CHAPTER 15
UNIVERSITY OF MASSACHUSETTS AT LOWELL

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A NAVIGATION VIDEO GAME FOR PERSONS WITH LIMITED MOBILITY

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INTRODUCTION
Due to the lack of fully functional three-dimensional (3D) games that can be controlled by a one-button input device, a navigation game was designed. It helps those with limited mobility develop hand-eye coordination. The player controls the game characters using a one-button input device. The goal of the game is to navigate the character to an object, collect that object and then proceed to the next object. Currently, the games that allow one-button interaction are two dimensional (2D) “cause and effect” type games. The video game created for this project incorporates the cause and effect functionality and adds direction control. The one button action in the video game allows the player to control the direction in which a game character moves. The characters in the game move in a forward direction and when the button is pressed the character turns. When the button is released the character moves in the new direction tangential to his release point, thus enabling more interaction with the user.

SUMMARY OF IMPACT
The video game requirements were derived in collaboration with care providers. Also taken into account were the preferences and abilities of the clients using the game. The video game has allowed its users to exercise what limited control they have while experiencing a 3D video game. One client uses video games as part of his physical therapy sessions (Fig 15.1). The client’s mobility is limited to short movements of his left arm. To maintain and build strength in this ability he spends a few hours a day playing video games via a PC and custom-made joystick. Prior to receiving the navigation video game he spent hours playing cause and effect type games, which prompted him when to “hit the button”. Now he can control direction and action of the player, allowing him to decide when to turn and when to push the button.

TECHNICAL DESCRIPTION
The game was created using 3D Game studio’s A6 authoring system. The authoring system allowed the creation of a 3D multi-level game with multiple control inputs in a matter of months. The A6 system is separated into three parts: the world editor (WED), the model editor (MED), and the script editor (SED). The WED is used to create the game’s environment. The MED is used to create the 3D characters and objects to be used in the WED. The SED is used to provide instruction to control interaction between the user, WED, and MED. The language used in the SED is a C-based scripting language called “C-Script”. C-Script is interpreted by other high-level programming languages and not compiled by a CPU. The interpreting behavior limits the different types of data structures allowed by the scripting language, which reduces the robustness of the language and simplifies its learning curve for new users. The C-Script language uses functions and actions to allow reliable interaction between models in the game. The function is passed information that is processed and returned. The action, similar to a function, is associated with the model(s) from within the WED. The action invokes the function to be performed by the model. Multiple models can reference the same action, but the values altered remain with the model and not the action. This property allows the controlling code to be minimized and to be distributed through the game. One example of this is the action to collect the object by the player. Multiple object models in the same level reference the same action but the model’s values remain independent so that when one model is collected the other model remains to be collected.

The varying functions were separated into several modules. The modules work together to complete
the game. Those modules are: 1) Main; 2) Sound; 3) Video; and 4) Movement. The core of the source code is the Main module that invokes the game and “listens” for keyboard commands. Keyboard commands were incorporated so that the care providers could turn the sound on or off, pause the game, or quickly exit the game with minimal effort. The mouse clicks are provided by the custom joystick that plugs into a custom PC mouse. The module contains the functions that call WAV format files used for the sound effects and level background music. The module contains the functions to call BMP files that display the opening and closing credits, as well as the images that indicate the level number. The module contains the functions that control the game character movement. At the start of the level the movement is initiated in an endless loop that moves the player in one direction. Pressing the button interrupts the loop to update the model’s PAN value turning the character. Once the button is released the model’s vector value is updated and the player moves in the new direction. The movement module also contains a random number generator to randomly start the character in a different position and direction for each level.

The levels are associated so that the order is one through five. Once the fifth level is complete it loops back to the first level. Game termination comes from the keyboard input of ‘q’ or ‘Q’. The player is then prompted to press ‘Y’ or ‘N’ to quit or continue, respectively.

The software cost was about $199.

Fig. 15.1. Client Playing the Game.
INTRODUCTION
The powered wheelchair (PW) was designed to enhance mobility (Fig. 15.2) of people with various disabilities. This device is a motorized wheelchair with many convenient built-in features. As shown in Fig. 15.2, the PW is a joystick controlled powerchair with a maximum speed of 8 mph and options such as actuated seat height adjustment and the ability to be easily disassembled into four main pieces. Upon completion, the PW was formally presented to the client.

The client is a 40-year-old woman with multiple sclerosis (MS), currently in the process of receiving a hip replacement. She will have significant trouble sitting and standing due to her pending hip replacement. The PW is intended to provide the client freedom to move within her environment unassisted.

Fig. 15.2. Powered Wheelchair (PW).
SUMMARY OF IMPACT
Many of the wheelchairs on the market today are “institutional” in terms of appearance. It can also be very difficult to find a chair with the options that one requires at a practical cost. The design criteria for the PW were defined by the capabilities and preferences of the client. A variable-height swivel seat will assist the client in transition into or out of the chair. Also, aesthetics became a major focal point in the design as well. The client now has a power-chair equipped with all of the specified options in a great-looking and well-proportioned package.

TECHNICAL DESCRIPTION
The fabrication of the wheelchair chassis (Fig 15.3) was accomplished by means of a “design around major component dimensions” approach. With the two 12V batteries and the lift actuator positioned in a manner to achieve equal weight distribution from front to rear, the “backbone” of the chassis was constructed around these components. Due to the lack of mechanical engineering resources available for the design, a 100% safety margin was adhered to for all aspects of the chassis fabrication.

As shown in Fig. 15.3, the chassis was constructed entirely with stainless steel, once the major components were incorporated into the central portion of the chassis. The wheel mounting points were welded in place to obtain a 23” by 21” wheelbase. Upon completion of the chassis fabrication, rigorous testing was performed by means of extensive loading and flexing. Body filler was applied to all weld-points prior to painting in order to achieve a quality finish beyond industry standards. Strict adherence to a 100% safety margin resulted in a heavier total weight.

Using two 12V batteries wired in series, the 24V source was wired directly to a junction block using 8-gauge wire. Exiting the junction block was a 14-gauge fused 24V input for the lift actuator circuitry and an 8-gauge fused 24V output for the Courtney Electronics PWM controller that was used to control the drive motors. Ultimately, it was decided that the analog Op-Amp circuit design might compromise reliability and longevity of the wheelchair operation due to high power consumption characteristics. With a three-month deadline and most efforts devoted to the wheelchair fabrication, using a pre-manufactured PWM controller was the most logical option.

The lift actuator circuitry is mainly comprised of an in-line fuse and a double-pole double-throw switch. The maximum input voltage for the actuator’s motor is 24V, so the actuator could be operated directly from the 24V source. The Dynamic joystick was powered at 5 volts constantly supplied by the PWM controller. The joystick control inputs consist of two wipers, a forward/reverse and a left/right control wire. Prior testing and data acquisition of the joystick characteristics enabled custom control circuit tuning by means of programming the PWM controller.

The cost of parts and materials was about $1500.
VOICE-ACTIVATED TELEVISION REMOTE CONTROL

Designers: Christopher Robinson, Joseph Tice, Nga Nguyen, Justin Ulrich, Radhames Martinez, and Anthony Serino
Supervising Professor: Professor Alan Rux
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INTRODUCTION
This project was designed and built for an Assistive Technology showroom. This showroom allows students to view exciting, challenging and useful devices that can be built based on theoretical knowledge obtained in college.

The project is an Environmental Control System (ECS). An ECS enables anyone to operate a wide range of domestic appliances and other vital functions by remote control.

SUMMARY OF IMPACT
This ECS (Fig 15.4) was designed to enhance the ability of people with disabilities. The ECS allows for independence to be maintained.

TECHNICAL DESCRIPTION
There are two main hardware components for the Voice Activated Television: 1) the transmitter box and 2) the receiver box.

The transmitter box is white and is where the components for the user group interfaces. Three out of six people in the group can transmit from the same transmitter. The circuitry was placed inside the box with the following dimensions: 3 inches high, 5 inches wide, and 8 inches long. This box was attached to the parallel port with a 50-line ribbon cable.

Inside the transmitter box are the two main components: 1) an encoder (HT12E); and 2) a transmitter (TWS-434a) (Fig 15.5). The encoder converts the parallel signal to series, which makes the transmitter send the data faster.

The receiver box is black and has the following dimensions: 3 inches high, 5 inches wide, and 8 inches long. The remote control for the 15-inch Magnavox flat screen television was mounted on top of the box.

The receiving circuit has the following main components: the RWS 434 receiver, decoder (HT12D), Basic Stamp 2e, and 5 dip relays that were hard wired to a microcontroller inside a remote control. The signal sent from the receiver to the decoder is converted back to parallel after going through the decoder. It then goes to the Basic Stamp, which is the IC that communicates with the relays.

The cost of parts and materials was approximately $500.
Fig. 15.5. Inside the Voice-Activated Television Control.
LIGHT AND SOUND BOX: A MULTI-SENSORY ROOM DEVICE

Designer: Eric M. Bass
Client Coordinator: Bonnie Paulino Lanen, Franciscan Children’s Hospital, Brighton, MA
Project Supervisor: Charles Maffeo, Ph.D
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INTRODUCTION
The Light and Sound Box (LSB), shown in Fig. 15.6, was designed to provide multiple sensory stimulations for children with multiple disabilities. The LSB is a box that will display a colored output along with a voice recording, given a colored input button press. After the LSB has been powered it begins blinking a default light pattern and continues to blink that pattern until the user presses an input button (see Fig. 15.6). The LSB was designed for a hospital day school program. The majority of the students in the school have multiple disabilities and restricted physical movement.

SUMMARY OF IMPACT
The LSB was designed specifically for children who have multiple disabilities. The goal was to provide a flexible device to be used in a dynamically changing environment. The teachers noted that because they could record their voices to the LSB they would use it not only as a visual and auditory stimulus tool for the very young children, but also as an educational tool for the older children. One specific example that a teacher illustrated was when objects were placed on the box and the children would answer specific questions by illuminating a certain object.

TECHNICAL DESCRIPTION
The LSB was constructed with four major sub-circuits (see Fig. 15.7): 1) a microcontroller sub-circuit; 2) an audio sub-circuit; 3) an amplification sub-circuit; and 4) a high-voltage sub-circuit. The microcontroller sub-circuit provided the processing of inputs to their corresponding outputs. The audio sub-circuit allowed the recording or playback of sounds from the LSB. The amplification sub-circuit was used to increase the sound output from the audio sub-circuit. The high voltage sub-circuit was used to isolate and control the light outputs from the LSB.

The microcontroller sub-circuit was assigned five inputs and eight outputs via software programmed directly into the microcontroller’s internal PROM (Programmable Read Only Memory). Four of the
five inputs to the microcontroller were assigned as switch input, and the primary interaction with the LSB was through four normally open or normally closed switches. The fifth input was assigned as a record button input and was designated as a normally open momentary switch that, when pressed, would produce an active low input to the microcontroller. Four of the eight outputs of the microcontroller were used to control a switching transistor that would enable a relay attached to the high voltage sub-circuit. The additional four outputs from the microcontroller were used to manage the audio sub-circuit. The microcontroller would handle the recording, skipping, resetting, and playback of voice recordings to the audio device.

The audio sub-circuit was comprised of an ISD1420 voice record/playback IC. It was chosen because it is an inexpensive single chip solution for the recording and playback of telephone quality \((f_s=6.4\text{kHz})\) sounds. Address inputs A6 and A7 were connected to +5 volts to allow the microcontroller to select which message was to be output. The message output was selected by pulsing address bits A0 or A4 with 5 volts, which respectively reset the internal address pointer to memory, address zero, or set the internal address pointer to the beginning of the next recorded message. The recording and playback of sounds to the device was controlled using the /REC and /PLAYE inputs in conjunction with the microcontroller. The additional level-activated play pin, /PLAYL, was connected through a 1kΩ resistor to 5 volts to prevent the LSB from unexpectedly playing a sound. The ANA OUT and ANA IN pins were connected to one another through a series RC circuit recommended by the manufacturer for the best input to output sound ratio results. A capacitive microphone was connected between the MIC and MIC REF pins. Additional microphone conditioning, RC circuitry, was used to filter out unwanted noise from the microphone. The ISD IC provided input pin that was set to amplify the analog input from the microphone to the ISD IC’s internal memory via a parallel RC network that consisted of a 470kΩ resistor and a 6.9µF capacitor. The SP+ output of the audio sub-circuit was connected to the non-inverting input of the amplification sub-circuit.

The amplification sub-circuit consisted of a LM386 low-power audio amplification IC configured as a non-inverting voltage follower with a gain of ~50dB.
EASYKIT ENVIRONMENTAL CONTROL DEVICE

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Client Coordinator: Prof. Alan Rux
Supervising Professor: Prof. Charles Maffeo
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INTRODUCTION
EasyKit Environmental Control device (EECD) was designed to provide remote control to household appliances for people with physical disabilities, such as visual impairment and quadriplegia. The device uses an IR universal remote to control a TV, VCR, DVD, and stereo. Its functions also include ON/OFF operations of lights, a fan, and an air cleaner. Though the device works as a switch-activated EECD, it was structured to allow a voice option in the future, depending on the clients need. The device is completely modular and portable.

SUMMARY OF IMPACT
The device was designed and built to meet the needs of the client. Due to workplace injury he became sensitive to electromagnetic radiation (EMR) and has poor vision. The large keypad employed in the device enables him to control his household appliances with little or no help. The device emits low power radiation. IR transmission is more directional than RF and reduces his EMR exposure level.

TECHNICAL DESCRIPTION
For simplicity, an existing universal remote was

Fig. 15.8. Switch-Activated EasyKit Environmental Control Device.
modified to become EECD (Fig. 15.8). The device also consists of an X-T transmitter to control ON/OFF devices. The circuit board of a universal remote (RCA) is made up of 33 switches. Each of these switches has two contacts: a_i and b_i. In order to activate a function, for example, function 1, a_1 and b_1 are connected or joined. After careful analysis, 7 x 5 matrix arrangements of these contacts were derived. Twelve wires, [7+5] were used to connect the RCA universal remote’s rows and columns matrix to two data selectors, respectively. The data selector is a multiplexer that selects a line at a given input to a common output. The common output of both data selectors were wired together. The power function can be activated by selecting channel two of both multiplexers. All 33 functions of the RCA universal remote are allowed using this set-up.

Three receivers used to turn devices ON/OFF were consolidated into one circuit board and mounted into a 3” x 6” box. Each of the receivers was permanently assigned addresses and was connected to a three-relay circuit. An X-T transmitter was then used to transmit IR signals to the receivers. Each time a signal is detected by the receiver, it checks whether the address matches its local address. When a match occurs, the receiver sends a high or low signal to the relay circuit to turn the device ON or OFF.

A 5x4 large matrix keypad was used to activate a function. This keypad was connected to an 8x8 matrix encoder that generates code on any key pressed on the keypad. An embedded program was written to use the codes generated and assigned inputs to the multiplexer and the X-T transmitter.

The ON/OFF devices required 7 functions, with a total of 40 [33+7] functions. In order to accommodate all these functions, 20 [5x4] keys with two switches (SW1 and SW2) were used. SW1 and SW2 in OFF position represent the first 20 functions. The switch SW1 in OFF position and SW2 in ON position represent the next 20 functions. SW1 ON position serves as the voice option for future improvement of the device. The two switches are connected to the tri-state buffer and the microcontroller. The tri-state buffer allows either the switch or voice inputs to the microcontroller, depending on the position of the switches. The table displayed in Fig. 15.9 summarizes this set-up.

<table>
<thead>
<tr>
<th>SW1</th>
<th>SW2</th>
<th>Function Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>OFF</td>
<td>First 20</td>
</tr>
<tr>
<td>OFF</td>
<td>ON</td>
<td>2nd 20</td>
</tr>
<tr>
<td>ON</td>
<td>ON</td>
<td>Voice Option (future Use)</td>
</tr>
</tbody>
</table>

Fig. 15.9. Summary of Functions.
INTRODUCTION
A client had been using Dragon Naturally Speaking (DNS) 4.0 and different macros, which were designed to facilitate her interaction with the PC for her part-time proofreading job. The current project (see Fig. 15.10) was to update the client’s system to the latest version of the DNS software, while addressing the system requirements for the new PC. Also, when necessary, new macros were written, to substitute for and improve on the ones she previously had, and to further expand the DNS vocabulary.

The final part of the project was to help her make the transition from the old system to the new one. This included copying relevant files from one computer to another, setting up a dial-up connection, importing Outlook folders, and training her to use the new software.

SUMMARY OF IMPACT
This project was custom-designed for the use and needs of the client, who has severe muscle weakness and gets tired very easily. She also has MCS, which makes her allergic to several artificially scented substances and other products. MCS also makes her sensitive to gases expelled by computer parts when they are heated and gases contained in new materials.

TECHNICAL DESCRIPTION
Macros are a series of commands and actions that can be stored and run. These series of commands usually help a user to automate tasks that become time-consuming and are performed regularly. The macros used in the project were limited to the Dragon Edition that the school purchased. This edition did not allow direct scripting of commands and only allowed the creation of plain text or picture macros. This limitation was not a problem since most of the macros needed by the client did not use any of the advanced features of macro scripting. The diagram in Fig. 15.11 shows how macros interface with other software in the system.

The producer of DNS 8.0 guarantees compatibility with most Microsoft products that facilitate the implementation of macros by making them global commands. Most of the macros written for this project have the following scripting format:

Sub ListenFullTitle()

'ListenFullTitle Macro

' Macro created 04/01/2006 by Giovani Seben

'Selection.TypeText Text: ="Listen to Our Stories: Words, Pictures, and Songs by Young People with Disabilities"
End Sub

This format can be repeated to create more macros such as the one above. However, if the command is not as long as the title above, an easier and better way to obtain the same result is to add words to Dragon’s vocabulary. In this design, instead of making the words macros, they are added to the vocabulary used by Dragon. Once a new word is added to the Dragon vocabulary, one can train it to be pronounced a certain way. This has the same effect as adding a macro for that command, with the benefit that the text will appear in the text format the user is using.

The cost of parts and materials was approximately $240.

Fig. 15.11. Macro Block Diagram.
THE MUSIC BOX SOUND RECORDER: A DEVICE THAT PROVIDES BRAIN STIMULATION TO CHILDREN WITH MULTIPLE HANDICAPS

Designers: Huong Ho
Client Coordinator: Lisa Szewczyk, Nashua Center, Nashua, NH
Supervising Professor: Jay Fu

INTRODUCTION
The Music Box Sound Recorder (MBSR) (Fig 15.12) is intended to help students with disabilities develop learning skills.

Development of various skills, such as listening, speaking, and reasoning, is important to allow children with disabilities to be able to actively participate in their communities.

SUMMARY OF IMPACT
The MBSR (Fig. 15.13) is a device that provides brain stimulation for children with disabilities. It is

Fig. 15.12. Music Box Sound Recorder.
designed in such a way that it can be easily used. The MBSR will be an effective tool for children that have difficulties learning. Six songs were recorded on the MBSR before delivery. The children enjoyed the Music Box Sound Recorder. In the future they can record other songs if they desire. The children are learning while they are having fun with the MBSR, because they are associating a particular button with a specific song.

TECHNICAL DESCRIPTION
The voice chip ISD4003_8 was used to record and playback songs of up to eight minutes. Since there are six different songs stored in this chip, each song is recorded to play up to one minute and twenty seconds. The Basic Stamp 2 was used to operate the ISD4003_8 chip because ISD was designed to be used in a microcontroller-based system. Six large jelly-bean buttons were used to play each song. If the MBSR is in play mode, pressing a button will play the corresponding song. If MBSR is in record mode, pressing a button will record the corresponding memory space. A toggle switch was used for playback and record mode. Another toggle switch was used for power on and off. When this switch is toggled to turn the power on, a red Power-LED lights up. When MBSR is in play mode, pressing any jelly-bean button will light up a green Play-LED. When MBSR is in record mode, pressing any jelly-bean button will light up a yellow Record-LED. A push-button was used for the stop function. While a song is playing or recording, a stop switch, when pressed, will stop a song from playing or recording. A microphone was used to receive the sound of the song into ISD4003. A speaker was used to play the sound of the song out of an LM386 amplifier.

An AC adaptor was used to power the MBSR, which requires 6 volts. The Basic Stamp needs a power supply of 6 volts. It has an onboard 5-volt regulator used to power the audio amplifier and an LM317 voltage regulator. The ISD4003 needs 3-volt power, which is supplied by the output voltage of the LM317 voltage regulator.

The cost of parts and materials was approximately $120.
LASER POINTER COMMUNICATION DEVICE AND LIGHT-OPERATED SWITCH

Designer: Israel Poore
Client Coordinator: Dr. Howard Shane, Children’s Hospital, Boston, Massachusetts
Supervising Professor: Walter McGuire, Alan Rux
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INTRODUCTION
Laser pointers are commonly used in lectures to point to projected information. They can also be used to point to items on a communication board, wall chart, or an input device with laser-controlled optical switches that can control devices such as lights, fans, stereos, TVs, and computers. This laser pointer is specifically designed to be used as an accessing tool for communication. The difference between this laser pointer and regular laser pointers is the safety factor. Regular laser pointers can cause damage to the retina if they are projected directly into someone’s eye.

A small laser module was fitted with a neutral density filter to reduce the power to a safe level. This module was then mounted internally to a headband to allow pointing with head movement and for the laser to be controlled by a momentary switch. The optical switch was designed with an array of photocells behind a ground-glass lens and will enable more uses of a laser pointer than those commonly used for communication.

SUMMARY OF IMPACT
Typical use of laser pointers for communication entails pointing at items either on a communication board or in a room. Many users of laser communication devices either cannot afford the high prices, or will opt to use an off-the-shelf high-power laser pointer as result, which is extremely dangerous as these can cause burns to the retina and even blindness. This laser pointer for communication is affordable compared to the purchase price of current communication lasers on the market. The communication laser size is 25 mm x 25 mm, which is smaller than current communication lasers on the market. The safety factor is as safe as GEWA’s laser. The output power is only 0.67mW. The activating switch for the laser is also lighter than the GEWA’s laser, due to three AAA size batteries instead of a battery pack. The optical switch will give more use to a laser pointer used for communicating to others that will help the client during daily activities. These two devices together will contribute to safe and effective communication and environmental control for those with severe communication disorders.

TECHNICAL DESCRIPTION
The laser pointer (see Fig. 15.14) was constructed from a 3mW, 650nm laser module with a size of 17.02mm x 10.44mm manufactured by US-Lasers, Inc. and distributed by Digi-Key Corporation. The laser housing was constructed from a round piece of wood, approximately 25 mm in diameter, an attached absorptive (0.6 optical density), and neutral density filter. The entire module was then glued to a piece of cardboard and inserted inside a headband with only the laser and filter protruding through. The optical switch is inside an enclosure approximately 200 mm x 160 mm. On the sides of the enclosure are two receptacles used to plug in devices that the user can control. Around the lens is a shield made of firm cardboard to prevent ambient light from activating the switch. The lens is approximately 55 mm x 55 mm x 2 mm ground glass. The ground glass is used to spread the beam of the laser, to not reflect any laser light back toward the user, and to prevent ambient light from activating the switch. The active area of the lens is approximately 37 mm x 37 mm. Underneath the lens is a 4x4 matrix of photocells, or photoresistors. These photocells, located approximately 2 inches from the lens, receive the light and report a voltage to a control circuit comprised of a comparator, a zener diode, and a toggle flip-flop. Around the photoresistors is a foil board to reflect oblique angles of incidence back to the photocell network. The power is controlled by a relay, connected to the power supplied from the power cable, and the
receptacles on the sides of the enclosure. Possible design improvements include larger lenses if larger ground glass lenses can be found. If so, a larger photocell network can be created, but increasing the resistance value of the photocells is recommended. In this design, the photocells value was rated at 8000 ohms in full light. Another design improvement would be to cut the neutral density filter to approximately 10 mm.

The cost of parts and materials was approximately $222.
INTRODUCTION
The Video Game Buddy (Fig. 15.15) was designed to enable a person with quadriplegia to play video games. The buttons on the video game controller are pressed or triggered by the user sipping into puff straws mounted on a headset. Head switches attached to a headrest trigger the directional pad. This device was specially designed for a client who has quadriplegia and had enjoyed playing video games prior to his accident.

SUMMARY OF IMPACT
The goal of the Video Game Buddy was to enable hands-free use for the user. The client uses other technology to help him with his everyday life. However, he was limited to turning on the television, talking on the phone, and getting around with a wheelchair. Due to the limited dexterity of his hand, he was not able to play video games in a traditional way with a controller. The Video Game Buddy allows the client to join the fun and experience additional independence. The unit requires minimal assistance to get started.

TECHNICAL DESCRIPTION
The Video Game Buddy is made of two parts: the input box and the switches (see Fig. 15.16). The input box is made of plastic with dimensions of 5 x 2 inches. This box is lightweight and allows enough room for the components needed. The components of the box are a solder board, Basic Stamp 2 module (BS2), a decoder, 3.5 mm jacks, and an Xbox controller by Microsoft™. The outer components of the Video Game Buddy are switches.

The switches used were a quad-puff system and compact head switches, both designed by Enabling Devices™. The quad-puff system was selected because it is an easy method for those with quadriplegia. The puff system was used as four inputs to the input box. Since there are many buttons on the Xbox controller, only nine of the buttons were used. It was designed this way to make the gaming experience less complicated with the four straws. Each straw input has the ability to control two buttons, except for the last straw, which controls three buttons. There are four head switches, used for the directional pad. The head switches are positioned so that the user can easily trigger the switch with slight pressure from the head.

The inputs from the puff straws are processed within the input box with the BS2. The BS2 sends a signal to the decoder, which sends a signal to the appropriate button on the Xbox controller. The inputs from the head switches are directly connected to the controller for real-time movement. When the controller is plugged in, the Microsoft™ Xbox console supplies power.

The cost of parts was approximately $375.
Fig. 15.16. Video Game Buddy Controller with Input Box.
RADIO FREQUENCY REMOTE-CONTROL LIGHT AND MUSIC BOX

Designer: Jocelyn Dorval
Client Coordinator: Bonnie Paulino, Kennedy Day School
Supervising Professor: Jay Fu

INTRODUCTION
The main goal of this project is to play different types of music and to blink the light-emitting diode activated by a remote. The entire design depends on the transmitter switching to operate. The circuit that operates the transmitter is a 6-volt DC power supply. The receiver contains a music chip and a versatile flasher that operates on a 5-volt DC power supply. The music and the LED flasher give the client the option of interacting with the device. This device is activated when the switch is on, and deactivated when the switch is turned off (see Fig. 15.17). The music is played via a preprogrammed chip each time the button is touched and the light is flashing. A problem with the versatile flasher was resolved by connecting pin number 9 of the driver ULN2803A to pin number 1 of the capacitor C1 of the crystal resonator. The positive 5-volt DC, which powers the circuit, was then connected to the positive LED number 8, causing the lights to blink.

Fig. 15.17. Remote Control LED Light and Music Box.
SUMMARY OF IMPACT
The device provides different means of interaction and encourages movement for children with disabilities in a hospital day school.

TECHNICAL DESCRIPTION
The transmitter device is enclosed in a black plastic box, 6” x 9” x 3”. There are two holes drilled into it with space between them for the buttons, a hole drilled for the antenna, a hole drilled for the light indicator power, and a hole drilled for the on/off switch. The receiver device box is also plastic and is the same size as the transmitter box. There is one hole drilled on the topside of the receiver box for the music button, eight horizontal holes drilled with spacing between them for the versatile flashing lights (LEDs), one hole drilled for the light music indicator, one hole drilled for the antenna, and one hole drilled for the signal light indicator. The actual board is connected via wires. This method of wiring is essential in terms of preventing a cumbersome design because most of the components must be on one board (see Fig. 15.18).

Six-volt DC (4 x 1.5 volts AA batteries) powers the transmitter device. A 5-volt DC adaptor powers the whole receiver circuit. The design has the following parts: two 5-volt relays, one transmitter/receiver/encoder/decoder, ten capacitors, three diodes, 11 LEDs, one programmed music chip, 17 resistors, five transistors, and one switch. This project offers the option of adjusting the frequency of the versatile flashers.

The total cost of parts and materials was approximately $70.

Fig. 15.18. Circuit of the Project.
MOTORIZED DYNAMIC STANDER: A SELF-PROPELLED STANDING VEHICLE FOR STUDENTS WHO CANNOT USE TRADITIONAL WHEELCHAIRS

Designers: John Foulkes and Jose Delgado
Client Coordinator: Alan Rux, University of Massachusetts Lowell
Supervising Professor: Dr. Donn Clark
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INTRODUCTION
The Motorized Dynamic Stander (MDS) (see Fig 15.19) was developed to provide mobility for students who cannot move around on their own and who lack the skills and strength required to operate manual dynamic standers. The device consists of a foot platform that the student stands on, an upright body pad to lean forward against, drive wheels, and casters for balance. Push-button hand controls are used to operate the power train. The intention is to enable students’ mobility within their school and classroom environments. The MDS also serves to stimulate the students and provide a more interactive educational experience.

SUMMARY OF IMPACT
The design criteria for the MDS were defined by the capabilities of the students who will use it. Because many of the students have limited capabilities, the MDS drive system has been designed to operate at very low speeds. Acceleration has been carefully controlled by software for smooth, safe operation. An RF remote kill switch provides a means for instructors to disable the MDS drive system while supervising their students. The existing Velcro straps have been retained, which allow the instructor to safely secure a student in the MDS.

TECHNICAL DESCRIPTION
The MDS was created by adding an electronic drive system to an existing commercially available manual dynamic stander. The existing manual hand wheels, chains, and drive wheels were removed. In place of the existing drive wheels, a pair of DC hub motors was bolted to the stander frame. The hub motors

Fig. 15.19. Motorized Dynamic Stander.
(shown in Fig. 15.20) are 8” wheels with integrated 24V DC motors and gearing.

Two 55Ah 12V sealed lead acid batteries were mounted to the lower frame members in front of the body pad, as close to the center of gravity as possible. These batteries are approximately the size of automotive batteries and weigh 39 lbs each. They are supported by a pair of 1/8”x 2” angle steel brackets that are bolted to the stander frame.

The electronic drive system uses Pulse Width Modulation (PWM) as a means of varying the DC voltage and hence the motor speed. The PWM signals are generated by a PIC microcontroller, which has been programmed to read inputs from the four push-buttons and generate PWM signals accordingly. The PWM signals enable inputs to a pair of H-Bridge motor driver boards. The H-Bridges also have motor direction control inputs, which are also generated by the PIC microcode. Each H-Bridge connects to the 24V battery system and drives one of the hub motors. The H-Bridges were installed in a pair of metal cases, which were mounted to the panel on the front of the body pad frame. The PIC microcontroller board is encased in a black plastic project box, which was also secured to the panel with locking Velcro for easy access. The H-Bridge motor direction control inputs must be set appropriately before the 24V power is applied. A DC solid state relay (SSR) was introduced to isolate the 24V connection from the H-Bridges until the control bits were set to the correct state. The PIC initialization code first sets the control bits correctly, and then sets the input of the SSR to engage the drive system. A rocker switch with an LED indicator mounted on the front of the push-button box activates the MDS. Once the switch is closed, the MDS is ready for use.

The cost of parts and materials was approximately $4200 (including $3300 for the existing manual dynamic stander).

Fig. 15.20. Hub Motors and Batteries.
INTRODUCTION
The Therapeutic Reclining Wheelchair (see Fig. 15.21) was designed to give a patient with hip and spine deformities the ability to relieve pain independently through the reclining of the wheelchair. The patient had a wheelchair with a reclining mechanism, but her condition did not allow her to use it. She requested a way to easily and independently perform the reclining function.

SUMMARY OF IMPACT
The ability to recline the wheelchair through the activation of a single push-button allows the client to independently relieve pain. This not only increases her quality of life but also provides her with an alternative approach to relieve pain that is not invasive or dangerous.

TECHNICAL DESCRIPTION
The wheelchair’s spring-loaded mechanism for managing the reclining function was removed and replaced with a linear actuator. To control the actuator, a hand-sized push-button was attached to the client’s voice panel. When activated, this push-button sends a signal to a Basic Stamp. The Basic Stamp executes a programmed routine when activated.

When activated, the microcontroller begins by retracting the linear actuator, thereby reclining the wheelchair. The microcontroller then monitors the position of the seat recline via an ADC feedback provided by the linear actuator. Once a preset point is reached, the actuator is told to pause for 1 second and then begin to extend. The extension of the linear actuator causes the seat to incline. This routine is performed three times and then the seat is returned to its original position and is ready to begin again.

The actuator also has a secondary set of controls, which allow for manual control of the actuator. This panel, when activated, overrides the momentary push-button control. It is provided to enable another individual to adjust the chair. This panel provides two push-buttons. The first push-button reclines the wheelchair and the second inclines the wheelchair.

The cost of parts and materials was approximately $1000.
Fig. 15.21. Therapeutic Reclining Wheelchair.
INTRODUCTION
The Voice-Activated Telephone (see Fig. 15.22) was designed for an elderly woman with limited vision and moderate arthritis. Voice commands allow the user of this phone to place calls without the need to look up phone numbers or press buttons. The phone can still be used as a normal telephone. This device makes life easier because voice commands do the work of dialing a phone number.

SUMMARY OF IMPACT
The client lives alone and she has trouble making phone calls, as it is difficult for her to read the numbers as well as to press the buttons on her phone. Having the Voice-Activated Telephone will help her feel safer in case of an emergency, because she will be able to contact 911 or family more easily. This system is designed specifically for the client in that telephone numbers of her family, friends, and others are pre-programmed.

TECHNICAL DESCRIPTION
The Voice-Activated Telephone has three parts: 1) a voice recognition circuit, 2) a telephone, and 3) a dialing circuit. The voice recognition circuit is based around the HM2007 voice recognition chip, which can be trained to recognize up to 40 words. The recognized words are stored into RAM memory, which is backed-up by battery to preserve the data. Power is provided to the rest of the circuit with an AC power supply.

The system is designed to be user-friendly. For operation, the client only needs to lift the phone handset and speak the name of the person she wishes to contact.

The HM2007 then selects the proper voice command number from the RAM and passes it to the BASIC STAMP 2 SX (BS2sx). The Basic Stamp continually waits for inputs to be received from the HM2007. After receiving the stored word number, the Basic Stamp responds by dialing the phone number associated with the voice command number. If the Basic Stamp receives an invalid command, an error light is displayed on the front of the unit. The Basic Stamp then returns to the beginning of its program and continues waiting for the next voice command.

To dial a number that is pre-programmed into the Basic Stamp, one of the BS2Sx I/O pins generates the appropriate dual-tone multiple frequency (DTMF). A small interface circuit was built to filter out and isolate the digital pin from the analog telephone lines. This circuit is connected directly to the telephone lines, through two relay switches, for hands-free dialing. The relays are normally open, allowing the telephone to be used as a standard phone if needed. The telephone used was a standard telephone that can be connected to any telephone system.

The cost of the materials to make the voice-activated phone was approximately $200, including $59 for the Basic Stamp and $30 for the telephone.
Fig. 15.22. Voice-Activated Telephone System.
VOICE-ACTIVATED UNIVERSAL REMOTE CONTROL

Designer: Mark R. Koch
Supervising Professor: Charles Maffeo
Client Coordinator: Fran Williams
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University of Massachusetts at Lowell
Lowell, Ma. 01852

INTRODUCTION
The Voice-Activated Universal Remote Control (see Fig. 15.23) was designed to provide an individual with paraplegia the ability to control a television and a cable box by voice. This device is composed of a voice-recognition circuit, an interface circuit, and a universal remote control.

SUMMARY OF IMPACT
The design criteria for the Voice-Activated Universal Remote Control were defined by the capabilities and needs of the client, who wished to control her television with her voice. Instead of always having to ask to have the channel changed or the volume adjusted, it is convenient for her to have complete control of the device. This lets the caretaker focus on other tasks. The design of the device lets the client speak a command, which acts as if a button is being pushed, and another command, which acts as the finger being released from the control. There are eight different voice commands, which include power, TV, cable, volume up, volume down, channel up, channel down and TV/Video.

TECHNICAL DESCRIPTION
The primary component of the Voice-Activated Universal Remote Control is the HM2007 voice-recognition chip (see Fig. 15.24). Combined with an 8K x 8K SRAM, 74LS373 Octal Transparent Latch, matrix keypad, and two TIL311 Hexadecimal displays, a working voice-recognition circuit was built. Training the circuit was the first task to be completed. This was done by entering a two-digit number on the keypad followed by the pound key, and speaking a command into the microphone. After storing all eight commands, the voice-recognition circuit is always “listening.” When the user speaks a command, the circuit processes the command and sends the correct four-bit binary number from the SRAM to the interface circuit.

The interface circuit consists of a 4-16 line decoder, LM555 timers, bi-polar transistors, and solid-state relays. A four-bit binary number from the voice-recognition circuit is fed into the 4-16 line decoder. From there, one of the outputs is selected based upon the input signal. This low output signal is then fed into an LM555 timer, which operates as a “one-shot timer;” it takes the low signal from the 4-16 decoder and triggers the high output. The one-shot timer delays the input signal for a brief instant. From here, the signal is fed into the base of a bi-polar transistor. From this, 5V is output from the emitter into the positive terminal of a solid-state relay. The other side of the relay is connected to two pins coming from the IC in the remote control, making a solid connection between the two, in turn activating the command spoken into the microphone.

Fig. 15.23. Voice-Activated Universal Remote Control.
Fig. 15.24. HM2007 Voice-Recognition Chip.
ELECTRONICALLY-ADJUSTABLE WORKSPACE

Designer: Matthew Farmer
Client Coordinator: Jimmy Magiera
Supervising Professor: Jay Fu
Electrical Engineering Department
University of Massachusetts at Lowell

INTRODUCTION
A desk was designed to allow people using chairs of different heights, such as standard desk chairs and wheelchairs, comfortable access to a specially designed computer. It is able to adjust in height to the appropriate level for its user. The desk needs only two positions: low and high. The low position accommodates a standard desk chair with a height of 36 inches from the floor to the top of the desk. The high position allows a wheelchair to go under the desk. The high and low positions are adjustable for use by clients with wheelchairs of varying heights.

SUMMARY OF IMPACT
Superior materials were utilized to create a fully-functional project that looks great and will last for years to come. This desk will be donated to a VA hospital to be used in a computer lab. A highly customized computer will be placed on this desk so that it may be used by those who are able to walk and those who use wheelchairs.

TECHNICAL DESCRIPTION
This project consists of three smaller projects: 1) the legs, 2) the desktop, and 3) the electronics (see Fig. 15.25). The legs enable the desk to change in height. The desktop is comprised of the working area and the housing of all moving components. The electronics use the input from the user and its sensors to control the operation of the desk in a safe manner. A schematic is shown in Fig. 15.26.

The telescoping legs are made from brushed aluminum. From top to bottom there is a gear, a bushing, a bearing, a second bushing, a spacer, a mounting bracket, a top section of the leg, a bottom section of the leg with a nut welded inside, and the footing. There is a threaded rod through the center of these components. The gear is screwed into this rod, allowing the bottom section of the leg to telescope in and out of the upper section of the leg as the screw turns. There is a slot in the upper section of the leg through which a screw slides through to ensure that the lower section does not simply spin.

The desktop is a standard size of three by six feet. It is made of two layers of particle board, and is covered by a sheet of Formica. The Formica top is durable and easy to clean. The table edges have all been rounded to minimize any personal injury that could occur by someone wheeling or walking into a corner. It also has a T-molded edge, which both looks nice and is slightly more forgiving than a hard Formica edge.

Below the tabletop is the gear box. This houses the chain, all of the gears attached to each of the legs, a chain tensioner, and the motor’s gear. All of the moving parts are enclosed in this area so there is no chance of an article of clothing getting soiled by grease or ripped by the chain.

This project is powered by standard 110 volt AC wall socket. There is a transformer inside the sealed electronic box, which steps this voltage down to 24V AC for use in the controls and relays. This was done to reduce the user’s interaction with high voltage
components. There is extremely thick wire housing connecting this electronic box to the motor to eliminate all chance of contact with a high voltage source.

In normal operation the desk starts at either the high or low position. The user then presses the opposite button and the desk moves in that direction. It continues to move until the appropriate limit switch, mounted to the rear left leg, is triggered. Once this limit switch is triggered, the circuit, which keeps the latch in the relay, is broken and the desk stops. If at any time the opposite direction button is pressed, the circuit for the latch in the current direction is broken and the circuit for the new direction is enabled. This is all controlled by the combination of the normally-closed and normally-open contacts on the bottom of the palm buttons. If the button corresponding to the current direction is ever pressed while the desk is moving, there is no change.

The emergency stop is comprised of two limit switches, which are placed under the table between the two drawers. There is a panel, to hold the place and keep a constant horizontal line with the bottom of the drawers, and a bottom base which connects to the back of the desk via a hinge. This panel prevents the possibility of injuring the knee on one of the drawers, and serves as an emergency stop if the down button is pressed while there is still something under this area. If this situation were to occur, the desk would start to slide down and once the object, such as a wheelchair or knee, pressed up against this panel, the limit switch would be triggered and the descent would stop. Special care was taken to allow for adjustment of the level of the panel and of the sensitivity of the limit switches.

The cost of parts and materials was approximately $1200.

Fig. 15.26. Schematic of Desk.
MULTIPLE SENSORY LIGHT PROJECTOR

Designer: Michael P. Montagna  
Supervising Professor: Alan Rux  
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Lowell, MA 01852

INTRODUCTION
The Multiple Sensory Light Projector (Fig. 15.27) was designed to provide visual and auditory stimulation to children with disabilities. Each of the three outputs from a three-channel audio equalizer trigger one of three display circuits, causing a pattern of lights to appear when a preset magnitude is achieved.

SUMMARY OF IMPACT
The Multiple Sensory Light Projector is to be used in a multiple sensory room, an environment in which an individual can explore and learn through sensory stimulation. This device is meant to supplement auditory and visual experiences.

TECHNICAL DESCRIPTION
The Multiple Sensory Light Projector is basic in construction. Packaging began with a white polymer cutting board, normally sold for culinary purposes, attached securely to a shallow box, which houses the power supply, circuitry, and display elements.

The circuit began with a simple 3-channel audio equalizer. As the audio signal passes through, it is split into three frequency ranges. Each stage of this element has a variable resistor on it to determine the amount of signal allowed to pass through each channel.

The output signal of each channel is then passed on to a vu meter, or level meter. The greater the amplitude of the signal the more outputs are turned on. In this case, because of the IC, five levels were chosen. The signal that comes from the second level of the vu meters activates a relay, which in turn activates the appropriate channel of the display.

The total cost of this project was approximately $80.
Fig. 15.27. Multiple Sensory Light Projector.
WIRELESS LEARNING DEVICE

Designers: Nestor Matias
Client Coordinator: Marie Haggerty
Client: The Shore Educational Collaborative School
Supervising Professor: Alan Rux
Computer and Electrical Engineering Department
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INTRODUCTION
The goal of this project was to build a fun and easy-to-use learning tool to help children with developmental language and cognitive challenges independently identify pictures (see Fig. 15.28). The device is a wireless base made up of five primary components: a receiver, a transmitter, a jellybean switch, a monitor, and a Basic Stamp 2.

SUMMARY OF IMPACT
The device provides independent practice in picture recognition and labeling. It allows the children to participate more in the classroom, provides more learning time, and requires less dependence on teachers.

This device was designed to be laid on top of a student desk, allowing it to be used by many users. Its design allows for easy removal (see Fig. 15.28 and 15.29).

TECHNICAL DESCRIPTION
Once the jellybean button is pressed a binary signal is sent to the encoder. The encoder decodes the binary signal, converts it into a square wave signal, and sends it to the transmitter. The transmitter sends a sine wave signal to the receiver. The receiver converts it into a square wave and sends this signal to the decoder. The decoder converts the signal to a binary code, which is then sent to an input pin of the Basic Stamp 2. The Basic Stamp 2 outputs a voltage of 5V to the input of the solid state relay. The relay outputs a voltage of 120V, illuminating the bulb, which is programmed to automatically shut off after 5 seconds. Components and wiring are shown in Fig. 15.30 and 15.31.

The cost of parts and materials was approximately $235.
Fig. 15.30. Learning Tech.

Fig. 15.31. Learning Tech
INTRODUCTION
This project is designed to allow remote control of 120V AC electrical outlets using a computer or other serial-capable device as a controller. It consists of two devices, the controller, and the power strip, which are connected wirelessly. The project was created for a man with cerebral palsy who uses a full-body wheelchair and interacts using a specialized computer, called the Vanguard, which is mounted to the chair. It allows him to turn lamps, fans, and other devices on and off at the touch of an on-screen button. Additionally, a nurse call button is implemented, because the client cannot use the standard hospital hand button. Calling a nurse may be accomplished with an on-screen button as well. The project is intended to provide the client with simple switch control of any appliance from his chair.

SUMMARY OF IMPACT
This project increases the client’s independence. Before this project, the client needed an aide to turn appliances on and off in his room. There was no way for the client to call a nurse if he needed one. Now, with these devices, the client can live a more self-sufficient life by controlling his own environment. He is also afforded extra safety, in having a method of calling a nurse from his chair.

TECHNICAL DESCRIPTION
The remote-controlled power strip is designed with flexibility in mind. Rather than anchoring a single unit to the wheelchair and forcing appliances to be located near the chair, the design incorporates radio frequency (RF) communication between two devices, freeing the controlled appliances from the chair. Additionally, rather than hard-wiring appliances to a switching controller, the project uses the interface of 120V AC outlets to support the maximum number of appliances and to allow easy configuration and replacement of the appliances. A block diagram is shown in Fig. 15.32.

The two devices communicate in a master-slave relationship. The master controller is connected to the Vanguard computer mounted on the wheelchair, and accepts commands from the Vanguard over an RS-232 serial connection. It interprets the command, and sends out an equivalent command over a serial RF link. A MAX232 level-converter IC is used to match the +/-12V levels from the serial line to the 5V/0V TTL levels supported by the processor. The master device is powered by an external battery pack of 7.2V at 2 amp-hours, which is internally regulated to 5V by a 7805 regulator IC. The case features two DB-9 serial ports, which allow pass-
through so that the device may be placed in serial between the Vanguard and an external PC (a common mode of operation for the Vanguard).

The slave device receives these commands over RF, and accordingly switches power on or off to one of its outlets or to the nurse call switch. It is built using a six-outlet power strip. The power strip on/off switch controls power to the slave device, which incorporates its own power supply built from a transformer, rectifier, capacitor, and the 7805 regulator. Internally, solid-state relays are used to control power flow to the power strip outlets, and two N2222 power transistors are used to drive the solid-state relays from TTL levels. A magnetic relay is used to control switching of the nurse call switch, which is interfaced with two ¼” mono jacks connected in pass-through configuration so that a traditional hand switch may be used for nurse call as well.

The devices are both built around the PIC16F687 microcontroller IC. The PIC16F687 is used to support asynchronous serial I/O and general purpose, one-bit I/O. In conjunction with the PIC, this project uses the Linx LR series of RF serial transmitter and receiver, and the Linx “Splatch” surface-mount antenna. The RF circuitry requires custom-printed circuit boards, which were drawn and etched by hand. Other circuitry was wired on prototyping boards. Enclosures for the two devices are plastic, to allow maximum transparency to the internal antennas. All components are shown in Fig. 15.33.

The cost of parts and materials for this project was about $200.

Fig. 15.33. Project Components.
SENSORY TOUCH AND SPEAK TOY FOR CHILDREN WITH MULTIPLE DISABILITIES

Designer: Royal Rowland
Client Coordinator: Marrie Haggerty, Shore Collaborative School, Chelsea, MA
Supervising Professor: Donn Clark
Department of Electrical Engineering
University of Massachusetts at Lowell
Lowell, MA

INTRODUCTION
A toy was designed for a multi-purpose educational agency serving students and adults with disabilities (Fig. 15.34).

The goals for the Sensory Touch and Speak game were to create a game that would teach students (ages 5-7) about different weather scenarios, while at the same time increasing dexterity and range of motion. The toy has six buttons, each with a different weather theme (sun, wind, rain, snow, moon, cloud). When a specific button is pushed there is an audio response, such as “cloud.” There are two modes selectable by the teacher, which includes “touch and speak” mode and “button search” mode. “Touch and speak” mode allows the student to press buttons at random and “button search” mode will ask students to find a button and then issue an audio response that tells them they have found the correct button.

SUMMARY OF IMPACT
The design, shown in Fig. 15.34, provides a touch and speak game for children with mild to severe cognitive disorders. The game was designed to be modified to fit any number of circumstances, using removable buttons and replaceable button covers.

TECHNICAL DESCRIPTION
The toy consists of four main components: 1) the box, 2) the “brains,” 3) the “voice,” and 4) the human interface. The internal components are shown in Fig. 15.35. For the project box the Pactec KE-20 series keyboard style project box was chosen. The reasons for this choice were the simplicity of modification, smooth plastic corners (safety), surface area (large buttons), and cost (around $40). For the “brains”, the 16F877 Microcontroller is used because of its versatility and because it requires almost no support circuitry. The controller has over 30 I/O pins and 7 analog inputs. Each I/O pin is controllable on the fly using software. The 16F877 uses flash memory (erasable), which is 8K x 14bits wide. For the “voice”, the Emic Text-to-Speech module was used. The Emic is easily interfaced to any TTL microcontroller that has two serial I/Os. Based on the Winbond WTS701, this device intelligently handles values, sentences, numbers, and common abbreviations using a natural female voice with simple serial string sentences. For the human interface soft touch buttons were used. The soft touch buttons used were supplied by the school. They are 2.2” x 3.2”. Each button contains a different weather picture (i.e. sun, moon, wind, rain, snow, and clouds), and when the student touches the button the game responds with an audio playback message. Each button was mounted so that it could be removed and cleaned.

Fig. 15.34. Completed Project.

The cost of parts and materials was about $170.
Fig. 15.35. Interior of Completed Project.
STORY BOX: A DEVICE WHICH USES A JELLYBEAN BUTTON TO RECORD AND PLAY MESSAGES

Designer: Ruvani Nagage
Client Coordinator: Susan Yackolow (Speech Therapy Assistant), New England Pediatric Care, North Billerica, MA
Supervising Professor: Jay Fu

INTRODUCTION
The Story Box was designed for individuals with learning and speech disabilities who also have minimal usage of their hands (Fig. 15.36 and 15.37). There are about six patients (all in their teen years) who will benefit from the project. The Story Box is a plastic box with a jellybean button on the top. There is a reset button, a power switch, and a mode (play/record) switch on one side of the box. It is activated and used by pressing these buttons. The contents of each page of a certain storybook are vocally recorded into the system as separate segments. For this project six segments were chosen with duration of 30 seconds each. Each story chosen...
The Story Box consists of a jellybean button, power switch, play/record switch, and reset button. The total recording time for the box is 3 minutes. These 3 minutes are given by two ISD chips (25.120). This time period was divided into 6 segments, 30 seconds each. These segments are controlled by a Basic Stamp 2. The button activates the segments, one after the other. The amplifier increases the volume of the contents being played.

The button is pressed to activate the first segment of the Story Box. This first segment is stored in ISD chip #1. Pressing this button again leads to the second segment, which is also in ISD1. Pressing the button 6 times will progress from segment 1 to segment 6. Segments 1, 2, and 3 are stored in ISD chip #1 and segments 4, 5, and 6 are stored in ISD chip #2. Logic 1 signal is then sent to Basic Stamp 2, which recognizes the voltage and analyzes it through a program. After running through the program this signal is sent to the input pins of the ISD25120 chips. The segment it is on decides which ISD chip to send the signal to. The ISD25120 chip then determines whether the system is in the recording mode or the play mode. If in play mode, the signal is amplified using an LM – 386 Driver Amplifier that goes out through a 16 Ω speaker and an audio output is received.

When the system is in the record mode, a stereo microphone is used to record audible data. When the recording is to be done, the button must be kept pushed down and the above signal cycle occurs through the Basic Stamp and then one of the ISD 25120 chips (depending on what segment is being used).

There is a reset button to take the user back to segment 1 in both the record mode and play mode.

The cost of parts and materials was about $400.
INTRODUCTION
Voice recognition was added to an intercom and camera system for a woman with quadriplegia. Each system was designed to be positioned at her bedside so that she can view and communicate with anyone in her home. She also has the ability to answer her front door and view her front doorstep. The project consists of two systems that work independently of one another. The camera system uses technology created by X10. The X10 system uses a home’s already existing power lines to send “on” or “off” signals to each camera. The video is sent over a wireless signal to a receiver. Currently, the X10 does not offer a voice activated camera system. The remedy to this problem was the application of Sensory’s VR Stamp in the development of a voice recognition circuit. To create consistency between the camera and intercom systems, another VR Stamp was used in the development of a voice-activated intercom.

SUMMARY OF IMPACT
The client lives alone. Since she lacks the ability to move freely, she cannot check her surroundings for potential threats. The completed camera and intercom systems (Fig. 15.38) alleviate this problem. She can now view each area of her home as well as view any activity at her front door. She can also choose to communicate with anyone she sees in these areas. This results in a safer environment that also allows her to answer the front door and welcome anyone into her home. When her caretaker is present, she also has the ability to communicate with him or report any emergency. An overall increase in quality of life is a great advantage of this project.

TECHNICAL DESCRIPTION
The VR stamp was implemented into the X10 camera system to interface the VR Stamp with a BASIC Stamp and RF transmitter. An applicable C program was written. It calls upon a library of voice recognition sets created using Sensor’s Quick T2SI software. This powerful software allows the designer to create voice sets by simply entering text and then later adjusting the pronunciation of each word. The main task of this project involved learning how to program the sophisticated VR Stamp. A vast array of macros and technical library files had to be created along with specialized functions that served the purpose of the camera and intercom systems. This included integrating error codes into the main program that optimized the recognition of a woman with a potentially frail voice. This program was then compiled and downloaded onto the VR Stamp using a specialized programming circuit board. Once the VR Stamp was set to issue signals by voice command, the BASIC Stamp then read those signals and handled the camera addressing by determining which device had to be activated and issued the corresponding command code to the RF transmitter. Following the
X10 transceiver’s protocol, the BASIC Stamp was programmed using the PBASIC language. The cameras are then controlled by X10’s transceiver, which reads the RF transmission and sends the appropriate signal to each camera over a home’s already installed electrical wiring. The camera system circuit is shown in Fig. 15.39.

A second VR Stamp was then embedded in a set of wireless home intercoms. Using the intercom’s own DC power to power the VR Stamp, a network stemming from the VR Stamp’s IO lines are then used to trigger the intercom’s paging functions. As with the camera system, a voice recognition set was created, called upon and manipulated by a C program, and then compiled and downloaded on to the chip.

Each system met its voltage requirements using AC to DC adaptors and LM317 voltage regulators. The sensitivity of each microphone was adjusted to remain consistent with the frequency response generated by a human voice at arm’s length.

The total cost for parts and materials was $673.

Fig. 15.39. Camera System Circuit.
SOUND ACTIVATED BUBBLE

Designer: Sergi Valme
Client Coordinator: Bonnie Paulino, Kennedy Day School Program
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INTRODUCTION
A sound activated device was designed to entertain children by generating bubbles whenever it is activated by a sound. The circuit operates on a 12-volt DC power supply. The activated switch turns on, either by clapping hands, or by any sound. It turns off after a time delay. The sound is picked up by the microphone, which feeds it to the amplifier. The amplified signal is fed to the two diodes, which function as half-wave voltage doublers to produce 12-volts at the output. A potentiometer could dramatically reduce the sensitivity. The device is shown in Fig. 15.40.

SUMMARY OF IMPACT
The goal of this project were to entertain and demonstrate cause and effect.

TECHNICAL DESCRIPTION
The box (see Fig. 15.41) is made of wood with clear polish. Components include: the sound activated switch, the music generator, the color-changing bubble light, the power surge protector, and all the wiring connections, all on the same board.

CONCLUSION
A 12-volt DC adapter powers the overall circuit. The bubble tube is made of a clear plastic. A strong base, which is made of wood, supports it and it is almost impossible to flip over. The voice activation is suitable for the project, and it includes the option of adjusting the sensitivity of the sound.

The cost of parts and materials was about $180.
Fig. 15.41. Box.
HANDS-FREE BALLOON INFLATOR SYSTEM

Designers: Wen Lu
Client Coordinator: Lisa Szewczyk, Nashua Center, NH
Supervising Professor: Prof. Alan Rux
Electrical Engineering Department
University of Massachusetts at Lowell, Lowell, MA

INTRODUCTION
The Hands-free Balloon Inflation System (HBIS) is an automated balloon inflation system designed to help people with disabilities to easily inflate balloons (see Fig. 15.42 and 15.44).

This automated balloon inflation machine starts to fill helium by simply one push of a button. When it detects that the balloon has been filled with enough gas, it immediately stops the process by shutting down the valve. The HBIS can automatically save and load the helium filling time pre-set by the user for different balloon types (volumes).

Upon completion, the HBIS was presented to a person with a disability who owns a balloon business but cannot handle typical balloon filling tools. This project will help him conduct his business more independently and enhance his self-confidence.

SUMMARY OF IMPACT
The user of this system is a person with a disability, and it is difficult for him to operate a complicated machine and quickly respond to the upcoming state change. The balloon inflation uses a swift gas flow from a high-pressure helium tank. The gas flow must be shut off immediately when the balloon has been inflated to an appropriate volume, otherwise the balloon will be overfilled and explode. The device automatically stops the gas when inflation is complete. The system saves and recalls the inflation time length for different balloon types, so that the user does not have to figure out the inflation time for a different balloon again when a new type (volume) of balloon is to be inflated.

The elapsing inflation time is shown on the screen to tell the user how many seconds are still left to inflate the balloon. The user can interrupt the inflation process any time by pushing a button. This function is useful in an emergency state, or when the user is trying to inflate a new type of balloon and does not know how long the inflation should be.

TECHNICAL DESCRIPTION
Fundamentally, HBIS has an integrated structure with electrical and pneumatic subsystems (see Fig. 15.43). It runs the application program written in PBASIC language on the Parallax Basic Stamp 2e microchip, receives the user input through 4X4 Matrix Keypad, as well as on-board and wired buttons, and outputs system internal states (inflation seconds countdown, etc.) and messages (error, input, prompt, etc.) to the user through a 2X16 Parallel LCD display. It starts the balloon inflation process by driving a relay to energize the solenoid valves, which let the helium gas flow through and fill the balloon.

The electrical subsystem is composed of the Basic Stamp 2e-IC and Super Carrier Board, 4X4 Matrix Keypad, a 74C922 encoder, 2X16 parallel LCD display, a relay driving power regulator, and peripheral circuits. The pneumatic subsystem has two solenoid valves and brass tubes, corners and valve fittings. The Basic Stamp 2e-IC and 74C922
encoder, power regulator, relay, and LCD input resistance arrays are located on one board, and the amplifier circuit to drive the relay, the relay itself, and solenoid valve power supply connections are on the peripheral board. The LCD and keypad are fixed on the front panel of the machine, while the start button, valve select button and reset buttons are also on the front panel. The pneumatic assembly is installed at the rear of the box with a tube outlet passing through to connect to the helium gas supply.

The Basic Stamp microchip (BS2e-IC) is the kernel of the entire system. The four data output lines and data available line of keypad encoder 74C922 are connected to the 4 input ports of BS2e-IC and they are scanned when data available input is high, to get the key code (0 to 15) pressed. BS2e-IC has 4 output lines to send the high and low character to be displayed on the LCD, and also controls the LCD instruction or text mode read/write. BS2e-IC outputs a digital high signal to the input of the amplifier circuit, which is used to drive a relay to connect the 12 volt DC power supply to one of the two solenoid valves. There is a valve selector switch to enable one valve (for latex or foil balloon) at a time. A big round start button is used to issue a pulse signal to tell the BS2e-IC program that the user is starting the inflation.

There is also an emergency reset button located on the front panel connected to the reset input of the BS2e-IC, which is used to reset the software program. When the program resets, all output is pulled down to low level voltage, stopping the relay and power to the solenoid valve thus restoring it to a normal closed state so that the helium gas flow is shut down.

The cost of parts and materials was about $262.
INTRODUCTION
The Wireless Pitching Machine (Fig. 15.45) was designed to provide sensory stimulation and social interaction for children with limited motor skills. This device is a modification of a commercially available pitching machine. A wireless controller, featuring large, easy-to-use buttons, was designed for the operator to pitch various types of pitches (curveball, fastball, etc.) to the batter. Upon completion, the pitching machine was presented to a client with poor motor skills who enjoys sporting events. With the help of this machine the child can pitch baseballs to his brother and participate in a league for children with special needs.

SUMMARY OF IMPACT
The design criteria for the pitching machine were defined by the capabilities of the client. He and his family desired a device that would allow the client to pitch baseballs to other family members.

TECHNICAL DESCRIPTION
The Wireless Controller
A plastic box was used as the housing for the wireless controller. The box was painted black to disguise the electric wiring inside. Velcro was used to hold the battery pack in place, yet provide accessibility to change the battery in the future. Holes were drilled into the box to screw the jellybean buttons down and to allow the cords to run back inside the box. Metal standoffs were then screwed into the box to secure the circuit board. Finally, a hole for the transmitter antenna was made while a nut fastened it in place.

A battery pack containing four AA batteries provided the power for the wireless controller. The 12V setup featured an ON/OFF switch to conserve power when the machine was not in use. This battery pack was chosen because it uses standard AA batteries that can be easily replaced. Since the circuit consumed less than 70mA, this set-up was more than adequate. To distribute the power, a 5V voltage regulator was used to provide the correct voltage values for the logic circuitry.

A four-input encoder (HT-12E) was used to select the motor speed via an antenna (TWS-434). When the red button was pressed, the motor changed to speed 1, and a left curve was thrown by the machine. When the yellow button was pressed, the motor changed to speed 2, and a fastball was thrown.

The Pitching Machine
The pitching machine had to be modified. The plastic box for the motor control had to be raised up 4 inches to allow room for a new circuit board. This was done by cutting four pieces of metal tubing 4 inches in length and using them as spacers between the plastic motor control box and the machine itself. Four long screws were then run through the tubing to reattach the box to the machine. To cover the open space left by the spacers, four pieces of heavy duty black cardboard were cut to the appropriate shape and glued into place. Black was chosen to match the rest of the machine. Finally, a hole for the receiving antenna was made on the top of the box while a nut fastened it in place.

A 12V deep cycle battery was used to power the pitching machine. This type of battery could be discharged completely and recharged many times without damaging the battery. Also, these batteries have a higher rating, meaning that the machine can run for a few hours before needing a recharge. To distribute the power, a 5V voltage regulator was used to provide the correct voltage values for the logic circuitry.

To change speed, the antenna (RWS-434) received a signal from the wireless control box and output the signal to the decoder (HT-12D). If the signal was
valid the LED would momentarily light. This light was used to verify that an RF signal was being transmitted.

The motor control chip was originally controlled by a mechanical knob. The connections to the knob were broken so that the decoder would control the motor speed instead.

The decoder was also used to tell the carousel when to spin, allowing a baseball to be rotated into the launch chamber of the machine. A timing circuit is triggered by the decoder every time a valid signal is received from the antenna. However, the timing circuit must be triggered by a logic 0 when pin 17 outputs a logic 1. To invert this signal, a multiplexer was recruited.

To rotate a baseball into the launch chamber, a 555 timing circuit was used. This circuit is activated when a valid signal is sent to the decoder and inverted by the multiplexer. A TIP31 transistor then provides the power to rotate the carousel motor to spin for about eight seconds, enough time for one baseball to rotate into the launch chamber.

The cost of parts and materials was about $750.
INTRODUCTION
HandiTalk was designed to be a communication and typing program for individuals with speech and physical impairments. One of its main features is ease of use. HandiTalk is a two-part system. The first part allows the user to type on a computer with look-ahead word selection features, or select preprogrammed messages from pictures (Fig. 15.47). The second part allows the user to have the computer speak the typed text or the requested message of the pictures for better communication.

SUMMARY OF IMPACT
The client can generate speech via HandiTalk. The product takes less than five minutes to learn to operate. It is easy and efficient for most patients with speech impairments to learn and use.

TECHNICAL DESCRIPTION
The input device is made from a momentary switch button. It is connected to a RS232 cable. HandiTalk software monitors the state change of the host computer RS232 port. Every time the button is pressed down, the highlighted item on the screen is selected. The computer then generates speech corresponding to that item.

The software has interfaces for the patient and the administrator. The administrator has the ability to control what the patient sees. The patient interface contains the Pictures and the Letters section. The Pictures section enables the patient to select from a table of pictures. The Letters section lets the patient spell out words to construct a sentence. The user can then choose to have the computer generate speech.

The hardware, cost of parts, and materials was about $21.
Fig. 15.47. HandiTalk Displays.