CHAPTER 19
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INTRODUCTION
The Variable Height Adjustment Wheelchair modification project involved a boy who has a severe case of cerebral palsy. The 10 year old, named Ben Young, lives and functions in a “normal” environment; however, he is unable to access things that are beyond his reach when he is seated in his wheelchair.

The wheelchair itself was a Jaguar model made by the INVACARE Corporation. The wheelchair is fully motorized and Ben is completely capable of operating the wheelchair without assistance. The object of the design process was to enable the child to raise and lower his chair in order to reach objects normally obtainable to a standing person. The modified chair needed to be stable in the uppermost position to ensure that tipping would not occur as the user reached for objects. In addition, the new feature needed to be easily accessible to a user having limited hand coordination.

The goal of the designers was to provide this modification in order to afford Ben greater independence during his daily tasks without changing the basic structure of the wheelchair. The primary constraint of the design was the implementation of the variable height adjustment device given the limited area (14” by 14”) beneath the chair.

SUMMARY OF IMPACT
The Variable Height Adjustment Wheelchair has allowed Ben the independence that he yearned for. He is now capable of reaching everyday objects such as a drinking glass or articles that have been placed on the shelving units in his room. He is no longer totally dependent on his parents to assist him in obtaining items that are slightly above the normal height of his wheelchair. Ben has gained the freedom that enables him to make a sandwich, since he can now reach the countertop, or to obtain things from the freezer. The addition to his wheelchair greatly improves Ben’s ability to access his environment and makes him feel more self-reliant.
TECHNICAL DESCRIPTION

A worm gear driven actuator system called a Telemag, produced by Magnetic Corporation, was chosen by the design team to be the best option of modification to Ben’s wheelchair. This system provides a retraction to stroke length ratio of 0.86. The retraction length is 13.5 inches and the stroke length is 11.5 inches. The system has a load capacity equivalent to 400 pounds and is DC operated. This is required since Ben’s wheelchair is powered by two DC batteries.

The Telemag is placed directly below the seat of the wheelchair. It is activated using a switch that was incorporated into the control panel of Ben’s wheelchair. By pressing the switch in the forward position, elevation occurs. To descend, the switch must simply be held in the opposite direction. This design allows Ben easy access to the control of his actuator and is simple enough for him to operate without great difficulty.

Once activated, it raises Ben to a height 11.5 inches above that of the normal seating position. Other structural modifications made to the chair ensure that Ben is not be harmed during the elevation or descent of the chair.

One safety consideration is the placing of tape switches in both armrests of Ben’s chair. This enables Ben to access the switch of the Telemag at all times. In addition, placing a microswitch between the seat plate tubes and the lower portion of the chair ensures that Ben cannot activate the Telemag and locomote at the same time. Hence, this reduces the chance of tipping while activating the Telemag by keeping the center of gravity of the chair low while locomotion is taking place.

During the activation of the Telemag, if the distributed load upon the tape switch is greater than 10 pounds, the switch will be employed and the Telemag will reverse its direction for 6 seconds, or 1.5 inches. In this way, the arm that Ben uses to activate the actuator cannot become trapped while he is activating the Telemag in the “up” direction.

Locomotion can only occur when the chair is in the lowered position. The center of equilibrium of the chair is offset when both elevation and locomotion occur at the same time. Due to this fact, it was felt that measures needed to be taken in order to ensure that Ben was unable to move his chair once elevation had occurred. To guarantee that this would not happen, a microswitch is placed between the upper and lower seat plate tubes such that the switch is opened during activation of the actuator; therefore restricting locomotion from occurring.

Several structure modifications were made to the frame of the Jaguar in order to enable the use of the Telemag. The front upright hinge plate tubes (footrest mounts) were removed. A support member was then placed directly behind their current location and...
a vertical solid footrest tube guide was placed in the current position of the front upright hinge plate tubes. These modifications stabilized the new hinge plate tubes. The rods were necessary because of large forces placed on the footrests, which are commonly used to open doors. The large forces on the footrests are distributed over the length of the new hinge plate tube-rod assembly. The hinge plates are connected to the seat tubes in order for the footrests to be elevated along with the seat. This stabilizes the positioning of Ben that enables him to lean forward when in the chair without risk of losing his balance while in the elevated position.

Figure 19.3. Cross section of the arm rests with the tape switch.

Figure 19.4. The microswitch as positioned on the support tubing.

Figure 19.5. Footrest modification.
The implementation of the system included structural modifications, additional mounting plates for the Telemag, a "safety circuit", tapeswitches in the armrests, and a microswitch to detour locomotion while in the elevated position. Excluding any engineering labor costs, the total cost of the chair was $3,101.47. This is less than 20% of any similar product now on the market.

Figure 19.6. Wheel chair frame and modifications in the standard and elevated positions.
INTRODUCTION
The Card Turning and Display Device, an electromechanical system, is a visual communication device designed to be applied in the educational process of mute students with both cognitive and motor impairments. The mechanism can be operated in an automatic or manual mode dependent on the recognition abilities of the user. Conditional to the number of cards chosen to display to the student, the device may be utilized to present answers from 8 to 48 questions without having to reload the unit.

SUMMARY OF IMPACT
The design was implemented to reduce the required time for a teacher to display and discard several pictorial answers to a question. It enables the instructor to ask a question, start the unit, and attend to something else while awaiting the student’s answer.

The Card Turning and Display Device allows the gradual increase in the number of options made available to the student and increases the communication spectrum of the user.

Figure 19.7. The Card Turning and Display Device While Being used by a Student.
TECHNICAL DESCRIPTION
The operation of the system is dependent upon a Motorola 68HC811E2FN mini board. Equipped with 4 DC motor ports, 8 analog inputs, 8 digital inputs, 4 programmable counter inputs and 5 timer outputs, the board controls the many changeable inputs to the system. There is a possibility of 1 to 6 cards being classified in a set together. The cards are consecutively displayed until the specified number in the set is reached, the system then relocates the rotational arm and the first card is displayed again. The unit relies on input from the student to decipher if a decision has been made. When in the manual setting, input from the student’s paddle switch signifies that a new card needs to be shown. As long as the student continues to apply pressure to the paddle switch, another card is displayed. However, if the student refrains from pushing the paddle switch, a time delay of 20 seconds runs and “It’s a Small World” is played to let the instructor know that a choice has been made. In the auto setting, the cards consecutively display until the paddle switch is pressed and the music is played.

Other electronic components of the device include a 24-volt power supply utilized in supplying power to all components contained in the unit. A driver board for the stepping motor is connected to the microprocessor. It controls all movement of the stepping motor by sending it the proper firing sequence. A Schmidt’s trigger circuit is utilized for the debouncing of the input buttons and a BCD conversion circuit was implemented to allow the display of the chosen question number to two seven segment LED displays. Finally, a priority encoder is used to read the position of the six position switch being utilized to input how many cards are to be in a set and a voltage divider circuit is needed to operate the music box at the proper voltage setting.
INTRODUCTION
A Pace Monitoring Feedback System was designed for a 14-year-old student with Cerebral Palsy. Having difficulty maintaining a constant pace level, the student has tendencies of decreasing the pace of his walking. As a part of his training program, he needs to continue to maintain the pace he is traveling and over a period of time, increase the speed of his pace as his motor control functions become more developed. The dishing provides the student with positive feedback to alert him as soon as his pace falls below a desired level, and motivate him to maintain a constant and adequate pace. Attached to a Walkman, the device allows the student to listen to his favorite tape while walking. However, when his pace becomes insufficient, the tape turns off and until he reaches the appropriate pace again, it remains off.

SUMMARY OF IMPACT
Several available pedometers and stride control units were evaluated at the beginning of the design process. Unfortunately, most are only applicable for jogging and exercising use. They are units placed directly on the extremity and are virtually impossible to read without bending over. This is not feasible for the legally blind project student who has difficulty with balance outside his vertical plane of motion.

TECHNICAL DESCRIPTION
A subminiature microswitch is the controller of the design. It implicates the pace of the student’s steps by...
reacting when each one is taken. It is waterproof, dust proof and has a lifetime of $1 \times 10^7$ operations. It is placed directly on the shoe of the student along with an adjustable mechanical system that ensures the switch placement against the floor regardless of the type of shoe worn. The transmitter is an already assembled unit purchased from Home Control Concepts and has dimensions of $1 \times 5$ inches. Two separate receivers obtain the transmitted signal from the student’s ankle device. The receivers are both normally open switches and control different mechanisms. One is located along with a Walkman at the waist of the student. A 555-timer circuit is used to determine the powering of the Walkman. In the absence of a pulse, the output from the timer circuit is low resulting in a Walkman that is not turned on. When a pulse is received, the Walkman plays for the student. The second output is transmitted to a remote monitoring system on the desk of the teacher. This allows the educator to monitor the student’s progress without being physically with him. The circuitry in this unit drives a display. With a CMOS 4013 dual flip flop and a CMOS 4012 dual NAND gate, an LED is lit. This signifies to the teacher that the student is in motion in the hallway.

![Figure 19.1](image)

**Figure 19.1 1.** a) The 555 timer circuit utilized in controlling the music source. b) The timing diagrams for the circuit elements.

![Figure 19.12](image)

**Figure 19.12.** The Circuitry for the Remote Monitoring Device and the Timing Diagrams for its Elements.
Computer Canopy

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INTRODUCTION
A computer canopy was designed to minimize the distractions existing in the classroom environment at Gorman Public School. In order to effectively teach any student, especially a multi-handicapped individual, the attention span must be maintained. Several problems encountered when using the computer as a teaching aid for the students. The canopy is used as a sheltering mechanism to remove the students from the main classroom and give them no other alternative than concentrating on the computer screen. For the non-verbal students of the class, the computer canopy is used to stimulate the student's awareness of their surroundings. These students are unable to yet function at a high enough level in order for interaction to take place with the computer. Reaction of the child in the closed environment created by the canopy provides valuable feedback that may be evaluated by the teacher. The direct application of the stimulus/response format of the canopy allows the instructor to assess exactly what signals that the students respond.

SUMMARY OF IMPACT
The computer canopy allows a student to be somewhat removed from the classroom environment. By sheltering the child from the outside, it leaves them nothing else to focus on but the computer screen. This enhances the productivity of that particular learning aid and quickens the comprehension rate of the child. The canopy has been found to decrease the redundancy of required explanations.

When the system is utilized as a tracking device, the educator is able to monitor the stimulus the child responds. This is helpful in finding which position of outside information is optimal for a specific child. For instance, a child responding much more attentively and quicker to information presented to the right rather than left side of the body, should be approached and instructed from this location. Presenting the student with stimulus from a weak point in their receptive are, and rewarding acknowledgments to this stimulus has also succeeded in widening the range of recognition of the child.

Figure 19.13. A student inside of the Computer Canopy. The teacher is able to control the powering of the lights through the remote control in her left hand, while observing the reaction of the student.
TECHNICAL DESCRIPTION
As shown in Figure 19.14, the partition was created from five panels of plywood. These panels are quite heavy. The weight of the unit ensures that a force from the child, such as running into the unit or hitting it, does not modify its position. Stabilizing the canopy further is a turning foot located on either side. This brace is turned and locked into position to detour the possibility of the entire unit being tipped over. Several options were considered when choosing this part of the design. The ratable foot was chosen for its low profile and ease of use. The foot is simply snapped into place and does not pose problems of tripping as it lies flatly on the floor during use.

The canopy can be collapsed to a storage position. This results 47" of width that is capable of being stored against a wall.

The control of the LEDs in the canopy is located behind the first panel on the left side when addressing the unit from the front. It has a remote that enables the teacher to present the child with stimulus and view their reactions accordingly. The LEDs are strategically placed at a level approximately 50 inches above the floor. This height was chosen from an average of measurements of the participating students while seated in their wheelchairs. The student of the greatest height is still forced to move his head when reacting to the stimulus. The position is also based on the upward placement of many of the students suffering from Cerebral Palsy. A variety of red, green, and white lights are available.

The entire system is manufactured for $300. Designed of plywood and paneling, the unit is painted a light blue color. When using the canopy, it rests on eight padded feet directly on the floor. Wheels are incorporated into the base of the canopy to allow ease of movement when it is in its collapsed position.

In designing the computer canopy, safety of the student was the main concern of the engineers.

Figure 19.14. The Computer Canopy.
Adjustable Tilt Board

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INTRODUCTION
An adjustable tilt board was designed for physically disabled students at Gorman Public School. Due to a limited range of motion the students are unable to write or read articles located on a standard desk or tabletop. The adjustable tilt board provides a continuous range of tilts from 0 to 75 degrees that allows the student to be presented with an article at eye level.

Prior solutions to the problem include stabilized tilting panels utilized in two possible positions. A 20 or 70 degree slant is available. This apparatus lacked the stability necessary for the children who have tendencies of applying large loads on the board when attempting to write.

The Adjustable Tilting Board, which was implemented, is light in weight. It is able to be utilized at a wide variety of angles and is stabilized to detour tipping. It may be used as either a display board or a writing surface.

SUMMARY OF IMPACT
Students with motor impairments find it difficult to accomplish everyday tasks. Physical disabilities limit the arm and hand placement of students, and make it inconvenient for writing. With the adjustable tilt board, angles of 15, 30, 45, 60 and 75° are utilized. With all of these options available, the board is easily utilized as a display board. It has also created a more optimal placement of the arm and hand for students who are writing.

The increased stability of the design has reduced the workload of the teacher. The Display Board is self-supporting and can withstand 35 pounds of force without encountering any structural problems. The board is designed of wood, giving it a light weight which permits the educational instructor to easily move the unit but also makes it heavy enough that students are unable to move the board when applying pressure in order to write on its surface.

Figure 19.15. The Adjustable Tilting Board enables the student to view assignments with greater ease.
TECHNICAL DESCRIPTION

Two panels connected by hinges create the adjustable tilt board. A slotted baseboard is used to obtain the five angle settings. Figure 19.16 shows the distance away from the fulcrum that the braces are located in order to obtain the various angles. The display board itself is 18 inches long with a clip on the top to hold papers. A book support and clamber were placed on the board as well.

Engineering analysis was performed on the system during the design process. It is required that the system be strong enough to withstand the pressure being applied by a student who is writing as well as one utilizing the board to hold papers or a book and pointing to chosen pictorial answers. The system not only needed to be strong enough to withstand the pressure being administered, but also must be able to remain stable if a student is to lean forward onto the unit. A uniform load is assumed on the tilt board and bending.

Following the calculations of all force factors, a safety factor 1.3 was incorporated into the design of the adjustable tilt board. The board is manually operated and no electrical components were incorporated in the design. The total cost of the unit was $24.47.

![Diagram](image)

Figure 19.16. The Adjustable Tilt Board.

![Diagram](image)

Figure 19.17. The Calculations of the Forces Required Ensuring the Stability of the Adjustable Tilt Board.