CHAPTER 7
DUKE UNIVERSITY

Pratt School of Engineering
Department of Biomedical Engineering
Duke University
136 Hudson Hall
Durham, NC 27708

Principal Investigator:

Larry Bohs

919-660-5155

lnb@duke.edu

AUTOMATIC ROCKING CHAIR

Designers: Katie Myers, Anne Marie Amacher, and Meredith Cantrell
Client Coordinator: Diane Scoggins, Hilltop Home
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

Children enjoy and can benefit from rhythmic motion, such as rocking, but many children with disabilities cannot rock themselves. The Automatic Rocking Chair incorporates a glider-style rocking chair powered by an electric gear motor. It has features such as: 1) a timer; 2) child-operable switch; 3) speed control.

SUMMARY OF IMPACT

The Automatic Rocking Chair benefits children with disabilities and their caregivers. A supervisor from a local children's home states, "This is a tremendous help for staff, by freeing up caregivers who previously had to stay right beside a rocking chair to manually keep it moving… The flexibility provided by the motor's speed control and by the positioning straps will permit us to use the chair with almost every child in our facility. And we are so impressed with… the tray top with hand-painted designs!"

TECHNICAL DESCRIPTION

The Automatic Rocking Chair (see Fig. 7.1) design is based upon a previous student project, but is tailored to the special needs of children living in a group home setting. The design translates the rotational motion of a gear motor into the translational motion of a Classic Glider Rocker by Storkcraft (model #002646350).

Components of the design are shown in Fig. 7.2. A fixed arm is attached to a 90-volt DC gear motor (Dayton #2H577) with two setscrews to create an offset shaft. This fixed arm is attached to a moveable arm by a bearing pin. The other end of the moveable arm attaches with a bearing onto the moveable dowel, which is made of ¾" aluminum rod. When the motor is turned on, the fixed arm rotates, driving the moveable arm back and forth laterally, thereby gliding the chair back and forth.

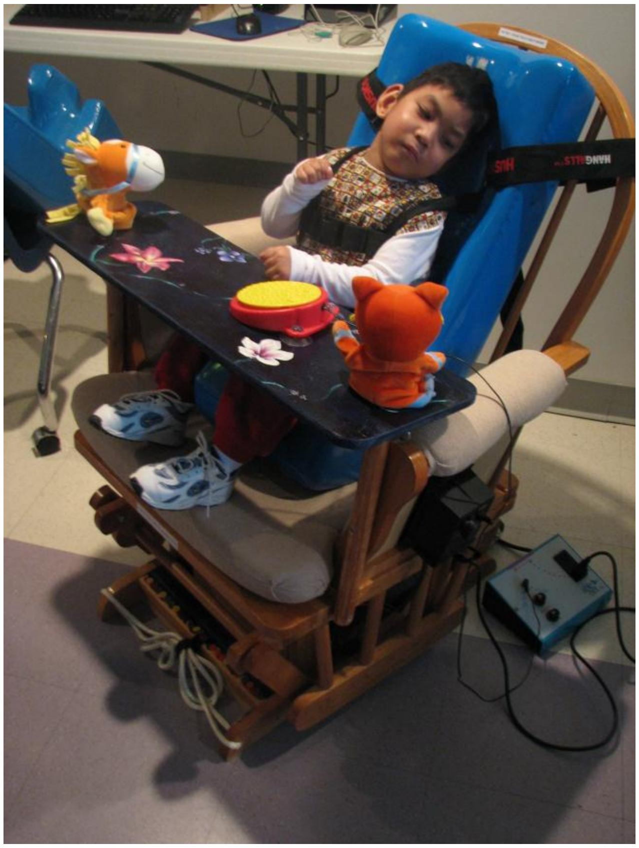

Fig. 7.1. Automatic Rocking Chair.

The motor provides 235 in-lbs of torque and operates at a maximum speed of 62-rpm. A Dart (model #5JJ58) speed control allows users to adjust the speed of the motor within a 0 to 30-rpm range. One rotation of the motor translates into one full swing of the chair, so the maximum rocking frequency of the chair is one swing every two seconds. The speed control is conveniently mounted on the side of the chair and plugs into a wall outlet.

A Powerlink2 device (Ablenet, Inc.) allows children to initiate the rocking motion via a switch selected by an aide. Because not all the children have the physical or cognitive ability to use this feature, the

PowerLink2 also has a setting that allows the teacher to turn on the device.

A custom adjustable-height desk provides a sturdy surface for the child-operable switch. Two wooden dowels, connected to the chair, slide through holes in the desk. Two pins fit through holes in the dowels to support the desk at four different heights.

A TumbleForms child seat attaches to the chair with two Velcro straps that fit through slits on the child seat and wrap around the back of the chair. To accommodate different children, the seat incline is adjustable. Wheels (attached to the back legs of the chair) and a lifting strap (attached to the front legs) make the chair transportable. Lifting the strap upwards tilts the chair back onto the wheels so it can be rolled into an adjacent room.

Cost of parts was approximately $850.

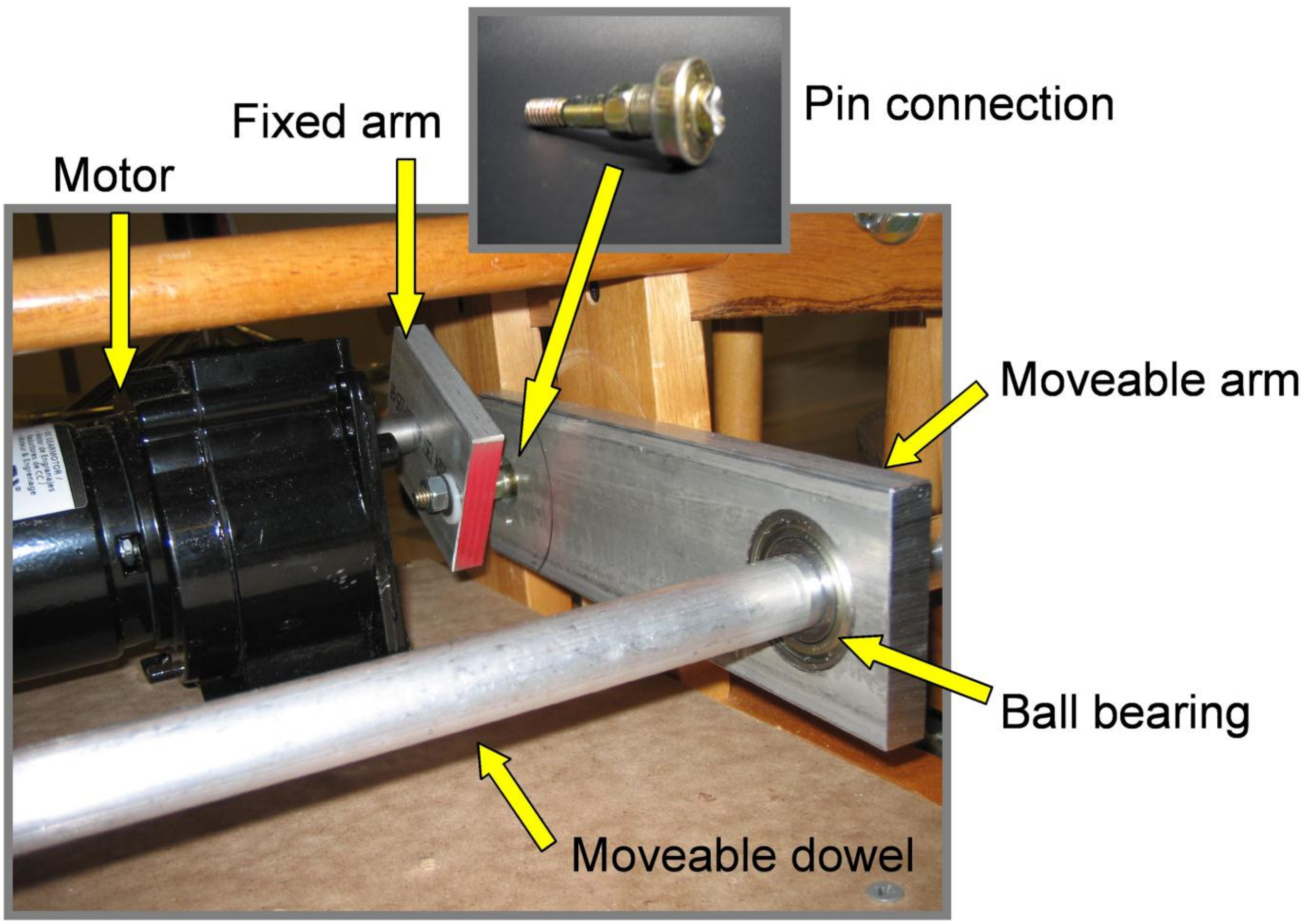

Fig. 7.2. Automatic Rocking Chair Components.

BATH CHAIR

Designers: Robert Buechler, Aaron Carlson, and Lenny Slutsky
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The Bath Chair was designed for an eight-year-old boy with Thrombocytopenia Absent Radius (TAR) Syndrome, who could not bathe independently because his arms are weak and very short. The Bath Chair has a PVC frame and mesh bath sponges as washing surfaces. A shower caddy is mounted to a safety railing on the right side of the chair, and showerheads attach to the top of the chair and to a safety railing on the left side. The client controls water flow for each showerhead using two push-button valves on a diverter.

SUMMARY OF IMPACT

The client previously needed help from his parents to bathe, but he can now bathe himself. His mother commented, "This is a huge step for (him) in terms of personal care... I can't put into words the joy it makes me feel to see him excited about gaining his independence."

TECHNICAL DESCRIPTION

The frame of the Bath Chair (Fig. 7.3) is made from 1 ½" furniture-grade PVC pipe. The base is rectangular and has two layers. The bottom layer is for structural support, and the top layer, which contains an extra horizontal crossbar, supports the seat. Safety rails on each side of the seat are made from one inch PVC.

Two showerheads are mounted to the frame of the chair: one at the top of the seat back and one on the left safety railing. A flexible hose attaches to the tub faucet via a threaded fitting. This hose is connected to a diverter valve, which connects to hoses for two showerheads. Each showerhead attaches to the frame on a rotating showerhead mount. A handle made from ¾" PVC pipe with a PVC tee attaches to each rotating mount, allowing the client to control the direction of water flow. The diverter has an on/off switch for each branch, which allows him to control the water supply to each showerhead.

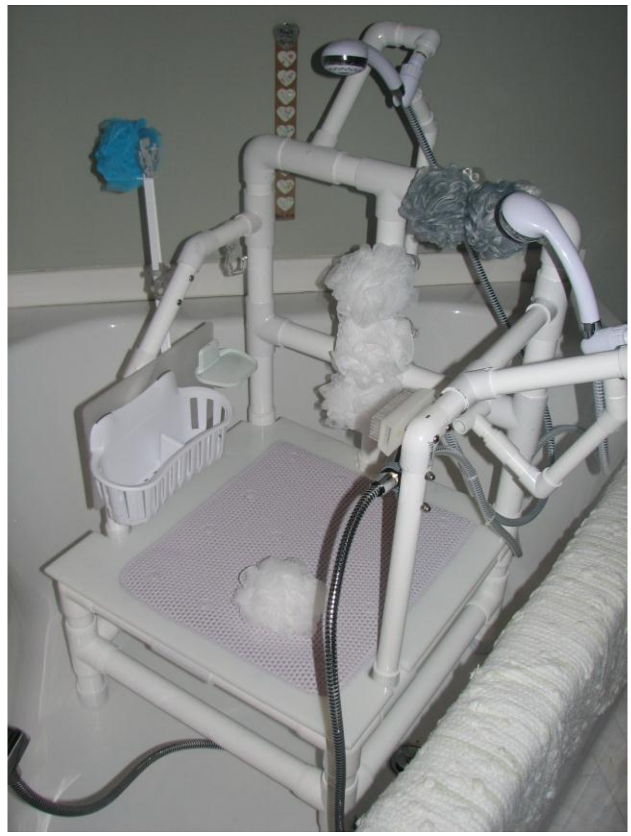

Fig. 7.3. Bath Chair.

The seat is made from ½" thick high density polyethylene with smooth routed edges. It is secured to the base with countersunk flat-head stainless steel machine screws. The top of the seat is covered with a ComfortArt™ Plus Non-Slip Bath Mat (Griptex), which gives the seat a comfortable non-slippery surface. Small holes drilled through the seat prevent pooling of water.

An acrylic sheet attached to the right safety railing provides a convenient location for bathing accessories. A soap/shower caddy, which holds soap, shampoo, and a cup that the client uses for rinsing, is mounted to the acrylic sheet. Bath sponges attached to the frame of the chair allow him to wash different parts of his body by rubbing against them: two sponges on the top bar for his head, three on the middle vertical bar on the back for his back, and one on the seat for his groin area and backside. Each bath sponge attaches to the frame using a custom attachment system, which consists of an ovular acrylic sheet with two acrylic disks secured to one side using rivets. The result is similar to the clasp of a manila envelope and holds the bath sponge tightly when the strings of the sponge are wound around the disks. This system makes the sponges secure and also easy to replace. Fig. 7.4 shows the client using the Bath Chair.

Cost of parts for the device was approximately $500.

Fig. 7.4. Client Using Bath Chair.

WHEELCHAIR RAMP POWER ASSIST

Designers: Daron Gunn, Audrey Burke, and Sophie Strike
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client currently uses a manual wheelchair and wanted to preserve her independent lifestyle in the event of an upper body injury. The goal of this project was to develop a device to help her ascend the ramp into her home more easily. The Wheelchair Ramp Power Assist pulls her up the ramp using a winch motor and a steel cable attached temporarily to her wheelchair. A remote control, held by the client, actuates the winch. A pull-cord safety switch mounted to the ramp rail stops the system in an emergency. This system provides powered assistance for the client and still allows her to ascend the ramp manually.

SUMMARY OF IMPACT

The client uses the device regularly and more often in cold and inclement weather. She commented, "The Ramp Assist has become a useful tool in my routine. It saves energy and stress on my shoulders. I used it daily during the winter and use it a few times a week in the spring. The Ramp Assist has given me an added and unexpected factor of safety and independence, especially in winter weather. The surface of the ramp ices over so on occasions when there was ice or snow, the Ramp Assist enabled me to get up without help. I could barely get up without it because my wheelchair tires would not grip on the ice or snow."

TECHNICAL DESCRIPTION

The Wheelchair Ramp Power Assist (see Fig. 7.5) uses a 12-volt DC winch (Superwinch T1500) with a 40′ steel cable that ends with a large spring hook. A second piece of steel cable with spring hooks attached to each end loops through this hook. The client attaches her chair to the system by attaching these two hooks to each armrest on her wheelchair (see Fig. 7.6).

The client controls the winch using a wireless remote system (Superwinch). The remote has two buttons, one for winding and one for unwinding the cable. The client must continually press the buttons on the remote to operate the winch. This feature provides a safety mechanism, because if the client drops the remote, the winch will automatically stop. The wireless receiver is housed in a weatherproof box and mounted at the top of the client's ramp near the winch.

Fig. 7.5. Wheelchair Ramp Power Assist Components.

The winch is powered by a 12-volt deep-cycle lead-acid battery, which is necessary because no outside power outlets exist at the client's condominium. The battery must be charged approximately every four weeks. A battery charger (Schumaker, Monroe, NC), battery tester (Motormite), and extension cord are provided. The battery and charger are stored out of sight under the ramp. The battery tester is mounted at eye level at the top of the ramp, alerting the client with an LED light when the battery needs charging. To charge the battery, the client attaches the extension cord from an outlet just inside her front door to the male AC plug securely mounted near the winch, and leaves it overnight. A double throw toggle switch with two positions, "winch" and "charge", guarantees that the winch cannot be used while the battery is charging, and vice versa.

An industrial single pull stop switch (Allied Electric, Southfield, MI) provides an additional safety mechanism. The pull stop connects to a cable that runs down the length of the ramp. Should the winch continue winding when the client releases the remote button, the client can pull the cable, cutting power to the winch and stopping all movement. The client can then unhook herself and ascend the ramp manually.

The winch cable is taken to the bottom of the ramp by reversing the winch direction while the client descends. Descending in this manner takes longer than descending freely, but she has improved her speed and comfort with practice.

Cost of parts was $840.

Fig. 7.6. Client Using Wheelchair Ramp Assist.

ICE SKATING CHAIR

Designers: Keigo Kawaji, Eric Blatt, and Kalpana Sampale
Client Coordinators: David Burns and Sue Cheng
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

An ice skating chair was developed to allow individuals who use wheelchairs to participate safely in skate-in events organized by a hockey league franchise. The device is a modified manual wheelchair on hockey skate blades. It enables participants to skate with assistance. The device includes a safety brake that automatically stops the chair when the assistant releases a lever. It is easy to operate by any experienced skater pushing from behind and accommodates transfer between chairs when off the ice.

SUMMARY OF IMPACT

The Ice Skating Chair provides an opportunity for hockey fans in wheelchairs to participate in skate-in events.

TECHNICAL DESCRIPTION

The Ice Skating Chair (see Fig. 7.7) was constructed by modifying a standard manual wheelchair. The rear wheels were replaced with skating blades, mounted parallel and 20″ apart. These were bolted to a 1/4″ aluminum plate, which is bolted to the wheelchair frame. The blades were tilted on a 13-degree angle, using aluminum wedges, to recline the chair backwards for user safety and comfort. Handlebars, made from bent conduit and padded with foam insulation and fabric, were attached to the rear of the wheelchair.

A braking mechanism provides safety in the event that the pusher loses control of the chair. This mechanism consists of a rectangular bar of one inch square steel tubing hinged on the front end and forced downward by a 70-lb compression spring at the rear. The brake is made of a five-inch-long metal plate that attaches to the bar three and a half inches from the point of rotation so that it contacts the ice when at rest. A bicycle cable attaches to the bar and to a brake lever on the handlebars. When the pusher releases the lever, the brake plate engages with the ice. The braking mechanism is calibrated by adjusting the cable length so that the brake rests on ice when the brake lever is released and is lifted a half inch above the ice when the brake lever is depressed.

Pads protect the user and other skaters in the event of a collision. The front protector consists of youth-size goalie pads (23″ x 11″) mounted to wooden panels that are attached to tubing inserted in the wheelchair leg supports. The tubing is custom bent to support the front padding system, which allows it to swing open while a skater loads or unloads from the chair. The tubing for each side joins in the center with a compression fitting, allowing for easy locking or unlocking. The right cover uses Velcro to allow users to access the bolt to adjust the foot rest height. Custom side protectors attach to the wheelchair armrests and provide protection as well as extra support for the user's arms. Finally, safety harnesses and supports for the neck, back, torso, pelvis, knee, and ankle were installed.

On-ice tests revealed that the chair glides smoothly as long as the pusher does not exceed a maximum safe speed of about eight-mph. Users can be transported off-ice by lifting on the rear handlebars and rolling the chair on the front wheels.

Cost of parts was approximately $520.

Fig. 7.7. Ice Skating Chair.

WHEELCHAIR GARDEN CART

Designers: Eric M. Spitz, Jordan M. Sadowsky, & John M. Schoenleber
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The Lawn Care Assisting Device (LCAD) helps a woman who uses a manual wheelchair to garden independently. The device's shape maximizes usable space and increases tool accessibility. The LCAD is composed primarily of Lexan and uses swivel caster wheels for optimal maneuverability. A sturdy removable shelf and a rear flap maximize the device's functionality. The LCAD easily attaches to and detaches from the wheelchair and transports items such as a watering pail, gardening tools, and yard waste. The client uses the device to water her garden and transport piles of leaves, among other tasks.

SUMMARY OF IMPACT

The LCAD enables the client to better enjoy one of her favorite pastimes. She commented, "This cart has made it so much easier for me to garden... I really appreciate it. It is great!"

TECHNICAL DESCRIPTION

The LCAD (see Fig. 7.8) easily attaches to the client's manual wheelchair, which allows her to transport yard waste (such as leaves), carry tools (a rake, clippers, etc.), and carry a full water pail.

Fig. 7.8. Lawn Care Assisting Device.

The device consists of a narrow chamber that fits between the rear wheels of the wheelchair and a larger primary chamber with a hinged rear flap. An elevated shelf within the primary chamber provides a convenient location for small tools and a watering can, within reach of the client while seated in her chair. An attachment hook holds the shelf on the side of the cart when it is removed to increase storage capacity of the main chamber. The chambers are constructed using 0.375" Lexan walls and a 0.22" polycarbonate base, attached rigidly using stainless steel, countersunk screws. Large rubber caster wheels are bolted onto the bottom of the cart, and the shelf, made from 0.375" Lexan, rests on Lexan blocks. The rear flap, a 0.093" sheet of Lexan, attaches to the base with a brass piano hinge. A lawnmower pull cord raises the flap. Magnets inlayed into an upper crossbar, connect with metallic sheets. The sheets are inlayed into the flap to hold the flap in the upright position. The user can easily detach the flap by pushing so it will lie like a ramp to allow the chambers to be filled with garden debris.

The front attachment mechanism uses two tubes, which connect to the safety wheel attachment supports on the client's wheelchair. They provide support in vertical and horizontal directions. A large hinged hook prevents the cart from pulling away from the wheelchair. Drainage holes allow water to drain from the chambers. A circular sander was used to smooth all corners and give the Lexan a scratch-resistant, foggy look.

Cost of parts for the LCAD was approximately $480.

Fig. 7.9. Client Using LCAD.

SOOTHING ROCKING CHAIR

Designers: Phil Nicholson, Justin Hilliard, and Josh Lundberg
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a 13-year-old boy with cerebral palsy. The purpose of this project was to develop a soothing environment for him to find comfort when anxiety levels are high. The Soothing Rocking Chair includes vibration and audio output with easy-to-use controls to accommodate his degree of motor capability. In addition, the device includes a removable desk workspace to provide a place to read and a digital photo album for viewing his own photos.

SUMMARY OF IMPACT

The client's mother commented, "The innovative combination of music, rocking and vibration has been of therapeutic value to our son. When he is feeling upset and anxious he chooses to retreat to his chair and "chill out." [He] will be having orthopedic surgery this summer, and the wide seat and reclining angle of this rocking chair will really help facilitate his recovery. I know he will be spending a lot of time in his chair this summer."

TECHNICAL DESCRIPTION

The Soothing Rocking Chair (see Fig. 7.10) consists of a gliding rocking chair that incorporates audible, tactile, and visual stimulation elements to engage the client's personal interest while providing a comfortable and soothing environment. A Boom Chair 2.0 (Lumisource, Inc.), which includes vibration and audio elements, forms the foundation for the device. The chair is mounted in a supportive wooden frame, modified from a SafeRocker Deluxe Adult Glider Rocker (Foundations, Inc.).

The Boom Chair includes vibration motors throughout and has large knobs on the side that allow the client to adjust the intensity of the vibration and sound. RCA jacks on the chair are used to play music through the speakers. A modified CD player connects to RCA jacks, which allow the client to select his own music. The CD player's remote is hard-wired to large pushbuttons

Fig. 7.10. Client Using Soothing Rocking Chair.

mounted to the chair, giving the client easy control of play, pause, skip, and stop functions.

A custom work desk allows the client to read books, draw pictures, or do homework while sitting (see Fig 7.11). The desk features a two-inch recessed work area that is large enough to fit a standard 8.5" by 11" piece of paper. The desk features a locking mechanism with ¼" spring pins inserted into dowels that connect the desk to the chair, which prevents the desk from tipping. An assistant is required to move the desk while the user is in the chair.

Because the client enjoys taking pictures and viewing them on the computer, a digital photo album (CRDMP4, Ziga USA, Inc) is mounted onto the structure supporting the chair. The album is mounted to a dowel rod, which slides into a custom slot on the chair so that the album can easily be attached or removed.

To provide additional stability to the Soothing Rocking Chair, eight inch long anti-tilt extensions attach to the rear legs, making it impossible for the client to tip the chair backwards. To help him enter and exit the chair safely, external wooden armrests are attached to each side of the chair. Extending approximately four inches above the original armrests, the external armrests help stabilize his body as he enters and exits the chair. A rear wooden connecting arm attaches between both external armrests to ensure that the client cannot fall out of the chair.

Cost of parts was about $800.

Fig. 7.11. Client Using Chair with Desk.

CONVERTIBLE TRI-CANE

Designers: Amanda Fuller, Yubo Gong, and Toby Kraus
Client Coordinator: Allison Darwin, OT
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a 95-year-old male with a fused left knee and mild dementia. He enjoys walking outside but tires easily and sometimes needs additional support, especially when walking on unfamiliar terrain. The Convertible Tri-Cane was designed for the client. It is a single-point cane that can be converted to a tri-point cane for additional support. The design uses a twist-and-push mechanism, which allows the client to easily convert between modes. The Convertible Tri-Cane allows for either left- or right-hand usage, and is also height adjustable.

SUMMARY OF IMPACT

The client did not initially feel he needed the additional support. However, as the project progressed he appeared much more interested in the stability the tri-point mode provided. His occupational therapist stated, "Since we started this project, he has realized that he needs more stability." It is now easier and safer for the client to walk outdoors. He can walk faster, more comfortably, and more independently.

TECHNICAL DESCRIPTION

The Convertible Tri-Cane (see Fig. 7.12) includes tripod legs and a sliding mechanism that provides easy conversion between single and tri-point modes. The tripod legs are made from ½", furniture-grade, black PVC, bonded with heavy-duty cement. PVC was chosen instead of aluminum to minimize weight. The PVC legs connect to a pivot, made by mounting a four-way joint onto the cane. PVC extensions insert into the horizontal extensions of the joint and are milled precisely to create a snug fit that still permits rotation.

An aluminum cross-brace connects the two legs together and is through-bolted to each leg with two screws and nylon lock washers. To connect the tripod mechanism to the sliding mechanism on the shaft of the cane, two hinge-arms attach between the cross-brace and a shaft collar on the base of the sliding mechanism. The hinge-arms are attached to the cross-brace via a custom U-shaped steel bracket. The sliding mechanism uses an aluminum tube, slightly larger in diameter than the client's cane. A slot milled vertically in this tube allows a pin on the cane shaft to keep the mechanism positioned properly. Two shaft collars at the top of the sliding tube allow the mechanism to lock in place. The lower aluminum collar provides a secure attachment to the sliding tube. The upper Delrin collar attaches to the lower collar and provides a snug fit around the cane shaft. A handled-screw in the Delrin collar allows the sliding mechanism to lock in place. When

Fig. 7.12. Convertible Tri-Cane.

the screw is tight, the slider and thus the tripod legs are immobilized in either the up or down position; when it is loosened with about one-half to one-third of a turn of the handle, the sliding mechanism easily moves up and down. Fig. 7.13 shows the client using the cane.

Cost of parts was about $400.

Fig. 7.13. Client Using Cane.

CUSTOM EASEL

Designers: Tommye Fitzpatrick, Jessica Son, Christine McMahon
Client Coordinator: Karen Hammers
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a five-year-old male with cerebral palsy. He has an unstable trunk and stiff arms that move best vertically at the elbow. He only has use of his left hand, which cannot comfortably grasp anything less than one inch in diameter, and he is suspected to have Cortical Vision Impairment. The Custom Easel has adjustable angles and a magnetic whiteboard. The angle of the easel work surface may be adjusted to the best angle for the client, depending on the activity. A modified paper cutter, modified glue bottle, book ledge, clothespin book clips, page-turning wand, and magnet clips help him independently glue, cut, hold books, and turn pages. The Custom Easel also accommodates his suspected visual impairment with a detachable magnifying device.

SUMMARY OF IMPACT

The client's teaching assistant stated, "This project is a huge step in achieving independence for him at school. Now he will be able to work on many more tasks by himself. As he gets older, the easel will be able to adapt as his needs change."

TECHNICAL DESCRIPTION

The Custom Easel (see Fig. 7.14) features a 13" x 18.5" magnetic white board work surface with a ¾" varnished oak frame. The 16" x 23" varnished oak easel base adjusts to four positions, from flat to almost 90 degrees, with a reinforced stainless steel brace that folds flat for carrying. A black non-skid mat keeps it from moving while the easel is in use.

A sliding magnifier was developed from a commercially available 22" x two inch varnished wooden drawer slide. The magnifier slides over the top of the easel work surface and is held in place on top by two metal brackets. The male part of the drawer slide is raised two and a half inches above the work surface, thereby magnifying the book or paper underneath without distorting the letters.

Fig. 7.14. Custom Easel.

Pegs on the male and female pieces of the slide allow the client to slide the magnifying sheet all the way to the left edge of the easel work surface so the client can turn book pages but simultaneously keep the male piece from falling out of the female piece. A cutting device was modified from a FISKARS® Ultrashape Xpress by shaving a rubber anti-skid pad down to fit around the blade, allowing the cutter blade to retract inside and not be exposed when the device is not in use. Two strips of magnetic tape attached to the bottom of the cutting device stabilize it against the magnetic white board. To hold paper in place while cutting, six sheet metal strips with magnetic tape attached to the back are supplied (two two inch, 7.5", 10.25", two 13"), to be placed around the edge of the paper.

A gluing device was modified from an Aleene's® Brush-On Tacky Glue bottle. The tacky glue is replaced with Elmer's® Washable School Glue. A rare earth magnet glued to the bottom of the glue bottle helps it stick to the magnetic white board work surface. A modified plastic salsa bowl fits like a skirt around the glue bottle, stabilizing it while in use. A one and a ½" tall foam roller, attached to an oak disk, is screwed into the top of the glue bottle so that the client can hold the glue brush more easily and comfortably.

To facilitate page-turning, a wand was created by gluing a ¾″ diameter round magnet and metal ring onto the end of a 4.5″ long, one inch diameter wooden dowel. Three-quarter-inch diameter magnets were also glued on plastic AccoTM Hot Clips, one magnet per clip were are placed on the edge of each page of a book for the client to turn. The clip magnets are not strong enough to stick to each other, but are strong enough to stick to the magnetic wand. Plastic magnet clips are used rather than metal paperclips because they give an added weight to the page, ensuring that once the client turns the page, the page will not flip back, frustrating the client.

Two rare earth magnets are placed on the back of a wooden ledge for a book to sit on, and five magnets are placed on the backs of two 6″ clothespins that hold either side of the book open. To make transporting the easel and all of its accessories around during the school day easy, a 23″ x 27″ durable nylon ArtBin® Tote Folio is provided. The main pocket of the folio is lined with cotton batting to prevent damage in the case of accidental drops or falls to the folio. Since the client's aide needs both hands free to push his wheelchair from classroom to classroom, the folio can either be worn slung over the shoulder using its shoulder strap, or it can hang on the back of the client's electric wheelchair. Fig. 7.15 shows the client using the easel.

Cost of parts was approximately $260.

Fig. 7.15. Client with Easel.

DIGITAL CAMERA ASSIST

Designers: Greg Larkin, Alissa Van Arnam, and Greg Darland
Supervising Professors: Kevin Caves, Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a 14-year-old boy with cerebral palsy who enjoys photography. He cannot consistently use a camera because it is difficult for him to hold it and the buttons are too small to access reliably. The Digital Camera Assist is a custom machined enclosure for a compact digital camera. It has a comfortable handle and large buttons that actuate standard camera functions. With it, the client can enjoy one of his favorite hobbies.

SUMMARY OF IMPACT

The client's mother commented, "This is the most amazing device. The design and materials used is just outstanding. [He] loves this camera more than any other toy or tool he owns. He always wants to take pictures wherever he goes… Having these adaptations has allowed [him] to pursue a hobby that he didn't have total access to before. It has facilitated his creativity, literacy, and computer skills. After he uses the camera to take the pictures, he wants to download them to his computer and has been writing sentences and building stories using these pictures. This is huge for [him]."

TECHNICAL DESCRIPTION

The Digital Camera Assist (see Fig. 7.16) consists of a custom housing that was fabricated using black Delrin® plastic. It is designed to accommodate the client's camera, a Casio Exim Z750. The housing has two parts, the base and top. The base secures the camera from three sides: 1) bottom; 2) left; 3) right. An extension off the left side allows for attachment of the handle. The base also houses the mechanisms of two buttons, the left and right review buttons, on the back side of the camera. A right hand grip attaches to the right side of the base.

Fig. 7.16. Digital Camera Assist (Rear View).

The top secures the camera inside the base piece. It attaches to the base by a hinge on the right side and a draw latch on the left side. The draw latch operates similar to the draw latch on the front of a toolbox. The top also houses the mechanisms for three buttons: 1) power; 2) shutter; 3) zoom.

The handle is fabricated using a black diameter Delrin® acetal plastic rod. This rod extends below the base piece on the left side of the camera. A bike grip attached to this rod provides a comfortable grip. The right hand grip was custom made to fit our client's hand from a piece of black Delrin® acetal plastic. It attaches by four screws to the right side of the base piece below the hinge.

The buttons are made from: 1) screws; 2) nuts; 3) screw caps; 4) springs. They attach to the housing through predrilled holes and are secured by the nuts. The springs retain the buttons in the "off" position when not being pressed.

A zoom control button was created using: 1) an additional piece of black Delrin®; 2) two small screws; 3) two small springs. It magnifies the existing zoom control on the camera and makes it easy for the client to zoom in and out with a horizontal shift of the button. A small eye hook on the left side of the base provides an attachment point for a camera strap. Fig. 7.17 shows the client using the device.

Cost of parts was about $350.

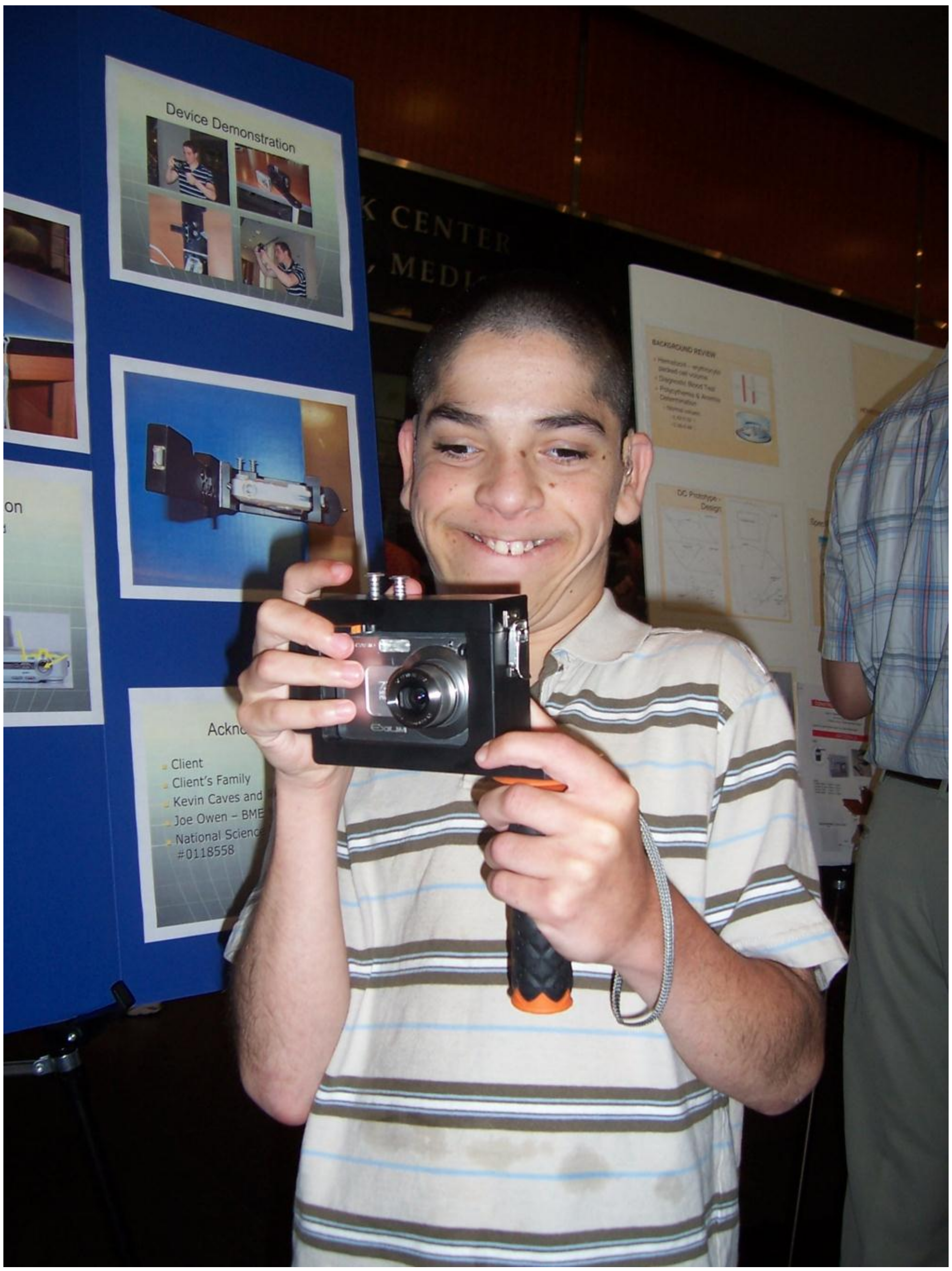

Fig. 7.17. Client Using Camera Assist.

EXERCISE MOTIVATOR

Designers: Turan Kayagil, Matan Setton, and Jenny Yuan
Client Coordinator: Catherine Alguire, OTR/L
Supervising Professors: Richard Goldberg and Kevin Caves
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a 14-year-old male with autism, attention deficit hyperactivity disorder, and mental retardation. He benefits from regular aerobic exercise on a stationary bicycle, but loses interest after less than eight minutes and relies on food and verbal reinforcements from his supervisors while pedaling. The Exercise Motivator links a commercial stationary bicycle to any assistive technology device accepting a standard switch input, such as a battery interrupter, PowerLink unit, or keyboard emulator. In addition, a universal remote has been adapted so the exercise motivator can trigger the remote to send play or pause commands to a CD or DVD player. When the user pedals above a threshold speed, the associated device is turned on. The exercise motivator also provides verbal prompts in response to sustained above or below-threshold activity.

SUMMARY OF IMPACT

The client coordinator commented, "This project does an outstanding job of meeting the highly specific activity support needs of this developmentally complex teen … I am especially excited that the output can be graded to adjust for learning and skill acquisition, as well as be flexible enough to easily use with a wide variety of other items. This unique device has the potential for meeting life-long activity support needs for this individual."

TECHNICAL DESCRIPTION

The Exercise Motivator (see Fig. 7.18 and Fig. 7.19) accepts the standard reed switch output, built into most stationary bikes, as an input to determine pedaling speed. For bikes without the reed switch output, an aftermarket switch can be installed. The device creates a switch closure output signal compatible with commercial assistive technology devices and connects to them with a 1/8″ plug. When the pedaling cadence reaches a threshold value, the Exercise Motivator turns on the external device.

The device is housed in a 5.3″ x 5.3″ x 2.0″ case. Primary control functions are accomplished by a BASIC Stamp 2 microcontroller (Parallax, Inc.). Voice prompt playback is accomplished using an MP3 playback module (Rogue Robotics Corp.). The device inputs include: 1) a 1/8″ (3.5 mm) mono jack for the bicycle; 2) a 1/8″ (3.5 mm) mono jack for an auxiliary switch (described below); 3) an SD flash memory card slot for the MP3 player; 4) a size N coaxial DC power jack. The outputs include: 1) two RCA phono jacks for external device control; 2) a 1/8″ (3.5 mm) stereo headphone jack for playing verbal prompts; 3) a piezo buzzer. Device controls include: 1) an illuminated power switch; 2) a mode select switch; 3) a threshold knob; 4) a recalibrate button to adjust the dynamic range of the threshold knob. The device is powered by a nine-volt DC, 300-mA power supply. Appropriate cables are provided for making connections.

The device compares pedaling speed to a threshold set by the position of a threshold control knob. The dynamic range of the threshold knob can be calibrated to a particular bicycle using the reset button on the front of the device.

The device has two separate outputs, which are switched by relays. It can be set in one of two modes using a mode switch. In "continuous" mode, output switch one is open below the threshold and closed above, and output switch two is closed below threshold and open above. In "momentary" mode, both outputs are open, but output one pulses closed on upwards threshold crossings, and output two on downwards crossings. Sustained activity above threshold elicits praise prompts played over the headphone jack, and below-threshold activity elicits encouragement. Voice prompts are selected randomly from a list and may be custom recorded on the memory card, which plugs into an accessible slot in the rear of the device. The device also has an auxiliary switch input, which allows an external button to be connected in series with the first output. In continuous mode, the button is active, but below threshold it does nothing. Removing the button automatically returns output one to its normal operations.

Cost of parts was approximately $550.

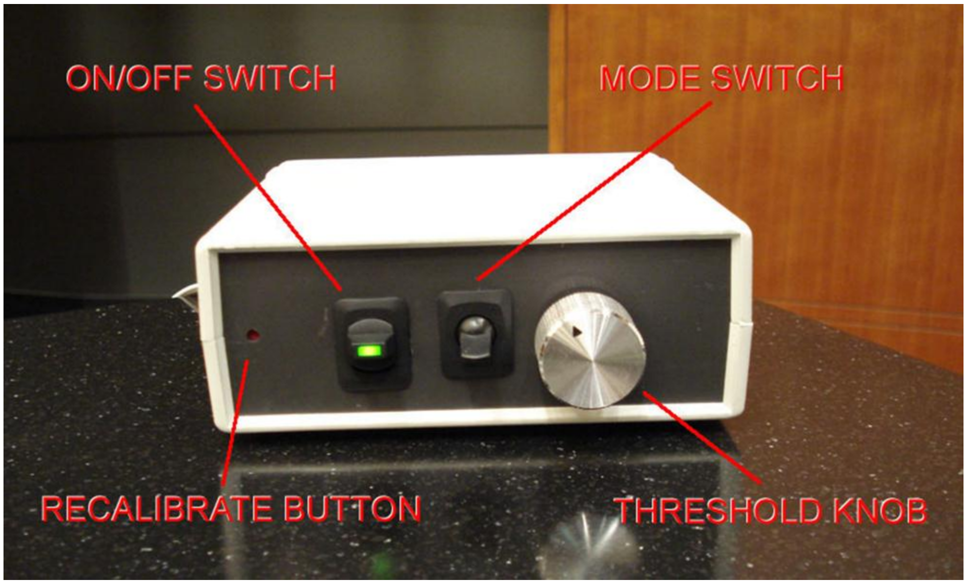

Fig. 7.18. Exercise Motivator, Front Panel.

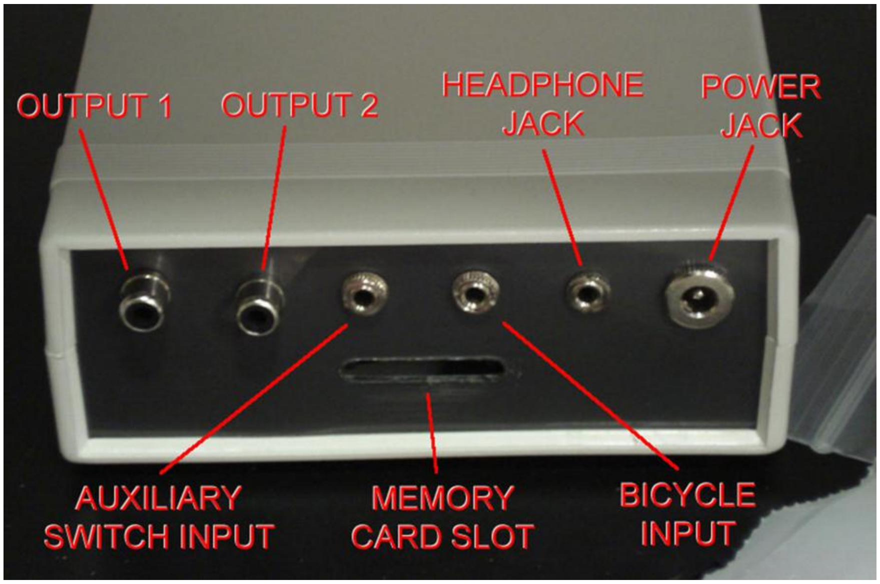

Fig. 7.19. Exercise Motivator, Rear Panel.

RAIN SHIELD

Designers: Kelsey Boitnott, Dennis Cattel, and Shawn J. Mendonca
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

A woman uses a manual wheelchair that she transports with her car. She gets wet on rainy days when getting in and out of the car and when traveling outside in the wheelchair. The Rain Shield uses a large commercial umbrella and custom attachments for the car and wheelchair to allow the client to remain relatively dry in these situations. An additional plastic shield attaches to the car and the umbrella to further improve protection when it is also windy.

SUMMARY OF IMPACT

The client commented, "As a new wheelchair user,

Fig. 7.20. Client Inside Rain Shield Attached to Car.

the rain has made it really difficult for me to get in and out using this chair. The rain shield is going to make it so much easier for me to get out and go to work and do my daily activities without getting wet."

TECHNICAL DESCRIPTION

The Rain Shield (see Fig. 7.20) includes four components: 1) the umbrella holder; 2) the wheelchair attachment; 3) the side panel; and 4) the umbrella closing system. The umbrella holder uses a 10.5" section of one and a half inch black diameter PVC pipe as a sheath to hold the umbrella upright. A semicircular notch, milled in the pipe near the top end, allows the umbrella to be secured to the pipe with a hose clamp. An eye screw attaches near the bottom of the pipe, and a carabiner clips through the eye screw. To mount the umbrella to the car, the user rests the umbrella between the opened door and the car roof, which is attached to the carabiner to the U-shaped door locking hook on the side of the car. A stainless steel L-bracket also attaches to the bottom of the black pipe, which is used to connect the umbrella to the wheelchair as described below.

The wheelchair attachment (see Fig. 7.21) mounts under the client's seat. The base of the wheelchair attachment consists of three 1/8" thick aluminum layers stacked on top of each other, with cuts and screws placed on specific areas depending on the functional use of the layer. A gap between the outer layers accepts the horizontal end of the L-shaped bracket on the umbrella holder. Once the bracket is slid into the base, it is secured by a pin. Two pairs of circular clamps secure the base to the wheelchair.

The clear vinyl side panel only needs to be used during extremely windy and rainy days. It attaches to the umbrella via six button snaps.

A closing system was devised to help the client close the umbrella after use, while seated in the driver's seat of the car. At the top end of the umbrella, nylon fishing wire is braided into the spokes. Below the spokes, this fishing wire is interwoven into a powder-coated black jack chain, which provides the main support of the closing system. A hanging hook attaches to the fishing wire/chain approximately 19" from the spokes. While the client is sitting in the driver's seat, the small carabiner is still attached to the door lock hook. The client then

Fig. 7.21. Client Using Wheelchair Umbrella Attachment.

pulls the hanging hook attached to the fishing wire/chain and attaches it to the outer hole of the L-shaped bracket. This closes the umbrella to a level where she can reach the umbrella slider and then fully close it.

Other features ensure stability, safety, and aesthetic appeal of the device. For connecting the umbrella to the car, a second attachment point was added to improve device stability. A large caribiner was attached to the grab bar in the front passenger side of the car. A nylon loop in the fishing wire/black chain approximately 20" from the umbrella spokes was attached to this caribiner on the grab bar. Also, a removable black nylon fabric cover was created for the umbrella holder to improve its appearance.

Cost of parts was about $440.

PORTABLE WHITE BOARD FOR HOSPITAL TEACHING

Designers: Brian Lee, Maher Salahi, and Vitaly Chibisov
Client Coordinator: Amanda Headley
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The Portable White Board was designed to enable mobile school teachers in hospitals to move a white board between hospital rooms. The Portable White Board includes three components: 1) a large whiteboard for the teacher to write on; 2) a smaller easel whiteboard for the student or patient; and 3) a support structure for both of them. The large white board can be adjusted vertically and radially. The support structure is made of the: 1) base; 2) suction cup; and 3) basket. The easel is simply a whiteboard that can stand by itself and is portable.

SUMMARY OF IMPACT

The client coordinator, a local teacher, commented: "I have been wanting something that would improve my delivery to my bedridden students for many years. The board will enable me to introduce algebra problems more easily by being able to use the board for many practice problems as well as notes that the student can immediately refer back to. The board is more effective than leaning over their bed."

TECHNICAL DESCRIPTION

The Portable White Board (see Fig. 7.22) includes: 1) a teacher's portable whiteboard; 2) a student's easel; and 3) a support structure. The teacher's whiteboard was manufactured from a large piece of raw white board material (Everwhiteproducts.com). A frame was fashioned from one-inch by one-inch pieces of stained red oak, with a groove cut to contain the board. A penholder was made from an L-shaped piece of aluminum, bent into a more favorable angle. These components were glued together and to the whiteboard.

The easel was constructed in a similar fashion as the main white board, except that it does not harbor a pen holder. The easel support was made out of a plastic board and a reconfigured 5/16" steel beam. The beam was bent into a U shape with the top ends bent inwards. The plastic was made to fold out using two hinges, with a groove for the steel beam. The assembly was secured with epoxy glue and acrylic cement.

The support structure base uses 3" x 1 ½" aluminum rails (80/20, Inc.), configured in the shape of an "H". The base is attached to 3" casters to allow for easy movement around the hospital corridors. A large suction cup, designed to handle 100 pounds of force (Wood's Powr-Grip Co., Inc.), is attached to the base, allowing the structure to be locked in place. The suction cup is mounted to a vertical pipe that sits inside the main vertical support pipe. The user lowers the suction cup to the floor by twisting and lowering the inner pipe and activates the suction by pumping a foot lever. A stainless steel pipe with outer diameter of 1 ¼" is mounted to the base using U-bolts and a custom acrylic spacer that rests between the U-bolt and pipe, holding the pipe securely.

The teacher's white board is mounted to an acrylic plate, which is mounted to the vertical pipe. A custom acrylic cam, with an ergonomic handle, allows the board to rotate radially but lock in place easily. A collar on the bottom of the acrylic plate contains a through hole. A series of holes drilled in the vertical pipe allows the height of the white board to be adjusted by inserting a pin through the collar hole and the desired pipe hole.

A milk crate basket was bolted to the base to provide storage space.

Cost of parts was about $500.

Fig. 7.22. Portable Whiteboard.