CHAPTER 8
MICHIGAN TECHNOLOGICAL UNIVERSITY

College of Engineering
Department of Biomedical Engineering
312 Chemical Sciences & Engineering
1400 Townsend Drive
Houghton, Michigan 49931-1295

Principal Investigator:

Debra D. Wright (906) 487-1989

wright@mtu.edu

INTERACTIVE AQUARIUM

Designers: Tonya Brabec, Geoffrey Cutsy, Julie Jefferson, Jamie Lehto, Michael Yandl
Client Coordinator: Diane Selinger, Copper Country Intermediate School District, Hancock MI
Supervising Professor: Dr. Debra Wright
Michigan Technological University
Department of Biomedical Engineering
1400 Townsend Drive
Houghton, MI 49931

INTRODUCTION

Children with disabilities typically have short attention spans, so teaching methods for them must be dynamic to stimulate the students' visual, tactile and auditory senses. Computer games, bubble columns, stereos and water toys are some examples of devices that assist in teaching students with disabilities (Tidmarsh, 2001). An interactive way to teach students cause-and-effect relationships is by the use of play tools that demonstrate these relationships. A client requested a device that would teach cause-and-effect relationships and social skills with switches in an aquatic environment. Students with multiple physical and cognitive disabilities intend to use the device. To meet these objectives, the Interactive Aquarium (IA) was developed.

SUMMARY OF IMPACT

The client has reacted positively to the addition of the IA to her classroom. It is an effective tool for teaching cause-and-effect relationships and provides an additional tool to develop these relationships in an entertaining manner. The IA is mounted on casters, which makes it easy to move to new locations, and is small enough to be used throughout the classroom. Virtually every student in the classroom will benefit from the use of this new device.

TECHNICAL DESCRIPTION

The IA is brightly colored and has four effects to get and keep the students' attention. The effects utilize visual and auditory stimuli: 1) a mobile of sea creatures, 2) an array of bubbles, 3) multicolored light shining into the water and 4) sound via a cassette player. The students activate the effects by switches mounted on the IA and can then learn the effects caused by their actions.

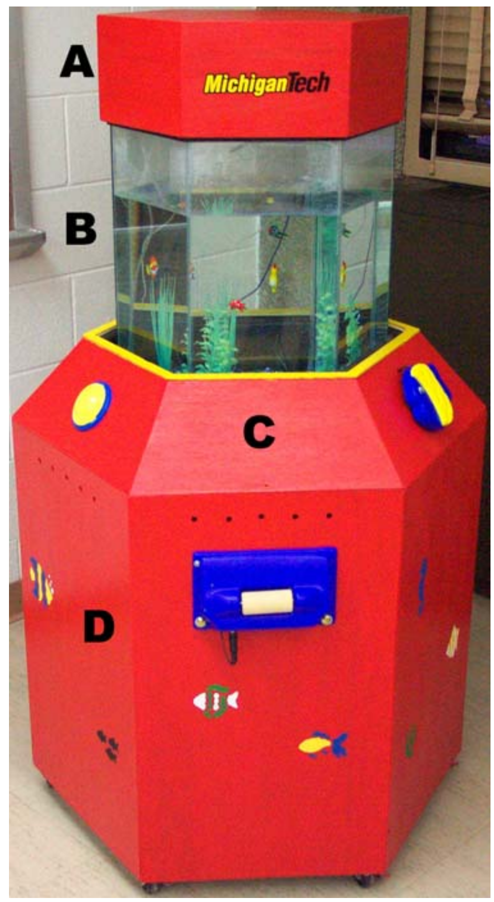

Figure 8.1. Interactive Aquarium.: (A) Lid Housing Motor and Bubbler; (B) Tank Containing Seaweed and Glass Fish Hanging in Water; (C) Two Switches Mounted on Crown of Stand; (D) Third Switch Mounted on Base of Stand.

The central attraction of the IA is a hexagonal 20-gallon aquarium. The aquarium sits concentrically on a frame built from steel tubing. The shortest measure across the cross-section of the stand is 26 inches and its height is 31 inches. Each corner of the hexagonal frame has two vertical members. Two steel tubes run across both the top and the bottom of the frame for shelf support. A four-inch crown surrounds the base of the tank, provides an aesthetically pleasing transition from the wider base to the narrower tank, and provides a sloped surface to attach switches. The steel frame of the stand and crown is encased by ¼" inch thick Luann panels. Built into the "back" side of the stand is a door with child safety lock for access to the interior of the frame. The controls and effects are held within the frame. The base of the frame sits upon six swiveling, locking caster wheels placed at each corner. Except for a single power cord extending through a 1 ½ inch hole cut into the base, the IA is entirely self-contained within the frame, tank and custom made wooden lid.

Three switches operate the four effects. The first switch operates a mobile of sea creatures. A small A/C motor and bubbler sit on Plexiglas on top of the tank. A custom made wooden lid encases the Plexiglas top, motor and bubbler. The mobile of sea creatures is attached to the motor and suspended in the water. A switch that is hard wired to the motor activates the mobile.

A second switch operates the bubbler and lights. The bubbler on top of the tank has two ¼ inch diameter plastic tubes that leave the bubbler, pass through holes in the Plexiglas and connect at the bottom of the aquarium to two bubble diffusers. The light fixture is mounted under the tank and shines light up into the tank. The light fixture has a 10W halogen lamp with a semitransparent color wheel rotating above it to change the color of the light illuminating the water. The bubbler and lights are powered by the PowerLink 3® (AbleNet, Inc.), and the switch is inserted into the PowerLink 3®. The PowerLink 3® has two inputs for switches, and each switch operates two electrical outlets. A third switch is connected through the PowerLink 3® to operate the final effect, a tape player hidden in the base.

The cost of is about $650 for materials.

REFERENCES

Tidmarsh, B. TFH 2001 Professional Catalog, (2001), pp. A4-A5, B60.

Tipton, Debbie. "Teaching Children with Disabilities,"Internet: kyky.essortment.com/teachingchildre_rdba.htm, November 26, 2001.

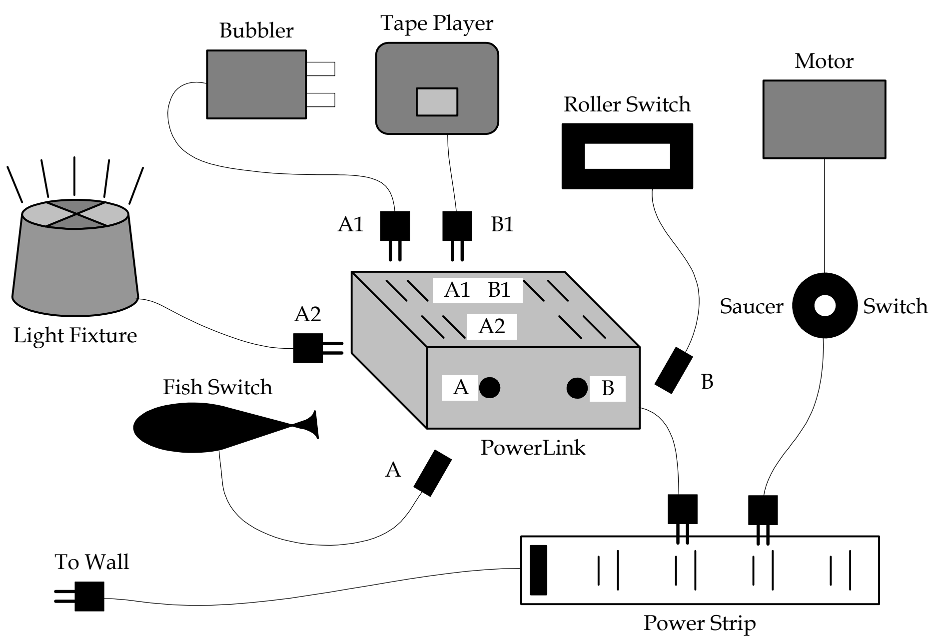

Figure 8.2. Schematic of Wiring Links between Causes (Switches) and Effects.

MULTI-SENSORY ENVIRONMENT

Designers: Mellisa Atkinson, Melanie Giasson, Margot Hutchins, Jessica Miller, and Laura Shoop
Client Coordinator: Diane Selinger, Copper Country Intermediate School District
Supervising Professor: Dr. Edward Lumsdaine
Michigan Technological University
Mechanical Engineering Department
1400 Townsend Drive
Houghton, MI 49931

INTRODUCTION

The multi-sensory environment was designed to provide stimulation to children who are severely multiply impaired (SMI). These students have both cognitive and physical disabilities. The structure will do this by providing the children with a dark and quiet environment to use their sensory devices. The environment incorporates visual, auditory, and tactile stimuli. These stimuli will help the children by engaging them in physical activities and help them to develop an understanding of cause and effect relationships. The environment will be used in a school.

SUMMARY OF IMPACT

The teacher who is primarily overseeing use of the device has expressed enthusiasm and delight at the addition of the Multi-Sensory Environment to her classroom. The students have all had an opportunity to experience the sensory room in "stimulation" mode, where numerous lights, sounds and aromas fill the room. All eight students demonstrated an awareness of the new and improved environment. Teachers have observed differences in facial expression, body movements, and behavior. Aside from being "aware", students who generally hang their heads while in their wheelchairs held their heads in a neutral position and looked around the room for up to seven minutes.

An experience with one specific student who has very little motor control due to severe spastic cerebral palsy was especially dramatic. In "stimulation" mode, the student was noticeably less spastic, and worked to maintain proper head position when he was in the environment. He also used the room in the "relaxation" mode with quiet music playing on the radio during his range of motion exercises. When finished, he stayed in the room for another 20 minutes and nearly fell asleep – a rare and significant occurrence for this particular student.

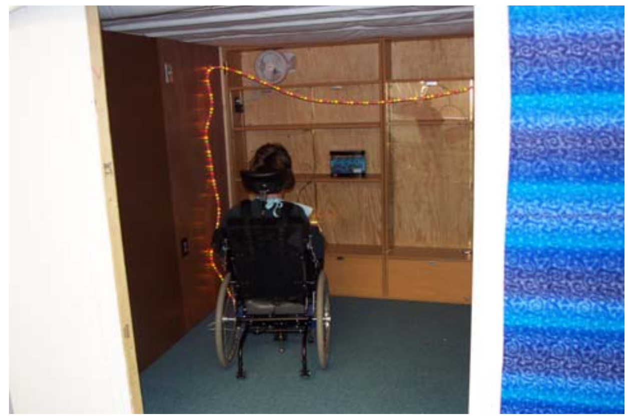

Figure 8.3: Student Inside Muliti-Sensory Structure at CCISD.

Future uses of the Multi-Sensory Environment will involve: 1) making more switches accessible to more students, 2) utilizing the room for small group activities, and 3) decorating the room for seasonal activities.

TECHNICAL DESCRIPTION

The structure is designed to create a quiet and dark environment that is temporary, so material selection is important.

The structure is made primarily of pine studs and Luan plywood. The frame is designed so that it will be portable and easy to assemble by separating into smaller sections when the pins in the hinges are removed. These smaller sections are two bookshelves, two sidewalls, two front walls, and the roof/door assembly. The bookshelves are adjustable to accommodate a variety of sensory devices. Acoustic foam is installed between the sheets of Luan and pegboard to absorb sound. The smooth plywood exterior acts as a barrier to reflect the sound waves on the exterior. Pegboard is used on the front panel of each sidewall to provide an easy way to attach tactile devices and switches.

The roof is made of fabric typically used as drapery lining to block out all light. The door is made of vinyl so it would be easy to clean. The roof is supported by electrical conduit to provide rigidity and is lined with foam to absorb sound. The door is also lined with foam. The roof and door are attached to the structure by fitting the holes in the conduit over wooden pegs and attaching the Velcro along each overhanging flap to ensure that there are no large gaps for sound or light to pass through un-damped.

The structure has six power outlets used to power the sensory devices. The outlets are wired through a timer switch, which will shut off the power to the structure and turn on a safety light if the child is left unattended for more than 15 minutes.

Light levels are reduced by 93.7% with the door open and 99.2% when the door is sealed using the Velcro. The sound levels are reduced from 76.3 to 59.8 dBA in the reverberation chamber using a white noise generator. A sound test was also performed in the classroom in the afternoon, when noise levels are typically higher. In the test, there was an improvement of 12 dBA from the outside of the structure, measured at 59.5 dBA, to the inside of the structure, measured at 47.5 dBA. This drop corresponds to a subjective sound level change from a restaurant or department store, to the noise level of an average conversation (Lord et al, 1987).

Safety is an especially important issue with this project, because the structure is intended for students with multiple disabilities. Plexiglas sheets

Figure 8.4: Outside of Multi-Sensory Structure with Door Closed.

with latches cover each bookshelf so the devices on the bookshelf are not accessible to the students. All outlets are covered with safety plugs. The oxygen and temperature levels are also monitored with two adults in the room for one hour to ensure that ventilation is adequate. Redundant hinges are used to lock the panels in place for stability of the structure.

The total cost for the structure was approximately $1200.

REFERENCES

Lord, Gatley, and Evensen. Noise Control for Engineers. Florida: Krieger Publishing Company, 1987.

ONE-ARM DRIVE SYSTEM FOR A WHEELED STANDER

Designers: Lauren Bullard, Peter Didyk, Erica Peters, Sarah Rupiper, Jayme Rusk, Danielle Unger
Client Coordinator: Kathy Penegor PT, Copper Country Intermediate School District, Hancock MI
Supervising Professor: Dr. David Nelson
Michigan Technological University
Department Of Biomedical Engineering
1400 Townsend Drive
Houghton, MI 49931

INTRODUCTION

A wheeled stander, which operates much like a standard wheelchair, is a device that allows individuals with little or no lower extremity control to be in an upright position. Wheeled standers can be physiologically and psychologically beneficial for individuals with cerebral palsy. However, many persons with cerebral palsy lack bilateral control of their upper extremities. A user cannot propel and control a wheeled stander without using both arms. The task presented was to design a one-arm drive system for a wheeled stander, to be used by a child.

The one-arm drive systems used on wheelchairs are not feasible for use on a wheeled stander because the axle would interfere with the user's body placement. A new design was required to preserve the full functionality of the wheeled stander. The design solution must allow the user to steer and propel the stander efficiently. It is to be a simple retrofit to existing standing walkers, requiring little or no modification of current devices. It should readily adapt for either left-hand or right-hand propulsion. The design will broaden the market for wheeled standers and enable a greater number of people to benefit from the advantages of a stander.

SUMMARY OF IMPACT

Many children with cerebral palsy experience life looking up from a wheelchair. Wheeled standers open their worlds to experiences and perspectives others take for granted. Past clients have stated that something as simple as seeing what is up on their kitchen countertops, being able to wash dishes at the sink, or seeing how "tall" they are compared to their peers can be very significant. Until now, the design of the wheeled standers did not accommodate the needs of many children who have asymmetrical upper extremity involvement. With this design modification, independent mobility in a standing position can be a reality. For people who spend much of their time in a wheelchair, the physiological and psychological benefits of using a wheeled stander are important. This device could enable a larger number of people to experience the benefits of a stander, due to this one-armed drive design modification.

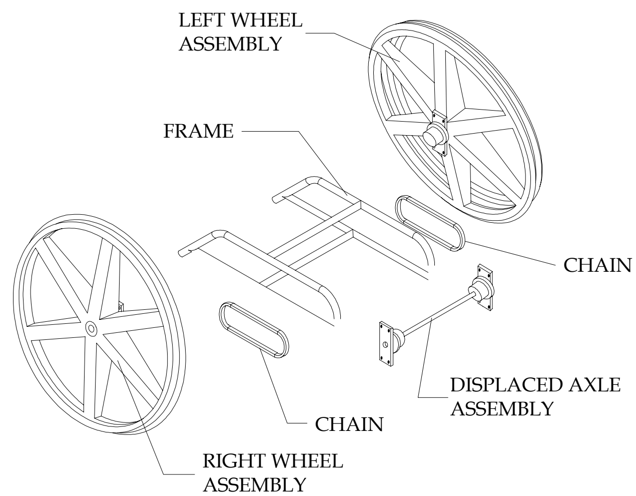

Figure 8.5. Exploded Drawing of Drive System.

The prototype was tested in the school where it will primarily be used. The testing revealed that the main design objectives have been met. The user is able to easily maneuver the stander on indoor flooring surfaces, which include carpet, tile, and hardwood flooring. The efficiency of the stander was confirmed by the user's ability to travel without fatigue and ascend an OSHA regulated incline (slope of 1:12 or less), both of which he is unable to do in his seated wheelchair.

Future improvements that may be incorporated in the prototype system include a cover for the drive chains and weight reduction.

TECHNICAL DESCRIPTION

The design solution was created through research of currently available one-arm drive wheelchair systems and basic mechanical engineering concepts. The main design requirements were determined through interviews with a physical therapist and the maker of the stander to be modified. These requirements include that the system be: 1) efficient in allowing the user to steer and propel the stander with one arm, 2) adaptable for either left or right arm use, 3) lightweight, 4) safe, and 5) easily maintained.

The final design concept is a displaced axle system with a dual push-rim on the driving wheel, illustrated in Fig. 8.5. The user controls the movement of the wheeled stander by grasping and rotating the rims. Turning only one rim will result in the stander turning in one direction, but will not propel the stander forward. The direction of turn is determined by which rim is rotated. The outer rim will cause the stander to turn in an inward direction of the rims. Turning the inner rim will turn it in the opposite direction. When they are turned together, the stander will travel along a straight path.

The inner rim is connected directly to the driving wheel like a normal wheelchair wheel. The outer rim has a hub at its center that is connected to an axle. This connection is secured by a keyway at both ends. The axle passes through the hub of the driving wheel and axle plate. Bearings inside the hub and axle plate allow the axle to rotate independently of the driving wheel. This first part of the system transmits the work provided by the user from the second push rim to the first sprocket. The rotation of the first sprocket drives an ANSI size 35 single strand roller chain along the side of the stander. The second sprocket is locked onto a ½ inch diameter solid 6061-T6 aluminum rod, the main displaced axle, by way of another sprocket key feature. This displaced axle is attached to both sides of the frame of the wheeled stander by a set of aluminum axle plates. Bearings at both ends allow free rotation of the axle. A second chain and sprocket system transmits the rotation back to the axle of the driven wheel. This wheel axle passes through the axle plate and is affixed to an aluminum spacer that is press fit into the hub of the driven wheel. This serves to transmit the rotary motion of the axle to the driven wheel, thus rotating the wheel. It is over this path, from the second push rim on dual-rim side of the stander to the hub of the opposite wheel, that the user's input is transmitted to control the direction of movement with only one arm.

The total cost for the materials is $275.21.

WHEELCHAIR LOADING AND SECURING MECHANISM FOR MINIVAN

Designers: Michael Chipman, Paul Piechowski, Benjamin Pinchback, Ryan Quinlan, Isaac Trowbridge, Scott Wallington
Client Coordinator: Jodi Tervo, Copper Country Intermediate School District, Hancock, MI
Advising Professor: Dr. John E. Beard
Michigan Technological University
Department of Mechanical Engineering
1400 Townsend Drive
Houghton, MI 49931

INTRODUCTION

A family requested a device that would ease loading and safely secure a wheelchair in a minivan. The objectives were: 1) no altering of seating or storage capabilities of the minivan, 2) use of a mechanical system, and 3) easy, safe and reliable use. The final device consists of two foldable ramps, mounted on roller carriages that extract from the driver-side sliding door of the minivan. The low incline grade of the ramps allows for easy loading of the chair into the minivan. When not in use, the ramps fold up and slide on a track into a storage position. While in storage, the device rests in a 0.3 square foot area next to the wheel well and does not obstruct the opening. A safety catch was also developed to prevent the wheelchair from slipping if the individual pushing the wheelchair slips or falls. This is particularly important in the winter. A crash-tested EZ-Lock system is installed on the floor of the van to secure the wheelchair to the minivan, and the occupant of the wheelchair is secured with a shoulder harness. Overall, the new system saves the family time and effort while providing them with a safe and easy system to load and secure their child in the minivan.

SUMMARY OF IMPACT

Prior to having this device, the family manually put the wheelchair in the van by tilting it back and lifting the front and then the rear wheels into the minivan. This method is strenuous, jostles the child, and causes damage to the wheelchair. Only one family member had enough strength to lift the child into the van. Once inside the van, four straps and a shoulder harness were used to secure the wheelchair to the van floor. This painstaking process took a significant amount of time and effort to complete. With the new loading and securing mechanism, every family member is able to load the wheelchair into the minivan, the ramps can be quickly unfolded or stored, and the EZ-Lock bracket provides safe and fast securing for the wheelchair. The family also maintains full storage and seating use of the van.

Figure 8.6. Fully Extended Wheelchair Ramp.

TECHNICAL DESCRIPTION

The ramps are fabricated from five-inch wide 6061 T6 Aluminum C-channel and are five feet long when extended. Fig. 8.6 shows the ramp fully extended out of the minivan. The channel is milled to a thickness of 0.19 inch, and the edges are 1.5 inches thick. Each ramp consists of two 30-inch long segments that are connected with a standard 4.5 inch door hinge. The hinges are fastened to the ramps with bolts through tapped holes. Pinch-guards are located at the hinges to reduce the likelihood of injury when extending the ramps from the van. The rings of the hinges were welded to increase their strength. Testing showed that each ramp by itself could support the weight of the child, wheelchair and parent with a safety factor of two. Grip tape covers the surface of the ramps to reduce slippage between the wheels and ramp.

Spring hinges connect the ramps to the track carriage. The torque on the hinges is adjustable and can hold the ramp upright when resting in the minivan. The spring hinges also reduce the force needed to lift the ramps from the ground into the minivan. To allow the chair to travel freely over the two tracks mounted inside the van, eight inch mini-ramps are hinged to the base of the main ramps. These mini ramps fold out to cover the tracks and stay in place when not in use by magnetic attachment.

The ramps slide on a track and carriage system consisting of stainless steel, aluminum, nylon, and steel bolts. The hinge at the base of each ramp connects to the carriage through a two-inch x five-inch stainless steel plate. Attached to this plate are two 1.12 inch x three inch cross members. Four machined nylon rollers attach by bolts to the cross members. Each roller contains two roller-blade bearings press fitted into the center of the roller, one on each end. One of the two carriages has pivots where the cross members bolt to the two inch x five inch plates. This allows the carriage to travel on the curved track. The two tracks that the carriages ride on have an octagonal cross-section. They are 1.5 inches wide and 3/8 inch high. One track has an s-shaped curve that is three feet long. This enables the ramp on the curved track to line-up behind the ramp on the straight track when the ramps are stored in the van. Fig. 8.7 shows the inside of the van when the ramps are stored. The curved track is milled using a CNC code to ensure precision and accuracy of a uniform cross-section. Each track is bolted to a 9.5 inch x 3 foot x 3/16 inch plate of aluminum with the bolts existing six inches apart from each other. The plate is then bolted to the floor of the minivan. This allows easy installation and removal of the mechanism.

The anti-rollback system mounts to the bottom of the wheelchair and consists of a safety cable with a clip. The safety cable is rolled onto a self-winding spool that is mounted on the bottom of the

Figure 8.7. Wheelchair Ramp in Storage Position.

wheelchair. To use the system, the operator attaches the clip to a hook inside of the van. The operator must hold the brake handle, which is mounted to the chair, in order to roll the chair up or down the ramp. When the handle is released, as in a slip or fall, the loss of tension on the connected brake cable causes a spring-loaded lever to engage a gear on the cable spool and stops the spool rotation. This prevents the safety cable from unwinding and locks the chair in its position until the brake handle is held again. After use, the safety cable winds onto the spool underneath the wheelchair.

The total cost of parts and materials is $1450.

ACKNOWLEDGEMENTS

The EZ-Lock Corporation donated a wheelchair lock worth $700 for the device.