Susan
bearing [8]. The locking mechanism will be a clicker push-button on the surface with a spring pin. It would be located on top of the rotating surface for high accessibility and require little force for Paige to operate. This design was chosen over the first, because the locking mechanism required using a drum pedal that would require it to be at a significantly lower height than the rotating surface to pull down the pin to disengage it. It would be difficult to implement this without elevating the rotating surface and diminishing its ergonomic capability for Paige. The optimal design for the shelving was a sliding drawer bookcase. This incorporated the features from the first design that would allow for Paige to extend the whole shelf forward to access all her stored items. In comparing the first and third design’s shelving, the units would not securely hold all Paige’s books, DVDs, and device on extension platforms that slid out without any side support. In order to compensate, the design will modify an existing drawer shelf. The technical specifications for the details in each component of the desk’s features will be further expanded on in the subunit sections below.

2.2 Optimal Design

2.2.1 Objective

The objective of this workstation project will be to incorporate different features to create a multi-tasking workspace area with organizational tools for Paige to use all her resources simultaneously and access them with little force motility. The main features that will implement this are the desk shape, a rotating surface, and a sliding bookcase shelf. This optimal design was selected mainly from the second alternative design described above but added some features from the other alternative designs as well as seen in Fig. 8.

Figure 8. Optimal Workstation Overview

The objective with the design of the desk shape is to accommodate to Paige’s dominant, left-hand side to provide space for her to easily access all her materials as well as room for her to efficiently maneuver around it in with her wheelchair. The rotating table surface, located close to desk edge for comfortable reach extension, should provide two electronic device workstations for Paige to rotate and lock in place to easily alternate between workspace positions. The sliding bookcase shelves extend and retract easily for Paige to access books, DVDs, and miscellaneous
items. The gliding platform also extends and retracts easily to provide a second workstation for Paige. The components surface edges should be covered with a liner to provide protection and prevent items from falling off the desk.

2.2.2 Subunits

2.2.2.1 Desk Construction Shape

The desk surface will be constructed in a carpentry shop out of Douglas fir kiln dried wood. Seventeen pieces of the 2”x6” – 8’ dimensional lumber at $4.08 a piece will be obtained from Kelly Fradet for the tabletop [11]. It will be built in a carpentry shop where it will be split in two, run through a joiner, and bonded together using Titebond II wood glue to form the desk work surface. The surface will then be coated with Minwax polyurethane varnish to improve the life and durability of the wood [12]. This optimal design, depicted in Fig. 9, will have a work station with a corner desk L-shape design with fillets on the corners.

Figure 9. Corner L-shape desk

The dimensions for the desk in height, right side length, and left-side length, will be 27.5 inches, 52 inches, and 72 inches, respectively. The specific desktop surface dimensions are modeled below in Fig. 10 to follow in the construction. The left extended side area will be 25 inches wide to support a 2 foot diameter rotating circular surface. On the perimeter of the desktop surface, ½ inch half round wood edging will be attached to act as a lip/bumper to prevent items from falling off of Paige’s desk.

Figure 10. Desk tabletop dimensions
For the support, the desk will have six metal post legs on each end in order to provide the maximum amount of allowable space for Paige’s wheelchair. The legs would be Hafele counter-34 twist legs (Fig. 11) with a 2-3/8 inch diameter and 34 ¼ inch length that cost $198 for two sets of eight [13]. The legs are composed of steel with a brushed chrome coating and can support 220 lbs of vertical load. They include a galvanized steel square mounting plate with screws that provide easy installment and detachment. The legs have a leveler foot that allows additional 1 inch upward height adjustment. To accommodate our client Paige, the metal post legs will be attached to blocks to increase the desk height by 2 ½ inches. The six blocks are constructed from 3 stacked 5x5 ¾ inch thick plywood squares that are held together by Titebond glue. These blocks would be mounted to desktop underside with four 3 inch screws in the respective desk leg locations.

![Figure 11. Hafele counter34 twist leg](image)

To test the desk frame, theoretical analysis is performed to test if metal post legs could hold up the desktop surface at their supportive weight capacity. Douglas fir is dimensioned at 35 lbs/ft³. With the calculations seen below, this was converted to pounds per inch cubed (equation 3) and multiplied with the computed volume of the desktop surface in inches (eq. 1 and 2) cubed, shown in Eq. 4 to obtain a total estimated weight of 71.09 lbs.

\[
\text{Desktop surface area: (72 in} \times 25 \text{ in}) + (27 \text{ in} \times 20 \text{ in}) = 1800 \text{ in}^2
\]

\[
\text{Desktop volume: 1800 in}^2 \times 1.5 \text{ in} = 2340 \text{ in}^3
\]

\[
\text{Dimensioned Douglas fir density conversion: } 35 \frac{\text{lbs}}{\text{ft}^3} \times \frac{\text{in}^3}{(12\text{in})^3} = 0.0202 \frac{\text{lbs}}{\text{in}^3}
\]

\[
\text{Total desktop surface weight: } 0.0202 \frac{\text{lbs}}{\text{in}^3} \times 2340 \text{ in}^3 = 71.09 \text{ lbs}
\]

Since each Hafele leg can support a capacity of up to 220 lbs, they should support the desktop surface weight. For further accuracy in testing, once completed, the desktop surface will be weighed. However, it should also support the additional weight of the following two subunit components: the rotating table surface (minimal weight) and the sliding bookcase (estimated weight of 40 lbs). This increases the total weight to support to approximately 120 lbs, which is still below the weight bearing capacity for one metal post leg. The two additional legs could be added for increased buttressing.

2.2.2.2 Rotating Table Surface
At the corner surface, on the upper left-hand side, a rotating surface will be attached on top. The rotating surface will be made by cutting out a 2 foot diameter, ¾ inch thick circular piece from plywood from the desk surface. A 14 inch square, ¾ inch thick circular base will also be cut from plywood. A commercial Lazy Susan 12” diameter bearing (Fig. 12) will be attached to the square base [10]. This whole component will be nailed to the large circular piece. The rotating surface would then be affixed to the desk surface by mounting it with screws to the base.

![Figure 12. Lazy Susan 12” bearing](image)

The locking mechanism to be implemented will consist of grasping knob attached to a cylinder pin, seen below in Fig. 13 that will lie through the circular rotating table, between it and into an incline block. This will be implemented by machining stock aluminum into a cylinder pin with a rounded head. The pin will be placed in a hole drilled in the rotating surface near its edge. A knob will be threaded into the top surface of the pin. The knob will provide a greater surface area so that Paige can easily pull up the mechanism with her hand to rotate and lock it into the block on the desk surface. On the opposite side of the pin’s position on the circular table, a second pin will be placed into a drilled hole. On the desk surface on the left-hand side, directly under a drilled hole position in the rotating surface, a block will be placed for the pin to lock into. The locking block will be four inches long and an inch high. It will have chamfered edges on either side with a flat one inch surface where a ¾ inch diameter hole will be drilled to a ½ inch depth to fit the cylinder pin to lock into.

![Figure 13. Rotating surface push-button locking mechanism and pin](image)

The overall locking mechanism will work similar to a shaft and pin. Paige will rotate the circular surface by pulling up the left-most pin to her that will raise the pin out of the hole in the incline block which will guide the pin down to its suspended height of ½ in above the desktop surface. This will allow the rotating surface to spin freely. Paige can then rotate the circular table it to the alternate position until the opposite pin slides up the incline plane and drop into the hole in the block to lock the rotating surface in place. This locking mechanism will allow for Paige to
use solely one hand to rotate the surface for a reasonable amount at which her left-arm can extend.

On one half of the rotating table surface, an adjustable incline easel/bookstand will be attached to support Paige’s electronic devices (Dyvanoxx, ipad) or books. The easel will be a Jasmine Book Reader Stand Holder (Fig. 14) made of medium density fibreboard that is humidity resistant [14].

![Figure 14. Jasmine Book Reader Stand Holder with degree level adjustments](image)

The easel surface is 15.35 x 11.02 (length by width) inches. Its features include a patented two way adjustment, height and degree of incline. It has a non-slip rubber backing, rounded corners (safety appeal), and hard and strong plastic adjusters. The stand component dimensions are 7 x 8.25 inches (length by width). Another feature is that on the front edge are two adjustable incline clips that can be rotated upward at an angle to hold books in place on the easel for Paige to read. The easel edges will be covered with a lip (quarter-rounded edging) to prevent any items from shifting and sliding off. The other half of the rotating surface workstation will be left alone to provide a space for Paige’s laptop. The testing of the rotating surface would involve Paige’s interaction with the device to determine its optimal positioning on the desk.

### 2.2.2.3 Sliding Bookcase

This design will include a bookcase on the left hand side on the desk to house Paige’s books and DVDs. The project custom builds a bookcase from plywood materials. Its dimensions are 24 inches in length, 16 inches in height, and 12 inches in depth. This will allow enough space (about an 8 inch separation) in the drawers to house Paige’s books and DVDs. The outer shell of the bookcase will be constructed similarly to the two drawer organizer seen in Fig. 15 except it will not have a top panel. Two open-face drawers will be built from 3 plywood panels similar to the two drawers below in Fig. 16. The drawers will attach to the bookcase on mounted 16 inch glide bearings that cost $15.83 each from Mansfield Supply.
The custom bookcase drawers will provide an open storage space that extends and retracts smoothly on bearings for Paige to easily retrieve her items. Wooden dividers will be attached as slats in the drawers in order to compartmentalize her items for easily accessible retrieval. The handle from the front panel will be attached to the edge of the bottom panels of both drawers. A metal handle will be added to each front edge of the bottom drawer panel for Paige to grip and pull out towards her to retrieve items and push back in. The bottom drawer will store her heavier books and the upper shelf, her lighter DVDs and items.

For testing, the sliding bookcase was first modeled in NX Unigraphics for optimal positioning on the desk. An overall view of the subunit features incorporated on the desk was modeled as seen in Fig. 17 below. The best positioning of the features was determined as seen in Fig. 16 where the sliding bookcase is the rectangle shape. The constraints to be considered involve the comfortable maximum length Paige can extend her arm correlating to the length from the edge of the desk to the edge of the bookcase which is 12.37 inches as seen in Fig. 16. This would test for the possibility of an extension handle. Also, it would undergo prototype testing with Paige for her accessibility in operating it to come forward and push backward. In addition, Paige will have to test on a bookshelf the ease of her retrieval of items to determine the maximum amount of slats for separations to prevent books from falling over.

Figure 15. Two Drawer Organizer

Figure 16. Dimensioned measurements for handle extension
2.2.2.4 Gliding platform

The gliding platform will provide the client with a simultaneous workstation with the rotating surface. The platform will be located adjacent to the rotating surface on the right-hand side of the desktop. It will consist of one sheet of plywood, 14 inches wide and 18 inches long. It will extend and retract on two 16 inch glide bearings. The top part of a glide bearing will be mounted with screws to bottom surface of the platform. The bottom portion of the glide bearings will be mounted to the desktop surface. The platform will have a metal handle attached to its front edges to allow for easy operation. The gliding platform will serve as a workspace to support the client’s laptop so that she can work on several things all at once in combination with the rotating surface. The plywood platform will be coated with a polyurethane varnish to stain and seal to make the wood waterproof.

2.3 Prototype

During the spring semester, the team worked on translating the optimal design into a functional prototype for our client’s use. In this section, the description of our prototype and its operation as well as its testing with the client, Paige, will be discussed. This review will consist of in depth descriptions and pictures of the prototype as well as the changes made to produce the final design after testing. This section will be outlined in the format of the optimal design section; first an overview of each subunit will be given and then a description of how each component produced the final working prototype.

2.3.1 Desk Construction Shape

The construction of the desk follows that of the optimal design. It was built in of one of the team member’s carpentry shop. Douglas fir kiln dried (2x4”x8”) wood was run through a joiner to cut down to a total sheet size of 8 feet long and 2 feet wide. A base was constructed for the desktop pieces to lay on where they were glued together with Titebond and clamped to dry for several days (Fig. 18). After the wood had dried, the right hand side was constructed by cutting off a 2 foot long piece from one side of the desktop sheet. It was then biscuit joined with Titebond glue to the upper right hand side of the left hand desktop table and left to dry.
The desktop was complete but once transferred to the machine shop location, its shape began deforming. The problem occurred when it was brought from the carpentry shop to the humid, hot machine shop. This environment caused the wood to warp and the desktop to bend inward. To repair it to a level surface, the desktop was soaked in water and the right hand side sawed off and shortened by 2 inches. We then clamped the wood down flat to a level surface and glued to right hand side back on. Once the glue dried and while the desktop was still clamped, angled steel beams were run along the underside of the desktop. They were mounted with carriage bolts to provide a rigid structure to prevent the wood from bending again (Fig. 19).

The desktop surface was sanded with a router and then several coats of polyurethane varnish were applied to stain and seal the surface. Half round edging, total of 21 feet to surround the perimeter was cut on the saw to size for each edge length. It was then nailed to the desk and varnished (Fig. 20).
The six legs were bolted to the underside of the desktop with steel mounting plates and screws to blocks. The legs were originally mounted to the desktop underside. However, during testing, Paige’s wheelchair did not fit well under the 34 ¼ inch desk height and it was determined that the desk required at least a 2 inch increase in height to accommodate the wheelchair. This was accomplished by constructing the height adjustment blocks. The blocks were made by sawing out eighteen 5x5 squares from ¾ inch thick plywood to stack in sets of three for the six legs. The three squares were glued with Titebond and clamped together to dry. The six leg mounting plates were then screwed into each of the six blocks and mounted with 3 inch screws to the desk underside (Fig. 21). The desk legs were then screwed to the bottom surface of the blocks to result in a 2 ½ inch height increase and an overall desk height of 36 ¾ inches with a maximum to 32 ¾ inches.

![Figure 21. Desk legs](image)

2.3.2 Rotating Surface

The building of the rotating surface matches that described in the optimal design with the design alternation to the locking mechanism changed after testing with Paige. The rotating surface was built from treated ¾ inch plywood. The 2 foot diameter circular surface was cut on a computer programmed saw machine to ensure accuracy. Two ½ inch diameter holes were drilled into the circular surface ½ inch from the edge on opposite sides from one another. The 14x14 inch square base was cut on the electric saw. A 12 inch diameter Lazy Susan circular bearing was mounted with screws between the base and the circular surface (Fig. 22).

![Figure 22. Lazy Susan bearing mount](image)

The locking mechanism consisted of constructing two grasping cylinder pins and a locking block. The cylinder pins were machined from stock tube Aluminum. The sizes of the pins were adjusted several times using the lathe machine to shave it to fit smoothly in the circular surface.
holes. The grasping part of the pin consisted of two knob screws. In order to attach them to the cylinder pins, two threaded holes were drilled halfway through the length of the pins. The knobs then screwed into the pins (Fig. 23). Originally the pins would operate by locking into a hole drilled in the desktop surface. However, after testing with Paige, it was determined the optimal location for her to operate the rotating surface would be positioned so it was partially overhanging the desktop edge between the left and right sides. Therefore, in order for the pins to allow the rotating surface to freely rotate a full turn, they needed to be shorted so that they would be suspended about a ½ inch off the desktop surface. During testing, Paige accidentally dislocated one of the pins from the rotating surface. The design was changed to incorporate stoppers in order to prevent this from occurring. Two holes were drilled ½ inch through the diameter and above the bottom edge of the pin. They were threaded and two pins were screwed in to produce the stoppers seen in Fig. 24.

Figure 23. Knob to cylinder pin

Figure 24. Grasping cylinder pins

The design of the locking hole was changed to that of a block that the cylinder pins would slide up and down inclined plane sides and lock in a center flat surface with a ½ inch diameter hole. The block was constructed by sawing a 4x1x1 (LxWxH) inch piece of plywood. In the center of the block, a ½ inch hole was drilled to a ¾ inch depth. A beveled edge was drilled into the top hole surface to guide the pin easily in and out of the hole when raised. Then, chamfered edges were created from each side by sawing off diagonal triangles to result in a 1 inch top surface area that included the ½ inch drilled hole. This block was mounted with Titebond and a screwed drilled from in the hole to the desktop (Fig. 25). The two cylinder pins were placed in the rotating surface and one was placed in the locking block to produce the optimal operating position for Paige. The rotating surface (Fig. 26) was mounted to the desktop with screws from the underside into its square base.
Two features were added to the rotating surface: an easel and a writing utensil holder. On one half (semicircle area) of the rotating table surface, an adjustable incline easel (Jasmine Book Reader Stand Holder) was attached to support Paige’s electronic devices (Dyvanoxx, ipad) or books. Half-round ½ inch wood edging was added to the easel’s sides to produce a protective lip (Fig. 27). Two writing utensil holders (Fig. 28) were constructed by sawing 3x4 inch plywood blocks and drilling nine various sized 2 inch deep drilled holes in each.

The operation of the rotating surface (Fig. 29) by the client Paige is as follows and requires only one hand, her left. From the locked position, with one of the grasping pins secured in the locking block hole, Paige will first lift of the pin up so that it is raised up out of the hole, the beveled edge will guide the pin to the right. Paige can then release it so that the pin slides partially down the inclined edge to its suspended position. Paige then uses her left hand to push the rotating surface to the right until the opposite pin reaches the locking block, slides up the inclined plane to drop into the hole and lock into place. This operation allows for Paige to alternate between two workstations, the semicircle halves of the rotating surface. Figure 30 shows Paige using the rotating surface feature.
2.3.2 Sliding Bookcase

The construction of the sliding bookcase follows that of the optimal design. First the outer shell of the bookcase was constructed from ¾ inch plywood. The bottom, back, and side panels were cut from the plywood and glued together with Titebond. Then were clamped together and left to dry as seen in Fig. 31. The two drawers were built the same way to fit in the outer bookcase shell. A center shelf and three 1 inch wide sticks to support the shelf were cut out as well. The shell, drawers, shelf, and support sticks were then primed and painted white. To assemble the bookcase, the three support sticks were drilled with screws to the center height position in the inner bookcase shell sides. The center shelf was placed on top and drilled into the support sticks (Fig. 32). Then, the top part of a 16 inch long metal glide bearing was mounted with screws to each outer side of the two drawers. The bottom parts of the glide bearings were drilled into both inner bookcase shell sides above the bottom panel and center shelf to produce Fig. 33. Last, a metal handle was attached to the center of the front edge of each of the two drawers with screws.
After testing with Paige, we determined the optimal amount and spacing of the divider slats (Fig. 34) to place in the bookcase drawers to hold her textbooks and miscellaneous items. The bottom drawer was measured to result in five slats that would produce the optimal space to hold one textbook while allowing Paige to withdraw it easily. Two slat dividers were determined as the amount to accommodate larger miscellaneous items on the top drawer. The dividers were constructed from ¾ inch thick plywood. Rectangle boards were cut on the saw to the height and depth of the drawers. Then a diagonal cut was made on the front divider edge to produce angled edges for facilitated access to books and aesthetic purposes. The dividers were then mounted with screws to the back and bottom panels of the drawers. The final sliding bookcase feature is shown below in Fig. 35.

2.3.4 Gliding Platform

The construction of the gliding platform exactly follows that of the optimal design as it was an added feature Paige requested after testing to create a simultaneous workstation together with the rotating surface. The platform is a workspace for Paige’s computer. The platform board was constructing from ¾ inch thick plywood. An 18 inch long by 14 inch wide rectangle was cut out from the plywood on the electric saw. Two 16 inch long metal glide bearings were attached to the bottom surface of the platform and then mounted on the desktop surface. The bearings were positioned so that the platform would be located next to the rotating surface on the right hand side. The bearings were mounted in the center of the desktop right side width. Once the platform was mounted, the surface was sanded and varnished with polyurethane. Last, a metal handle was
mounted with screws to the front edge of the platform for Paige to extend and retract easily. The platform is shown below in Fig. 36.

![Figure 36. Gliding Platform](image)

2.3.5 Workstation Testing and Modification

During the middle of the spring semester, we had Paige come and visit the machine shop to test out the workstation and receive input on any further modifications to the prototype. The following modifications were made after testing which are also described in each component section above. The desk height was increased for Paige’s wheelchair to fit under (with stacked 2 ½ inch blocks), the rotating surface was positioned from the original left hand side to overhang between the left and right sides with a locking block mechanism for its operation, and dividers were incorporated into the sliding bookcase drawers. The family also asked for some additional features; writing utensil holders and a gliding platform next to the rotating surface right hand side for her computer. We added these features to our final prototype. The prototype before Paige came to visit can be seen in Fig. 37 below. Paige visited the shop after our final presentation and we presented the final prototype (Fig. 38) to her which she and her whole family enjoyed and were satisfied with to meet her needs (Fig. 39).

![Figure 37. First prototype](image)
3. Realistic Constraints

There are several constraints that play a significant role in the design of Paige’s workstation. The types of realistic constraints to be considered include economic, environmental, sustainability, manufacturability, ethical, social, political, and health and safety concerns. The ultimate goal, in accordance with engineering standards, is making certain that the design is feasible and that the final product will benefit our client without compromising her safety.

3.1 Engineering Standards

This workstation will be constructed to meet industrial standards and state regulation for design in a carpentry shop. The engineering constraints considered included the materials to be used in the desk construction such as the type of lumber and wood glue. The desk will incorporate protective covering features and ensure accessibility for our client’s safety. All the team members will undergo machine shop training, including safety training, so that desk can be optimally fabricated for the technical specifications. Some commercial products available will be implemented in the design and the parts will be documented for assembly instructions. Since it will be built in one of the team member’s carpentry shop, this will reduce the budget costs. Low
production costs and optimal manufacturing are important for engineering standards in the industry.

3.2 Health Concerns

Health constraints play a major role in consideration of our client’s medical condition, cerebral palsy. Since Paige only has one-sided controlling motility in her left hand, the desk’s design for her will be constrained to that specific side. The shape of the desk and the workspace and organization components will be modified to adapt to her left-hand side. Also, because her condition limits her strength capacity, the design features need to adhere to the maximum forces she can produce. The desk’s features should be able to operate easily with little force required, as well as allow for minimum arm extension to reach items. Also, Paige often drops things so it is important the desk incorporates bumpers and gripping docks to prevent her items from falling off onto the floor where she cannot reach to retrieve them. Last, her physical therapists should evaluate the final model of the workstation to make sure it accommodates to Paige’s disabilities in the best fashion.

3.3 Safety Concerns

Another important aspect is the safety constraints involved to protect Paige. The design should not compromise her comfort or limit her range of motion. The workstation should be easily accessible to Paige’s wheelchair, with enough space provided for her to smoothly enter and maneuver around in. There should be no sharp corners on the desk. Therefore the design will include soft, protective coverings on the edges of the desk, rotating and shelving surfaces to prevent injuries when Paige comes into contact with these design elements. Safety issues will be further addressed in the following section.

3.4 Economic and Manufacturability

The economic and manufacturability constraints will play a role in the project’s design. The budget should be mostly set and the goal will be to not go over. This restricts our team to research the lowest possible prices on products and look into companies nearby to reduce shipping costs. Although the desk will be a custom optimal design, it will be built from scratch, which should significantly lower the manufacturing costs. The manufacturing will have to be precise but should be feasible since we have access to a carpentry shop and the skills to create the workstation. In terms of the certain features such as the rotating surface with locking mechanism, and moving shelves, pre-existing parts should be considered and weighed against manufacturing them from scratch. This should be compared in terms of financial constraints and ease of production.

3.5 Sustainability

Finally, in terms of sustainability, Paige desires a desk that can last for the many years she will be in school and work. The desk design should have as maintenance free a product as possible in mind. Paige is known to be a hard user with all her devices, so it is crucial that the desk be sturdy and composed on material that has high resistance to wear. Also, the social aspect
should keep Paige’s communication at the highest level. Since a large part of this is done through her electronic devices, the desk should primarily implement the features and components to make her gadget accessibility as maximum.

4. Safety Issues

Safety issues are important to address for our client Paige because of her medical condition. Since the purpose of the workstation is to increase her independence by creating a desk that she can self-operate, it needs to be secure so that there are no safety hazards in using its components. The major aspect is the mechanical concern for the composition of the desk structure and moving elements. Paige is a hard user, so the desk should be made of tough materials. The optimal design implements steel legs and a stabilizing corner base so as to keep the workstation structure secure and limit movement if Paige bumps into the legs with her wheelchair. As mentioned above in the previous section, any front edges of the desk that Paige could possibly come into contact with should be protected. This will be accomplished by covering the desk tabletop, rotating surface, and moving shelf edges and corners with a foam edge guard.

All the moving mechanical components should be securely attached to the surfaces in a locked position. The rotating surface should move smoothly and the locking mechanism should have all parts shielded and secure so that no components can detach and harm the user. The moving shelves should be secured so that the top shelf does not accidentally fall. If needed, a brace will be placed under the extension platform drawers to provide additional stability. To prevent any safety hazards, only lightweight items such as DVDs will be placed on the top shelf for storage. Also, the maximum height of the top shelf will be at face height position so that there is no danger of anything falling on top of Paige when she goes to retrieve an item.

Possible mechanical hazards are the most to be considered since Paige’s desk will not have any electrical components except for her computer devices. Any wires or chargers will be placed towards the back of the desk so that Paige is shielded from coming into contact with them. Also, since the leg products to be used in the optimal design have an inch height adjustment, evaluation will have to be made to ascertain that all legs are the same height and secured in a locked position.

5. Impact of Engineering Solutions

The engineering solution for the workstation uses existing products on the market and will modify them and use certain elements for different applications in order to create unique product that is different from any handicap accessible desk available. The fact that we will be building the desk by hand as a custom left-handed dominant design makes it unique for Paige and her condition. Because our design is not universal, it is built specifically for Paige; it may not be adaptable for other persons with disabilities. Certain elements such as the rotating surface with locking mechanism and movable platform shelving could be incorporated into desk design for people with disabilities. Also for people with cerebral palsy or other medical conditions that limit them with motility in one side, the desk could be used a basis to accommodate for one-sided dominant people with disabilities. The desk is not just made for people in wheelchairs and could be applied to the office use where people are often one side dominant and want to conserve space. However, because this senior design desk project will not be made commercially available on the market, the product may not have a significant global impact. It does accommodate to the
societal context through its features to make electronic communication more easily accessible in a multitasking workspace for Paige. However, applying this beyond our client in a broad context is limited to marketing incentives which will not be pursued.

The design has a low environmental impact as none of the materials used can be seen as a hazard. Also because it will be located in Paige’s room there is little possibility it could negatively affect the environment. It does not contain any toxic or radioactive materials. Also the design’s purpose is to create a desk with low maintenance so that element will rarely have to be replaced and disposed out in the environment.

6. Life-long Learning

Thus far, our team has gained much knowledge about the design process. In creating this optimal design, we have learned a lot about how to apply solutions specific for the medical conditions of people with disabilities. Since Paige is left-hand dominant, we had to brainstorm solutions for a workstation that could accommodate to her and incorporate motile features that would acquire little force to operate. In the mechanical aspect, we researched different products that allow maximum workspace in a small amount of area and found existing products like Lazy Susan’s that could be modified for application. To design a locking mechanism for the rotating surface that Paige could operate with a single hand was difficult but we learned how to use pre-existing products like a retractable pen mechanism. We were able to do this by using comparison tables such as the Pugh matrix table to combine the ideas of our team in a product with the maximum feasibility and advantages.

We have learned how to plan a budget and research commercial items that could be modified to lower costs as well as combining construction of the desk itself in a carpentry shop by hand. The team has acquired new programming knowledge in using autoCAD programs to specifically aid in the design process for how components will be assembled together. Most importantly, we have come to realize that adaptation and flexibility are required in the design process. Machining elements will require more skills to attain to make the mechanisms work to their full potential. Even though we have combined three alternative designs into this optimal design, modifications and adjustments to the design will continue to be made as the year progresses.

7. Budget and Timeline

7.1 Budget

The team was first allotted a budget of $1000. This budget was raised to $2000 and then our team appealed to extend the budget to $3000. This was done because the budget had to be split between the five projects (the all-terrain wheelchair for Melody, this workstation project and a hot-tub lift for Paige, and a specialized seat and activity table for Sean). Table 1 below shows the final budget for this workstation project of $458.24.
### Timeline

The following table (Table 2) shows an Excel version of the timeline for this workstation project that was created in Microsoft Project. The full version can be found on the team website. (https://www.bme.uconn.edu/sendesSpring13/Team1/Project%20Timelines.htm)

<table>
<thead>
<tr>
<th>Task #</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Model rotating surface on desk</td>
<td>1 day</td>
<td>Fri 11/2/12</td>
<td>Fri 11/2/12</td>
</tr>
<tr>
<td>2</td>
<td>Model sliding bookcase on desk</td>
<td>1 day</td>
<td>Mon 11/5/12</td>
<td>Mon 11/5/12</td>
</tr>
<tr>
<td>3</td>
<td>Determine best positioning of features</td>
<td>1 day</td>
<td>Sat 11/3/12</td>
<td>Sat 11/3/12</td>
</tr>
<tr>
<td>4</td>
<td>Research locking mechanism</td>
<td>1 day</td>
<td>Fri 11/2/12</td>
<td>Fri 11/2/12</td>
</tr>
<tr>
<td>5</td>
<td>Go to NEAT for locking mechanism</td>
<td>1 day</td>
<td>Mon 2/18/13</td>
<td>Mon 2/18/13</td>
</tr>
<tr>
<td>6</td>
<td>Design and model new locking pin mechanism</td>
<td>7 days</td>
<td>Sat 11/24/12</td>
<td>Mon 12/3/12</td>
</tr>
<tr>
<td>7</td>
<td>Construct workstation tabletop surface</td>
<td>66 days</td>
<td>Sat 11/3/12</td>
<td>Fri 2/1/13</td>
</tr>
<tr>
<td>8</td>
<td>Splice lumber, glue pieces, and clamp together</td>
<td>1 day</td>
<td>Sat 11/3/12</td>
<td>Sat 11/3/12</td>
</tr>
<tr>
<td>9</td>
<td>Run surface through planar and cut to dimensions</td>
<td>1 day</td>
<td>Sat 11/10/12</td>
<td>Sat 11/10/12</td>
</tr>
<tr>
<td>10</td>
<td>Cut surface to construct right edge and glue together</td>
<td>1 day</td>
<td>Sun 12/2/12</td>
<td>Sun 12/2/12</td>
</tr>
<tr>
<td>11</td>
<td>Repair broken seam: add dowels and beam reinforcements</td>
<td>1 day</td>
<td>Sat 2/2/13</td>
<td>Sat 2/2/13</td>
</tr>
<tr>
<td>12</td>
<td>Sand surface and apply wood finish</td>
<td>34 days</td>
<td>Sat 2/9/13</td>
<td>Wed 3/27/13</td>
</tr>
<tr>
<td>13</td>
<td>Add half round edging</td>
<td>1 day</td>
<td>Thu 3/28/13</td>
<td>Thu 3/28/13</td>
</tr>
<tr>
<td>14</td>
<td>Repair Warped Desktop</td>
<td>9 days</td>
<td>Tue 3/12/13</td>
<td>Fri 3/22/13</td>
</tr>
<tr>
<td>15</td>
<td>Strip plywood supports and moisten tabletop supports</td>
<td>3 days</td>
<td>Tue 3/12/13</td>
<td>Thu 3/14/13</td>
</tr>
<tr>
<td>16</td>
<td>Clamp desk to surface and apply angle beam supports</td>
<td>7 days</td>
<td>Fri 3/15/13</td>
<td>Mon 3/25/13</td>
</tr>
<tr>
<td>17</td>
<td>Construct sliding bookcase</td>
<td>10 days</td>
<td>Fri 2/8/13</td>
<td>Thu 2/21/13</td>
</tr>
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<td></td>
<td>Activity Description</td>
<td>Duration</td>
<td>Start Date</td>
<td>End Date</td>
</tr>
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<tr>
<td>18</td>
<td>Build outer wall panels</td>
<td>1 day</td>
<td>Fri 2/8/13</td>
<td>Fri 2/8/13</td>
</tr>
<tr>
<td>19</td>
<td>Build drawers</td>
<td>1 day</td>
<td>Fri 2/8/13</td>
<td>Fri 2/8/13</td>
</tr>
<tr>
<td>20</td>
<td>Prime and paint bookcase</td>
<td>3 days</td>
<td>Thu 2/21/13</td>
<td>Mon 2/25/13</td>
</tr>
<tr>
<td>21</td>
<td>Assemble shelf and drawers</td>
<td>1 day</td>
<td>Fri 3/15/13</td>
<td>Fri 3/15/13</td>
</tr>
<tr>
<td>22</td>
<td>Attaching glide bearings</td>
<td>1 day</td>
<td>Fri 2/15/13</td>
<td>Fri 2/15/13</td>
</tr>
<tr>
<td>23</td>
<td>Add divider slats</td>
<td>2 days</td>
<td>Wed 4/10/13</td>
<td>Thu 4/11/13</td>
</tr>
<tr>
<td>24</td>
<td><strong>Build rotating surface</strong></td>
<td><strong>13 days</strong></td>
<td><strong>Tue 2/5/13</strong></td>
<td><strong>Thu 2/21/13</strong></td>
</tr>
<tr>
<td>25</td>
<td>Cut base and rotating surface circles</td>
<td>1 day</td>
<td>Tue 2/5/13</td>
<td>Tue 2/5/13</td>
</tr>
<tr>
<td>26</td>
<td>Attach Lazy Susan bearing</td>
<td>1 day</td>
<td>Tue 2/26/13</td>
<td>Tue 2/26/13</td>
</tr>
<tr>
<td>27</td>
<td>Wood fill and varnish bearing</td>
<td>1 day</td>
<td>Tue 3/12/13</td>
<td>Tue 3/12/13</td>
</tr>
<tr>
<td>28</td>
<td>Order desk post legs</td>
<td>1 day</td>
<td>Tue 2/19/13</td>
<td>Tue 2/19/13</td>
</tr>
<tr>
<td>29</td>
<td>Attach desk post legs</td>
<td>1 day</td>
<td>Wed 3/20/13</td>
<td>Wed 3/20/13</td>
</tr>
<tr>
<td>30</td>
<td><strong>Modify rotating surface to implement locking mechanism</strong></td>
<td><strong>3 days</strong></td>
<td><strong>Thu 2/28/13</strong></td>
<td><strong>Mon 3/4/13</strong></td>
</tr>
<tr>
<td>31</td>
<td>Drill two holes on opposite sides for edges</td>
<td>1 day</td>
<td>Thu 2/28/13</td>
<td>Thu 2/28/13</td>
</tr>
<tr>
<td>32</td>
<td>Construct locking hole block</td>
<td>4 days</td>
<td>Mon 4/1/13</td>
<td>Thu 4/4/13</td>
</tr>
<tr>
<td>33</td>
<td><strong>Assemble locking mechanism in rotating surface and between desk</strong></td>
<td><strong>16 days</strong></td>
<td><strong>Thu 1/31/13</strong></td>
<td><strong>Thu 2/21/13</strong></td>
</tr>
<tr>
<td>34</td>
<td>Machine two cylinder pins with grasping head</td>
<td>1 day</td>
<td>Thu 1/31/13</td>
<td>Thu 1/31/13</td>
</tr>
<tr>
<td>35</td>
<td>Insert pin into drilled holes</td>
<td>1 day</td>
<td>Thu 2/28/13</td>
<td>Thu 2/28/13</td>
</tr>
<tr>
<td>36</td>
<td>Affix rotating surface to desktop surface</td>
<td>1 day</td>
<td>Fri 3/29/13</td>
<td>Fri 3/29/13</td>
</tr>
<tr>
<td>37</td>
<td>Order and attach easel to rotating surface</td>
<td>1 day</td>
<td>Fri 3/29/13</td>
<td>Fri 3/29/13</td>
</tr>
<tr>
<td>38</td>
<td>Affix sliding bookcase to desktop surface</td>
<td>1 day</td>
<td>Thu 3/28/13</td>
<td>Thu 3/28/13</td>
</tr>
<tr>
<td>39</td>
<td><strong>Prototype Testing</strong></td>
<td><strong>5 days</strong></td>
<td><strong>Sun 3/17/13</strong></td>
<td><strong>Thu 3/21/13</strong></td>
</tr>
<tr>
<td>40</td>
<td>Test and modify rotating surface feature</td>
<td>1 day</td>
<td>Sun 3/17/13</td>
<td>Sun 3/17/13</td>
</tr>
<tr>
<td>41</td>
<td>Test rotating surface with locking mechanism with Paige for motility</td>
<td>1 day</td>
<td>Sun 3/17/13</td>
<td>Sun 3/17/13</td>
</tr>
<tr>
<td>42</td>
<td>Test leg support stability for maximum capacity</td>
<td>1 day</td>
<td>Sun 3/17/13</td>
<td>Sun 3/17/13</td>
</tr>
<tr>
<td>43</td>
<td>Test sliding bookcase for possible added extension</td>
<td>1 day</td>
<td>Sun 3/17/13</td>
<td>Sun 3/17/13</td>
</tr>
<tr>
<td>44</td>
<td>Troubleshoot for any possible additional features</td>
<td>1 day</td>
<td>Sun 3/17/13</td>
<td>Sun 3/17/13</td>
</tr>
<tr>
<td>45</td>
<td>Safety testing</td>
<td>5 days</td>
<td>Sun 3/3/13</td>
<td>Thu 3/7/13</td>
</tr>
<tr>
<td>46</td>
<td><strong>Meeting with Paige (deliver completed desk!)</strong></td>
<td><strong>1 day</strong></td>
<td><strong>Sat 4/27/13</strong></td>
<td><strong>Sat 4/27/13</strong></td>
</tr>
<tr>
<td>47</td>
<td>Check dimensions and height preference</td>
<td>1 day</td>
<td>Sat 4/20/13</td>
<td>Sat 4/20/13</td>
</tr>
<tr>
<td></td>
<td>Client testing period</td>
<td>6 days</td>
<td>Sat 4/20/13</td>
<td>Fri 4/26/13</td>
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Table 2. Timeline for Paige’s workstation

8. Team members contributions to the Project
This section gives an overview as to what each team member has contributed to the design process this semester, and what they will work on during the spring semester. Although the team has worked together to design and begin building this project, we have broken up the responsibilities by assigning a team member to take charge of each task. There are certain aspects of the design process that all of the team members have participated in. This includes visiting with our client to get design input and taking turns presenting our weekly progress.

8.1 Ana Groff

Ana’s contribution to this workstation project includes the research and development of the actual workstation design. Since our team has five projects, each member took on a specific project to be responsible for the details while the rest of the team provided design input so Ana was in charge of the workstation. She wrote all the reports, developed the budget and timeline, and ordered all the parts. Ana also modeled the desk dimensions and features on Unigraphics and helped build the desk construction by hand – splicing lumber, running it through a planar, and gluing it together, confirming the available parts throughout the process. She designed and worked on the logic behind the rotating and locking mechanism for the rotating surface feature. Ana helped help construct the angled steel beams to support the desktop and prevent warping. She built the rotating surface and its locking mechanism. She helped paint and assemble the sliding bookcase and built the divider slats for the drawers. She also helped build the gliding platform and the stacking blocks to increase the desk height.

8.2 Brandon Calavan

As Brandon owns a carpentry shop, he therefore contributed most of the input for the desk construction due to his experience. He provided the information on what kind of lumber to use, how the desk would be built, and the wood glue and finish it would need for assembly. He led the construction of the desktop work surface, showing the team how to splice it through a table saw, create a frame to build it on, plane the lumber, and glue the sections together as of now. He provided input on using a chair rotator for the locking mechanism feature. Brandon did a lot of the woodwork. He built the bookcase, shelf, and drawers and helped assemble it. He also built the gliding platform. He assembled the angled steel beams to the desktop and glued the desktop together. He also fixed the warp and treated the wood. Brandon attached the metal post legs to the stacking blocks to the desktop underside.

8.3 Dylan Rinker

Dylan provided input on the mechanism for how the rotating surface would operate and gave alternative designs using flaps that would be aligned underneath the desktop to create a locking mechanism. He also helped in the desk construction, in running the lumber through the planar and splicing the sections. He gave design input for the sliding bookcase as an alternative design.

8.4 Sebastian Pineo

Sebastian helped continue the building of the desk by pulling the sections through the planar and helping glue the sections together. He helped paint the sliding bookcase.
8.5 Steve Benn

Steve provided input on the desk construction. He also helped build the desktop, splicing the lumber, building the frame, gluing the sections together, and running it through a planar to shave it down. He researched some on the desk leg optimal design as well. He helped paint the sliding bookcase.

9. Conclusion

In conclusion, the objective of this project is to create a workstation for our client with cerebral palsy, Paige Librandi, to increase her independence. It will incorporate several operable features that will provide an efficient and multitasking workspace for her to accomplish tasks. It aims to be accessible to her wheelchair and accommodate to her left-hand dominant side, as well as prevent her items from falling off the edge. After researching previous products, the team came up with three alternative designs for the desk and then chose an optimal design. This design will consist of an L-shape desk with quarter-round edging that incorporates two features: a rotating surface with locking mechanism, and a sliding extension bookcase. Ultimately, the design’s purpose is to be accessible to Paige and her devices, and easily operable with low force motility.

Several realistic constraints were considered in the design that evaluated engineering standards, safety, manufacturability, and sustainability. The design would incorporate protective edging and fillets to eliminate sharp corners on all the features of the workstation. It will be manufactured and assembled by hand from lumber, custom built for our client to provide a sturdy structure that will endure against Paige’s hard use. With a projected budget of $176.50 and a detailed timeline for task completion our team will continue progress on the construction of desk. The team will finish before April 2013 and even plans to complete the workstation before the second spring semester in hopes that Paige will be able to use it earlier for school.

10. References


11. Acknowledgements

The team would like to thank the following individuals for their contributions to this design project:

Librandi family: Design input
John Enderle: Design advice and guidance
Sarah Brittain: Design advising
Kelly Fradet lumber: Diane with donations
NEAT marketplace: Don and staff helping find items
Machine Shop: Pete and Serge's advice and materials
Jennifer Delroises: Parts ordering and purchases
Orlando Echevarria: for help with setting up the website and backing up the files

12. Appendix

12.1 Updated Specifications
Current work station technical specifications

Physical:
  Materials:  Douglas fir kiln dried wood
              Galvanized steel post legs
              Angled steel beams
              Plywood sheets
              Lazy Susan bearing
              Stock aluminum

Mechanical:
  Size:  Desk:
         Minimum desk space: 72x51 inches (L x W)
         Rotating table surface: 2 ft diameter
         Sliding bookcase:
         24.13x15.75x11.63 inches (LxHxD)
         Gliding platform:
         14x18 inches (WxL)
  Weight: ~100 lbs
  Features: Rotational part, extension shelving, gliding platform fillets, half round edging

Environmental:
  Storage Temperature: -10 – 120 °F
  Operating temperature: 64 – 97 °F
  Operating environment: Indoor bedroom

Safety:  half round edging, fillet corners, wheelchair space

Maintenance:  Cleaning, miscellaneous repair (oil cylinder pin shaft in hole and all bearings)
## 12.2 Purchase Requisitions and Price Quotes

### PURCHASE ORDER REQUISITION - UCONN BME SENIOR DESIGN LAB

Instructions: Students are to fill out boxed areas with white background
Each Vendor will require a different purchase requisition

<table>
<thead>
<tr>
<th>Date: 10/16/2012</th>
<th>TEAM #: 1</th>
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</thead>
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<td>Student Name: Ana Groff</td>
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<tr>
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<tr>
<td>ADDRESS: 1527 Storrs Rd, Storrs CT 06268</td>
<td>Total Expenses $33</td>
</tr>
<tr>
<td>PHONE: 860-429-2990</td>
<td></td>
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<tr>
<td>CONTACT:</td>
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#### ONLY ONE COMPANY PER REQUISITION

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<tr>
<th>Catalog #</th>
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<th>Unit</th>
<th>QTY</th>
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**Comments**: We will go to Mansfield supply to order the items ourselves and call Jennifer for the order purchase and confirmation. We are planning to go on this Friday or Saturday in the morning. The prices should be correct, if not estimated costs.

**Shipping**: $0.00

**Total**: $32.91

**ORDERING FROM SEARS; WALMART, HOME DEPOT; and other large department stores is not permitted.**

**TA Authorization**: (Do NOT submit to BME Office without a signature)

---

**Office Use ONLY**

Order Date: Order #: 

In/Out: Account #: 

COMMENTS: 

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Each Vendor will require a different purchase requisition

Date: 11/13/2012
TEAM #: 1

VENDOR: Amazon
ADDRESS: 1200 12th Ave. South, Ste. 1200 Seattle, WA 98144-2734
PHONE: 1-866-216-1072

<table>
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Ships free from Amazon with super saver shipping

Shipping: $0.00
Total: $29.99

ORDERING FROM SEARS, WALMART, HOME DEPOT; and other large department stores is not permitted.

TA Authorization: ____________________________

(Do NOT submit to BME Office without a signature)

Office Use ONLY

Order Date: ____________________________
Order #: ____________________________
Initials: ____________________________
Account #: ____________________________
COMMENTS: ____________________________