CHAPTER 7
DUKE UNIVERSITY

Pratt School of Engineering
Department of Biomedical Engineering
136 Hudson Hall, Box 90281
Durham, NC 27708-0281

Principal Investigator:

Larry N. Bohs (919) 660-5155

lnb@duke.edu

FOOT-OPERATED CAMERA SYSTEM

Designers: Eric Lai, Anthony Lau, and Tom Rose
Client Coordinator: Luanne Holland, Durham County Schools
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

A wheelchair-mounted, foot-controlled camera system was developed to allow a client to take digital photos unassisted. The client was an eight-year-old boy with cerebral palsy, who had limited fine motor control in his upper extremities, but good control of his feet. The system consists of a digital camera with a panning mechanism, an external LCD display, and foot pedal controls for shutter release and panning. The completed system is removable and easy to operate, and gives the client the ability to take digital pictures independently.

SUMMARY OF IMPACT

The device will allow the client to take pictures unassisted. His mother commented that she liked "how it's got a large range of motion" and that the client "can take pictures of just about anything he wants." The system's portability will allow the client to use it in classrooms and on field trips, thereby increasing his level of interaction with classmates and family members.

TECHNICAL DESCRIPTION

The Foot-Operated Camera System (Figure 7.1) consists of a commercial digital camera (Olympus Stylus 300) with shutter remote, a 5" LCD screen, a commercial tilting mechanism with remote (Bescor MP-101), and a custom mounting apparatus for attaching the devices to the client's power wheelchair.

The camera's remote control was replaced with a large switch shaped like a dog's paw (Radio Shack), which was attached to the left footrest of the client's wheelchair with Velcro. The camera's 1.5" LCD screen was too small for the client to use effectively, so a 5" LCD screen and associated battery compartment were attached in easy view, using a gooseneck attachment clip from a microphone boom stand.

Figure 7.1. Foot-Operated Camera System, with Camera and Screen Rotated Out

The camera was attached to the top of the tilting mechanism, which was attached to a custom mounting arm using a tripod mount. The tilting mechanism allowed the camera to rotate +/- 90° horizontally and +/- 15° vertically, and its remote control was attached to the right footrest using Velcro.

A mounting arm was constructed from 5/8" diameter copper tubing, painted black. A custom clamp was machined to connect one end of the copper tubing to the horizontal side bar of the wheelchair. This clamp functioned like a sandwich, with two recessed openings for clamping the wheelchair side bar and the copper tubing together. A hole was drilled through the clamp and copper tubing, through which a quick release pin was inserted, to secure the support structure while allowing for easy removal. After testing, a series of holes were drilled in the copper tubing to allow the camera and LCD to be placed farther from the client as he grows.

Removing the system from the wheelchair involves removing the spring pin from the mounting clamp, sliding the mounting arm from the clamp, and removing the foot controls from their Velcro pads. The client's parents can mount or remove the system in less than two minutes. Figure 7.2 shows the client using the device.

Cost of parts for the Foot-Operated Camera System was approximately $700.

Figure 7.2. Client Using Foot Operated Camera, with LCD Screen Rotated 180 degrees

RECREATIONAL SWING AID

Designers: Mike Holliday, Eric Lai, and Mike Scott
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The client, a seven-year-old boy with TAR syndrome, lacks radius bones and, therefore, has short arms and weak hands, which limit his reach and strength. The client had difficulty participating with his peers and siblings in many of his favorite recreational activities, including the use of a playground swing. The goal of this project was to create a device that allowed the client to swing independently and reach greater heights than before. A swing aid was designed with front and back safety pads, a durable nylon safety strap, easy-grip handles attached to the swing chain, and a clip used by the client to secure or remove the front safety pad.

SUMMARY OF IMPACT

The client has quickly become comfortable with the Recreational Swing Aid, and now can go "super high" without parental assistance. The swing aid will provide him with greater independence and confidence at home and school by allowing him to participate with his peers in this common recreational activity. The client's mother commented that the "swing has enabled him to enjoy going outside again with the rest of the family. It is great to see him wanting to do things most 'normal' kids do, and enjoying the fun of childhood."

TECHNICAL DESCRIPTION

The completed Recreational Swing Aid is shown in Figure 7.3. The primary components of the aid were constructed from a child's water life vest. After removing the two arm flaps, the life vest was cut horizontally, forming the back safety pad from the lower two-thirds of the vest and the front safety pad from the remaining piece. 1″ nylon straps were attached to the clips of the back pad with brass grommets.

Two metal clips connected a 2″ nylon safety strap above the back safety pad. To prevent the strap from sliding between the client's back and the back pad, the strap was placed through a nylon loop extending from the top of the back pad. The remaining slack of the 2″ nylon loop was sewn vertically into the back pad and secured under the swing seat by a large brass grommet. This prevented the client from sliding off the swing in the open area between the back pad and the seat.

Figure 7.3. Recreational Swing Aid

On each swing chain, a 1″ nylon strap extended through a plastic fastener and looped through a rubber bicycle grip. This allowed the client to easily and securely lean forward and backward in the natural swinging motion.

Two ¾″ nylon straps were sewn into the front pad and fixed to the left swing chain at two separate plastic fasteners. At the opposite side of the front pad, these straps were sewn together and ended at one piece of a clip, which is used by the client to securely attach the front pad between the swing chains. A plastic fastener rigidly connected the alternate end of this clip to the swing chain so that the client could use both hands to direct the alternate free end of the clip into the locked position. Figure 7.4 shows the client using the device.

The cost of parts for the recreational swing aid was $75, not including the original swing seat and chains.

Figure 7.4. Client Using Recreational Swing Aid

OVEN HELPER

Designers: Roni Prucz, Justin Brower, and William Hong
Client Coordinator: Annette Lauber, North Carolina Assistive Technology Project
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The Oven Helper was designed for a client who loves to cook, but has difficulty using large baking and casserole dishes due to her cerebral palsy and use of a wheelchair. The device assists her with the lifting and lowering of heavy pans into and out of an oven. The device utilizes a gas spring mechanism to help her move pans between the stovetop and middle oven rack. Pans are vertically displaced through single-hand pushing or pulling actions. The device is mobile, easy to operate, and suitable for use by individuals with back pain or who use wheelchairs.

SUMMARY OF IMPACT

Providing the client with this device allows her to cook items previously not possible. Besides enhancing self-reliance, the device allows the client to cook larger portions of food for storing or serving to guests, and increases the diversity of dishes that can be made, such as large casseroles. The client commented, "The oven helper can help me in so many ways in the kitchen. It feels as though it was made to be there. I could not be happier with the result."

TECHNICAL DESCRIPTION

The Oven Helper (Figure 7.5) was built by modifying a commercial height-adjustable rolling table. The L-shaped frame was modified to obtain the desired minimum level of 22" and the maximum height of 36," which corresponded to the client's middle oven rack and stovetop respectively. After substantial research, a gas spring was chosen as the lifting mechanism. Testing revealed that commercial springs did not possess the proper extension and force, so a custom spring was ordered from Easy Lift Springs (Melbourne, FL), with a stroke of 15," a compressed length of 18," and a 21.5 lb force at full extension. This spring also featured a locking system controlled by a Bowden wire.

Figure 7.5. Oven Helper

The spring was mounted inside the square telescoping tubing of the original rolling table, which required careful modification to allow the spring to recess into the tabletop and the release head to sit below the frame of the device. A small notch was also cut in the frame to accommodate the Bowden wire.

When the prototype was tested with the client, several problems became apparent. At full extension, the inner and outer telescoping shafts overlapped by only 1." The weight of the table thus caused the inner shaft to sag toward the cantilevered end of the table, and the client could not lower the device due to the resulting friction between the telescoping shafts. Additionally, the client could not comfortably reach the top of the table. These problems were resolved by attaching two linear drawer glides, one inside and one outside the shaft.

Custom clamps secured the external linear glide to the shaft. A padded handle was mounted below the tabletop, with the spring release lever attached for easy operation by the client.

To hold the Oven Helper in place while in use, a soft rubber keyboard wrist pad was affixed horizontally to the lower frame, which provided substantial friction against the opened oven door. Raised lips were added to two sides of the tabletop to prevent dishes from sliding off of the device.

Figure 7.6 and Figure 7.7 show the client using the device.

Cost of parts for the Oven Helper was approximately $550.

Figure 7.6. Client using Oven Helper to Remove Item from Oven

Figure 7.7. Client Using Oven Helper to Put Item on Stovetop

PENCIL DISPENSER AND COUNTER

Designers: Leahthan Domeshek, Kelly Fong, and Evan Harrell
Client Coordinator: Judy Stroupe, Orange Enterprises
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The Pencil Dispenser and Counter helps workers at a vocational rehabilitation facility count a specific number of pencils. The device is first loaded with pencils and set to a specific goal count by a supervisor. Once the set-up is complete, the worker pulls a lever to dispense and count one pencil, which falls into a bottom hopper with a folding wall. Each time the worker pulls the lever, another pencil is dispensed and the count is incremented on a large digital display. An audible signal sounds when the worker reaches the goal count. The device is inexpensive, portable, easy to operate and suitable for use by individuals who lack fine motor control.

SUMMARY OF IMPACT

In the past, employees had difficulty handling and counting pencils. An assistant oversaw and helped with pencil sorting at all times. The Pencil Dispenser and Counter will help make employees more independent and efficient in this task, while still allowing them to be an important part of the process. A supervisor commented, "The employees used to count eight to ten pencils in an hour and then need a break, now they can count that many in five minutes."

TECHNICAL DESCRIPTION

The Pencil Dispenser and Counter (Figure 7.8) uses a rotating cylinder with a slot big enough to hold one pencil. When the user pulls a lever, the cylinder rotates and the pencil falls into a bottom hopper. A torsion spring helps return the lever and cylinder to the loading position. A stopper, padded for protection and shock absorption, stops the lever in the correct position to allow another pencil to fall into the slot in the cylinder. The cylinder shaft is supported on flange bearings to make it durable and easy to rotate. The pencil container is V-shaped and holds at least 150 pencils in a compact space while also allowing easy loading of the cylinder.

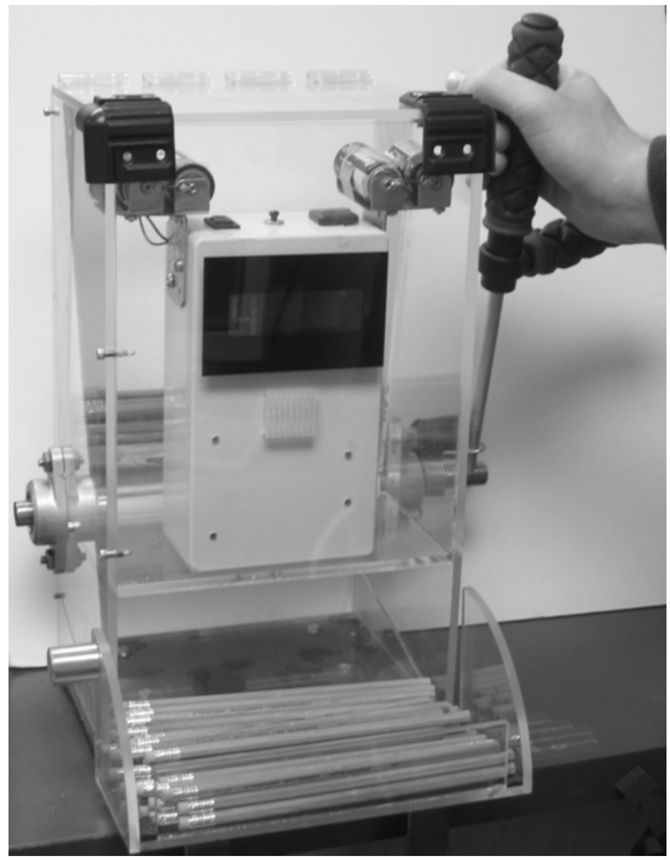

Figure 7.8. Pencil Dispenser and Counter

The count is actuated using a momentary toggle switch, which resides in a circumferential groove in the cylinder. The switch is activated when a pencil rotates past the switch as the lever is pulled down. The switch is connected to a BASIC Stamp II microprocessor, which tallies the count and controls the system. An up/down rocker switch sets the goal count from 0-100 in increments of five, and a buzzer beeps four times once the goal count is reached. An LCD with large character display and a continuous backlight shows the number of pencils dispensed. Four C batteries power the device for over 100 hours, and are easily replaced.

The pencils fall out of the cylinder into a bottom hopper, which has a slanted floor so the pencils roll down to the front of the device. The flap of the hopper is mounted to the main frame of the device using a hinge, and the flap can be folded for storage. Quarter-circle walls attached to the sides of the bottom flap prevent pencils from spilling out during retrieval. Two integral clamps and rubber padding stabilize the device to a work table. Figure 7.9 shows the device in use.

The device was evaluated to assess durability, ease of use, effectiveness, and safety. Durability was assessed throughout the design stages of the device and was the main reason for using the clamps, rubber bottom, and bearings. Jamming was minimized to below one percent in a 500-pencil trial. After testing the device with employees, we determined that they could operate the lever and unload the pencils from the bottom hopper.

Cost of parts for the Pencil Dispenser and Counter was approximately $400.

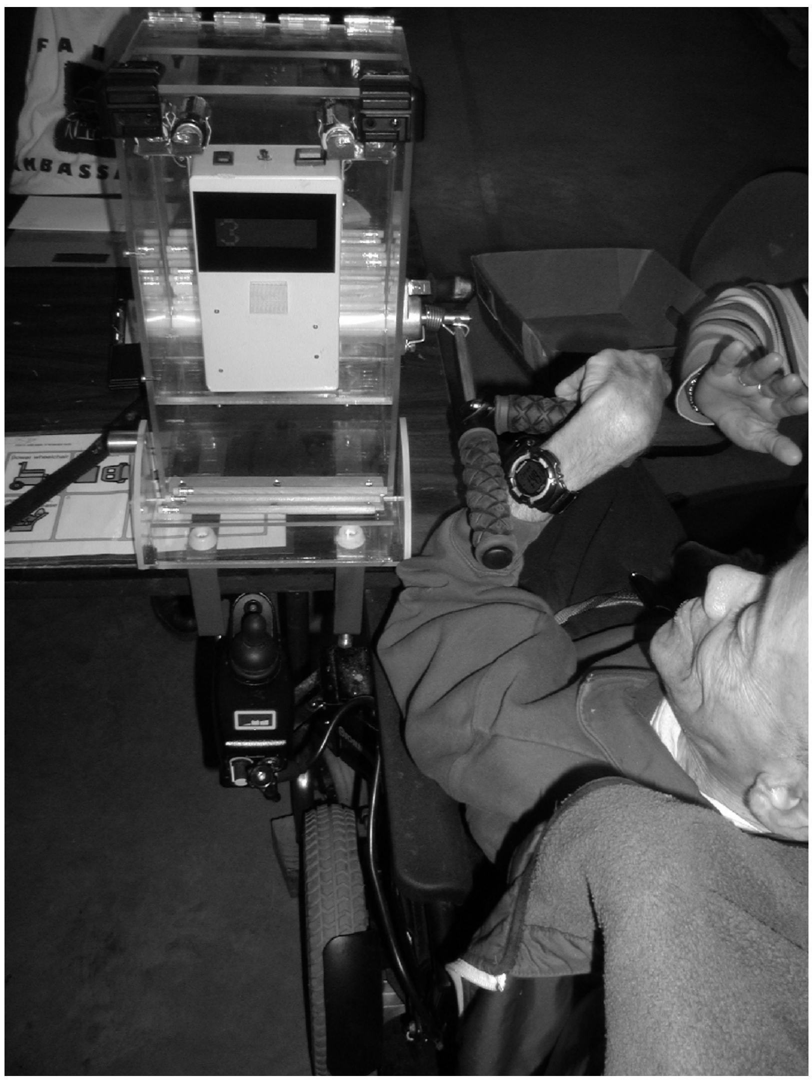

Figure 7.9. Employee Using Pencil Counter

MODIFIED ELECTRIC SCOOTER

Designers: Kevin Ko, Aya Eguchi, and Eric Schwartz
Client Coordinator: Jodi Petry, Lenox Baker Hospital
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

A Schwinn S180 electric scooter was modified for safe and comfortable use by an 11-year-old boy with right-side hemiplegia. The modifications aid with balance, steering, and comfort, as well as limiting the maximum speed. As a result, the client can safely and comfortably ride the scooter, which he was unable to do previously.

SUMMARY OF IMPACT

The modified scooter allows the client to use his electric scooter comfortably, independently, and safely. He can now ride with family and friends during trips to the beach, thereby fostering self-confidence. In a letter, the client said, "Thank you very much for all the hard work you all did on my scooter. I will be able to ride with my brothers and sister and not be left sitting out watching them have all the fun. I won't have to work as hard as them! I'll be the coolest kid in the neighborhood with the coolest ride! Thank you."

TECHNICAL DESCRIPTION

The modified scooter (Figure 7.10) includes: 1) a foot guard to prevent the right foot from falling off the scooter; 2) modified handlebars to facilitate left-handed control; 3) a stabilizing mechanism for help with balance; 4) a modified seat and right arm support to maintain the client's posture while riding; and 5) a speed governor to maintain a safe operating speed.

The foot guard was made from aluminum sheet metal, which was molded to the contour of the floorboard's right, outer edge. The metal wraps around the underside of the floorboard and is attached by four countersunk 3/16" flat headed bolts. The top edge of the foot guard extends 1.5" from the bottom edge, which is sufficient to block a foot from sliding off that side of the scooter.

Figure 7.10. Modified Scooter

The handlebars were modified to reside closer to the client's body and facilitate steering with the left hand. Two sections of aluminum tubing, 8" long, were attached to provide an L-shaped extension to the original bar. The throttle and hand brake were attached to this extension, bringing the scooter controls 8" closer to the user's body.

A robust pair of training wheels (Fat wheels, Mechanical Innovations, Inc, Charlotte, NC) was attached to aid the client's balance. One-inch axle extenders were added to properly attach the Fat wheels. During testing of this mechanism, excessive stress on the training wheels caused the mounting bracket to bend. Therefore, an additional triangular plate was welded to the bracket, and a larger-diameter axle extender was created and attached.

Because the client found it difficult to maintain his posture with the original seat, an 18" high-back seat (Freedom Concepts, Inc., Winnipeg, MB), which included side-supports, was purchased and mounted. A custom armrest was fabricated from a sheet of aluminum, slightly curved to an arm's contour, lined with an adhesive foam and Poly-Fil, and covered with black vinyl. The armrest was supported by two aluminum shafts, one attached to the backrest, and one attached to the bottom of the seat. A ball was attached to the end of the armrest to provide a gripping surface for the right hand.

A mechanical speed governor was implemented to limit the maximum speed of the scooter, which was initially too high for use. Three holes were drilled in the throttle mechanism to accept setscrews, such that three different maximum speeds could be selected. In this way, the client's parents can gradually increase the maximum speed of the scooter as the client becomes more skilled and comfortable. Figure 7.11 shows the client using the scooter.

Cost of parts for the scooter modifications was approximately $500.

Figure 7.11. Client Using Modified Scooter

ALL TERRAIN WALKER

Designers: Dan Choi, Stephanie Chi, and Fong Ming Hooi
Client Coordinator: Barbara Howard, Duke University Hospital
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The All Terrain Walker was developed to help the client, a 12-year-old girl with cerebral palsy, travel more efficiently on rough surfaces. An Otto Bock Busy Bee frame was modified by adding large front wheels, swivel rear wheels with shock absorption, an additional frame member for stability, and padded handlebar grips. These modifications yield a responsive and stable all-terrain walker that allows the user to travel on rough surfaces such as trails and grass, as well as on pavement and other smooth surfaces.

SUMMARY OF IMPACT

The All Terrain Walker will enable the client to participate in more outdoor activities with her family. Her mother commented that, "Mobility devices for [the client] equal freedom; freedom to get where she wants, when she wants, at a relatively normal rate of speed (or better!). This 'all-terrain walker' will expand the geography of her world, since we otherwise could not go to the places it will get her to. I think the whole process of building it for her, with her input, also offered her more evidence that she has value as a human being. Otherwise, why would everyone bother?"

TECHNICAL DESCRIPTION

The All Terrain Walker (Figure 7.12) was created by modifying a commercial walker frame (Busy Bee; Otto Bock, Minneapolis, MN). The modifications included large front wheels to allow the client to negotiate rocks, roots, and other bumps, swivel rear wheels, frame stabilization, and padded handlebar grips.

The front swivel wheels of the Busy Bee were removed. 20" alloy wheels (Baby Jogger, Richmond, VA) were mounted to the front of the frame by welding on steel cylinders that accepted the quick release axles of the commercial wheels. The cylinders were welded at the proper height to keep the frame level with these large wheels.

Figure 7.12. All Terrain Walker

The fixed rear wheels of the original frame were replaced with two shock-absorbing swivel wheels (Frog Legs, Inc., Vinton, IA). The swivel wheels were attached using standard caster housings built for wheelchairs, which were bolted to a steel plate welded to the legs of the walker frame. The walker frame was shortened in this area to account for the larger size of the Frog Legs casters compared to the original wheels.

The walker frame was stabilized by adding a 3/4" steel tube, bent to allow more rear clearance for the client's feet. It was welded to the walker frame at the bottom of the rear legs. The grips on the handrails of the original frame were replaced with tennis grip tape, which the client found more comfortable.

The client tested the All Terrain Walker on rough grass and found the walker to be easier to roll on such surfaces. One disadvantage is that the large front wheels also made it somewhat more difficult to control speed when going down a steep paved hill. Because the walker is designed for off-road travel, it will require supervision until the user learns how to control its response. Figure 7.13 shows the client using the walker.

Cost of parts for the All Terrain Walker was approximately $470.

Figure 7.13. Client Using All Terrain Walker

ROTATIONAL WORKSTATION

Designers: Dan Southam, Brian Goldberg, and Mike Scott
Client Coordinator: Barbara Howard, Duke University Hospital
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

A six-year-old client previously had difficulty completing his homework and working on the computer without adult assistance because he was born with TAR syndrome, a condition resulting in short arms and weakened hands. A custom computer workstation was built that allows him to work independently at his desk. The design consists of a rotating surface that provides easy access to a magnetic writing stand and a wireless keyboard, both with adjustable incline. The client presses and releases a foot pedal to lock the rotating surface in the desired position, while a commercial desk chair with a back pad provides appropriate support. Using this device, the client can complete his work and operate the computer independently and comfortably.

SUMMARY OF IMPACT

The Rotational Workstation (see Figure 7.14) will enable the client to complete his homework, paint or draw pictures, and use a computer without adult assistance. The client's mother commented, "He loves it! He is using it to make all kinds of stuff, and feels so important having his own desk. There is nothing on the desk he can't operate, and it works very well."

TECHNICAL DESCRIPTION

The Rotational Workstation includes a rotating surface, adjustable writing stand, wireless keyboard, an adjustable-height desk, and a desk chair.

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 series of holes were drilled near the outer edge of one sector of the desk to accommodate the client's pens, pencils, and markers.

A commercial adjustable easel was attached to the rotating surface, and a clipboard attached to the

Figure 7.14. Rotational Workstation

easel. A magnetic writing surface was glued to the clipboard, and a foam-padded lever was built to make the clip easy for the client to use. Magnets with small handles and a check memo rail were provided so that the client could secure his writing paper to the clipboard using the clip on the top and magnets on the sides, thus allowing him to draw and erase without tearing the paper.

The rotating surface was attached via the Lazy Susan bearing to a commercial adjustable-height desk. Thick foam weather-stripping was secured to the edge of the desk to improve the client's comfort as he leaned over to use the writing stand or keyboard. A commercial desk chair with low ground-to-seat height was found appropriate for the client, after adding a back pad and extra foam cushioning at the rear of the backrest to support his torso while reaching the workstation components.

Finally, 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. The client could depress a drum pedal, connected to the pin by a bike cable, to disengage the pin while he rotated the surface to an alternate position.

Figure 7.15 shows the client using the Rotational Workstation. Cost of parts for the device was approximately $550.

Figure 7.15. Client Using Workstation

PAPER MANAGEMENT SYSTEM

Designers: Clayton Eiswirth, Megan Hanson, and Sean Huffman
Client Coordinator: Judy Stroupe, Orange Enterprises
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The client is a middle-aged man with cerebral palsy. His place of employment is an organization that employs adults with disabilities, helps them develop job skills, and works at placing them in jobs within the community. The client and his employer requested a device that would help the client collate two pieces of paper and fold them in a tri-fold, using only coarse movements with his left hand. The design included three components: a folding mechanism, a clipping mechanism, and a collating mechanism.

SUMMARY OF IMPACT

The Paper Management System allows the client and others to collate and fold up to three pieces of paper at a time, a task not previously possible. The client's supervisor commented, "He would have had so much difficulty trying to do something like this before. By just using these handles the task is greatly simplified."

TECHNICAL DESCRIPTION

The overall design (as shown in use, in Figure 7.16) incorporates three components for folding, holding, and collating the paper. The folding surface is comprised of three ¼" polycarbonate panels that are connected by custom hinges, which attach on the bottom of the panels, creating a smooth surface. A standard tri-fold is achieved by using the two levers to first fold one panel, open it, then fold the second panel and open it. A wooden L-corner with attached rubber provides an edge for the client to push the paper against. The holding component descends from the rear of the device to clip the paper in place while folding. A square aluminum bar is attached to a piece of steel sheet metal, the clip. The sheet metal has a 4" track cut lengthwise out of its center. The bar is fitted through the guide tracks of two sets of polycarbonate. The outer set prevents rotation with vertical guide tracks and is attached to a 10" drawer slide. The inner set is fixed in place with angled tracks bored into the sides, allowing the bar to raise and lower as the outer set is moved back and forth with an attached copper lever. This action causes the clip to slide onto the center panel of the folding component. Magnets inlaid in the polycarbonate keep the clip from moving once it reaches the folding surface. After a paper is folded, moving the lever back raises the clip, and a vertical rod pushes the folded paper from the clip.

A commercial product was used so that several sheets of paper could be collated and folded simultaneously. This collator had a right-handed lever to move a set of pages out of stationary trays. However, the client needed a left-handed lever. We fixed the lever arm in place, put the collation trays on 10" drawer slides, and added a left-handed lever arm. When the client slides this lever arm, it moves the trays along the drawer slides, and the collated sheets of paper are pushed out toward the paper-folding surface.

Cost of parts for the Paper Handling System was approximately $330.

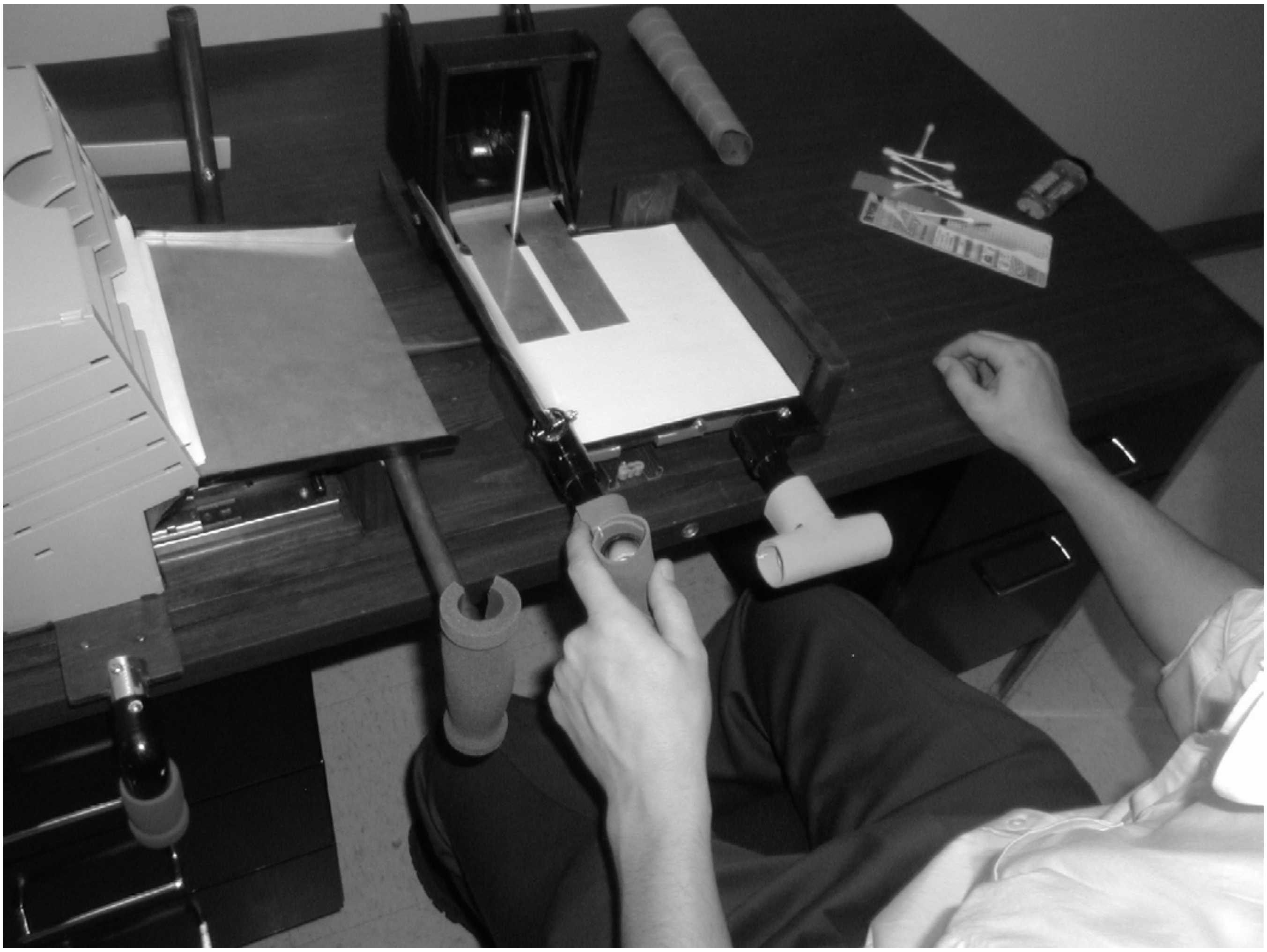

Figure 7.16. The Paper Management System, Shown Starting the First Fold

3-D SOUND STATION

Designers: Jonathan Weiss, George Crowell, and Mike Chu
Client Coordinator: Luanne Holland and Susan Parker, Durham Public Schools
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The goal of the project was to provide a versatile stimulation and entertainment system, activated by switch presses. The client is a ten-year-old boy with multiple disabilities, including limited vision as well as cognitive and developmental delays. The 3-D Sound Station includes speakers, large pushbutton switches, an LED tube, music keyboard, and an MP3 player, all mounted on an adjustable stand. Several modes, selectable by the therapist, allow the station to provide different types of cognitive training and feedback for the client.

SUMMARY OF IMPACT

The client is often unable to independently participate in class activities and has had limited success with commercially available technologies. The 3-D Sound Station will aid in therapy and provide the client with entertainment. The client was intrigued by the device from the first interactions. The supervisor, who is also the client's speech-language therapist said, "The device looks great and [the client] seems to enjoy it."

TECHNICAL DESCRIPTION

The 3-D Sound Station (Figure 7.17) includes five main components: an MP3 player, speakers, user input switches, an LED tube, and a detachable musical keyboard. In addition, a teacher interface box allows the teacher to switch between different operating modes of the device. The MP3 player (Rogue Robotics, Toronto, Ontario) is controlled via RS232 serial commands from a PIC microcontroller. Because it uses an SD flash card, the audio files can easily be updated by the client's teachers, using any computer.

Four powered speakers provide audio feedback; one pair acts as the left channel, and the other pair acts as the right. The two high-contrast interactive switches (Enabling Devices, Hastings-on-Hudson, NY) provide light and vibration feedback when pressed. The LED tube (purchased at crazypc.com) provides bright colorful light for visual feedback, as well as encouragement for the client to look up and sit up straight. The musical keyboard (purchased at Radio Shack) connects directly to the speakers via a headphone jack.

The 3-D Sound Station has six operating modes. The first three modes are programmed to teach the user cause and effect. Mode 1 outputs the same auditory reward upon activation, regardless of which switch is pressed, while Mode 2 outputs a different reward sound for the left and right switches. Mode 3 chooses a random song from Folder A when the left switch is activated, and chooses a different random song from Folder B when the right switch is activated. Currently, Folder A contains music files while Folder B contains voice clips of the client's father. However, these folders can be reprogrammed to contain any desired audio files.

Mode 4 encourages the user to follow directional auditory cues. A five-second sample of a file randomly selected from Folder A is played out of the left speakers only, and consequently, a five second sample of a file randomly selected from Folder B is played out of the right speakers only. The user is then allowed ten seconds to choose by activating the respective switch. Once selected, the file is played through all four speakers. This mode stimulates a cognitive response from the user and allows him to make decisions. Mode 5 can be programmed to allow the client to respond to simple questions. Currently, pressing the left switch produces a recorded "No," while the right switch produces "Yes".

The first five modes can be programmed via the teacher interface, which uses two six-position knobs, to determine how long the audio response will play: 5, 15, 30, and 60 seconds, momentary, or full-length. In all six modes, the LED tube lights during the audio response.

In Mode 6, the switches are deactivated and a musical keyboard, which has been placed on the tabletop by a teacher, is powered on. The keyboard sounds play through the four speakers of the device.

The components are mounted on a sturdy music stand, to which a sheet of polycarbonate is attached. The music stand allows for adjustment in both height and tilt angle. A wooden disk, attached to the bottom of the stand, provides good stability. A PIC16F876 controls the system and power is supplied by a 16V, 500 mA wall transformer.

Cost of parts for the 3-D Sound Station was approximately $520.

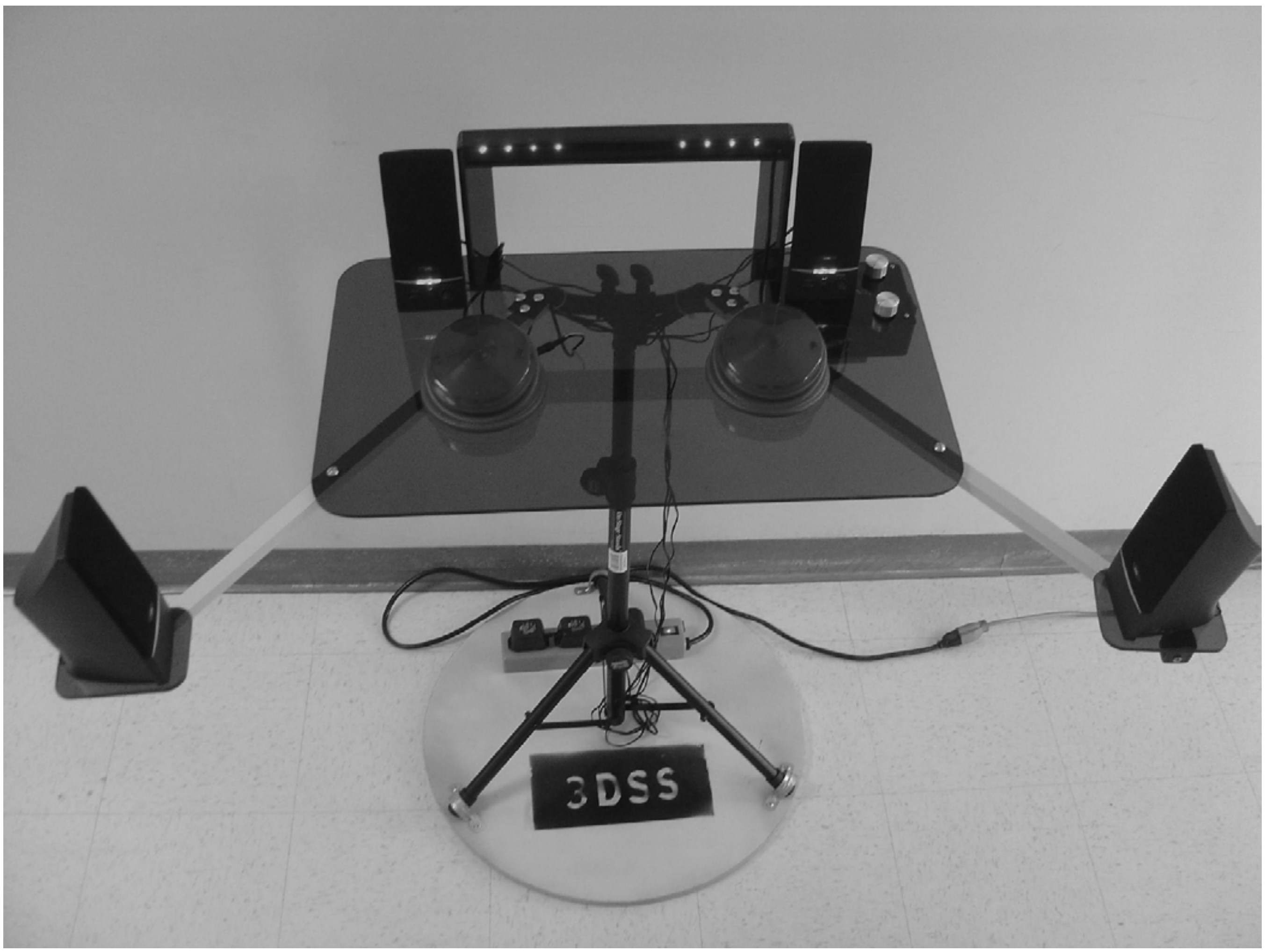

Figure 7.17. 3-D Sound Station

READER'S ASSISTIVE DEVICE

Designers: Tina Chang, Xander Chen, and Michele Nguyen
Client Coordinator: Leslie Lerea, Director, UNC SPIRE program
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The client is a post-doctoral researcher with Friedrich's Ataxia. She has a tendency to skip lines when she reads and has difficulty turning pages. The goal of this project was to assist her in making reading more comfortable. This goal was achieved by constructing a device with an adjustable bookstand, an electronic masking device, and a manual page turner. The device shows only three lines of text while blocking out the rest, helping the client focus on what she is reading. It also makes turning pages less strenuous. Overall, this novel device gives the client the ability to read more quickly and comfortably.

SUMMARY OF IMPACT

The Reader's Assistive Device allows the client to read more comfortably and efficiently, enhancing the progress of her research and allowing her to teach a class with less assistance. The client was excited that she could easily control the up and down movements of the masking device simply by pushing or pulling the joystick.

TECHNICAL DESCRIPTION

The Reader's Assistive Device (Figure 7.18) includes a bookstand, masking device, and page turner. The bookstand was built from ½" thick oak, with rubber grips added to the base. It provides easy angle adjustment and folds for storage. An accessory LED light provides even illumination of the text with no glare.

The masking device uses a clear Lexan sheet, which lays over the page to weigh down the paper and acts as the support and foundation for the mask. The slotted mask was fashioned from black Lexan, with vertical movement regulated by metal guides attached to the edges of the clear sheet. A DC gear motor with rack and pinion mechanism moves the mask vertically, controlled by a two-way joystick.

Figure 7.18. Reader's Assistive Device.

Six D-type batteries power the 9V motor. The masking device is attached to the bookstand using a drawer slide, which enables the masking device to be moved laterally to cover both pages.

The manual page turner consists of a spring with a sponge end, mounted to the masking device. The spring is covered with black Tygon tubing for safety and aesthetics. Post-it adhesive is applied onto the sponge using the roller applicator, enabling about 30 successful cycles of turning per application. To turn a page, the client presses down on the page turner spring, then grips the double handlebar and slides the masking device laterally. At the end of the lateral movement, the pressure on the spring is released and the page flips over. Terminal rollers at the ends of the bookstand ensure that the masking device does not slide off the bookstand, and facilitate sliding back in the other direction. Figure 7.19 shows the client using the Reader's Assistive Device.

Cost of parts was approximately $330.

Figure 7.19. Client Using Device

ASSISTIVE FOOT CARE DEVICE

Designers: Avery Capone, Shaun Noonan, and Connie Siang
Client Coordinator: Annette Lauber, NC Assistive Technology Project
Supervising Professors: Kevin Caves, Richard Goldberg
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

A foot care device was designed and constructed for a middle-aged woman with cerebral palsy, who had difficulty bending over and reaching to cut her toenails. She had previously used a conventional toenail clipper, which had often taken her up to 20 minutes per foot. The constructed device allows her to clip her toenails while sitting comfortably in her wheelchair, significantly reducing the time and energy that it takes her to perform the task.

SUMMARY OF IMPACT

The Assistive Foot Care Device will improve the client's ability to trim her toenails quickly and effectively. According to the client, "You have no idea what an improvement this is over the past."

TECHNICAL DESCRIPTION

The Assistive Foot Care Device (Figure 7.20) is modeled after commercial reaching devices, which provide a grasping mechanism at the end of a rod, controlled by a trigger grip. The device consists of five main components: the trigger/handle, chassis, force transmission system, vision enhancement mechanism, and trimmer.

A handle with a plastic handgrip was removed from a commercial hand-held reacher (Featherlight). The plastic trigger lever was replaced with a custom aluminum lever for stability and strength. The handle and trigger were dipped in Plasti-Dip to create a softer finish. The chassis was constructed from aluminum u-bar, chosen for its durability and light weight. The u-bar allowed a protective housing for the internal components of the device while allowing easy accessibility.

The chassis provides a 134-degree angle, selected as optimal for the client while seated in her wheelchair, which was created by making angled cuts in the u-bar and fixing them with aluminum binding posts. The upper part of the chassis was dipped in Plasti-

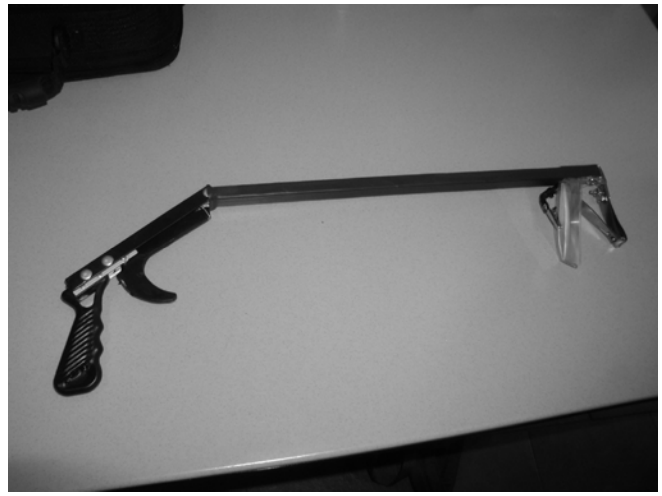

Figure 7.20. Assistive Foot Care Device

Dip, while the lower half of the chassis was coated in heat-shrink wrap to enclose the force transmission system. The force transmission system used high-strength kite string, which was attached to a hole in the trigger at one end, run down the chassis through a retaining eyebolt, and to a hole in the clipper lever at the other end.

To improve precision, a small magnifying sheet was mounted to the chassis with alligator clips attached together by pliant wire, so that it is adjustable. The alligator clips allow the magnifying sheet to be removed if the client so chooses. The trimmer uses high-quality large commercial clippers (Brookstone), with a hole drilled for the string. A steel L-bracket mounts the trimmer to the chassis.

In evaluations, the client estimated that this device will reduce the amount of time that it previously took her to perform foot care maintenance by 80% and that the device will reduce the amount of exertion required to trim her toenails by 90%. Figure 7.21 shows the client with the Assistive Foot Care Device.

Cost of parts was approximately $100.

Figure 7.21. Client Using Assistive Footcare Device

ACCESSIBLE BALL MAZE

Designers: Twinkle Gupta, Julianna Swanson, and Amanda Zimmerman
Client Coordinator: Beth Leiro, Physical Therapist
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The client, a two-year-old with arthrogryposis, has multiple joint limitations and uses a wheelchair for mobility. To enhance his interaction with peers and increase his opportunity to engage in outdoor activities, his caregivers sought to create a new playground activity at his school. The goal was to design a wheelchair-accessible outdoor ball maze that allows the client to maneuver the entry of the balls and to play simultaneously with his peers outdoors.

SUMMARY OF IMPACT

The client, his peers, and the staff at the preschool were immediately captivated by the ball maze. One teacher commented, "It's great that the pattern isn't the same every time, that the pattern is not predictable. It keeps the kids entertained for a while." On its first day in use, the ball maze increased the client's outdoor interaction with his peers, with up to five children playing at once. The client's physical therapist stated, "It's important for [the client] to be able to have appropriate activities on the playground that have appeal to both him and his classmates."

TECHNICAL DESCRIPTION

The Accessible Ball Maze (Fig 7.22) uses golf balls enclosed in a clear housing. Three focal areas of the design include the entry mechanism, the internal components of the maze, and the exit mechanism.

Because of the client's limited range of motion and strength, the device was designed so that caregivers can load a large hopper in the top of the device with golf balls. Fifty colored golf balls were provided for use with the device. The client or his classmates can release one ball at a time by pulling on a rope. This lowers a long lever with a spring-loaded hinge to guide a ball into the maze. Sometimes the golf balls can get jammed in this hopper. To break this jam, they can pull on a "jiggler," an "L"-shaped wooden rod that was added to one end at the top of the maze. To make the jiggler and rope accessible to the client and other individuals with fine motor impairments, the rope has knots tied in the end and the jiggler rod has multiple drilled holes, in which to grab or stick a finger. Also, the jiggler was purposefully long to minimize the force required for operation.

Once released, a ball travels through the maze along ramps, a double staircase, spiral staircase, ringing pipes, and other components. These components were chosen to provide a fun auditory and visual experience. The ball travels randomly down one of two separate paths through the maze. At the bottom of the maze, the ball lands on an inclined piece of sheet metal and rolls to a locked collection bin in the bottom corner. The bin is an easily removable drawer that the caregiver can unlock to move the balls back to the top of the maze. Holes in the bottom of the bin allow for water drainage.

The maze is permanently installed in the playground of an early intervention center, where the client attends pre-school. It is located under a pavilion for protection from the weather. The frame of the maze is made of pressure treated wood and the sides are made from Plexiglas.

Cost of parts for the Accessible Ball Maze was approximately $440.

Figure 7.22. Accessible Ball Maze.

MODIFIED SCOOTER

Designers: Jeremy Kim, Miao Wang and Charles Tao
Client Coordinator: Lisa Mangino, Physical Therapist
Supervising Professors: Kevin Caves, and Richard Goldberg
Department of Biomedical Engineering
Duke University,
Durham, NC 27708

INTRODUCTION

The client is an active seven-year-old boy with TAR syndrome, which causes very short arms, and reduced dexterity in his legs. His peers enjoy using scooters to ride around his neighborhood, an activity that requires balancing on one foot while propelling with the other. Because of his disability, the client cannot use a commercial scooter. A commercial scooter was modified by adding forward outriggers, a side platform and wheel, a braking mechanism, handle bar extensions and pads, and a vertically adjustable seat. The client can use the scooter on his neighborhood streets, allowing him to participate with his siblings and peers.

SUMMARY OF IMPACT

The modified scooter gives the client another means of riding a self-propelled device outdoors. The client's mother commented that the scooter "has really increased his inclusion in family activities outside. He always had to be put in a wagon, or helped greatly if we were going to walk around the block. Now, with his scooter, he can completely independently go around the block and require no assistance from the rest of the family. It gives him a great sense of pride to keep up with his siblings as we walk or ride bikes and scooters around the block."

TECHNICAL DESCRIPTION

The Modified Scooter (Figure 7.23) was constructed from a Razor brand scooter. Modifications included forward outriggers, a seat, a foot platform with side wheel, a steering mechanism, and brakes.

The outrigger frame was made from three pieces of 1" square, 1/8" thick aluminum tubing. The wheels, made from commercial casters, were bolted to this frame. To reduce rolling resistance, the plastic wheels that were originally mounted on the casters were replaced with low-friction skateboard wheels.

The seat mount was created by bolting the handlebar mount of a spare Razor scooter to the rear of the modified scooter frame. A standard bicycle seat and seat post were secured in the handlebar mount shaft.

The quick release mechanism of the handlebar mount allows for simple and quick adjustments of the seat height.

To provide more surface for the client's feet on the scooter, a platform was shaped from a 24-inch square piece of 1/8" thick aluminum sheet, and bolted to the scooter's frame. A rollerblade wheel was attached to the rear side of the plate, and a guard was attached to the top of the plate to prevent the client's foot from contacting the wheel.

The steering mechanism of the original scooter was modified using two pairs of mountain bike handlebar extensions on each side. Each pair of extensions was first linked together in an "L" shape, and then attached to each end of the original handlebars. Cushioned pads were constructed from rounded wooden blocks covered with soft sponge, and bolted into the extensions.

A braking mechanism was created from a bicycle U-brake system, attached to the rear scooter wheel. The rubber brake pads were replaced with metal pads, to give a smoother braking operation. The hand lever from the bike brake was cut short and mounted on the scooter body, just in front of the foot platform, for accessibility with the right foot. A bicycle brake cable was connected between the lever and the U-brake at the rear wheel.

Cost of parts for the Modified Scooter was approximately $400.

Figure 7.23. Client with Modified Scooter


1205