

CHAPTER 19
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ASSISTIVE TECHNOLOGY FOR BOX ASSEMBLY AND CHANNEL TUBE PRODUCTION

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INTRODUCTION

Todd and Sarah (pseudonyms) are adult employees who work at Community Workforce Solutions (CWS), a local organization based in Raleigh, NC, that employs people with disabilities. Each of the clients would like to be able to perform their jobs independently and rapidly, as they get paid according to the amount of work that they can complete.

One of Todd's tasks at CWS is to assemble a cardboard box in an eight-step process from the initial unfolded cardboard template. Because of his cognitive disabilities, he has difficulty with multi-step processes, and needs to be reminded which step comes next. We developed a box folding template that reduces the process to only four steps, making this task much easier for Todd (Figure 19.1).

One of Sarah's tasks is to cut two pieces of reinforced filament tape and place them in a cross pattern over the end of a clear plastic tube. She has limited fine motor control, which results in some shakiness. As a result, she cannot easily grasp and use cutting tools, so it is difficult for her to cut tape, in particular filament tape because it is resistant to cutting. It is also difficult for her to place the tape over the end of the plastic tubes due to her poor motor control. We developed a cutting device that makes it simpler to cut the tape and helps to create the cross pattern.

STATEMENT OF IMPACT

Before the completion of our devices, neither Todd nor Sarah could independently complete these tasks. With the Box-Folding Assistant and Turntable Cutting Device, they can complete their tasks and do so in a timely manner that will allow them to make



Fig.19.1.The Box Folding Assistant.

more money per hour. Barry Wilson, production manager of CWS, stated: "I think this will really help Sarah and Todd. They want to do anything they possibly can do; a lot of times they have to have an assistant person helping them out, telling them what to do. These devices are going to help them learn to do it by themselves, which give them more and more confidence." Todd exclaimed, "I like it, I'm the man!" after several successful rounds of folding boxes. With regards to the turntable cutter, Sarah explained "it is much easier than using scissors."

TECHNICAL DESCRIPTION

The box folding assistant consists of four connected pieces of 1.3" PVC piping that form a square inset. An unfolded box is placed above the inset, and the user then presses the center down through the PVC supports. The curvature of the PVC pipe assists increasing the box template as this motion is completed. Four shorter sections of pipe at the four corners of the device encourage the short side flaps to fold upward first, facilitating the rest of the box folding task. This forms the basic shape of the box, all in one step.

To help with the placement of the box template over the folding assistant, three acrylic pieces that mimic the shape of the box template are placed around the folding assistance component. This helps instruct the user where to place the box before beginning the folding process. The acrylic pieces stand at a height of two inches, offset from the side of the box folder by 1.5" inches on either lateral side. The shape and bright color of these pieces both draw the user's attention and allow the user to quickly recognize how to align the box during device use.

The final component aids the user to crease the unfolded template. A flat acrylic piece in the shape of a cross with a handle for easy use is provided, as seen in Figure 19.1. This component aids in creating the creases along several flaps. In particular, the 0.177" thickness of the acrylic corresponds to the width of the double-crease of the side flaps. This allows the user to fold the flap over the acrylic to easily form the double-crease, which had been the most difficult part of creasing the box for our clients.

The turntable cutting device consists of a turntable, a handle, and a shuttle with a rotary cutting blade. To operate this device, the user pulls one piece of tape across the Teflon pieces on the turntable, and then

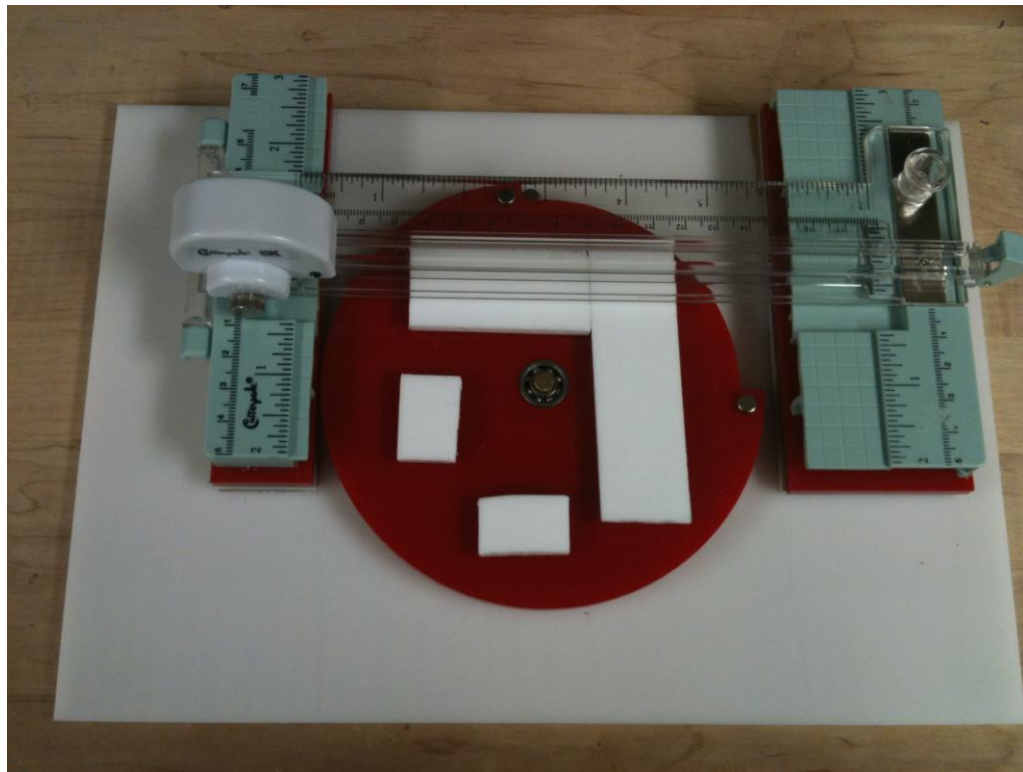


Fig. 19.2. Turntable Cutting Device.

runs the shuttle along the track across the tape, as with a paper cutter. The user then rotates the turntable 90° to repeat the process for a second piece of tape. The tape can then be removed from the turntable, already in the necessary cross pattern and ready to be placed on the end of the tube.

The handle of the device has been created from a commercially available paper trimmer (Cutterpede Mini Paper Trimmer). This paper trimmer uses a rotary blade attached to a rounded shuttle which runs along a track. The track runs the length of the handle (~8in), and the handle of the shuttle must be depressed in order for the blade to extend. This provides a safety guard for the essential blade of the device. We separated the base of this commercial product into three segments: two end pieces, which we kept in our design, and the middle, which we discarded. Both ends of the device were mounted on rectangular acrylic pieces to bring the handle to the level of the turntable face.

The spinning turntable for this device is created from three circular pieces: the base, a spacer, and the turntable face. The acrylic base provides a level area upon which all components of the device are

mounted. The uppermost acrylic piece has four Teflon pieces, attached 1" from the center. This forms two orthogonal sets of surfaces over which the tape is cut, allowing the tape to be pre-cut in the cross pattern necessary for this task. To enable rotation of the turntable, we placed a rod through the center of each of the circular components. One ball bearing is inserted into the center of the rotating face. In addition, a stopping mechanism limits the rotation of the turntable to 90 degrees, and magnets help to hold the turntable at the two endpoints of rotation.

By client request, a second face plate was created. At CWS, employees often share jobs, and in this case, one employee would cut the tape to be placed on the channel tube, while the second would place the tape. To accommodate this arrangement, the second face plate was designed to allow repetitive cutting of single 3" pieces of tape. Two parallel pieces of Teflon are attached to the face 3" apart, allowing the user to rapidly produce single pieces of tape. This plate replaces the rotating turntable face and is immobilized as it locks over the stopping mechanism.

The total cost of both devices was \$200.



Fig.19.3. Client using the Box Folding Assistant.



Fig. 19.4. Client using the Turntable Cutting Device.

THE PORT-O-YAK

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INTRODUCTION

Our client Emily (pseudonym) is an athlete with Myelomenigocele Spina bifida, which over the years has worn away the cartilage in her hips. She uses a manual wheelchair as her primary source of transportation, resulting in excellent upper body strength and range of motion. She can stand and walk, but she easily tires if she is standing for a minute or two. While standing, she is not able to pick up heavy objects.

Emily is an accomplished kayaker, having competed at the Paralympic level. She has a 17 foot, 32 pound, carbon fiber kayak and a practice location that requires her to drive with the kayak from her home to the launch spot. However, she is not able to transport the kayak on and off the roof rack of her van, and to and from the water. As a result, she needs assistance both at home and at the launch site when she wants to go kayaking. For this project, we have modified a commercial roof rack (Figure 19.5-Top) to enable Emily to load and unload the kayak from her van by herself. We have also designed a cart (Figure 19.5-Bottom) that helps her move the kayak between her van and the kayak's storage location at home, and to and from the water at the launch spot. Both the rack and the cart are safe and resistant to the harsh elements associated with kayaking including high humidity, moisture and sand.

STATEMENT OF IMPACT

As a competitive athlete, our client wants to be able to train without needing help from her friends and family. Our client's passion is to be active and independent. With the Port-O-Yak, our client is able to load her kayak on her van, take it to the launch location, unload the kayak, and go out on the water. After some time on the lake, she can reverse the process. When we asked her about the impact of this project, she replied, "This is simply going to be amazing".



Fig.19.5. Modified roof rack and custom cart.

TECHNICAL DESCRIPTION

Our design exists in two parts, a kayak rack and a cart. The rack is designed by modifying a Thule Hullavator rack. The cart is designed to transport the user and kayak to and from the water. She can propel the cart by sitting on the attached seat and pushing on the ground with her feet.

The purpose of the extending car rack is to lower the kayak from the roof of the van to a level where Emily can access it from her wheelchair. It was made by modifying a Thule 897XT Hullavator, which attaches to Thule basic square bars that fit onto the factory

tracks that came with our client's van. The Hullavator rack rotates the kayak down to the driver side of the car. In order to further lower the kayak, we constructed a custom sliding mechanism. The sliding piece is comprised of 1.5" H aluminum bar that was ground down to 0.85" on one side. The shorter side fits snugly in the track on the top of the Thule Hullavator. The H bar has a 0.5" bridge that provides the stiffness to allow the slider to hang below the commercial rack without it flexing or swinging. The H bar holds the rack cradle, pins and safety hardware. Spring loaded pins are attached on each aluminum H bar in order to allow for the sliding extender to stay locked in place until the user is ready to fully slide down the new extension. As an extra precaution against unexpected release during road travel, we added a universal 0.75" cotter pin that gets placed through the extender and the commercial rack to hold them in place. We attached rubber pads to the back of the Hullavator to protect the side of the van when the rack gets lowered to that position. After the full extension process and once the sliding H bars have been released and eased down, the kayak is then ready to be unstrapped and rolled onto the cart.

The cart is designed to support our client, the kayak and 50 lbs. of gear. The steering tiller and back chassis system is from a commercial garden pull cart. It has four 13" inflated rubber wheels, tested to 500 lbs., which allows the cart to firmly roll over the rough terrain. The back of the cart is fitted with a light plastic seat, a steering tiller, and a brake lever. The seat is situated to the right of the kayak and fully supports the user over the back wheels near the steering tiller. An aluminum brake lever with a rubber stopper pushes against the back right wheel for braking. On the left side of the cart, the kayak fits into a custom built cradle. The cradle is made from four 3' curved aluminum tubes. Each section is made from $\frac{3}{4}$ " aluminum tubing with a $\frac{1}{4}$ " side wall. They are all bent to fit the shape of the top and bottom of the kayak. This allows the kayak to sit on its side with the bottom facing away from the client. All aluminum tubing is coated in 1" rubber insulating tubing to protect the kayak from bruising on the metal.



Fig. 19.6. The starting position with kayak on top of the van.



Fig.19.7.The client moving lifting the kayak from the rack in its lowered position, and moving it to the cart for transporting it to the water.

The cart is built in two pieces for easier storage in the back of the van during transport. The rear chassis is a U shaped aluminum square bar of 1.5". To assemble the cart, the user slides the two prongs of this U directly over the 8" steel prongs that extend from the back of the front chassis. It is held together with 5" standard safety pins. The cart's total length is 3' and its total width is 16".

The total cost of the rack and cart was \$386. This includes the cost of a used Thule Hullavator rack for \$100, but the client purchased the Thule square bars separately.

TITLE: HORSEPLAY SIGNALING SYSTEM

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INTRODUCTION

The primary client for this project is Jim (pseudonym), a young adult who participates in horseback riding at the North Carolina Therapeutic Riding Center (NCTRC). Jim has been diagnosed with spastic quadriplegia, cortical field vision, and uses a wheelchair. Jim is able to independently maintain his balance on a horse but has visual impairments, characterized by poor forward vision and blindness at some angles.

When riding, he follows a course around an arena that is marked by weaving poles. Riders with visual impairments have difficulty knowing when they reach a pole, so volunteers tap the poles to indicate their position using sounds. This task occupies volunteers' time and prevents them from assisting other riders. I have developed a wireless navigation system (Figure 19.8) that automatically emits audible beeps when the rider approaches a pole. This will enable Jim and riders with visual impairments to navigate their horse independently with minimal input from volunteers.

SUMMARY OF IMPACT

A therapist who works with our client commented that: "The system's adjustability in terms of range, volume, and tone, as well as its portability, will enable it to be tailored to a wide variety of riders to suit individual needs. Because the device is triggered by the rider, it removes the instructor and volunteers from the loop and allows the rider more independence than would otherwise be possible." Our client indicated that he finds the system to be helpful in indicating the location of the weaving poles. When using the system, he was able to independently guide the horse along a course.

TECHNICAL DESCRIPTION

The system is comprised of two devices: a radio beacon worn by the rider and a set of 5 radio detectors, each mounted to a weaving pole. As the



Fig. 19.8. The five radio beacons, with speakers mounted inside, that get mounted on weaving poles, and one radio detector that is worn by the user on a hip belt.



Fig. 19.9. The client wearing the hip belt and preparing to ride in the outdoor arena.

rider approaches a pole, the detector will begin producing a tone so that the rider knows the relative location of the pole. When the rider passes the pole, the detector will silence as it loses radio contact with the beacon. This process repeats as the rider moves around the course.

Every beacon and detector contains a radio transceiver (nRF24L01, Nordic Semiconductor) that operates in the 2.4 GHz range. The beacon transmits a signal five times/second, while the detector's transceiver constantly listens for the beacon's signal. The system relies on microcontrollers (PIC 18F2420, Microchip, Inc.) to setup the communication protocol to process the data exchanged between the radio transceivers. Communication between the transceivers and microcontrollers uses SPI, a serial protocol for exchanging data. A computer program was written in the C programming language to implement the SPI protocol on the microcontroller and perform the signal strength measurements. A custom circuit board was designed and fabricated for both the beacon and detector.

The beacon is worn around rider's torso and its electronics are contained inside an "amphipod belt". The beacon's circuitry is encased in an acrylic housing and is principally comprised of the radio transmitter, antenna, and the microcontroller. Other circuitry includes a voltage regulator to protect the circuit and LEDs to indicate the beacon's transmission power level.

The beacon's microcontroller configures the radio transceiver to act as a transmitter. The

microcontroller controls all aspects of the transmission, including the transmitter's power level, the data sequence to transmit, and the number of transmissions per second. The transmitter's signal strength can also be adjusted by the user; this feature allows the range of the system to be optimized for a particular activity.

The detector includes the same electronic components as the beacon, but the microcontroller is running a different program and the circuitry also includes a speaker to generate audible tones. The detector's components are mounted inside a marine grade 4x4x4" plastic electrical box which is attached to a weaving pole using bungee cords.

The detector's microcontroller is programmed to continuously search the airwaves for the signal transmitted by the beacon. When the detector finds that the received signal has reached a minimum power level, it will begin counting the number of successful data receptions within a given period of time. This measurement is used to determine the signal's strength. When the signal strength reaches a critical level, the detector will begin sounding; guiding the rider towards the pole. Each detector generates a different sound to make the system less confusing to the rider. The distance at which the sounding begins is proportional to the beacon's transmission power and can be set for distances between 5' and 25'.

The total cost of this project is \$421 for 1 detector and 5 beacons.

VIEW IT

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INTRODUCTION

Our client, Bob (pseudonym), is a young boy with septo-optic dysplasia, which is a visual impairment, and autism. He has decreased vision in both eyes and can only see in certain spots of his visual field. He therefore must move his head until the object of interest appears in one of those spots. His visual impairments most greatly affect his reading and writing; Bob is only able to read and write when his eyes are a few inches from the page. For example, to read a 26-point font, he needs to have his eyes only 2-3 inches from the page, and to read a smaller font, he must be at an eye-lash distance.

As a result, Bob must bend over his classroom desk to do all of his reading and writing activities. His teacher and occupational therapist were concerned that this would cause long term damage to his spine. Commercial devices, such as a slant board, are helpful but still do not position the materials at an appropriate location. We have developed a device that allows him to maintain an upright position at his desk while performing his classroom assignments. To accomplish this task, we have customized a portable Versa Table to fit his needs (Figure 19.10).

STATEMENT OF IMPACT

The View It Display Stand allows Bob to sit vertically while reading and writing. The device therefore prevents damage that would be caused to the client's spine if he were to continue bending over his desk to perform his classroom activities. Also, according to the client's teacher, this device helps Bob to stay focused in the classroom: "during your weekly visits, you are able to get him to do more work with your device than I get him to do in the entire rest of the day".

TECHNICAL DESCRIPTION

The device is a work surface mounted to a supporting arm with adjustable positioning. The work surface is capable of holding books and papers while reading



Fig. 19.10. The View It stand.



Fig.19.10. The client using the View It stand to draw.

or writing. After being attached to a desk in front of the client, the work surface is positioned vertically at the appropriate distance. The distance is adjustable to allow Bob to see different font sizes or give him

room to write. With this device, Bob is able to remain seated completely upright while accomplishing his classroom activities.

The base of the device is a 12" by 12" piece of oak which is coated in a polyurethane finish and the commercial Versa Table is permanently attached to this base using construction glue. A clamp, which tightens by turning a star knob, secures the device to the client's desk using a bolt with a rubber stopper. When the star knob is turned, the rubber stopper tightens against the underside of the desk and prevents the device from sliding. The clamp, which holds the bolt in place, is screwed into the bottom of the base. To make the device sit flat, the clamp was set into the wood by milling out a section of the oak. This ensured that the bottom of the clamp would be flush with the bottom of the oak base.

The position of the device is controlled by the tension of four bolts attached to separate plastic knobs. The bottom knobs control the height and front to back motion of the work surface, while the top knobs adjust its tilt. To position, just loosen the appropriate knob(s), adjust to the desired location, and re-tighten the knob(s). The angle of the work surface has a 90 degree range from completely vertical to completely horizontal. The horizontal position is useful for

storage because the device is in its most compact state.

The work surface is a 12" x 16" piece of white birch veneer with a lacquer finish. Fastened to the surface's front is a 12" x 16" magnetic dry erase board. The dry erase board is black to create a strong contrast between the background and Bob's reading or writing materials. Since the white pages stand out against the black of the dry erase board, this helps Bob to focus on his assignments and makes it easier for him to see. The dry erase board can also be used as its own writing surface and is easy to clean, which is important because it will constantly be in contact with the client's hands and face.

There are three methods of holding books or papers on the device. The first is by using magnets to hold papers to the magnetic dry erase board. The second is a clip board which is screwed into the top of the work surface and can be used for both books and papers. The third is a book holder which uses two vertical projections to keep books open and secure. The book holder is detachable so it can be out of the way while not in use. It slides on and off the work surface's bottom ledge and the books are placed on the board behind the projections of the holder.

The total cost of this device is \$255.

