CHAPTER 7
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INTRODUCTION
A play activity center was designed to stimulate the senses of children with limited physical and cognitive abilities in an outdoor setting. The device consists of a frame structure with five activity stations and nine different activities. The frame structure is weatherproof and height-adjustable. It can be easily dismantled for storage. The activities stimulate the visual, auditory and tactile senses and reinforce the sense of cause and effect. The components are interchangeable and removable for cleaning or storage. The device is inexpensive and easy to modify and clean.

SUMMARY OF IMPACT
This device will enable the residents a private, nonprofit residential center that serves children with profound developmental disabilities to engage in outdoor play activities. The device can be modified easily to include other activities in the future. The client coordinator commented, “We have looked for many years for playground equipment that would address the needs of our children. Our new play station has opened up a whole world of fun for our children. It is appealing and accessible. The variety of activities stimulates all the senses, which helps our children to learn to explore and to interact with their environment. The play station opens up a whole world of outdoor recreational activities for our children... and will definitely allow (the) children to play more independently.”

TECHNICAL DESCRIPTION
The Outdoor Play Activity Center (Fig. 7.1) consists of five activity stations, allowing five children in wheelchairs to play simultaneously. Nine interchangeable activities are provided.

The frame is constructed from 1 ¼” red furniture-grade PVC. To provide stability but also allow the device to be removed if necessary, the 5’ long vertical posts of the frame are inserted into 12” long stainless steel sleeves, 2” in diameter, which are submerged into holes in the ground, made with a garden auger and drill. The six vertical pipes are connected via L- or T-joints to similar PVC beams, 32.5” long, parallel to the ground. The resulting height of the PVC beams is 4’. Five green powder-coated clothesline hooks are evenly spaced on the vertical posts, 26” to 44” above ground. Each hook extends 6” in front of the vertical post, so that the wheelchairs can remain on the flat concrete patio, away from the adjacent grass slope.

For each activity station, a 36” long, ½” PVC pipe is supported at each end by the clothesline hooks. Two of the nine stations are directly connected to these horizontal activity bars. The remaining stations are connected to the activity bars via custom attachments with three components. A nylon strap loops around the PVC bar and extends 5” to a plastic buckle. This buckle allows length adjustment of the nylon strap. The other end of the nylon strap loops through the terminal link of an 8” segment of garden-grade plastic chain. The other terminal link of this chain attaches to a connecting device, either a
metal key ring or a plastic latch, which attaches to the activity.

A variety of activities were designed to meet the needs of the client. The designs were inspired by toys currently on the market. All the activities are visually stimulating as they are brightly colored. Three of the activities stimulate the tactile sense. Activity A consists of strings of plastic beads hung vertically from a dowel rod. Activity B is a series of three rubber balls of varying textures. Activity C uses a commercially available children’s toy that vibrates and talks when activated. This toy was switch adapted with a standard 1/8” phone jack so that vibration and sound occur only upon pressing the switch.

Five other activities also reinforce the learning of cause and effect. Activity D is a commercially available bubble maker that was switch adapted to produce bubbles when the switch is pressed. Activity E consists of painted wooden balls within a clear plastic container. The container is attached directly to the horizontal activity bar and has three large knobs around the perimeter. When the user pushes the knobs, the container rotates and balls roll around within. Activities F through I also reinforce the concept of cause and effect and stimulate the auditory sense. Activity F is a “rain-stick.” A clear plastic tube containing beads and obstructions to the beads is attached directly to the horizontal activity bar. When the user rotates the tube about the horizontal bar, beads fall from one end to the other, creating a sound similar to rain. Activity G consists of seven hand bells, each producing a different note when hit. Activity H is constructed from four plastic Christmas ornaments, each containing small beads that rattle when the ornaments are swung. Activity I consists of a large colorful wooden butterfly attached to a commercially available wind chime. Figure 7.2 shows two clients using the center.

Cost of parts was approximately $600.

Fig. 7.2. Clients Using Play Center.
FOOT-ACTION GUITAR STRUMMER

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INTRODUCTION
The client is a 17-year-old boy who had a left hemispheric stroke at the age of three that affected the right side of his body. Because of the stroke, he does not have the dexterity and fine motor control necessary in his right arm to strum a guitar. A device was built to allow him to strum the guitar using his left foot. The strumming mechanism is composed of a pick rod, which holds six individual guitar picks, and two complementary-action solenoids that move the rod across the strings. This mechanism is mounted to the guitar face and controlled by a momentary switch within a foot pedal. The system is powered by an AC/DC converter that plugs into a wall socket. The device is portable, produces good sound quality, and requires minimal user effort.

SUMMARY OF IMPACT
This device has enabled the client to start taking guitar lessons. The client’s mother commented, “I had to make him put down the guitar and leave for school this morning, so I would say the project has been a success. (He) is progressing in his lessons and last night he was practicing the chords for new songs. He says it's pretty hard but he is confident he'll learn. This whole experience has been good for his self-esteem, and has given him a hobby.”

TECHNICAL DESCRIPTION
The Foot-Actuated Guitar Strummer (Fig. 7.3) consists of a pick rod, two solenoids, a guitar mount, and a foot pedal. When the user pushes on the pedal with his foot, the device strums downward, and when he releases the pedal, the device strums upward.

The pick rod is constructed from a ½” square Delrin rod. Six slits, cut 1/8” into the bottom of the rod, hold six standard guitar flat picks so that the separation between picks equals that between the guitar strings.

One push and one pull solenoid are connected together with the pick rod, allowing independent timing for the up-strum and down-strum. A hole drilled along the axis of the pick rod accepts the push-solenoid plunger, which is secured to the pick rod with a setscrew. Both solenoids are powered with a 12V, 5A AC/DC wall plug, which allows the strummer to be activated indefinitely. The surfaces of the push solenoid plunger are padded with neoprene to mitigate excess noise from the solenoids stopping and starting during operation. A Plexiglas enclosure with air holes prevents user contact with the hot surfaces of the solenoids.

The solenoids and pick rod are attached to a base plate with a machined bottom, which slides into a
track mounted on the guitar. Ball detents on the track allow for easy and consistent positioning, and a wing screw secures the strumming components to the sliding track.

The foot pedal uses commercial footswitch housing. The commercially supplied switch was replaced with a SPDT momentary switch connected to the power supply such that one solenoid is activated at all times. Pressing the pedal activates one solenoid while releasing the pedal activates the other. This method of control allows for a playing speed comparable to hand strumming. A standard ¼" stereo guitar cable connects between the SPDT switch in the pedal and the solenoids on the guitar. Each connection in the system uses a different sized plug and jack to ensure correct connection of components.

The device was tested to determine the maximum strumming rate and the temperature escalation over time. The maximum strumming rate was 17 strums per second corresponding to 9 pedal presses and 8 releases per second. This high frequency should prevent strumming rate from being a limiting factor in any musical composition. The surface temperature of the solenoids rose sharply to a temperature of 140°F. However, the enclosure attained a maximum temperature of 89.6°F, low enough to protect the user from potential injury. Figure 7.4 shows the client using the Foot-Action Guitar Strummer.

Cost of parts for the device was approximately $525.

Fig. 7.4. Client Using Guitar Strummer.
PERSONAL PLAY CANOPY

Designers: Kelvin Ho, Jenna Olson, Rivai Tan
Client Coordinator: Nancy Hoopingarner, Physical Therapist, Durham Schools
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INTRODUCTION
A play system was developed for a nine-year-old child with severe cognitive and physical disabilities. It consists of a wheelchair canopy with activities that produce sounds when struck, two head-operated levers that strike the activities, and a textured panel on a wheelchair tray. The system promotes mental, physical, and social development of the child through play.

SUMMARY OF IMPACT
This Personal Play Canopy will allow the client to be engaged both independently and with other children on the playground and in the classroom. The canopy will allow her to spend more time on the playground despite her sensitivity to light. Her physical therapist hopes that the device will help her develop her understanding of cause and effect, as well as her ability to actuate switches using head control.

TECHNICAL DESCRIPTION
The Personal Play Canopy (Fig. 7.5) consists of three main components: a headset, a canopy with musical attachments, and wheelchair tray with a touch panel. The headset contains two independent levers, one for each side of the client’s head. An ABS plastic box houses each lever mechanism. Each lever is actuated by pushing on a 4.5” diameter padded button, which is connected to the lever with a ½” diameter nylon guide rod. Exterior to the housing box, the guide rod extends through a 2” long 1.77 lbs/in compression spring. The spring pushes against the side of the housing box and button recovering the position of the lever. A 2.5” x 1.5” x 0.5” Delrin sleeve, attached to the side of the housing box, ensures that the guide rod moves perpendicular to the box wall and in the plane of the lever swing. The lever is 15.7” long, with 10.7” protruding from the front end of the housing box through a 3” x ¾” slot that allows the lever to swing.

The lever is made from a commercial drumstick. It is attached to the housing box with a pivot screw near the large end of the lever. The guide rod attaches to the stick with a freely rotating screw, 2.5” forward of the pivot screw. When the button is pushed, the lever pivots on the pin and moves laterally outward to strike an object. The levers are mounted onto the wheelchair handlebars using a system made from PVC tubing.

The canopy is modified from a commercial wheelchair canopy (WeatherBreaker, Deistco, Chico, CA), which attaches to two aluminum tubes fastened vertically onto the wheelchair frame. Eyebolts are attached at intervals along the upper canopy frame, through grommets in the canopy.
Musical activities are attached to the eyebolts using lengths of nylon rope with plastic hooks on either end.

The 16” x 12” wheelchair tray is constructed from clear Plexiglas, with rounded edges and a semicircular cutout to accommodate the user’s body. The tray is attached to two hollow red PVC pipes, which slide over the wheelchair armrests for easy mounting.

The textured panel consists of a variety of soft textures glued onto a 12” x 12” plywood square covered with white felt. A Lazy Susan bearing is attached to the bottom of the plywood square, allowing the textured panel to rotate while on the tray. Non-slip Dycem pads are attached to the base of the textured panel to prevent it from sliding on the tray surface. Figure 7.6 shows the client using the device.

Cost of parts was $520.
STEADY STEPPER

Designers: Christian Agudelo, Dorothy Lowell and Troy Swimmer
Client Coordinator: Annette Lauber, North Carolina Assistive Technology Project
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INTRODUCTION
Our client is an energetic and active adult who has cerebral palsy (CP) and uses a wheelchair. We designed the Steady Stepper to address her request for a safe and effective weight-bearing home workout. This device utilizes a stair-stepper coupled with a custom railing system to aid in transitioning from the wheelchair to the stair-stepper, and to provide stability while stepping. Interchangeable wooden pegs mounted to the bottom of each step allow for a varying range of motion. Weight distribution over each step, and variable foot position, provide variable workout intensity.

SUMMARY OF IMPACT
The Steady Stepper gives the client the opportunity to exercise independently in the comfort of her home. She commented, “I am so pleased about the stepper and especially the versatility that was built into it which went beyond my expectation. My maximum time of using it in a single session is seven minutes, which is great. It really helps to relax my leg muscles. The stepper fits so easily into my regular routine and I anticipate years of use to help me maintain good health.”

TECHNICAL DESCRIPTION
The Steady Stepper (Fig. 7.7) uses a commercial portable stepper attached to a custom railing system. The railing system consists of four side handrails: two top handrails and two bottom handrails, which attach to a wooden base. Each handrail is made of U-shaped pieces of 1” diameter aluminum piping. The front rail attaches diagonally across the four side rails and serves as a truss to prevent parallelogram failure. Caps on the extruding aluminum pipe prevent injury. Each handrail is covered in a foam grip. The aluminum railing is attached to a wooden base with shotgun clamps, which are welded to four 4”x2” aluminum plates, bolted to the base.

The wooden base extends 10” past the railing so that the client’s wheelchair can be rolled onto the base and secured by locking the wheels. The leading edge of the base is angled 45º to ease the transition. Two wooden placement strips are bolted to the base-plate to prevent the stair-stepper from moving horizontally. Since the stepper is not permanently attached to the base-plate, it can be easily removed if desired. The exercise monitor of the stepper is attached to the middle of the front handrail with a Velcro strap, allowing the user to adjust the angle of the display.

Five pairs of color-coded stoppers allow the client to vary her workout intensity by screwing a different pair into the bottom of each step, thereby altering the maximum step travel. The stopper lengths are 1” (black), 2” (red), 2.5” (green), 3” (yellow), and 3.5” (blue).

Cost of parts for the Steady Stepper was approximately $510.
Fig. 7.7. Client Using the Steady Stepper.
POWER SOCCER BUMPER ATTACHMENTS

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Client Coordinator: Kim Lyons, Durham Parks and Recreation
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INTRODUCTION

Bumpers are required in power soccer to protect the player and provide a flat striking surface. The commercial bumpers used by the team were difficult to attach and detach, and unstable during game play. Two new attachment mechanisms were developed to be compatible with commercial bumpers. One attaches to the footrest supports, and the other attaches to the stable sidebars of the wheelchair. Bumpers can now attach more quickly than before, using hardware that makes them more durable during game play.

SUMMARY OF IMPACT

The power soccer team coach commented, “Thanks to the (device), our team can play a whole tournament without repairs... In the past, individual guards would have to be fixed and readjusted any time a player made contact with another chair. This would leave very little time for playing or coaching. Now we can focus on playing.”

TECHNICAL DESCRIPTION

After examining the wheelchairs and commercial bumpers of the team, two attachment approaches were determined to be necessary: one to the lower horizontal bars of the wheelchair frame (Fig. 7.8), and the other to the footrest support bars (Fig. 7.9).

For both types of wheelchairs, the bumpers themselves were first made to be more durable. As wheelchairs collided during game play, the two bolts on the front of the bumper would slide together, causing adjacent sides of the bumper to collapse. To address this problem, a 2x8” retainer bar of 1/16” steel was added behind these bolts, thereby preventing them from moving together.

The original hardware of the bumpers was also replaced. Instead of the six hex-head bolts, combo-head machine screws were added so they could be tightened with either a Philips- or flat-head screwdriver. Split lock washers and nylon-insert locknuts were used to prevent loosening of the hardware after repeated impact.

To attach the stabilized bumpers to wheelchairs with usable footrests, circular hose clamps were mounted to permanent locations on the bumpers. Two clamps were used on each side, such that the open ends of the clamps faced inward from the bumper sides. A nut was welded to one side of each clamp, so that when the bumpers were inserted over the footrest supports, a machine screw with a large phenolic knob could be used to tighten the clamps over the footrest supports.

For the wheelchairs with unusable footrests, the bumper was attached to the lowest horizontal side members on the wheelchair base, using custom clamps made from stainless steel plates and commercial pipe joints. On each wheelchair side member, two plates were bolted together so as to sandwich the member. A 1.5” rotating pipe-to-plate joint was bolted to the outer of these plates, and fixed in rotational position with a screw. Attached to the bumper was a matching joint with a free angle to absorb the impact of a collision. A 1.5”aluminum pipe connected these two joints. The aluminum bars were permanently connected to the joints on the bumper, so they could be inserted into the joints on the wheelchair and secured with an Allen screw before games.

Cost of parts for the Power Soccer Bumper Attachments was about $690.
Fig. 7.8. Bumper Attachment for Wheelchair Frame.

Fig. 7.9. Bumper Attachment for Footrest Supports.
INTRODUCTION
The client is an active seven-year-old boy with TAR syndrome, which causes him to have very short arms. A biomimetic reaching assist device (BRAD) was developed to enable him to acquire, manipulate, and transport objects out of reach. Special features of BRAD include: a TIG-welded aircraft aluminum harness, a horizontally folding tubular arm with a 40” reach, plastic rubber-tipped pincers controlled by a bike brake, an acrylic tray to allow access to retrieved objects, foam padding on the shoulder straps and chest plate, a nylon cord to enable the client to control arm extension and folding, and a furniture-grade PVC docking station for device storage. With this device, the client can extend and retract the arm, perform fine-motor skills such as opening a cabinet, and retrieve a variety of objects including cups and snacks.

SUMMARY OF IMPACT
The client’s mother commented, “The reacher greatly increases (his) ability to get things off of higher shelves. More importantly, it helps him use a creative way of thinking about solutions to problems he faces. It is much more than just a piece of equipment for him. It helps him think of ways he can have more independence.”

TECHNICAL DESCRIPTION
The BRAD (Fig. 7.10) consists of a modified drum harness (CSCI Competitor Snare Drum Carrier, Pearl Corporation) with a hinged two-segment arm and fixed support member. Both are made of 1” square aluminum tubing, attached to the chest plate. The base arm segment and support member are TIG-welded to the aluminum chest plate and to each other. A butterfly hinge, attached with rivets, connects the two arm segments.

A pair of rubber-tipped pincers, from a commercial reacher (PikStik, Reid Industries), was modified for control by a bike brake/cable system. It was then attached to the end of the arm.

The bike brake lever is attached to the chest plate so the client can operate the pincer with his right hand. A nylon cord with three wooden balls is attached through guiding rings to the outer arm. The client pulls on the cord with his left hand to extend the outer arm, and releases the cord while tilting his torso to fold the arm inward using gravity. An acrylic tray, lined with black felt, is mounted to the support member. When the outer arm is folded inward, the pincers can drop an object on the tray, allowing the client to retrieve it.

Fig. 7.10. Reaching Assist on Docking Station.
A docking station, made from black and blue furniture-grade PVC, allows the client to suspend the BRAD by two wings attached to the shoulder straps of the harness. This enables him to mount and remove the device without assistance. The commercial shoulder harness padding did not provide a stable operating platform or comfortable fit. Open cell foam was contoured to our client’s upper body and attached to the shoulder straps with Velcro, which will enable replacement as he grows. Figure 7.11 shows the client using the Biomimetic Reaching Assist.

Cost of parts was approximately $680.

Fig. 7.11. Client Using BRAD.
IMPROVED BEEPBALL

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Client Coordinator: Kim Lyons
Supervising Professors: Richard Goldberg, Kevin Caves
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INTRODUCTION
Beepball is a sport similar to softball, designed for individuals who are visually impaired. A beeping transmitter inside a 16-inch softball informs players of the ball's location. The beeping transmitter in current commercial beepballs sometimes fails after a hard hit, and is often difficult for players to hear. The goal was to create a new, more durable Beepball. This ball has two speakers to provide louder sound if the ball lands on one speaker. In addition, the ball charges faster and lasts longer on a charge than commercial models.

SUMMARY OF IMPACT
In initial testing, the new beepball was well liked. The coach of one Beepball team said, “It’s a great ball. I could really tell the difference in the way the players tracked the ball in the field.” Several of the players had positive reactions to the ball, especially the two-speaker design and the slightly higher pitch of the beeping. After one player made a play on the ball, a teammate shouted, “Great play!” to which he responded “Great ball! I really like the way it sounds!”

TECHNICAL DESCRIPTION
The Improved Beepball (Fig. 7.12) comprises a large softball (16” circumference), which houses a battery, on/off switch, beeping circuit, and speakers.

The beepball uses a 7.4 V rechargeable lithium ion battery, which is compact (2x1x0.6”) and has no “memory,” providing longer battery life. The battery is connected to a 1/8” audio jack, mounted flush to the surface of the ball, allowing the external battery charger to connect to the battery. The battery charges using a commercial wall-outlet-mounted unit (Universal Smart Charger, Batteryspace.com), which produces 8.4V DC. A switch on the charger allows the user to change the charging voltage, but we fixed this switch in place using epoxy. A red LED on the charger indicates that the battery is charging, and a green LED indicates when charging is complete.

The beeping circuit uses a 556 timer, which functions as two 555 timers in series. The first creates a tone at 1480 Hz. The second turns the tone on and off at 4Hz. The circuit resides on a 2”x1.3” custom circuit board, designed using ExpressPCB.

To protect the circuitry from large forces, the battery pack and circuit board are encased in a cylinder of polydimethylsiloxane (PDMS), a silicone-based elastomer, which solidifies into a polymer gel after the base and curing agent are mixed together. A metal support for the charger jack, coated in PlastiDip® to eliminate electrical shorting, was inserted halfway into the PDMS before it set to help stabilize the jack. Sound permeable fabric is sewn beneath 1” holes in the leather covering of the ball, so that no potentially damaging materials can enter the speaker chambers.

The circuit board is connected to two separate speaker chambers, 1” in diameter. The chambers consist of a piezoelectric tweeter (Taiyo Yuden, MODEL #MLS20070), sandwiched between a ½” PVC tube and a ¼” PVC tube, sealed with a ¼” solid cap at the bottom. The chambers are sealed with epoxy. Cylindrical foam pieces fit around the speaker chamber, and extend the diameter of the chamber to 1 3/8 inches, allowing it to fit snugly inside one core of the ball.

Before the cylinder could be placed in the ball, a cylindrical portion of cotton had to be removed from the inside the ball. It is easier to cut this cotton by compression force rather than by pulling, so tools were created out of 6” sections of steel pipe, sharpened on one end for cutting. A hole drilled through the diameter on the other end allowed a screwdriver to be used as a handle. Creating cores in the ball was quick, precise and easy using these tools.
To prevent the transmitting device from flying out of the ball after it is hit with a bat, the model has a cross-member design, with two perpendicular cores of differing diameters through the center of the ball. The battery pack, circuit board and audio jack fit into the larger cylinder. The two speaker chambers are attached together, in tension, by an elastic cord in the other core. This tension keeps the two speaker chambers together, centered inside the ball.

The charger jack is connected to the oscillator circuit such that when a pin is in the audio jack, the ball does not beep. In this way, the battery charge can be reserved by silencing the ball while it is charging. The Improved Beepball achieves a sound pressure level of 95 decibels at 3 inches, equivalent to commercial models. The battery lasts over 14 hours or at least seven times that of other beepballs, and charges in only five minutes.

Cost of parts was about $100.

Fig. 7.12. Improved Beepball.
FALLS RECOVERY LIFTING DEVICE

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Client Coordinator: Sue Cheng, OTR/L
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INTRODUCTION
The client is an adult with Freidrich’s Ataxia, who has great difficulty getting back into his wheelchair whenever he falls out. The Falls Recovery Lifting Device uses a hydraulic jack that lifts a chair 22” vertically from near floor level. When the chair is pumped to the desired height, the client can easily perform a sliding or standing transfer from the device back into his wheelchair.

SUMMARY OF IMPACT
The device provides the client with a safe and reliable means to return to his wheelchair after a fall. Although such events are infrequent, the recovery process previously had been time-consuming and hazardous, since he had relied on his wife to help him. A typical recovery would take them one hour or more. Now, after a fall, the client’s wife may retrieve the device, using the attached wheels to roll it over to the location of the fall. Once the device is in position, recovery takes approximately two to three minutes. The client’s wife remarked, “This will work well; two or three minutes is nothing compared to the hour or more that this used to take.”

TECHNICAL DESCRIPTION
The Falls Recovery Lifting Device (Fig. 7.13) consists of a hydraulic jack, an aluminum base, and a stand with attached seat. The jack is a three-ton long-ram bottle jack, normally used in cranes and engine hoists, which travels vertically by manually pumping a one-piece handle. One hundred and twenty pumps cause the ram to travel its full length. Releasing a valve on the side of the base and pushing down on the ram manually returns the jack.

The base is constructed from 2”x2” square aluminum tubing and ½” thick solid aluminum plate. The jack is secured to the top portion of the base with a 5/8” machine bolt. The bottom portion of the base consists of a 30”x12” plate, bolted to two 30” long square tubes. Two 2” radius non-rotating wheels are attached to the ends of the tubes making the device easy to move. The device can be picked up by the legs and moved around like a wheelbarrow.

The seat from a commercial heavy plastic chair is attached to two sections of 1” diameter steel conduit. The conduit is bent to support the seat of the chair and also bent over the back of the chair to form overhead hand grips. The grips are for the client to use for support when sliding from the ground onto the seat, and during the lift. The seat is connected to the bottle jack via a piece of 2” square tubing. The square tubing has a 1” clearance hole that fits the top
of the lift piston, which allows the seat apparatus to be detached at any time.

A track, constructed from two ¾”x¾” aluminum square tubes and mounted behind the chair, prevents the seat from rotating during use. A 2” radius non-rotating wheel is attached to the back of the chair to slide on the column of the jack while being guided by the track. The track is secured to L-brackets on the bottom and top of the jack.

Cost of parts for the device was about $615.
PANDAROO: PERSONALIZED STUFFED ANIMAL COMPANION

Designers: Ling Bei, Courtney Olmsted, Yao Quan Xie
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INTRODUCTION
Children can face considerable psychosocial anxieties during hospital stays, especially when parents or guardians are absent. The PandaRoo comfort toy was designed to help alleviate these anxieties, through audio and visual components that can be customized to suit individual needs. The audio component consists of an MP3 player housed in a miniature backpack, which can be easily attached to and removed from stuffed animals of various sizes. This allows the child to use his or her favorite stuffed animal, while the hospital can own the costly electronics and use them on multiple patients. This eliminates the need to sterilize stuffed animals before reuse. The MP3 player features four user-selected playback modes. Additionally, playback buttons are situated along the edges of a picture pocket that spans across the backpack straps, thus creating a unified user interface on the front of the stuffed animal. The user presses one of four buttons on the backpack to play one of the MP3 recordings. These could be a parent reading a story, singing a lullaby, or a recording of a favorite song.

SUMMARY OF IMPACT
By reducing pediatric patients’ anxieties during their hospital stays, PandaRoo will provide comfort and entertainment, particularly when children are not with their primary caretakers. The hospital supervisor and other therapists expressed excitement about the possibility of using PandaRoo in the clinic for their own patients. The supervisor stated, “I think this is definitely something we can use that will be a source of comfort for those kids who are here without their parents.”

TECHNICAL DESCRIPTION
The PandaRoo (Fig. 7.15) consists of a custom miniature backpack with an embedded MP3 player and user controls. Because the electronics are housed in the backpack, a stuffed animal of the child’s choice can “carry” the backpack, and the device can be used by multiple patients. In addition, the backpack provides a way for the unit to be sanitized: the electronics are removed, and the backpack itself is then washed.

The audio component of PandaRoo uses a Rogue Robotics MP3 Playback Module that is controlled by a PIC 16F876 microcontroller. Although the current MP3 module has no direct recording capabilities, Rogue Robotics is currently developing a newer version with recording capabilities that can be used for a future model. In the meantime, any MP3 recording can be easily downloaded to PandaRoo using a personal computer and a flash memory card reader. The electronics are powered by a standard 9V battery, and the voltage is reduced to 5V using a regulator. The regulator has a shutdown pin so that the PIC can shutoff its own power supply to conserve battery power. The audio component is housed in an ABS plastic enclosure.

Fig. 7.15. PandaRoo with Electronics Box Exposed.
The visual component of PandaRoo involves a picture pocket, located on the front of the stuffed animal. The picture pocket is attached to the backpack straps on only one edge, allowing the backpack to easily mount to the stuffed animal. Four brightly colored, waterproof buttons are located along the edges of the pocket. Each button selects playback of a different pre-recorded message. Wires from the buttons to the electronics housing run through one of the backpack straps, and contain connectors so the electronics can be easily detached before washing the backpack.

The audio interface provides four different playback modes, controlled by two independent slider switches located on the electronics enclosure. These switches are designed for access by the patient’s caretakers. The first pair of playback modes selects either Custom or Default. Some children’s anxieties are worsened when they only hear their parents’ or guardians’ voices and do not see them physically. For these users, the MP3 player can be set to play default lullabies and stories featuring neutral voices. For children who are comfortable with listening to their parents’ or guardians’ voices, the MP3 player can be switched to playback of custom clips instead. The second set of playback modes selects between Single Play and All Play modes. In Single Play, the MP3 module only plays one clip (custom or default, depending on the first setting) when a playback button is pressed. This helps to engage the child since he or she has to actively and frequently interact with the toy in order to elicit audio responses. However, some patients do better with accessing all clips on the push of a single button, hence, the existence of the All Play mode.

Finally, the device powers down automatically after five minutes of consecutive inactivity, so as to conserve battery power. In this case, it can be turned back on using an on-off switch located on the front of the backpack.

Cost of parts for the PandaRoo was about $300.

Fig. 7.16. PandaRoo in use.
THIGH-CONTROLLED PIANO PEDAL

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INTRODUCTION
The client is a man with double below-knee amputation who plays the piano, but cannot actuate the sustain pedal reliably with his prosthetic legs. The Thigh-Controlled Piano Pedal allows him to use his thigh to push and release the pedal. The design uses a mechanical lever that is pushed horizontally to actuate the sustain pedal. It also has a mechanism to pre-load the pedal, which reduces the force needed to actuate the pedal, and a wedge system to anchor the device to the piano. The device allows him to reliably use the sustain pedal, thereby improving his playing quality and enjoyment.

SUMMARY OF IMPACT
The device, which anchors solidly to any piano, allows the client to use the lateral motion of his thigh to depress a pre-loaded piano pedal. The device is portable yet solid and durable enough to aid the client’s paying of music for years to come. The client commented, “Life has been a lot different to me in the past 16 months, since my second amputation. I’ve had more obstacles than I’ve ever had but one by one I’ve conquered each negative and turned it into a positive and now I’ve got my music back. I will be forever grateful and thankful.”

TECHNICAL DESCRIPTION
The Thigh-Controlled Piano Pedal (Fig. 7.17) involves a pedal assist device, a wedge anchoring system, and a lever. The pedal assist device consists of an aluminum frame and an adjustable, spring-loaded cylinder. Once the device is placed over the sustain pedal, the cylinder is tightened against the pedal until the played notes are sustained. It deactivates by loosening slightly. The spring inside of the cylinder is compressed against the pedal, substantially reducing the additional force required. The process lowers the pedal enough so that minimal motion is needed to engage the pedal and sustain the notes played on the piano.

Fig. 7.17. Thigh-Controlled Piano Pedal.

The wedge anchoring system uses the piano pedal casing as an anchor, and can be slid underneath most pianos directly in front of the pedals. A Quick-Grip™ clamp, typically used for woodworking, is anchored to the top of the pedal assist device. When the clamp is squeezed, it pulls on a wedge that presses against the base of the piano pedal housing and the floor. This holds the device in place during use. The handle of the Quick-Grip™ clamp and the adjustment knob for the pedal assist device are both set at heights accessible by the client.

A right-angle lever is utilized to depress the sustain pedal. The short end of the lever rests on the pedal when the device is being used. The vertex of the
lever is anchored with a pin joint at the top of the pedal assist device. The 24” long arm of the lever makes contact with the outer right knee and thigh of the client. To depress the pedal, the client shifts his leg laterally outward, and to release the pedal, he moves his leg back to the resting position. Varying pedal heights (initial heights and depressed heights) are accommodated by foam pads of varying diameter. These pads can be placed around the lever arm at the contact point with the client’s thigh, and can improve device comfort.

Cost of the device was approximately $205.

Fig. 7.18. Piano Pedal in Use.
INTRODUCTION
The client is an eight-year-old boy with cerebral palsy and autism. Due to a recent leg surgery, he spends little time voluntarily walking. The aim of this project is to build a device that would use music to stimulate the client to walk on his own. The Walking Motivator includes a pedometer to detect motion, a microprocessor, an MP3 music player, and headphones. Other than the headphones, the entire device fits inside a small pouch that straps onto the client’s hip. As long as the client walks, the music plays; when he stops, he receives a message to motivate him to keep walking. The device is very effective for stimulating the client to walk.

SUMMARY OF IMPACT
During testing of the device at the client’s school, the client’s actions showed he was affected by the starting and stopping of the music. After several minutes of successful testing with the client, his teacher stated that the device would encourage him to focus more on walking. The client seemed upset when the device was taken away from him, a good sign. Finally, his therapist was pleased that the Walking Motivator’s most efficient operation was when steady steps were continuously taken, as steady walking was one of her goals for the client. With help from his teachers and therapists to successfully integrate its use into his classroom activities, and perhaps eventually his parents for use at home, the client will build leg strength, gain more comfort in walking, and be more self-reliant for traversing longer distances.

TECHNICAL DESCRIPTION
The Walking Motivator (Fig. 7.19) is a motion-activated music player, containing a pedometer, a PIC microcontroller and an MP3 player. A commercial pedometer (Digiwalker SW 701, Yamax Corp, Tokyo) contains a switch, which closes and opens each time the user takes a step. The pedometer was modified to disable all features other than this switch. Wires from the switch are connected to a PIC microprocessor (16F876, Microchip Corp, Chandler, AZ) in such a way that each step produces a low pulse (5V to zero). Software in the processor continuously monitors this signal, interpreting each low pulse as a step. When the software first detects a step, it triggers an MP3 player (Rouge Robotics, Toronto) to start playing music as a reward.

When the PIC detects walking motion, the music is played continually until no walking motion is detected for six seconds. After six seconds, the music is stopped and a motivational cue is played, which explains that music will start again if the user starts to walk again. The PIC program contains a filter to guard against false positive detections of walking. This filter determines the frequency of steps, and if it is too high, triggers a different message that informs the user that the device will not play music unless normal walking is resumed. Additionally, if the PIC detects no walking motion for six seconds, it powers itself down to a sleep mode to conserve battery power.
Music was collected from the client’s teacher and uploaded to a Flash memory card, which plugs into the MP3 player. Ninety-one songs are stored on the card.

The pedometer, PIC, and MP3 player are packaged in a 3-1/4"W x 4-1/2"D x 1-1/2"H ABS plastic project box, which contains an easily accessible 9V battery holder. A voltage regulator drops the voltage to 5V for the microprocessor. Headphone wires exit the box and connect to standard audio headphones.

The device is worn on the hip of the client to allow for maximum efficiency of walking detection. The project box must be oriented properly for the pedometer to work reliably. This is ensured by attaching the device inside a camera case, which has been connected to a luggage strap, and strapping this ensemble around the waist of the client.

Cost of parts for the device was approximately $390.
SPEEDY RECOVERY VEHICLE

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INTRODUCTION
Children in hospital settings can experience feelings of fear and anxiety when faced with the task of getting into wheelchairs. The purpose of this project was to design and assemble a wheelchair that is fun and visually appealing to children. The Speedy Recovery Vehicle combines the functionality of traditional wheelchairs with the visually appealing design of racing dune buggies. The vehicle includes a custom welded frame, a reclining seat, and a colorful interactive steering wheel. Its small size makes it easy to store, and ideal for children in the two to six-year-old age group.

SUMMARY OF IMPACT
The Speedy Recovery Vehicle has the potential to help children who are scared of riding on traditional wheelchairs become cooperating patients. The supervisor remarked, “The speedy recovery vehicle is a kid-friendly means of transportation for sick kids. I think as physical therapists we will use it to motivate kids to get out of bed and sit up in a chair. It will also be a helpful way of getting them to want to go to the gym. This will allow kids to get the therapy that they need, without as much trauma.”

TECHNICAL DESCRIPTION
The Speedy Recovery Vehicle (Fig. 7.21) includes a custom welded frame, smooth rolling wheels, a reclining seat, footrests, a steering wheel, arm rests, a safety belt, an IV pole, and a storage area for an oxygen tank. The frame is constructed from 1” diameter aluminum tubing, making it lightweight and non-porous. Contoured handles make it easy for hospital staff to push the vehicle, and they can clean and sterilize it with traditional disinfectants made for non-porous equipment. The front caster wheels are solid polyurethane and 2” in diameter, while the rear pneumatic wheels have an 8” diameter. Custom welding of the frame was performed by KBC Machine Shop (Sterling Heights, Michigan).

The seat of the vehicle, like a wheelchair, can be reclined 30 degrees back from upright, in 5-degree increments by moving a retaining pin. The seat is made out of plywood and covered with high-quality foam and non-porous vinyl fabric. It easily supports the weight of a child in the 2-6 age group. The back support of the seat is 18” tall. The seat is 14” x 14” inches, and is 12” from the base of the vehicle.

The frame is painted red, and racing stripes and a decorative logo are stitched into the seat fabric. The vehicle is 42” long and 16” wide, allowing it to be stored more easily than other devices available for children in the hospital.

Two pairs of footrests are provided, both constructed from the same materials as the seat. One pair resides on the floor of the vehicle; 12” lower than the seat, and can support the child’s legs at a 90-degree angle. The other pair resides on the front of the vehicle, supporting a child’s extended legs. Either pair can be topped with an appropriate pillow to provide for different sized children.

The steering wheel is mounted on a pivoting arm, so it can be rotated out of the way when placing a child inside the vehicle. It contains a cartoon of the highway that moves as the wheel is rotated and bright buttons with pictures of different animals that make sounds when pushed.

An oxygen tank can be stored either in an upright position on a 4.5” wide metal platform at the rear of the vehicle, or at a 45-degree angle under the seat. A metal chain attached to the back of the seat prevents the oxygen tank from toppling when stored upright. A holding device is built underneath the seat for the 45-degree angle storage, and the footrest serves as a ledge for the bottom of the tank.

An IV pole, constructed from 1/2” aluminum tubing, extends 29 inches from the top of the seat of the vehicle. It contains a hook at the top that can support the IV. Aluminum armrests on each side of
the seat prevent the child from falling out sideways. One end of each armrest is attached to the seat frame with a pin that can easily be removed by the hospital staff to move the armrest out of the way when placing a child inside. A safety belt is attached to the bottom seat cushion to secure the child firmly in the seat.

Cost of the Speedy Recovery Vehicle was about $610.
NSF 2006 Engineering Senior Design Projects to Aid Persons with Disabilities