CHAPTER 14
UNIVERSITY OF TENNESSEE AT CHATTANOOGA

College of Engineering and Computer Science
Chattanooga, Tennessee 37403

Principal Investigator:
Edward H. McMahon (615) 755-4771
INTRODUCTION
The following introduces a multi-project playground built by the Senior Design Class at a local elementary school. The class was approached by a representative of the school that has a large population of disabled children. The class selected individual children in the class on which to base the designs.

Overall the playground is comprised of a path for wheelchair bound students and two other devices, a large kaleidoscope and a "water-house" for children with impaired vision. The path, overall layout, and associated features described here. The Kaleidoscope and "Waterhouse are described in separate reports.

The path for wheelchairs is made of concrete. In two places, small ripples are placed in the path for a vibration effect. Along the path, various entertainment devices are placed, including fun house of mirrors, multi-image mirrors and a caricature board with face holes accessible to wheelchair bound students.

SUMMARY OF IMPACT
The pathway is the result of various conceptual designs for a nine-year-old student. She suffers from cerebral palsy and spina bifida. She is confined to a wheelchair and has limited use of her hands and arms. The objective is to design a play activity that accommodates her wheelchair and provides for socialization with multi-sensory stimulation.

The resulting path and associated devices make it possible for this child and all other children in the school with very limited mobility to enjoy their play experience. No such experience was previously available.

Figure 14.1. Playground — Path.
**TECHNICAL DESCRIPTION**

**Path** - The perimeter of the path was 240 feet and used eight yards of concrete. The site was surveyed and stakes were placed to define the corner points of the sidewalk and then marked with paint. The sidewalk was excavated to a depth of 6 inches and forms were installed. Two inches of gravel were placed in the form. The holes were dug for the posts for the mirrors and caricatures and concreted in place. With the help of two professional finishers the concrete was poured and finished. When the concrete was cured the forms were removed and the path was backfilled with dirt.

**Fun House Mirrors** - When the sidewalk was finished two fun house type mirrors were designed and constructed. One mirror produced a tall thin image and the other a short and fat image. The frames are made out of pressure treated 2” x 12” pressure treated lumber. Mirrored Plexiglas is selected for the mirrors. The mirrors are located on 6” x 6” poles. To determine the proper height of the focal point of the mirrors, the eye level of a child in a wheelchair was measured and found to be approximately three and one half feet.

The detailed dimensions of the mirror were calculated and channels were cut into the 2” x 12” frames with a router to define the curvature. Three sides of the frame were joined and the mirrored Plexiglas slid into the channels. The fourth side was attached and the 2” x 12” frames were attached to the posts with lag bolts.

**Multi-image Mirror** - The multi-image mirror is a square, five-by-five matrix of six-inch facets. The center points of all the facets lie in a common plane that is three inches above the backing. Each facet has is pivoted on its center point such that a line from the center normal to the plane of the facet intersects with all other such lines at a point thirty-six inches from the most central facet. This geometry produced an interesting optical effect. When an image is near the compound focal point, it is visible on all facets simultaneously and movement produces multiple images similar to a wall of televisions tuned to the same channel.

The facets were constructed by making 6” x 6” square tubes 5 feet long. The desired angles were calculated and drawn on the tubes and cut on a band saw. The facets were carefully sanded and mirrored Plexiglas was cut and glued to each box. The boxes were caulked, primed and painted before being attached to the backing board. The whole device was then caulked and painted before attaching to the posts at the site.

**Caricature Boards** - The boards are made of thin sheeting with painted images. Holes are in the sheeting material to allow the user to stick his/her face through the hole to take on the look of the image presented on the board. A contest was held at the school and the children were given the opportunity to draw their own images. The most popular ones were selected to appear on the boards. PVC board was used to construct the images. An art student contracted to paint the images on the boards. The location of the face holes was cut to accommodate both wheelchair and non-wheelchair bound children. The boards were painted and framed. The framed boards were then attached to the 6” x 6” posts. Spending for the path and associated activities totaled $750.

Figure 14.2. Diagram of Playground-Path.
Playground - Kaleidoscope

Designers: D. Bradley, J. George, T. Slatton, T. Moore
Client Coordinator: T. Travers, McConnell Elementary School
Supervising Professor: Dr. Edward H. McMahon
College of Engineering and Computer Science
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION
Part of the playground experience was a large kaleidoscope. The kaleidoscope is a large reproduction of the smaller devices available in toy stores. The kaleidoscope provides sensory stimulation with refracted sunlight, mirrored surfaces and various color schemes. The child using the device can turn a handle to change the color pattern while they look through the eyepiece. The kaleidoscope is approximately 12 feet tall.

SUMMARY OF IMPACT
The device was designed for a four-year-old Ataxic cerebral palsy client. She has limited movement, balance, and coordination. The equipment is designed within the limits of her disabilities and to provide independence, and at the same time the ability to interact with other non-disabled children.

The device described above met these criteria by providing a device that she could operate and is attractive to both children with disabilities and non-disabled children.

TECHNICAL DESCRIPTION
There are three main components of the kaleidoscope; the main body, the drive system, and the finishing/weatherproofing.

The main body of the kaleidoscope is made of a triangular plywood tube with Plexiglas mirrors on the inner surface. The three legs are made of 2" x 6" x 16' treated lumber. The three sides of the mirrored tube are made by gluing 4' x 8' pieces of mirrored Plexiglas to sheets of birch plywood with liquid nails. The long sides of these pieces were then cut at a 30-degree angle on a table saw. The triangular tube was formed and the joints secured using subfloor adhesive and wood screws.

Figure 14.3. Playground — Kaleidoscope.
The legs were cut with a 30” angle and meshed with the triangle and secured using screws and subfloor adhesive. The hexagonal cover of the kaleidoscope was made of exterior grade plywood. It is constructed using methods similar to those described for the main body.

The color wheel and drive system were constructed in the shop. A hand crank at the bottom of the kaleidoscope is used to turn the color wheel at the top of the kaleidoscope. The color wheel is constructed of plywood and Plexiglas. A groove was cut in the color wheel and a V-belt was used to turn the wheel. The color wheel rotates on roller casters. The shaft and pulley are supported by bearings. A flexible shaft is used at the bottom and a wheel was attached to the shaft for the children to use to rotate the color wheel.

Finally, a hole was cut in one side of the mirrored tube and a piece of tubing with a Plexiglas end was attached to provide for viewing the kaleidoscope. The whole unit was caulked and a weatherproof coating was applied.

Spending for the kaleidoscope totaled $450.

Figure 14.4 Diagram of Playground – Kaleidoscope
INTRODUCTION
The problem statement for the Waterhouse group was to design a piece of playground equipment to stimulate interest, promote exercise, and provide social interaction for visually-impaired children. The concept is to provide stimulation to both auditory and tactile senses of visually impaired children. A pulsating "rainfall" is intended to provide this stimulation and allow the children to interact with the water in a safe manner.

The water is pulsed on a “tin” roof and gutters collect the water. These gutters and three down spouts funnel the water down the cascades into the water trough where children can play safely.

SUMMARY OF IMPACT
The device was designed for a visually impaired boy in order to provide stimulation as well as improve his muscle tone and coordination. The device is to be accessible, usable by all children, and interesting. Of the several concepts that are generated, the waterhouse is most effective in providing auditory stimulation and tactile stimulation by allowing the child to play with water, by himself and with others, in a safe manner. This activity promotes social interaction between all children.

TECHNICAL DESCRIPTION
The overall size of the Waterhouse is six feet along the path and ten feet wide. The support posts are 6” x 6” treated wood. The water is supplied from the outside water faucet. A pulsating shower nozzle is used to provide the auditory stimulus. Gutters are installed to collect the water from the metal roof. The water cascaded down the three downspouts to the water trough. The water drains from the trough through a 4-inch dram into a corrugated pipe leading to the drainage area. The water drainage consists of slotted corrugated pipe spiraled in a 7 foot by 7 foot by 2 foot area layered with gravel.
To construct the device, a water supply trench was dug from the faucet to the Waterhouse. The trench was layered with gravel and 1/2" PVC pipe was used for the supply. The 7-foot square by 2-foot deep drainage area was filled with 8 inches of gravel. On top of the gravel, the slotted corrugated pipe was placed in a spiral fashion and covered with gravel. Mesh cloth was placed on the gravel and filled with dirt.

The 6”x6” posters were placed and cemented in place. The roofing system consists of the rafters and metal roofing material. The water trough was prefabricated and installed on the site. The water was connected to the pipe, including a spring-loaded valve, a ball valve and a pulsating water head. The children operate the spring-loaded valve with a pull cord to supply water to the system. The ball valve controls the supply to the system and the pulsating head provides the sound on the metal roof as discussed previously.

Spending for the Waterhouse totaled $400.
INTRODUCTION
The problem as identified by the design team was, “Design a water-containing device which will visually and tactically stimulate an autistic boy of the mental age of two. This device is made with extensive safety precautions. Specifically, the shape of the device and the materials are child-safe. The device should be portable and easy to clean. The client is able to place his hands inside the device and have complete mobility of them. The device is of feasible dimensions, in keeping with the dimensions of the classroom and the size of the client.”

The design consists of a clear plastic box that is partially filled with water. Two rubber gloves are extended into the interior of the box to allow the child to play with the water. The device is made of 1/4-inch thick Plexiglas. Gloves are sealed to the Plexiglas. Its overall dimensions are 18 inches long and 12 inches wide, with a sloping top. A drainage valve is also included to allow the tank to be easily drained for transport.

SUMMARY OF IMPACT
The primary stimulation for the client involving water is visual. Although he enjoys playing with water, he also sits or stands for long periods watching bubbles or water flow from a faucet. He is aware of cause and effect and can operate simple buttons or devices if it would result in a reaction within the system of water. The client functions on a high level for an autistic child and is very patient and non-violent.

One of the considerations is a safety concern pertaining to the sharp edges associated with a square tank. A second consideration is the durability of the device. Other concerns included the weight and size of the device, the changeability of the stimuli within the tank, as well as the ease of cleaning of the device. The mobility of the client’s hands while in the device is also an issue requiring addressing.

To ensure compatibility with the client, a full-scale model was constructed of cardboard, and gloves sized to fit the client were purchased. The team then met with the client to evaluate the child’s interaction with the device. Based on this meeting, a determination was made to purchase slightly larger gloves. The bubble maker, which is a separate device, is attached either tank for safety reasons, and a decision was made to cover the corners with rubber bumpers or pads. The design team worked well with the client and the instructor to ensure that all of the needs are met and that the device fit the individual.

TECHNICAL DESCRIPTION
The tank and its top are made of one-quarter inch thick Plexiglas. Its base is eighteen inches long and twelve inches deep. The front wall is five inches high and the back wall is twelve inches high. The walls are fused to the base and each other with methyl chloride (a Plexiglas adhesive). The top is hinged to the back wall with an eighteen-inch acrylic piano hinge and to the front wall with an acrylic childproof lock. The top makes a 60° angle with the vertical back wall. Water fills the tank to a depth of approximately four inches or one inch below the top of the front wall. A “fill line” marker is included to ensure that the tank is not overfilled. Two 3/4-inch-diameter holes are drilled in the top for the insertion of latex gloves. These gloves are regular latex gloves, the type that can be purchased in most supermarkets. The centers of the holes are located at a distance of 3½ inches from the bottom front of the hood, and a distance of 5 inches from either side of the hood. Plexiglas fitting are used to fasten the latex gloves to the holes and to provide a smooth surface for the client’s wrists. A battery operated bubble generation pump is glued or bracketed to the outside of the back wall. Its hose is attached to a plastic bar located at the inside rear of the tank that allows bubbles to be released into the water.
Several items are placed in the tank for additional visual and tactile stimulation. These include cups, plastic toys and gravel. A hose and faucet attachment are provided to fill the tank with water, and a suction pump, which is also included, is used to remove the water as well as to clean the gravel.

The cart is approximately twenty-five inches high and has locking wheels to insure stability while the device is in use. The cart is then modified to ensure stability with the addition of a horizontal brace across the back legs. Finally, the cart was cleaned, pruned where necessary, and painted bright yellow.

The cost for the device was $325, including having the tank professionally constructed to assure a leak proof device.
INTRODUCTION
The client is a 14-year-old student at Orange Grove School. He is a spastic quadriplegic, mentally retarded, blind, and has severe scoliosis. Due to the pinching of the nerves along the spine, severe pain exists. Currently, the client sits only in his wheelchair while he is at Orange Grove. The caregivers would like the client to have some other chair that he could sit in and for that chair to have the ability to glide back and forth.

The problem was to design a device that will hold a Tumbleform® chair in a laid-back position at a given angle and mounted safely to a device that supports a gliding motion. The device must be comfortable, and be able to securely support the occupant’s head, torso, feet and hands with safety straps.

SUMMARY OF IMPACT
The project has been a great success. The glider operates as expected and the client remains in motion for a reasonably long time once motion is started. It is easy to push the client. Most important the client is very content in the chair.

TECHNICAL DESCRIPTION
The glider is composed of three major parts: frame, swing, and chair. The frame is the largest part of the device. The members of the frame are all 1.25 inches by 1.25 inches with a wall thickness of 0.06 inches. The dimensions of the frame base are 2.5 feet wide by 4 feet long. The width of the frame is limited to 2.5 feet so that it can be easily moved through doors. The 4-foot length is necessary to prevent tipping during the swing. The four vertical members are 2.1 feet in length and angled slightly inward to improve stability and accessibility. The two upper members are 3 feet in length, giving the frame an overall height of 2 feet. This height helps keep the center of gravity low, which enhances the stability of the glider. Four rubber bumpers are placed on the vertical members of the frame 6.38 inches above the base. The purpose of these is to limit the distance that the swing can travel. A strip of steel 2 inches wide and 0.09 inches thick is placed 3.5 inches high between the front and back vertical members on either side of the frame. Pins are placed through the center of these strips and through a hole in the side members of the swing to lock the swing in place. Rubber strips are placed on the bottom of the base to prevent slipping when the glider is in use. The inside and outside of the vertical portion of the frame are covered with sheets of plastic to avoid possible injury due to pinch points.

The swing section of the glider consists of four swing arms and the swing base. These swing arms are 1.33 feet long, 1 inch wide and 0.25 inches thick, and connect the swing base to the frame. These connections are made using eight precision bearings. The bearings are used to obtain a smooth gliding motion. The dimensions of the swing base are 2 feet long and 2.5 feet wide, and made of 1.25 inches by 1.25 inches by 0.06 inches steel tubing.

The chair base is attached to the swing base by two front legs and one back leg. The front legs are 1.25 feet long and hinged at the point where they attach to the chair base. The back leg is 2 feet long and is hinged at the swing base. All three legs are 1.25 inches by 1.25 inches by 0.06 inches square steel tubing. The base of the chair is made of a 4 feet by 2.0 feet by 0.06-inch sheet of steel. Half of the 4-foot length supports the bottom of the chair while the other half supports the back of the chair. The arm rests are attached at the bottom of the horizontal portion of the chair base, and extend up 1.0 foot and bend around 1.5 feet to the vertical part of the chair frame. Two 1 foot by 1 inch by 0.125 inch strips of steel are attached vertically to the back of the chair base. These are spaced 1.25 inches apart so that the back leg will fit snugly between them. Holes are drilled along the length of the strips as well as a hole in the top of the back leg. A pin is placed through the strips and the
back leg to hold the chair in position. The angle of the chair depends on where the back leg is pinned in the strips. Two-foot supports are attached to the front of the chair base by a strip of steel that is 1.5 feet by 2.0 inches by 0.125 inches. The two-foot supports are attached to the strip by a bolt and can be adjusted by loosening the bolt and sliding them up or down.

The cost for the device was $725 including the Tumbleform®.
Entertainment Center

Designers: Laitik Al-Gkeawi, Eldon Cooper, Charles Kneckt, Dennis Long
Client Coordinator: May Lou Bergenback, Dennis Wilkes-Orange Grove Center
Supervising Professor: Dr. Edward H. McMahon
College of Engineering and Computer Science
University of Tennessee at Chattanooga
Chattanooga, TN 37403

INTRODUCTION
The client has cerebral palsy accompanied by visual impairment and is prone to self-stimulation. The design project is aimed at developing an entertainment center that occupies the client and develops improved motor skills. The activities in the center should be focused on auditory and tactile stimulation and the controls should be large and colorful enough to enable the client to operate them. The design should be rugged with no sharp corners.

The resulting device contained three auditory devices. Two of the auditory devices are a chime and a buzzer. The third auditory device is a voice record/playback device. The tactile devices include a vibrating surface and a fan. The activities are activated by large push buttons.

SUMMARY OF IMPACT
The immediate response to the entertainment center is very positive. The large buttons are easy to access and operate. The client appeared to quickly grasp the connection between the buttons and the response and tended to play with more than one activity at a time. The design met the desired criteria.

TECHNICAL DESCRIPTION
The entertainment center is constructed of oak plywood that is stained maple and covered with polyurethane. The unit is 21" wide 12" deep and 14" high in the back. The front panel slopes at 45 degrees to a height of 4" in the front. The sloping panel contains the five devices and the rear panel contains the controls. The rear panel contains the power supply switch (DC Converter or Batteries), the Play/Record switch, the jack for the external supply, the jack for the battery charger, and a jack for the microphone. The rear panel opens for access to the electronics. The microphone for the voice recorder is kept inside the maintenance access door. Inside is the fuse for circuit protection, the rechargeable battery and all of the circuit connections. The bottom of the center is covered with a rubber mat to prevent the device from sliding on the table or desk.

The center is powered by a 12-VDC rechargeable battery with a life of 20 hours at 150 mA.

The fan is a 12-VDC brushless fan selected for safety and quietness. The fan is controlled by a potentiometer to allow the client to vary the speed. A vent in the rear panel serves as the air inlet to the fan. The buzzer is mounted on the upper left corner. It is a 12-VDC low current buzzer and is operated by a 2 1/4" mushroom head momentary contact switch. The chime, which is placed in the lower left corner, is a 12-VDC low current chime. It is also activated by a 2 1/4" mushroom head momentary contact switch.

The vibrating surface is based on a 3-VDC vibrator. It is mounted in the lower right hand comer. The surface is activated when a large button type surface is pushed. The final device is a voice record/Playback system. The device is based on voice/record IC chip requiring a 6 VDC power supply. The device is activated by a 2 1/4" mushroom head momentary contact button. The total system consists of a microphone, a play/record button mounted on the back panel and a small speaker.

The cost for the device was $450.
Chapter 14: University of Tennessee at Chattanooga 161

Figure 14.9. Entertainment Center.

Voice Circuit

Figure 14.10. Voice Circuit.
INTRODUCTION
The design group was given the task of developing a device that would teach a twelve-year-old female a cause and effect relationship, while enhancing her motor skills, keeping her attention and providing positive reinforcement. The client had an eating disorder called “pica” that causes her to eat anything, even non-edibles. The basic functions of the device are to dispense a reward, create interest and enhance motor skills. Some of the secondary functions include resist abuse, allow portability, assure safety, contain reward and permit cleaning.

The device makes noise and is colorful in order to create interest. A button(s) on the front of the device will have to be pressed to activate the dispenser. This will enhance motor skills and hand eye coordination. Upon pressing and releasing the button, an edible reward will be dispensed to the user.

SUMMARY OF IMPACT
The design successfully met the needs of the client. The large colorful buttons, noisemaker and transparent case are encouraging to the client. The client quickly learned how to use the device and is excited about the delivered snack. The device is easy to maintain.

TECHNICAL DESCRIPTION
The box is made of 0.25-inch polycarbonate (Lexan®). The bottom of the box is 0.5-inch plywood. It is 18 inches tall, 15.75 inches wide, and 10 inches deep, with a 4-inch button panel extending forward that is 4 inches high. The lid is hinged on the backside and latches in the front. A nylon strap is attached from side to side across the top for carrying purposes. Four suction cups are attached to the bottom of the box to prevent the user from sliding it off the table.

Directly below the two buttons are 3 inch brass spur gears meshed with sections of the matching rack. Both gears are mounted on a common shaft, as are a 3.5 inch pulley and a 3 inch pulley. The shaft is 3/8 x 15.75-inch stainless rod with #10-24 machine screws tapped in each end.

Nylon guides for the racks were made from 1.75-inch nylon dowel. In addition, the guides were drilled from the topside with a .25 inch hole in which there are springs inserted. These holes were then partially redrilled with a 7/16-inch drill bit in order to accommodate the stops connected to the bottoms of the buttons.

The dispensing system consists of three plates. The bottom plate is also the divider for the box that is of .25 inch Lexan. Two holes were made in the divider, one for the shaft of the dispensing system and one for the cereal to pass through. The center disk is 5.75 inches in diameter and 0.75 inches thick with a 3/8-inch hole through its center. It has also been fitted with a short groove to accept the driver shaft. The top plate is 0.25 inch thick and 6 inches in diameter. It has a 3/8-inch hole through its center and a slot so that it may slide over the driver shaft. The upper disk is 0.25 inch thick and 6 inches in diameter. It has a 3/8-inch hole through its center and a slot so that it may slide over the driver shaft. This upper disk also has a .75 inch wide slot machined 90 degrees approximately 0.25 inch from its outer edge. The upper two disks are made of a food grade plastic. In this system the lower and upper disks remain stationary as the center disks oscillate. At rest, the hole in the center and lower disks are aligned and the upper disk groove is aligned edge to edge with the hole in the center disk. As the center disk moves, its hole moves into the slot of the upper disk allowing cereal to fall into the hole. As it moves back, its hole slides out of the upper groove and realigns with the lower hole allowing the cereal to fall below the divider plate (also the lower disk). The driver shaft is 3/8-inch stainless rod with a one-inch pin through its upper end and a flat notch on its lower end. The lower section of this driver shaft is also notched flat on its upper end along with a collar, so that the two may engage without slippage. It is mounted in a nylon guide...
from the bottom of the box and has a 1.5-inch pulley on the lower half.

The noisemaker is made of 1.5-inch stainless tubing with capped ends and 3/8-inch lock-collars on each side. It is mounted on 3/8 x 15.75-inch stainless rod that is tapped with #10-24 machine screws on each end. A 1.5” pulley is also mounted on this same shaft.

The primary shaft under the buttons is connected to the driver shaft for the dispenser system and the noisemaker shaft via two heavy-duty O-rings.

The cost for this device is $365.
INTRODUCTION

The objective of the design is to teach a cause and effect relationship by stimulating the senses. After we obtained some information about the client, our group discussed each alternative solution developed by the first group. The alternative chosen was a triangular-tabletop podium. The podium has a push button that causes lights to flash. By having the client push the button and then see the lights flash, the cause and effect relationship is evident.

The device works as follows. The person taking care of the client activates the main power switch (rocker switch). This switch is located on the back panel. The podium is placed on the table or on the floor in front of the client who wears the speakers over his head. The client then pushes the push button switches, located in the middle of the front panel. The lights flash on and off in the same rows where he pushed the button. If the client pushes the button next to it, a different tone activates flashing lights in the corresponding row. There are three rows of lights and three different tones.

SUMMARY OF IMPACT

The client is a six-year-old autistic individual with Down’s Syndrome. The most important consideration is that Ian does not yet understand the cause and effect relationship and the group was given the objective of designing a simple device that uses lights and sound to teach this concept.

TECHNICAL DESCRIPTION

This podium is constructed of 1/4” Plexiglas. The overall size is 8” x 16” and the front face of the podium is be tilted back at 45 degrees.

The LED’s are located around the sides of the switches. The distance between each two LED’s are 2-inches vertically and 1-inch horizontally. There are four LED’s in the first row (two in each side), six LED’s in the second row (three on each side), eight LED’s in the third row and 10 LED’s in the fourth row, five on each side, for a total of twenty-eight LED’s. A small door on the back panel would hinged inward for battery access. A small suitcase type lock could be used to keep the door locked. The speaker for the audio isolator is located in the top left side of the face.

The circuitry of the podium is powered by one rechargeable D-cell battery located inside the podium. The battery requires one D-cell battery holder. The holder is wired to a socket in the back panel. An external battery charger is plugged into this socket to recharge the battery. The circuitry itself requires an LED flasher chip, twenty-eight LED’s, twenty-eight plastic sockets for the LED’s, six throw momentary switches, a rocker switch, 18 and 22 gauge wire, a small breadboard to hold the circuitry, capacitors, resistors, relays, Audio Isolator. See Figure 14.14 for a circuit diagram.

The cost for the device is $520.
Figure 14.13. Cause and Effect Device.

Figure 14.14. Diagram of the device.