

CHAPTER 20

WAYNE STATE UNIVERSITY

Departments of Physical Medicine and Rehabilitation, Mechanical
Engineering
261 Mack Blvd
Detroit MI 48201

Principal Investigator:

*Bertram N. Ezenwa, Ph.D. (313) 993-0649
bertram_nworah@msn.com*

College of Engineering
Department of Electrical & Computer Engineering
5050 Anthony Wayne Drive
Detroit, MI 48202

Principal Investigator:

*Robert F. Erlandson, Ph.D., (313) 577-3900
rerlands@ece.eng.wayne.edu*

ADAPTED ASSESSMENT OF WORK INTEREST

Designers: Dan Li, Guanhua Zhao, and Vijay Gummadi

Client Coordinator: David Hardin

Jo Brighton Skills Center

Supervising Professor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

A center provides hands-on vocational training services for special education students between the ages of 15 and 26. In order to determine what type of vocational activities their students are interested in, staff members use a vocational interest test. The original test requires that the students select from a book the type of work that they are interested in and then pencil in their choices on a paper score sheet. This method of evaluation is difficult for many students. The students need staff to guide them through the book and then help them score their choices. The Adapted Assessment of Work Interest (AAWI) presents the testing material in a computerized format using visual scanning software and single-switch input, and then automatically scores each exam, reducing the need for constant staff assistance.

SUMMARY OF IMPACT

The AAWI allows students with disabilities to complete an assessment of their vocational interests independently. The program presents them with verbal and graphical directions and prompts, as well as the opportunity to use alternative input mechanisms. The system is based on an "error-proof" design, allowing students to work independently without the threat of making a mistake during the process, and it provides constant feedback to the students, which aids in maintaining their attention throughout the process. The students have responded favorably to the application, and the vocational evaluation process has been improved since refining the ability to identify students' interests.

TECHNICAL DESCRIPTION

AAWI was written in Visual Basic 5.0 and displays photos of different types of vocational tasks on the screen from which the user may select. The photos are displayed two at a time, and an automated on-screen scanning mechanism highlights them one at a

time as a voice prompt announces what job the picture represents (Figure 20.1 (Top)). After both pictures are displayed, a voice prompt instructs the user to select the job that he/she likes best. The user can select the highlighted photo using a mouse or hitting a single-switch. A touch screen window may also be used for user input. If the student has still not made a selection after five scanning cycles, a voice prompt reminds the student to make a selection.

As students work through the test, their selections are recorded in a database, which is used to generate a graph of each student's responses. Each vocation on the graph is assigned a different color to allow the instructor to easily tell one vocation from another, and the graph displays the student's responses in order from the greatest to the least number of hits (Figure 20.1. (Bottom)).

Staff may create a variety of session settings to meet needs of different students. Within each setting, staff may adjust the image scan time, image delay time, and the color of the highlight. While creating or reviewing these settings, staff may also view the pictures and listen to the audio files used by the software. If changes need to be made, AAWI allows staff to add new pictures and/or audio to the database.

In order to protect student records, AAWI provides user-level security for software access and student information. An instructor may only test and view the records of students assigned to him/her. AAWI also allows for the creation of new instructor and student profiles. Student profiles contain the student's first and last names, birth date, operating school district, disability code, assessment date, gender, and instruction identification number, while instructor profiles contain the instructor's name and ID number.

To function optimally, AAWI requires a Pentium-grade CPU with Windows 95, 98, or NT, a color monitor, a single-switch or touch-screen window (if a mouse will not be used), and computer speakers. If

staff wish to add or replace photos in the system, a digital camera or scanning device will also be necessary.

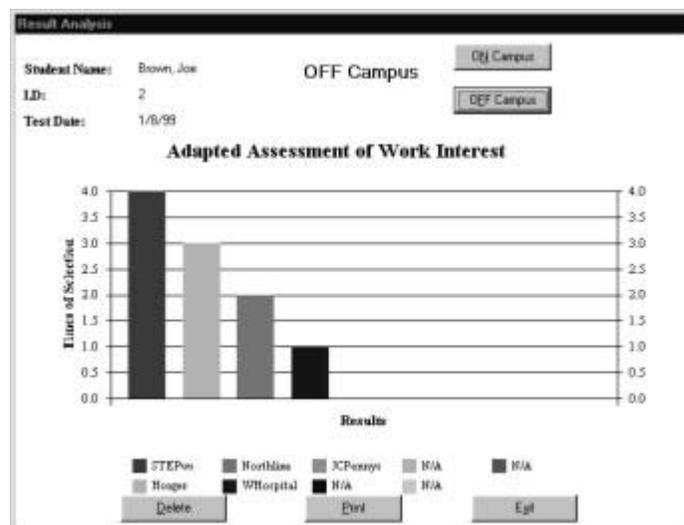


Figure 20.1. (Top) Two Different Vocational Tasks. (Bottom) Graph Showing the Student's Responses.

ADAPTED MANUAL RIBBON CUTTER

Designer: Vijay Gummadi

Client Coordinator: April Saval

Services to Enhance Potential (STEP)

Supervisor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

An agency provides supported employment services for persons with developmental disabilities. It is sometimes difficult to place successfully individuals with serious disabilities due to their skill level and/or inability to adapt to job tasks as required by the employer. One such task involves cutting heavy, industrial-grade ribbon to specific lengths. Before the intervention, a worker measured the ribbon manually with a ruler and cut it into 15" lengths with scissors. This method not only required a great deal of staff intervention, but it posed a danger to the worker. The design described here allows the worker to pull the ribbon from a spool to a clearly marked point on a wooden frame and cut it with an enclosed roller blade (Figure 20.2).

SUMMARY OF IMPACT

The Ribbon Cutter intervention reduces both the cognitive and physical requirements of the task; thus, the worker is able to work more independently than before with less threat of physical harm. The cutting device is completely enclosed in a wooden casing so that the worker cannot cut himself, and the length to which the ribbon should be cut is clearly marked on the wooden base of the device. With the length marked, the worker does not have to manipulate a ruler. Due to this intervention, the targeted worker has a competitive job in his community. Working allows the person to become a significant contributor to his community and follow in the natural transition from school to work. The ribbon cutter intervention has enabled this person to be more independent and presents another means of placing people with disabilities into jobs in their communities.

TECHNICAL DESCRIPTION

The Ribbon Cutter consists of a wooden spool casing, a roller blade and roller blade track set on a 30" x 12" piece of plywood. To meet the worker's needs, the spool casing was constructed to:

- Enable the user to replace easily an empty spool with a new one,
- Hide the amount of ribbon left on the spool,
- Offer sufficient resistance to the free flow of ribbon off of the spool, and
- Allow the user to roll easily excess ribbon back onto the spool.

To meet the needs of the targeted worker, the amount of ribbon left on the spool was blocked from view. Each time that the roll fell below approximately an inch in diameter, the user would stop working. With the spool covered, he works until the spool is completely exhausted.

With the ribbon spool in place, the user grasps the end of the ribbon and pulls it under the blade track to a plastic marker at the end of the wooden base. A rubber stopper on the bottom of the spool casing prevents the spool from unwinding freely and presenting the worker with more ribbon than he needs. When the ribbon is unwound to the correct position, a piece of Velcro™ holds the ribbon in place while the user rolls the blade down the blade track, cutting the material.

This method of cutting ribbon allows for consistently accurate measurements with minimal staff supervision. It is simple to use and maintain, and costs approximately \$70 for the materials and machining of parts.

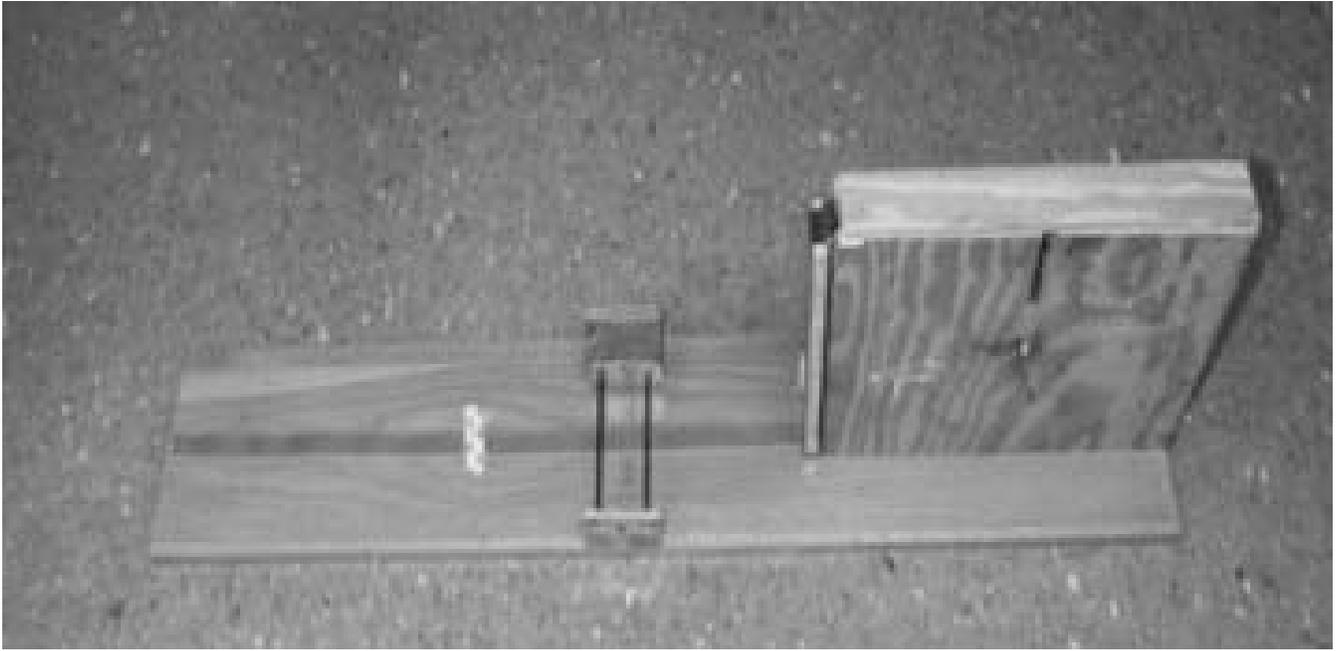


Figure 20.2. Adapted Ribbon Cutter.

INVENTORY CONTROL SYSTEM

Designers: Kurt Breault II, Fanie Ann Joseph, Anuj Saxena, Jason Stombaugh, and Vijay Gummadi

Client Coordinator: Chris Mason

Arenac Opportunities, Inc.

Supervising Professor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

An agency provides vocational training for mentally and physically challenged individuals aged 26 years and up. One training task involves counting and packaging small items. Most of the workers in training are unable to count reliably, so staff had to complete the task for them. The Inventory Control System (ICS) allows students previously unable to do the task to work reliably and with increased independence. To facilitate this independence, the ICS:

- Automates the counting procedure for shipment packaging,
- Credits the number of pieces produced to the corresponding employee,
- Calculates the number of hours worked by each employee,
- Maintains a database of the employees' names and their identification numbers, and
- Maintains a database of the various products produced by the company.

SUMMARY OF IMPACT

The most significant impact of this project is that it created jobs for workers with disabilities. The ICS builds quality assurance into the task by error proofing the process. The workers are guided through the process by a series of prompts, which instruct the workers as to what their next step is.

TECHNICAL DESCRIPTION

The ICS package includes a Micron Radio Frequency (RF) MicroTag reader and an Ohaus Portable Electronic Scale, which connect via two communication ports to a PC. The inventory control software was developed in Visual Basic 5.0 and interfaces both the scanner and the scale to the computer. The software also maintains the databases

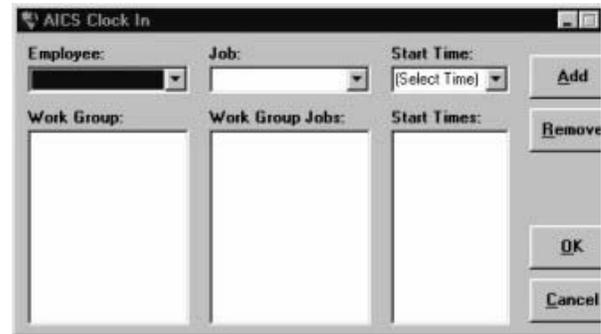


Figure 20.3. AICS Clock-in Screen.

necessary for automating the counting and packaging processes.

Before starting the assigned task, ICS directs the staff member configuring the system to set a certain number of the parts being counted on the scale. The software then determines the weight of each part so that, when the staff member enters a target shipment count, the software will be able to determine if that goal has been reached by monitoring the amount of weight on the scale. After entering the information about the task, staff must "clock in" each worker as shown in Figure 20.3. "Clocking in" involves selecting an employee's name, the name of the task, and the start time. After being clocked in, each worker is assigned a work bin. Each work bin is identified by a Micron MicroTag UltraThin tag that contains a unique identification number. When the worker scans the tag on his/her bin across the MicroTag reader, the system recognizes the bin as being assigned to that particular worker, displays the worker's name and assignment on the screen, and prepares to log that worker's production.

When the worker's bin is successfully identified, auditory prompts guide him/her through the rest of the weighing process. If the weight detected on the scale is greater or less than the weight of the target shipment count, a voice prompt will instruct the worker to remove/add parts from the bin. When the

target shipment count is reached, a voice prompt informs the employee that the goal has been reached and to place the pieces from the bin into the shipment box. The database is updated when the target count is reached, logging the worker's progress, then the program waits for someone to scan another work bin.

Throughout the process, the ICS screen will display the current shipment count and the staff-defined target shipment count for the job. This allows staff and workers to be constantly aware of the progress being made. At the end of the day, each employee must be "clocked out" at the same screen used for the "clock in" procedure. The software will then calculate the number of hours worked by each employee and record the results in the database.

Information about each employee's progress can be viewed using the ICS summary tool, which displays each employee's name, ID number, job title, and the total number of pieces counted (Figure 20.4).

The ICS is a highly customized application and allows staff to keep detailed information on each of the workers. To run optimally, the system requires a Pentium-grade CPU with Windows 95, 98, or NT, a color monitor, an Ohaus Scale, and a Micron RF MicroTag reader and RF tags. The cost of the MicroTag reader and Ohaus Scale is \$1050.

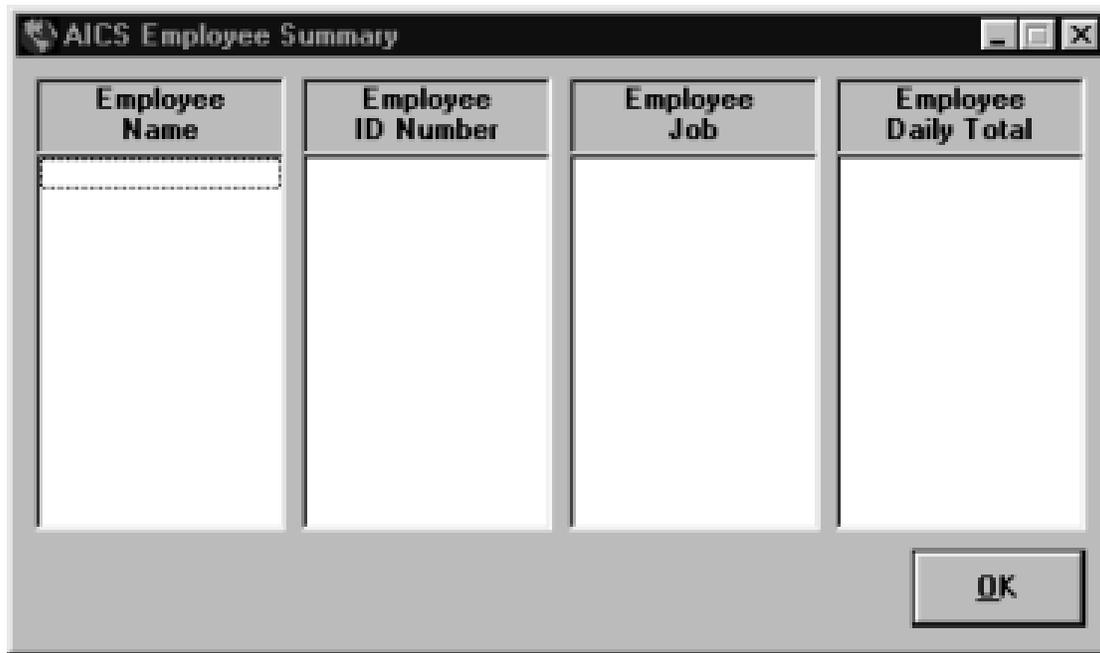


Figure 20.4. AICS Summary Tool.

AUTOMATED PAGE-TURNER

Designers: Nasr Abdul-Mujeeb, Michael Antaran, Mik Kovac, Saad Rauf, and Gregory Slack

Modification Designers: Chris Bujak and David Sant

Client Coordinator: Lynne Hagmann

Western Wayne Skill Center

Supervisor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

A center provides pre-vocational and vocational training services for individuals aged 15 to 26 years with disabilities ranging from learning impairments to severe cognitive and physical impairments. Students are taught clerical tasks, such as data entry, as well as counting tasks, such as counting papers for mailing. Before the accommodation, students doing data entry required a great deal of staff assistance to focus on one line on the paper at a time and to switch pages after inputting all of the data from one page.

Students counting papers had to have a great deal of finger dexterity and be able to count reliably to do the task or else rely on staff to manipulate the paper. The page-turner accommodation automates both of these processes so that students can manipulate the paper handling by using a single switch.

SUMMARY OF IMPACT

The Page Turner provides an effective means of viewing or counting single sheets of 8.5"-by-11" sheets of paper. The device can be used in two different modes: a line-by-line mode and a continuous mode.

For data entry tasks, the line-by-line mode is used so that, when a template or shield is placed over the paper, the student can see only one line at a time. To move from one line to the next, the students simply hit a single switch. This accommodation prevents students who have tracking or attention difficulties from losing their place on the page.

For paper counting tasks, which use the continuous mode, the device can be interfaced to programmable counting devices, thus reducing the cognitive demand of the task. The accommodations provided by the automated page-turner have allowed for a greater number of students to participate in paper

handling tasks without having to rely on a great amount of staff intervention.

TECHNICAL DESCRIPTION

There are two basic components to the Page Turner (Figure 20.5). These components consist of the mechanical paper handling system and electronic control system. The mechanical paper handling system consists of a DC gear motor with an 80:1 reduction ratio that is connected to a set of opposing feed rollers by a timing belt. The opposing rollers work by allowing the topmost paper in a stack to be drawn into the unit while an opposing roller is used to push down any other papers that have been drawn up along with the first page. The electronic control system consists of many parts, including a sensor to detect when the paper is properly stacked on the paper tray, a paper eject sensor that is used to determine when a page has left the rollers, and the electronic control unit, which has the mode selection switch and the connection for the user switch.

When a user presses the user switch, several events occur. The controller checks the status of the mode switch and determines if it is in continuous mode or line-by-line mode. If the entire page is to eject, then the motor is energized, forcing the top page up until the paper activates the topmost sensor. Once this happens, the motor is reversed until the bottommost sensor is cleared. This will return any partially drawn-up pages and clear any paper jams. If the mode switch was set to the line-by-line mode, the paper is advanced one line per switch hit until the top sensor is activated, at which point the page is ejected using the same method as the continuous mode. The automated page-turner is a modular unit and can be interfaced to other devices.

The hardware and software for this design and the design modifications cost \$480.



Figure 20.5. Side View of the Automated Page Turner.

MULTIMEDIA ASSESSMENT TOOL FOR CHILDREN WITH DISABILITIES (MAT)

Designers: Ganesh Babu Chelliah, Ramana Prabhu Lokanathan, Vijay Gummadi

Client Coordinator: Patricia Nizio

Detroit Institute for Children

Supervisor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

An agency provides children with disabilities specialized medical, dental, and rehabilitative care as well as high-tech adaptive equipment. Therapists and teachers have difficulty assessing the language and mathematics competencies of children with multiple severed disabilities because standardized assessment tests typically require inferencing of skills beyond the scope of the assessment tests, generalization from concrete examples to abstract drawings, verbalization of answers, and pointing responses. Such requirements are beyond the physical and motor capacities of many clients. Therefore, a multi-purpose, multimedia computer system for early language and mathematics knowledge and skills has been designed to allow staff to evaluate such skills in this population.

SUMMARY OF IMPACT

The children using the Multimedia Assessment Tool (MAT) are primarily between the ages of five and fifteen years and have limited physical capabilities due to cerebral palsy and quadriplegia. Due to these disabilities, most of these students have difficulty sitting independently, walking, or using their hands to communicate. The children can, however, use the MAT to demonstrate what they know of a particular vocabulary group, such as "animals" or "objects," by simply activating a switch to select pictures scanned across a screen. This activity allows staff members to determine each child's level of receptive language development and provides the children with the opportunity to demonstrate what they are capable of given the appropriate forms of assistive technology. MAT also allows the children to practice the motor skills associated with listening, watching, and maintaining attention that are necessary for operating computers and improving communication skills.

TECHNICAL DESCRIPTION

The Multimedia Assessment Tool is a computer-based tool designed in Visual Basic 5.0 that runs a series of tests designed to assess the cognitive capacities of children with disabilities. The tests are based on the children's ability to identify objects, shapes, colors, language structures, and descriptive concepts. The software has the ability to run sessions based on different categories (such as animals, objects, or shapes) as well as at different levels of difficulty. For example, in the exercise shown in Figure 20.6, the program displays four different animals from which the user may select.

A verbal prompting mechanism linked to that exercise instructs the student to identify one particular animal from the set. An automated, speed-adjustable scanning procedure highlights each object at a steady rate, allowing children to make a selection with a single switch or a mouse when their choice is highlighted. If their selection is correct, the program will move to the next exercise. If the choice is incorrect, the same exercise will be repeated. Verbal prompting is provided to maintain the children's attention and to guide them through each exercise.

The number of pictures displayed in the program depends on the level of difficulty specified by the staff. As the level of difficulty decreases, the student is required to choose among a reduced number of pictures. The system also allows staff to create user-defined session settings to meet the needs of individual students. These settings include the color of the highlight scan, width of the highlight scan, image scan time, image delay time, and the number of scans over each image before session termination.

MAT can be run in two different modes: learning mode or assessment mode. In the learning mode, the student's learning process is reinforced by

repeated voice prompts and the display of the correct picture in the case of a wrong selection by a student. In the assessment mode, software does not correct the student in the case of an incorrect selection. Rather, the system records all details of the selections made, the time taken to make each selection, and which picture was selected. Data collected during the assessment mode can then be tabulated and displayed in graphical form by MAT's multi-functional report generator.

In addition to the report generator, MAT maintains a database of student and staff information. This database offers controlled access to student information, which is available via password only to staff members assigned to that student. While

preparing MAT sessions for their assigned students, staff may record new audio prompts, overwrite existing audio prompts, and play existing audio prompts. This feature also contains a preview of the images associated with each audio file, allowing staff to preview the MAT settings before starting the session.

To function optimally, MAT requires a Pentium-grade CPU with Windows 95, 98, or NT, a color monitor, a single switch (if a mouse will not be used), and computer speakers. If staff wish to add or replace photos in the system, a digital camera or scanning device will also be necessary.



Figure 20.6. Display of Selectable Items.

PAPER SHREDDING WORKSTATION

Designers: Jason Kennedy, David Slanec, Jason Witt

Client Coordinator: Donna Case

Bryant Center

Supervising Professors: Dr. Robert Erlandson, Department of Electrical and Computer Engineering, and Dr. Leslie

Monplaisir, Department of Industrial and Manufacturing Engineering

Wayne State University

Detroit, MI 48202

INTRODUCTION

An agency provides training and services for students between the ages of 13 and 26 who have various types of cognitive, physical, and emotional impairments. One of the projects in which the students participate involves the shredding of paper products. Due to the limited finger dexterity of the students, this task requires a great deal of staff intervention, and the limited space around the shredding device causes cramped conditions in group work situations. Thus, the paper shredding process has been redesigned to include a workstation table and a shredder cage to promote a comfortable team atmosphere, reduce the number of steps in the process, and accommodate the positioning needs of a variety of students.

SUMMARY OF IMPACT

Without assistive enhancements, most of the students involved with the paper shredding process have physical impairments that make it difficult to pick up one sheet of paper at a time and place it into a commercial paper shredder. With the redesigned paper shredding workstation, the students are able to push the paper into the shredding device safely and accurately each time. In addition to these features, the redesign allows students to work with less staff supervision than before, which has contributed an increase in successful job placements among this population.

TECHNICAL DESCRIPTION

While researching the new design of the paper shredding process, observations regarding the layout of the facility and the flow of the shredding process were collected and charted. These data showed that the original shredding process contained several non-value-added steps, many of which were related to the students' need to wait for staff assistance.

As shown in Figure 20.7, the re-designed system consists of a workstation table with paper separator tray that leads to a shredder cart. To shred paper, the student selects a sheet of paper from the tray and slides the sheet along the guides on the table to the chute that leads to the shredder cart. The paper then slides down the chute and into the shredder.

To meet the varying heights of seated workers, the workstation table can be adjusted to heights of 26 1/2", 30 1/4" and 33 7/8" tall. The table was designed to support a number of configurations in order to facilitate a teamwork atmosphere while accommodating the positioning needs of a variety of students. Other ergonomic concerns, such as work surface thickness, leg and wheelchair clearance, and safety were also taken into consideration in the design of the workstation table.

The shredder cart consists of two major parts: a shredder cart base and a shredder cage. Both are adjustable to accommodate a variety of shredder models. By placing the shredder onto its own cart, the shredder can be easily moved off-site for other shredding contracts, and it can be positioned at various angles to suit each student's individual needs.

In order to aid students in freeing a single sheet of paper without the assistance of an instructor, a paper separator tray was implemented. The tray has an angled back that pushes each sheet of paper slightly forward, allowing the student to slide easily each sheet off of the paper stack and onto the workstation table. It also allows for a variety of adjustments to accommodate the needs of each student.

The frame of the system is constructed of Creform materials. Creform is a pipe-and-joint material handling system that is strong and easily adjustable.

The design's flexibility and error-proofing qualities enable students to rely less on staff for assistance and to complete a greater percentage of the process independently. The redesign also reduces the amount of non-value-added steps in the shredding process, which significantly increases productivity.

The Creform materials for the project cost

approximately \$640.



Figure 20.7. Paper Shredding Workstation.

PARTS DISPENSING AND COUNTING SYSTEM

Designers: David Sant, Vijay Gummadi

Client Coordinator: Ronald Zapinski

Keith Bovenschen School

Supervising Professor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

A school for students between the ages of 3 and 26 who have various disabilities required improved means of enabling students to perform counting and sorting tasks. As a means of keeping the students active in the community and promoting positive work skills, the staff engages the students in a variety of counting and sorting tasks. The school has contracts with local businesses to package items by count or by weight. The students, however, have limited finger dexterity and cannot count reliably without assistance. The modular Parts Dispensing and Counting System combines sensor technology with existing assistive technology devices to help students with disabilities accurately count and sort small materials.

SUMMARY OF IMPACT

Students with cognitive and physical impairments are sometimes unable to participate in vocational tasks due to their impairments. The Parts Dispensing and Counting System allows students to start the task by simply hitting a switch. When switches are used to compensate for physical or mental performance, a larger population of students can participate. Because the process is begun by hitting a single switch, this project provides an additional benefit in promoting the understanding of cause-and-effect relationships. The noise of the materials rotating in the dispensing bin aids in holding the students' attention.

TECHNICAL DESCRIPTION

The system setup consists of a coffee can mounted on roller bearings. It is powered by a motor that rotates at approximately 30 RPM. The can's lid has four holes for the parts to fall through located at

diametrically opposite ends, and a funnel located at the base of the apparatus collects and routes the parts as they are dispensed into a collection bin. The speed of the motor and the size of the lid holes can be adjusted to accommodate the size and weight of the parts being dispensed. The motor, rotating can, and funnel are supported by a Creform frame. (See Figure 20.8).

At the bottom of the funnel are infrared sensors that detect each part as it passes through the funnel. An ETL Counter Controller, which can be programmed to count a specific number of parts, keeps track of the number of parts passed by the infrared sensor. When the session's counting goal has been reached, the process halts, allowing staff or other students to replace the current collection bin with another. To start the process again, the user hits the switch connected to the ETL Counter Controller.

The system can also be interfaced to an ETL Indexing Turntable for increased functionality. By incorporating the turntable, staff may set collection bins at up to eight indexed stop points on the turntable. When one packaging goal has been reached, the turntable advances to the next indexed position, and, after the switch is hit again, the system will begin to dispense material into the new collection box (see Figure 20.9, next page).

By allowing the system to handle both the material handling and counting procedures, the cognitive and physical demands of the task are reduced, allowing individuals with a variety of disabilities to participate. The system costs approximately \$400 without the turntable and \$1000 with the turntable.

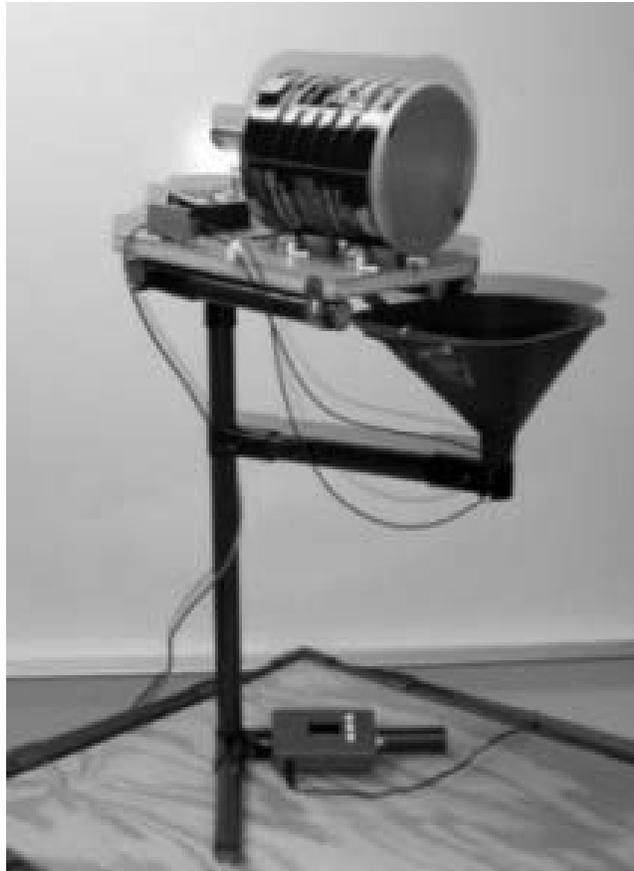


Figure 20.8. Parts Dispensing and Counting System.

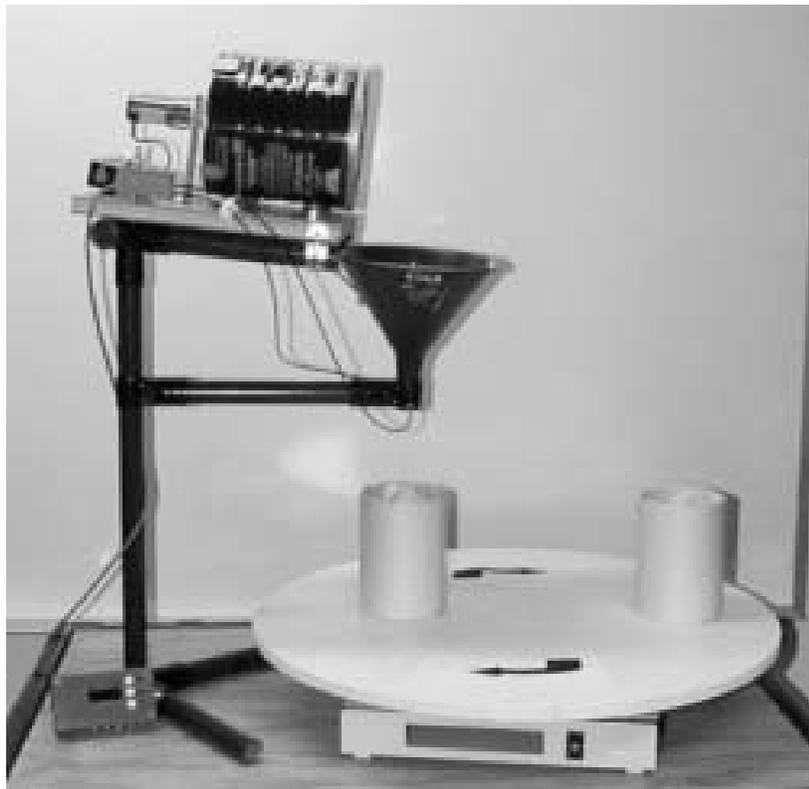


Figure 20.9. System Interfaced to an ETL Indexing Turntable.

RF TECHNOLOGY FOR MANIPULATIVE PLAY

Designer: Weijie Fu

Client Coordinator: Robert Erlandson, Ph.D.

The Enabling Technologies Laboratory

Supervisor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

One of the challenges in introducing new technology into educational environments is that teachers, therapists, and other support staff are usually unfamiliar with, and, in turn, reluctant to try, the new technology. This project, which incorporates Radio Frequency (RF) hardware with a Visual Basic interface, allows the staff at an agency for individuals with disabilities to provide a hands-on demonstration of the potentials of RF technology to other special education faculty and staff. This project particularly indicates the potential of using RF technology with manipulative play to teach students with disabilities the concepts of relative size, color differentiation, and other skills.

SUMMARY OF IMPACT

Demonstrating a practical application of RF technology to special education teachers and staff makes them more comfortable with the technology and more able to brainstorm over uses for the technology. After an application sample, the staff suggested several applications for using RF technology to aid their disabled students. One such idea was the Inventory Control System (AICS), which was then developed as an independent student design project. By providing clients with a module with which to experiment, they were better able to think of ways to use current technology to help their students work or to assess their abilities.

TECHNICAL DESCRIPTION

The RF project incorporates a PC, a Micron Radio Frequency (RF) MicroTag reader, the associated RF tags, three wooden blocks of varying sizes and colors, and a custom Visual Basic 5 interface. To encourage manipulative play, the interface is designed as a game that can run in two different modes: a "size" mode and a "color" mode. In the "size" mode, the program will ask the user to select a block by its size—small, medium, or large. In the "color" mode, the student will be asked to select a

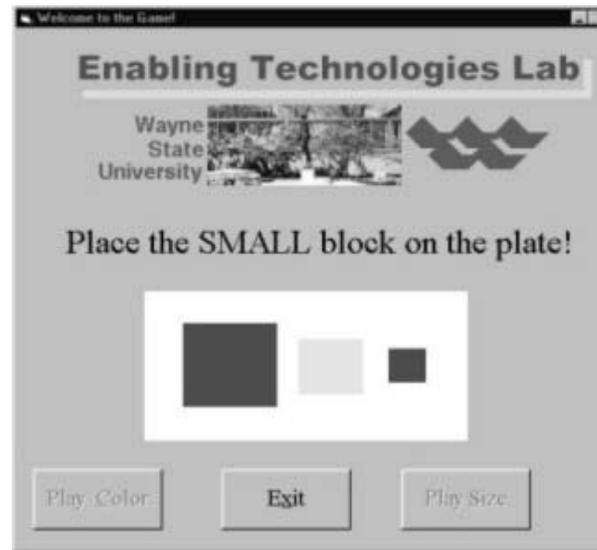


Figure 20.10. RF Manipulative Play Interface.

block by its color—red, green, or yellow. (Figure 20.10)

One RF tag, each having a unique code, is embedded in each of the blocks, so that when the student selects a block and scans it over the RF MicroTag reader (see Figure 20.11), the reader identifies the code from the tag and sends it to the PC in ASCII format. The application stores the code in memory, and then determines if the correct block has been selected by comparing the code scanned with the code of the desired block. The application provides auditory and visual feedback to the user as to whether or not his/her choice was correct, and, if incorrect, displays the incorrect choice with a slash through it.

By playing the two games, students may practice interactively with concrete concepts, such as color, as well as abstract, relative concepts, such as size. Also, by experiencing the potential of RF technology first-hand, special education faculty and staff have been able to develop more sophisticated ideas for

integrating it into new and existing forms of assistive technology.

The cost of the Micron RF MicroTag reader and the other hardware (RF Tags, wooden blocks) is approximately \$450.



Figure 20.11. Micron RF MicroTag Reader, RF Tags, and Colored Blocks.

SWITCH OPERATED RIBBON CUTTER

Designers: Henry Broth, Mark Chuong, Will Barlow, David Sant

Client Coordinator: April Saval

Services to Enhance Potential (STEP)

Supervisor: Robert Erlandson, Ph.D.

Department of Electrical and Computer Engineering

Wayne State University, Detroit, MI 48202

INTRODUCTION

In an agency that provides supported employment services for persons with developmental disabilities, one of the tasks assigned to several clients involves cutting heavy, industrial-grade ribbon to specific lengths. The first intervention to help make the process safer and error-free used a custom-designed manual ribbon cutter. The student using the manual intervention pulled the ribbon to a marked place on the cutting platform and then rolled a blade cased in a wooden box over the ribbon, cutting it to the proper length. While successful for several clients, this method of cutting ribbon is still beyond the capacities of other workers with disabilities. The switch operated ribbon cutter automates the measuring and cutting processes so that workers with severe cognitive and/or physical limitations can competently participate by simply hitting a single switch.

SUMMARY OF IMPACT

The switch operated ribbon cutter provides a job for workers who may have difficulty measuring on their own. After the worker hits the switch, the device measures the ribbon to the pre-defined length and then automatically cuts it to the proper length. Staff may adjust the length of ribbon to be cut for each session, making it easy for workers and staff to switch from one job to the next. The device is easy to maintain.

TECHNICAL DESCRIPTION

The Ribbon Cutter is designed to provide a means of dispensing and cutting linear material, such as ribbon, to pre-measured lengths. Once the desired length has been defined, the system will store that setting and automatically dispense and cut ribbon at that length each time the user switch is been pressed. The system consists of:

- A ribbon spool,

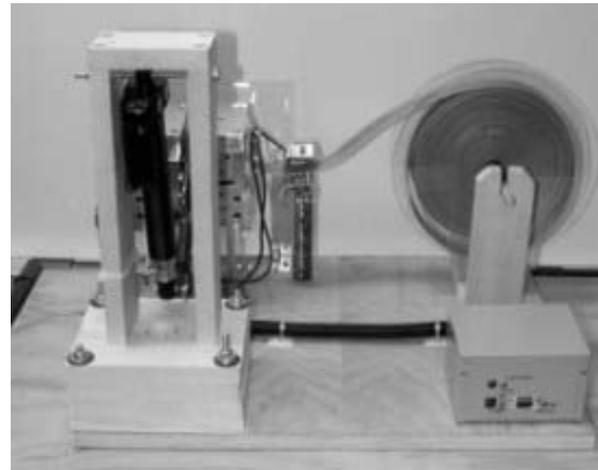


Figure 20.12. Switch Activated Ribbon Cutter.

- A cutting mechanism, and
- A control box (Figure 20.12).

The system is controlled by two toggle switches on the rear of the control box (figure 20.13). The power switch turns the unit on and off while the mode switch allows the user to program the cutter for a new length (Program Position) or simply dispense ribbon (Run Position). A 3.5mm jack is also located on the control panel. This jack is used to connect the device to a user switch. Each time that the switch connected to this jack is closed, the system will activate and dispense ribbon.

When the user hits the user switch in "run" mode, the ribbon is fed into the cutting mechanism, which is powered by a DC motor at 29RPM, until it has advanced to the programmed length. An encoder wheel attached to the cutting mechanism determines when the programmed length has been reached, at which time an electric actuator activates the cutting arm. This process repeats each time that the user hits the switch.

Staff may program new ribbon lengths by switching into "program" mode. To set the new ribbon length,

one holds the switch down, which causes the ribbon to feed into the cutting mechanism, until the desired length has been reached. After confirming the correct length, one switches back into “run” mode, at which time the system is ready to use.

The ribbon cutter is equipped with sensors to detect the state of the device, and this status is displayed by a dual color LED located on the panel of the control box. This LED can change from red to green to indicate various conditions. For example, if the

light is green, the cutter is ready to be used. If it is red, it is in use. If it is flashing red, the device is out of ribbon, and if it is flashing green, it is ready to load ribbon. If the LED is alternating between red and green, the user is in the “program” mode.

The final cost of the ribbon cutter is approximately \$270 for the hardware and software components.



Figure 20.13. The Ribbon Cutter Control Box.

DESIGN OF A MULTI-FREQUENCY VIBRATING SYSTEM FOR A STROKE PATIENT

Designers: Dan Molnar and Pete Novak

Supervising Professor: Bertram N. Ezenwa, Ph.D.

*Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering
Wayne State University
Detroit, Michigan 40201*

INTRODUCTION

A vibrating system was built aid in the rehabilitation of a patient who had a stroke. The vibrating action is intended to stimulate the nerves in his weakened limbs. This system consists of a platform coupled to a head that vibrates at selected frequencies, amplitudes, and adjustable planes. The adjustable planes can vary from a vertical reference plane to 40 degrees away from the reference. The system has controls for frequency, amplitude, and plane adjustment. The frequency of vibration can be varied. The system is mounted on castors for ease of transportation. The system is shown in Figure 20.14.

SUMMARY OF IMPACT

It is known that electrical stimulation elicits muscular contraction, which facilitates limb movement. The amount of muscular contraction using surface electrical stimulation has been associated with stimulation amplitude and frequency. Electrical stimulation requires a considerable amount of preparation before use, and has associated risks such as skin irritation or mild shock. The risks, preparation time, and fear of consequences of injecting current into the body tend to turn people away from electrical stimulation. Mechanical stimulation, by contrast, requires little or no preparation, and none of the associated risks of electrical stimulation.

The greatest impact of this design is that, if successful, more people will be willing to use the system. Since early intervention is very important in stroke patients, it will help lead to quicker recovery in stroke patients. It can also be very useful for preventing bone loss since exerting stress along the bone helps to build bone density.

TECHNICAL DESCRIPTION

Specifications for the vibrating system were as follows:

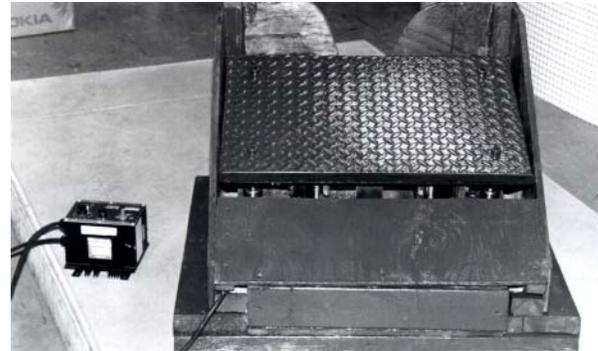


Figure 20.14. Picture of the Multi-Frequency Vibration System For Stroke Patients.

- Variable vibration amplitude between 0 to 0.25 inches,
- Variable vibration frequency from 0 to 25 Hz,
- Vibrating platform surface angle adjustment from 0 to 40 degrees of inclination,
- Capability of withstanding a 120 pound load during vibration, and
- Transportability.

The design utilizes a vibrating platform (a 1/4-inch steel diamond plate) mounted to four 1-inch-diameter, hardened steel guideposts. The posts ride inside four linear bearings, which are attached to the tilting base (1/2-inch aluminum plate). The platform was also fixed to the output end of each lever. The levers are constructed of one-inch square tubing with four attached bearings. The bearing portions of the levers are actuated by the offset cams (Figure 20.15), which are turned by a belt connection to the electric motor. The adjustable fulcrum is made of 1/2-inch-diameter steel shaft. The fulcrum shaft rides on four guide bearings. The fulcrum position is adjusted by turning a power screw. The entire machine is attached to a steel base platform by five 1/2-inch steel support plates. The system is made of

durable parts and is stable and simple to operate. All rotating parts were covered to prevent injury.

The completed design project resulted in a successful vibrating platform. It met all

requirements. The total cost of the vibrating platform is \$1,320.

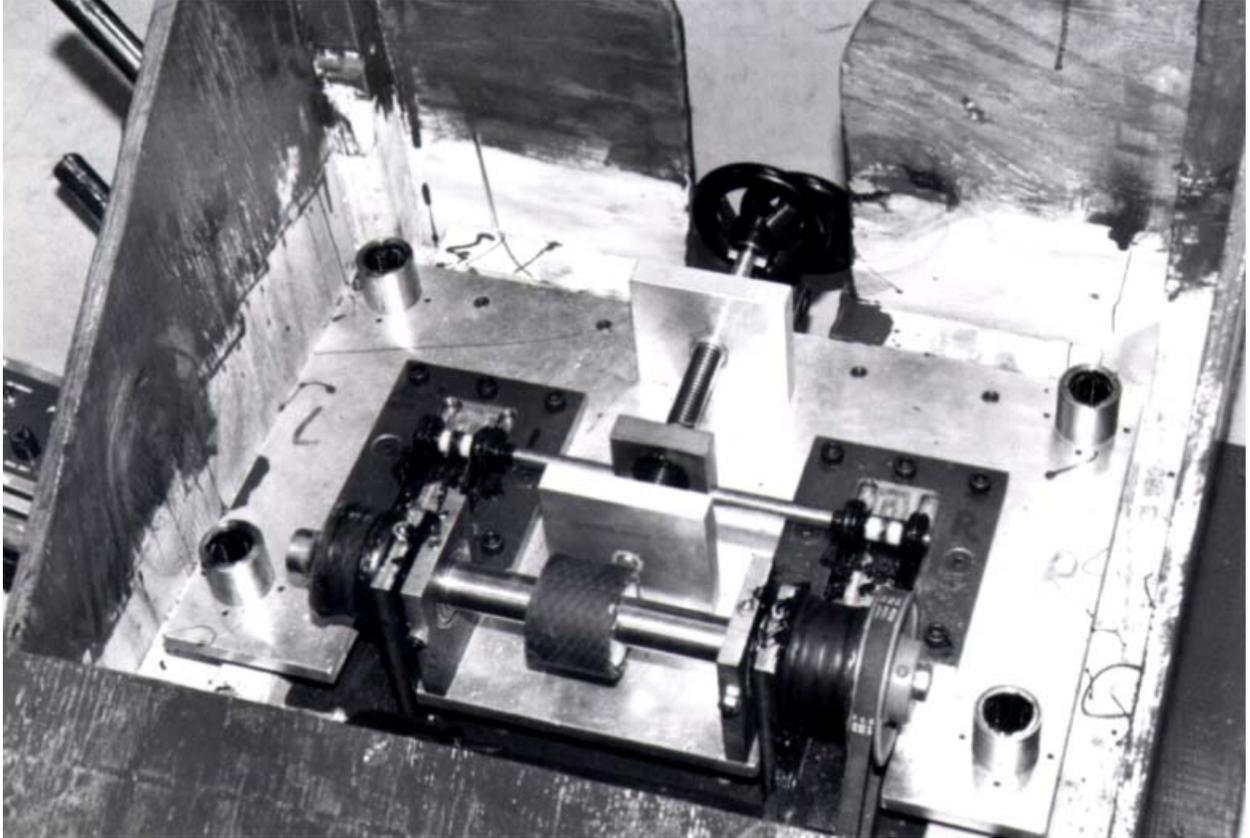


Figure 20.15. Bearing Portions of the Levers Actuated by the Offset Cams.

WALKER DESIGN MODIFICATION FOR A CHILD WITH CEREBRAL PALSY

Designers: Alex Deych And Rooz Narimissa
Client Coordinator: Ms. Bristol, Ferry Elementary School, Grosse Pointe Woods
Supervising Professor: Bertram N. Ezenwa, Ph.D.
Departments of Physical Medicine and Rehabilitation, and Mechanical Engineering
Wayne State University
Detroit, Michigan 40201

INTRODUCTION

A support walker was adapted for a child with cerebral palsy. His KAYE Posture Control Walker had a pelvic stabilizer to help support his lower back, a mountain climbing harness to secure him from falling, and forearm supports to restrict his arms from moving side to side. However, the child's upper body kept swinging from side to side, his legs were not strong enough to support his body weight, and his arms kept moving in all directions. As he walks with the walker, his body leans forward and down, and his legs are dragged behind. To help the child maintain his posture the walker was modified for his current height and weight. An additional low-cost restraint system was made to be removable so that it could be utilized with other devices such as his wheelchair. A close-up of the restraint system is shown attached to the walker in Figure 20.16.

SUMMARY OF THE IMPACT

The project helps stabilize the child and enables him to put some weight on his bones, especially at the joints. This will in turn make the bone and the joints develop properly during the fast growing age of childhood.

TECHNICAL DESCRIPTION

To help the child maintain his posture it was necessary to modify the walker to accommodate his current height and weight. The additional restraint system had to be removable so that it could be utilized with other devices such as the wheelchair. The child's weight is 50 lbs. and the height is 50

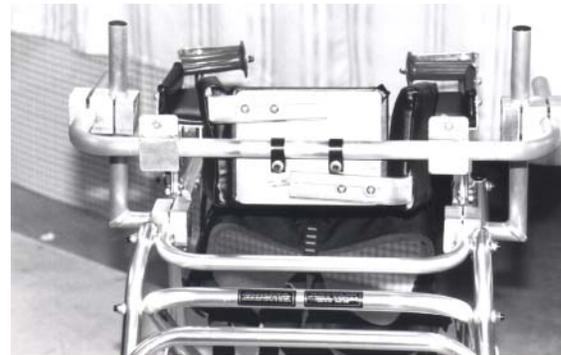


Figure 20.16. Restraint System Attached To The Walker. It Has A Four-Point Universal Coupling For Attaching To Round And Square Tubing.

inches. The child's posture is never vertical, as he is constantly leaned forward and down. Figure 20.17 below shows the Free Body Diagram with applied body weight.

Because legs never contribute to the movement, the center of gravity is at the midpoint of the object's upper body area indicated by point A in Figure 20.17 Left. When the child's center of gravity passes through the walker center of gravity, the motion starts shown in Figure 20.18 below. The force necessary to create the motion can be represented using the following equations:

$$F = W\cos30\cos60 - F\mu = 50\cos30\cos60$$

$$- F\mu = 21.65 - F\mu , \tag{1}$$

W is the total weight of the client.

$F\mu$ is the force due to friction created by the walker wheels on the floor surface and is given by $F\mu = \mu N$, where μ is the coefficient of friction and N is the normal force (perpendicular to the surface). In our case, N will be equal to the combined weight of the child and the walker. Coefficient of friction will depend on the surface on which the walker is moving; the more slippery the surface, the smaller the coefficient of friction.

$W\cos 30$ is the force normal to the child's posture in the walker. We chose 30° to represent the angle of inclination. It was chosen based on our initial observations. The angle will vary from case to case depending on the posture of the object.

$W\cos 30\cos 60$ is the resultant force in the horizontal direction.

The force F represented in equation (1) above is the force needed to start the motion based on the body weight alone. To stop the motion, force F would have to be zero, which means that our friction force would have to be equal to the horizontal component of body weight:

$$F\mu = W\cos 30\cos 60.$$

In other words, the walker will not move if the walker is on some soft surface such as a thick carpet or sand. The task, however, was to eliminate the contribution of the body weight and instead, generate the movement from the legs. The only way that could happen is by eliminating horizontal component of force ($50\cos 30\cos 60$), which is only possible if there is an angle of 90° between the child and the surface, such that the child must stand upright, as shown in Figure 20.17 Right. Notice that the center of gravity is moved down (point B) because the legs now contribute to the overall weight, and there is no longer a component in the horizontal direction.

It is still possible to have a slight inclination forward and not produce any movement as long as the center of gravity of the child does not pass through the center of gravity of the walker (Figure 20.18). An aluminum bar was attached to the walker about 12 inches above the current height of the walker. Aluminum was used because it is lighter than steel, more cost effective, and easier to work with. The height and the position of the aluminum bar are adjustable so that he will be able to use it for several years.

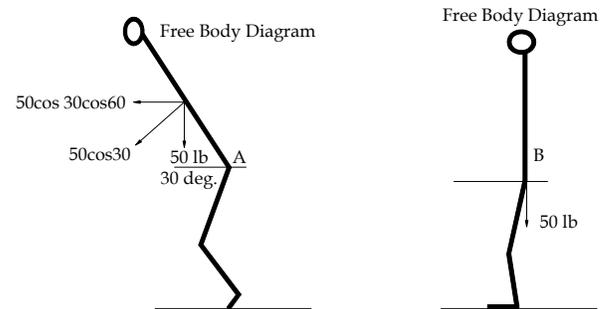


Figure 20.17. Free Body Illustration of The Problem, Left, and the Resultant Solution, Right.

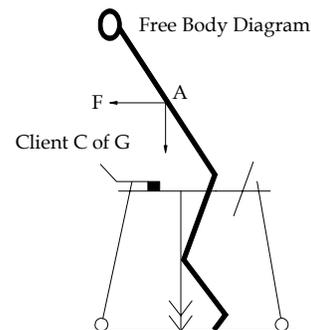


Figure 20.18. Free Body Diagram Illustration of the System Functionality.

The aluminum piece is supported by the sliding collars, which make it possible for the whole system to be flexible. The pelvic stabilizer is brought up and is secured on the aluminum piece. The forearm supports were not changed, as they are needed to ensure that the arms are restrained from any unnecessary movement. An additional strap (with Velcro) is used to restrain the child's upper body from leaning forward. By straightening his posture, the child has to use his legs to start the movement. At first, the strap will have to tightly secure the child; however, as the time goes, the child may gain some control over his own weight and movement, in which case the strap may be loosened around his upper body area. When the child's posture is straightened he is not able to push the walker as fast. Most of the push power will come from the legs and not from the upper body weight.

The total cost of the walker is \$800

WRITING ARM FOR A CHILD WITH CEREBRAL PALSY

*Designers: Karen Rothacker
Supervising Professor: Bertram N. Ezenwa, Ph.D.
Department of Mechanical Engineering
Wayne State University
Detroit, Michigan 40201*

INTRODUCTION

An assistive device was designed for a boy with cerebral palsy (CP) to control or restrict his spastic arm movements during writing. His horizontal motions were excessive for writing and the vertical arm motions could potentially inflict injury, as the client's writing pen would come dangerously close to his eyes. When he attempted to write, the non-writing arm would go into extension over his head and behind his back. The client is of normal intelligence and belongs in the first grade. However, because of his uncontrolled tightening of the skeletal muscles he is unable to write and is currently held back in kindergarten.

The system was designed to restrict the client's motions to those needed to write on an 8.5" x 11" sheet of paper. This was accomplished by integrating custom components to support the trunk, the fore and upper arms, and for adjustment of distal and proximal portions of the upper arm. The custom made system is shown in Figure 20.19.

SUMMARY OF IMPACT

It is frustrating for a child to be unable to express himself in writing as because of conditions beyond his control. It is also frustrating for a child to be held back while his/her classmates move on to the next class. This system will enable our client continue his education at the appropriate pace and prevent him from inflicting injury to himself.

TECHNICAL DESCRIPTION

The goal was to design and fabricate a device that the client can attach to his arm to help him write by restricting all motions not needed for writing. The range of motion for critical writing movements was analyzed. The necessary motions for writing/drawing are as follows:

- The wrist is free from restrictions;



Figure 20.19 System That Enables A CP Child Write And Draw By Limiting Unnecessary Arm Movement.

- The forearm is in the plane parallel to the writing desk,
- The elbow is bent and acts as a restricted pivot point, and the arm should not go into full extension;
- The elbow still must move slightly upward and outward during rotation;
- The shoulder and thorax can translate as a unit, keeping the upper arm flexed and somewhat perpendicular to the desk surface and allowing the forearm, upper arm and shoulder to move as a unit in a horizontal plane;
- Downward motions are limited by the desk surface;
- Upward motions need to be restricted;
- The position of the upper body is upright;
- The non-writing arm is impeded.

A horizontal pivot point at the elbow was fabricated to restrict the forearm motions to a horizontal plane. The hinge is set to allow for an 80-degree swing arc. The forearm is anchored down on a pivoting board at two points just proximal of the wrist so that the wrist has unrestricted motion, just distal of the elbow (Figure 20.20).

A second horizontal pivot point at the thorax was fabricated to allow the forearm, upper arm, and shoulder to rotate in a horizontal plane with respect to a pivot point on the thorax. It is adjustable in the vertical direction to accommodate different seat to tabletop heights. Upward and downward motions of the arm are thwarted once the pivot point is set. A prototype was built to the design engineer's dimensions, so that the concept function could be verified more frequently and the design could be developed through a more rapid development phase. A concept system was built for the client based on the performance of the prototype system. During initial trial, a decision was made to limit all pivot point rotations with set-screws, which can be re-drilled and reset for adjustments.

A functional device was fabricated to the dimensions of the client and design modifications discovered from the prototype testing. The client was able to write within a 8.0" x 11.5" sheet of paper.

Three out of four corners of the paper were reachable. The lower right-hand corner was not within reach for two reasons: The "thorax to elbow plate" was too long and the "thorax to elbow plate" had limited rearward motion because of the wheel chair back.

It was found that the thorax vinyl vest, used to position and hold the thorax plate on the client's side, was slipping slightly around the client's thorax. A foam/plastic that could be molded to the client's body contour would be more comfortable, not slip and distribute forces more evenly than a flat aluminum thorax plate sewn into a vinyl vest.

It was found that limiting the writing arm motions to a horizontal plane eliminated the need to restrict the motions of non-writing arm and shoulder. The client showed only minor non-writing arm movements or spasms (clenching fist). The clients restricted writing arm range gave him a less need for corrective movements and thus better concentration. The increased weight of the device to make it more rigid, initially thought to be a detriment to the design, actually may be dampening some of the muscle spasms.

The cost of the project is \$20.00

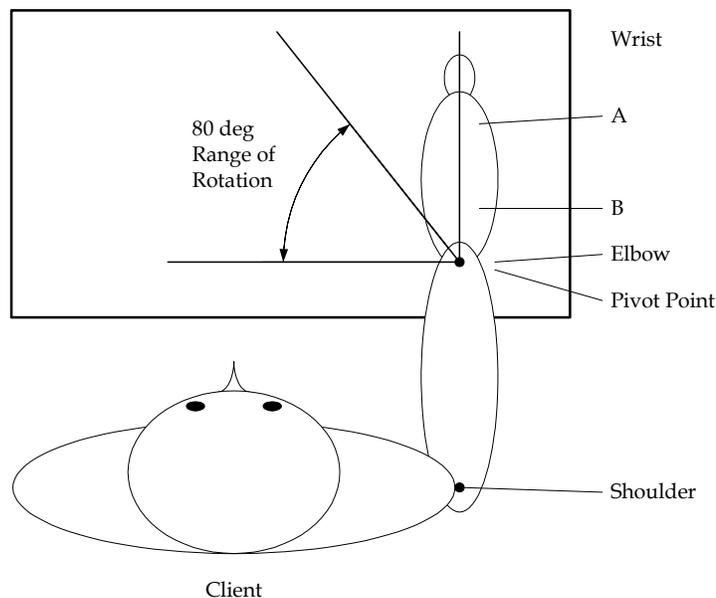


Figure 20.20. Two-Point Pivoting Platform For Restraining Unnecessary Motion During Writing.

COMMUNICATION DEVICE MOUNT

*Designers: Norman Haidous
Supervising Professor: Bertram N. Ezenwa, Ph.D.
Department of Mechanical Engineering
Wayne State University
Detroit, Michigan 40201*

INTRODUCTION

The client with a muscular disease is unable to walk independently. He is non-verbal. The control of his neck is limited such that he looks in an upward direction. He needs a tool to hold an augmentative communication device for him to use while lying in bed or sitting upright on his chair. A mounting device was developed by integrating a hospital-type over-the-bed table, a camera tri-pod extension arm and mounting unit, a camera mount swivel bracket, and a communication device-mounting bracket.

SUMMARY OF IMPACT

The ability to communicate is especially important for individuals with physical impairments. The use of this system will have psychological benefits by enabling the client to do simple things like turn on and off the radio or TV. The system can also be used to call for help when the user is in trouble and the caregiver is away. It will lessen the work of the caregiver, who does not have to be there at all times for every task the client can now do for himself.

TECHNICAL DESCRIPTION

The communication device weighs 7lbs, with dimensions of 12.5 by 10.5 by 2.25 inches. The display size is approximately 12" diagonal, and has an active matrix color LCD w/ 800x600 resolution. Wood was used to machine the interface part between the Tri-pod extendable neck and the over-the-bed table surface. To prevent the wood interface from splitting, it was treated with shellac before it was painted. Countersinks were placed at the top to help get a better grip between the piece and the table. The main hole was made to have a very tight fit; some of the wood on the inner diameter was shaved to allow room for the welding compound. The aluminum tube was sanded lightly so that the weld material would hold. A cold weld was performed using a product called J-B Weld. This product is designed to work with both wood and aluminum. The finished piece was allowed to dry for approximately ten hours before it was handled.



Figure 20.21. Augmentative Communication Device Mount.

Through careful analysis it was determined that the best place for the welded piece to sit was front and off slightly to the right on the over-the-bed table. Measurements were taken and the piece was placed in the center of the table. The first $\frac{1}{4}$ " hole was drilled through and bolted down using a $\frac{1}{4}$ " nylon lock nut. On the bottom a brass washer was placed and then a stand $\frac{1}{4}$ " nut was placed. To prevent the table from being placed too close to the patient's lap, four nylon lock nuts with rounded tops were used. The top of the platform has a removable plate that is used to hold a camera. Two $\frac{1}{4}$ " holes were drilled and a lock nut was placed underneath to hold the augmentative communication device. Figure 20.21 illustrates the tri-pod mounting unit.

The adjustable rod allows for the attached device to be placed above the patient's head and then adjusted. The device holding the mount can move in any direction and be locked. When the pole is in its normal upright position with the tray table horizontal, the pole will experience negligible load due to the 7-pound augmentative device. Tests suggest that the maximum angular tilt of the tray table for safe usage is 30 degrees.

The cost of the system is \$279.00.

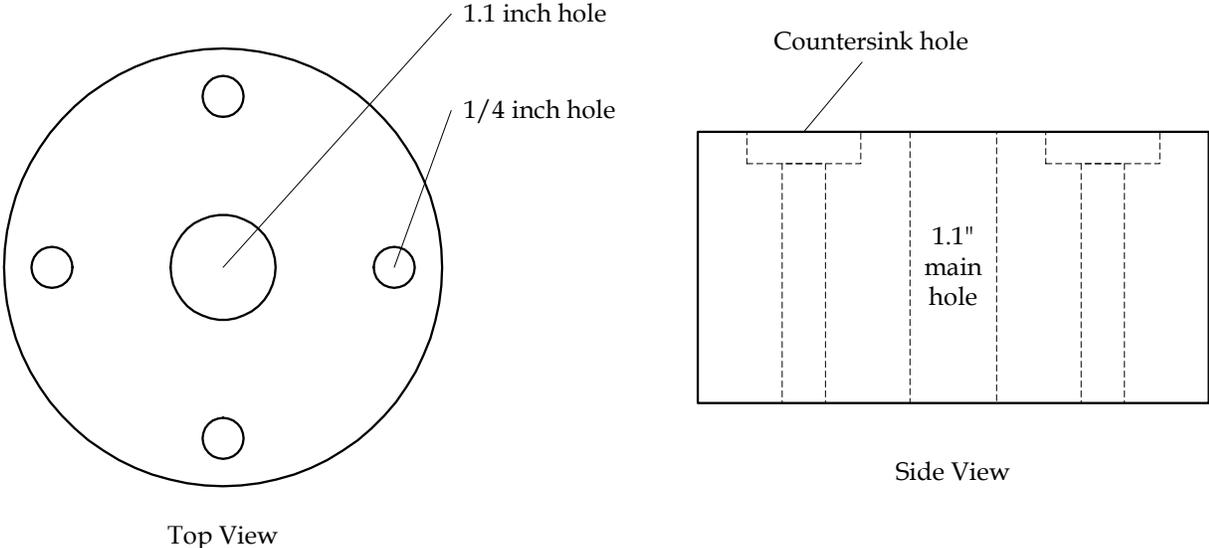


Figure 20.21. The Top And Side View Of The Tri-Pod Mounting Unit, The Main And The Countersink Holes.

MOUNTING AND AUTOMATED CONTROL FOR A DIGIVOX ARM

*Designers: David Sutter and Kevin Aguilar
Supervising Professor: Bertram N. Ezenwa, Ph.D.
Department of Mechanical Engineering
Wayne State University
Detroit, Michigan 40201*

INTRODUCTION

A client who uses a wheelchair has a Digivox augmentative communication device for daily communication. The Digivox is connected to an arm that rotates about two axes around a bi-directional hinge. However, when it is rotated horizontally, the weight of the communication device causes it to fall vertically, potentially damaging the unit. When not in use, the system is lowered in the vertical plane. A system able to control the raising and lowering of the system was developed. The system could prevent potential damage to the communication device. Figure 20.23 shows the bench test setup for the system.

SUMMARY OF IMPACT

The client depends on the augmentative device for communication. Any damage to the system will make it impossible for the client to communicate. This design will save replacement or repair costs. It will enable caregivers to be away from the client certain that when he needs help they will be immediately contacted.

TECHNICAL DESCRIPTION

Design issues to address included the design of a mechanism to damp the vertical drop, the client's reduced range of motion and strength to lift the

device against gravity, and the damping force when damping is need.

The implemented concept was an electric motor, which will draw power from an existing battery to move the communication device, attached to a shaft, up and down. The motor would be mounted under the wheelchair seat on top of the battery, as illustrated during bench test. Power would be transmitted from the motor to the Digivox arm by attaching a wire cable to the motor shaft through a pre-drilled hole and routing the cable through the Digivox arm and attaching the cable rigidly to the vertical arm. Any exposed wire was encased in a nylon sheath for safety reasons. Upon attaching the cable, a toggle switch was wired from the motor to the battery.

The operation of the system would be as follows: When the switch is toggled in one direction (down), the arm will rotate downwards, and when the switch is toggled in the opposite direction (up), the arm will rotate upwards. The torque in the motor prevents the arm from falling in the stop position, and dampens the movement when the arm rotates downwards.

The cost of the system is \$568.00.

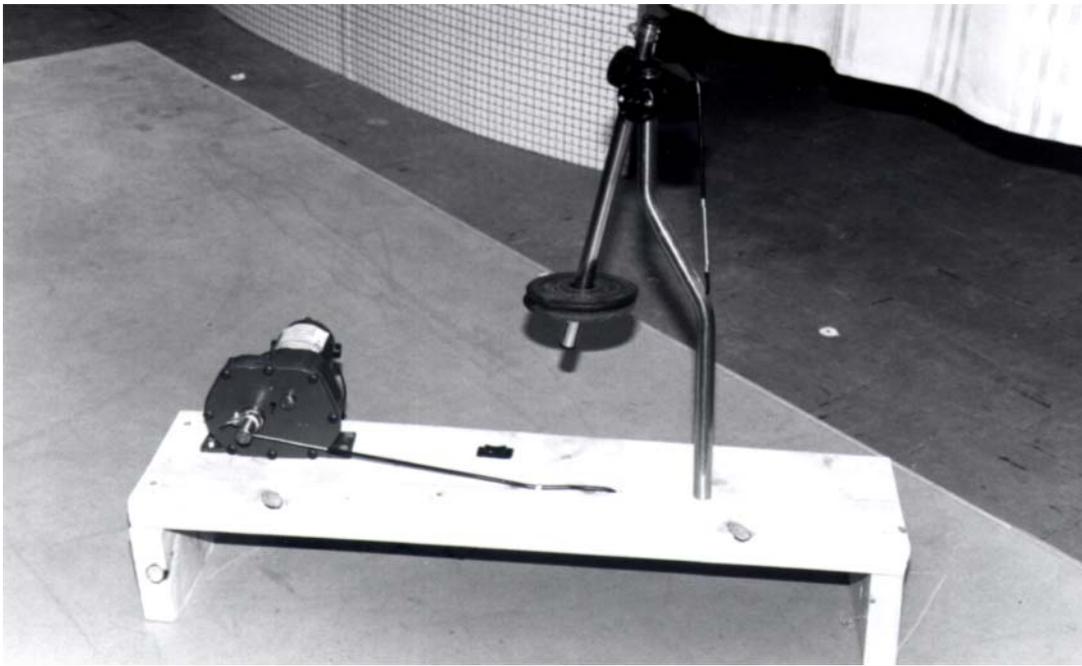


Figure 20.23. Mounting and Automated Control of a Digivox Arm.

VERSATILE JOYSTICK MOUNT

*Designers: Brenda Jones
Supervising Professor: Bertram N. Ezenwa, Ph.D.
Department of Mechanical Engineering
Wayne State University
Detroit, Michigan 40201*

INTRODUCTION

A joystick-mounting device capable of being clamped to a power or manual wheelchair was designed for a client with physical disabilities. The mount is versatile enough to clamp to round tubing or the edge of a table with square edges. The mount holds the joystick in a stable position in the vertical and horizontal planes. The arms of the segment are adjustable to cover a 180-degree radius.

The design goal was accomplished by integrating off-the-shelf parts, which consisted of two aluminum rods, a 2-way panhead, a handle, a steel rod, a connector, and three adjusters. The system, mounted on a manual wheelchair, is shown in Figure 20.24.

SUMMARY OF IMPACT

The versatility of the integrated product enabled the client the choice of using the joystick while on a power or manual wheelchair. The client could use the system for mounting other joysticks used for fun and/or for environmental control.

TECHNICAL DESCRIPTION

The wheel and armrest of the manual and power wheelchair become obstacles of the joystick mount in the horizontal direction. Therefore, an adjuster on a steel rod was added to allow the mount to rotate away from the body of the wheelchair. Another potential obstacle for the joystick mount was the patient's tray. The 2-way panhead with the rotating device connected to the vertical arm of the mount allows the joystick to be moved further in front of

the client's body. The joystick cord, connected to a switch for the client to operate, is attached to the arms of the segment with ties.

Components of the system are described below.

- The clamp has a removable embedded piece to fit the round or square tubing on a manual or power wheelchair.
- An aluminum rod with length adjusters is connected to the clamp to allow movement in the horizontal direction.
- A steel rod, adjuster, and connector connect the joystick mount.
- A second aluminum rod, connected to a 2-way panhead, is the joystick mount.
- The 2-way panhead is connected to a rotating device to allow the joystick mount to move in the vertical direction.
- A handle connected to the 2-way panhead mount allows the joystick to pivot in a secured position in a 180-degree radius.
- Arm adjusters allow for arm movement of the segment in the horizontal and vertical planes

After system integration, the system performed the basic functions satisfactorily. It will however, be necessary for custom development in order to reduce the weight of the integrated system.

The total cost of the system is \$99.00



Figure 20.24. System Mounted on a Manual Wheelchair.

ADAPTIVE FOOD PREPARATION DEVICES

Student Design Projects:

Analysis of commercial food preparation process flow

Designers: Dan Kempisty, Muhammad Khan, and Rachel Seguin

Client Coordinator: Susan Hardin, OTR

Jo Brighton Skills Center

Supervising Professors: Dr. Robert Erlandson, Department of Electrical and Computer Engineering, and Dr. Leslie Monplaisir, Department of Industrial and Manufacturing Engineering

Commercial food preparation kit

Designers: Dan Kempisty, Muhammad Khan, and Rachel Seguin

Client Coordinator: Susan Hardin, OTR

Jo Brighton Skills Center

Supervising Professors: Dr. Robert Erlandson and Dr. Leslie Monplaisir

Computerized receipt creation system

Designer: Clay Sheckles

Client Coordinator: Susan Hardin, OTR

Jo Brighton Skills Center

Supervising Professor: Dr. Robert Erlandson

Computerized weighing and measuring system ("Bakery 98")

Original Designers: Mohammed Akkal, Emad Abu Aljazer, Manoj Kumar, Syed Alam, Mohsi Mohammed

Modification Designer: David Sant

Client Coordinator: Susan Hardin, OTR

Jo Brighton Skills Center

Supervising Professor: Dr. Robert Erlandson

INTRODUCTION

A vocational training center for special education students aged 16-26 provides opportunities for people with disabilities to attain their preferred life outcomes. To do this, the center provides vocational and a vocational training in a variety of job clusters in the center and in the community. Vocational training classrooms include a commercial bakery and commercial food preparation services. To provide an error-proof environment in these classrooms and a more effective learning environment for the students, four design projects were developed. Expertise from industrial, mechanical, and electrical/computer engineering fields was used in the execution of these projects, which include:

- An analysis of commercial food preparation process flow,
- A commercial food preparation kit,
- A computerized receipt creation system, and

- A computerized weighing and measuring system called "Bakery 98."

The projects were conducted with an accessible design philosophy. Accessible design, also known as universal design, simply means designing a product or service so that it can be used by as large a segment of the population as possible, and it includes the incorporation of quality tools and technology. With the growth of classroom technology, it is vital that the classroom environment be structured to support computers and computerized learning/teaching aids. The projects combine quality classroom ergonomics with technology to produce a stable, organized learning environment.

SUMMARY OF IMPACT

The combination of the four student design projects has had significant impact on the day-to-day operations at the center. First, the redesign of the food preparation classroom based on the process flow analysis allows students to complete more

tasks independently than before. Because the classroom is organized using a visual structuring system, the students can set up, operate, and restock their workstations without having to read signs or rely upon supervisory input. The students are more empowered now, and staff members have more time to teach universal skills or help students who need additional instruction.

The commercial food preparation kit project grew from the process flow analysis project. The kit, which keeps all of the tools necessary for each job in one contained unit, eliminated a great deal of the confusion and traffic involved with looking for and retrieving the tools for each task. Students could easily locate their kit without staff assistance, and, with a quick visual scan, be certain that they had all of the tools needed to begin working. With this accommodation, the students were able to get to work more quickly and have more time for learning new skills.

The third project, a computerized receipt creation program, enables students with limited reading skills to take and receive food orders. It uses alternative keyboard entry hardware, picture icons, and voice prompts to allow the student taking the order to communicate effectively with the students receiving the orders in the kitchen. This tool created a job for workers who cannot write or hold a writing implement, as the previous method of logging customer orders involved circling an iconographic representation of the customer's order on a paper receipt.

The last project, Bakery 98, allows students in the commercial bakery classroom to accurately weigh and measure bakery ingredients without supervisory input. The scale gives students verbal and visual cues and prompts that guide them through the weighing process as well as positive feedback to indicate when a goal has been met. Bakery 98 allows students with severe cognitive disabilities to participate actively in a portion of the baking process that they could not be a part of before. Due to the increased number of competent participants, the amount of products produced in the bakery has increased.

The combination of these four projects has provided a highly accessible, error-free learning environment in which nearly all students have the capacity to participate.

TECHNICAL DESCRIPTIONS

Project 1: Analysis of Commercial Food Preparation Process Flow

The commercial food preparation classroom functions to teach students with various types of disabilities skills that will allow them to be productive in community work settings. One problem with the center's food preparation process, however, was that the students rely a great deal on staff to complete each task. The process flow of the food preparation classroom was analyzed and recommendations were made as to how to re-engineer the environment to increase student independence.

The analysis of the food preparation site was conducted using process analysis tools. These tools include process flow sheets and cause/effect fishbone diagrams. The process flow diagrams illustrated the sequence in which the processes were performed in the classroom and if the process involved an operation, inspection, transport, storage, or delay. An efficient process consists of mostly operations and very little transportation, delay, and/or inspection. The fishbone diagrams broke down each step in the process to show the cause and effect of each major component. AutoCAD drawings of the facility were composed and staff members helped to determine the best way to arrange the environment.

It was found that the root causes of the students' constant need for staff assistance were the poor layout of the classroom and the poor organization of stored materials. Students were easily frustrated and confused by the inconsistent nature of the environment, which led to the need for staff assistance. To remedy this problem, the workplace was reorganized using visual structuring. Visual structuring involves using icons, color-coding, and other visual means of organizing the workplace. Icons were placed on drawers to indicate which tools were inside. Recipes and the corresponding ingredients and instructions were color coded and identified with picture icons, and the shelves and other storage areas were labeled as to which tools or equipment belonged in which spot. This type of organization, which was emulated in the commercial bakery classroom, established a sense of consistency in the classroom.

Because everything was always kept in the same place, there was less need for students to wander around, looking for tools. Because the classroom was structured visually, students did not have to know how to read in order to know what materials to gather—they only had to identify colors and pictures. By reducing the cognitive demands of the tasks, the tasks have become accessible to a greater population of students than before.

Project 2: Commercial Food Preparation Kit

While the visual structuring of the commercial food preparation and bakery classrooms increased the accessibility of the classroom tasks, it was decided that a more efficient means for gathering supplies and stored materials in the commercial kitchen was necessary. Students were still spending a great deal of time and effort walking through the kitchen retrieving the tools for each task, particularly in the commercial kitchen.

To reduce the amount of time required to gather materials and supplies, a kit of tools was fabricated

for each workstation in the kitchen. Consistent with the organization pattern of the kitchen and bakery, the kits were designed using a visual structuring system that demarcated and labeled where each item should be stored. Icons and shadow diagrams were used to define the placement of the tools in each kit so that, after the workers used the tools, they would be able to easily recognize where to replace the tools in the kit. Having a specific place for each tool was found to reduce the potential for clutter and misplaced equipment.

The kits were made out of commercial dish racks (see Figures 20.25 and 20.26) so that, after the tools in the kit were used, the entire kit could be placed in a dishwasher for cleaning without having to disassemble the kit. The cost of the kit, minus the kitchen utensils that the center already had, was approximately \$40.



Figure 20.25. A Standard Dish Rack.

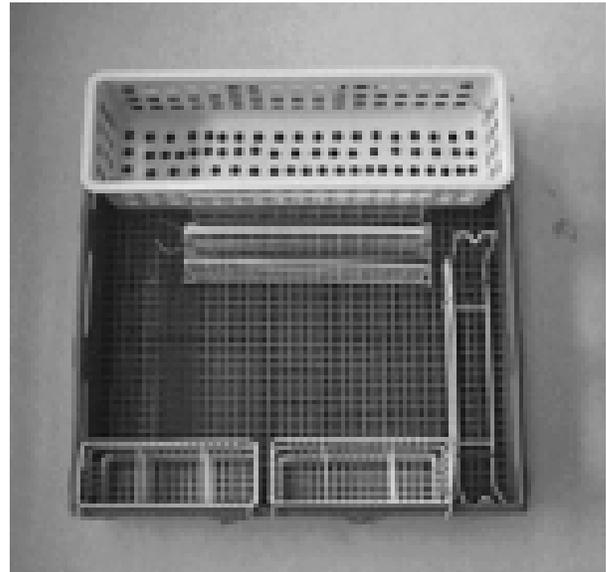


Figure 20.26. Dish Rack Used for Kitting.

Project 3: Computerized Receipt Creation System

With the food preparation areas organized, a means of facilitating a smooth, error-free system for taking customer orders had to be created. Before the computerized intervention, the order-taking system involved written menus and icon-coded receipts. The workers would circle the icon on the receipt that represented the customer's choice and send the receipt back to the kitchen area.

The receipt creation system was designed to replace the paper receipts previously used and provide a medium through which more students could participate in the kitchen's activities. The system replaces the paper receipts by using a custom-designed Visual Basic 5.0 application to print receipts to a standard color printer.

Order information is sent to the computer through an Intellikeys touch pad, which has a custom overlay containing icons of all the kitchen's menu items as well as several simple function keys, such as "start over" (Figure 20.27).

To place an order, the worker simply presses the icon representing the customer's menu choice and the customer's desired condiments. For example, if a customer orders a hamburger with lettuce and mustard, the worker would press the hamburger icon, then press the "plus" sign followed by the

lettuce icon, then press the "plus" icon again, followed by the mustard icon. As the worker enters this order information, the information is displayed on the computer's monitor, providing a visual confirmation of what the worker has entered. Additionally, the program has a voice feedback mechanism that prompts the worker for order information as well as audibly confirms each order item as it is entered. When the order is complete, the worker presses the "done" icon, and the order is printed to the color printer in the kitchen.

The Receipt Creation System has a number of sophisticated features designed to promote an organized, accessible workplace as well as assist with record-keeping chores. First, when the worker entering customer orders presses "Done," the system sorts all of the orders by color. The kitchen area has different colors associated with each food preparation process; for example, the deli items are red, and the grill items are blue. Sorting the orders by color allows the kitchen staff to identify easily which orders go to which workstation.

In addition to facilitating an organized work atmosphere, the system saves statistics each day on the orders taken. When the Receipt Creation System is started each day, it prompts the user to enter the current date. As each order is taken throughout the day, statistics on which orders were taken are logged in a database. Before shutting down the



Figure 20.27. Intellikeys Touchpad with Custom Overlay.

system at the end of the day, the program compiles a final tally of the items ordered that day and saves those statistics in the system database. Such data are useful inventory tools and aid staff in determining what supplies need to be ordered.

To run optimally, the Receipt Creation System requires at least a Pentium-grade CPU with Windows 95, 98, or NT, a color monitor, a color printer, an Intellikeys touch pad input device, and computer speakers. An Intellikeys touch pad costs approximately \$400.

Project 4: Computerized Weighing and Counting System ("Bakery 98")

Besides the commercial food preparation classroom, the center provides student training in an on-site commercial bakery. In the bakery, the students participate in the preparation and sale of assorted baked goods. Many of the students, however, have difficulty interpreting the dials on the mechanical scales used to measure and weigh ingredients. Staff members had attempted to reduce the cognitive demands of the task by color-coding markers on the dials, but the task was still highly error-prone. This frustrated the students and made them dependent on staff intervention in order to complete the measuring and weighing processes.

An original assistive technology intervention was introduced in 1996 and involved a digital scale interfaced to a PC. The associated software allowed staff to input the ingredients and amounts of ingredients necessary for each recipe using a touch screen, and it guided students through the weighing and measuring processes with verbal and visual prompts. While this initial effort was a successful proof of concept, it was inherently unreliable. The project modification features a simpler user interface, increased reliability, a rewritten recipe editor, and a smaller overall program size.

The Bakery 98 modification is divided into two separate applications: a recipe editor and a talking scale. As shown in Figure 20.28, the recipe editor allows staff to add or remove recipes, edit ingredients for the recipes, adjust the weight tolerances for each ingredient, and specify the amount of each ingredient to be used in each recipe. Each recipe and each ingredient has its own icon and audio file, which can also be changed in the recipe editor. The recipe editor can store up to

twelve recipes and twelve ingredients with their associated icons and wave files at one time.

The talking scale component of Bakery 98 allows the user to work with the recipes stored in the recipe editor. The user first selects the recipes with which the students are to work, and then selects the ingredients that the students are to measure. For example, if a teacher decides that the students need to measure enough flour to make two batches of chocolate chip cookies, he or she would press the chocolate chip cookie icon on the screen twice. From the next menu, he or she would select the "flour" icon from the list of ingredients. Each time that a recipe or an ingredient is selected, the audio file associated with the selection is played.

After selecting the recipe and the ingredients to be measured, the user places an empty bowl on the digital scale that is interfaced to the PC. The scale itself has a "tare" function to account for the weight of the bowl. When the weighing process begins, a bar graph along with a numeric display shows the current weight of the ingredient being measured in pounds and ounces (Figure 20.29). Voice prompts instruct the user to either "add some more" or "take some out" until the target weight is reached, and, when the scale detects that the target weight has been reached, a voice prompt announces that the session is over. Staff must select the "continue" button for the student to begin weighing the next selected ingredient.

The user interface of Bakery 98 is designed to work with an Edmark Touch Window for user input as well as with standard keyboard shortcuts and a mouse. Because the target population using this product typically has a short attention span, an adjustable timed prompting mechanism was built into the weighing process. If the program receives no user input for a specified period of time (between 1 and 99 seconds), a prompt will sound, alerting the user to stay on task.

The system runs on Microsoft Windows 95 and interfaces to a Pelouze 4000 Series Scale. To run optimally, the system requires a Pentium-grade CPU, 32MB RAM, and 5MB hard disk space.

The hardware for the system modification cost approximately \$300.

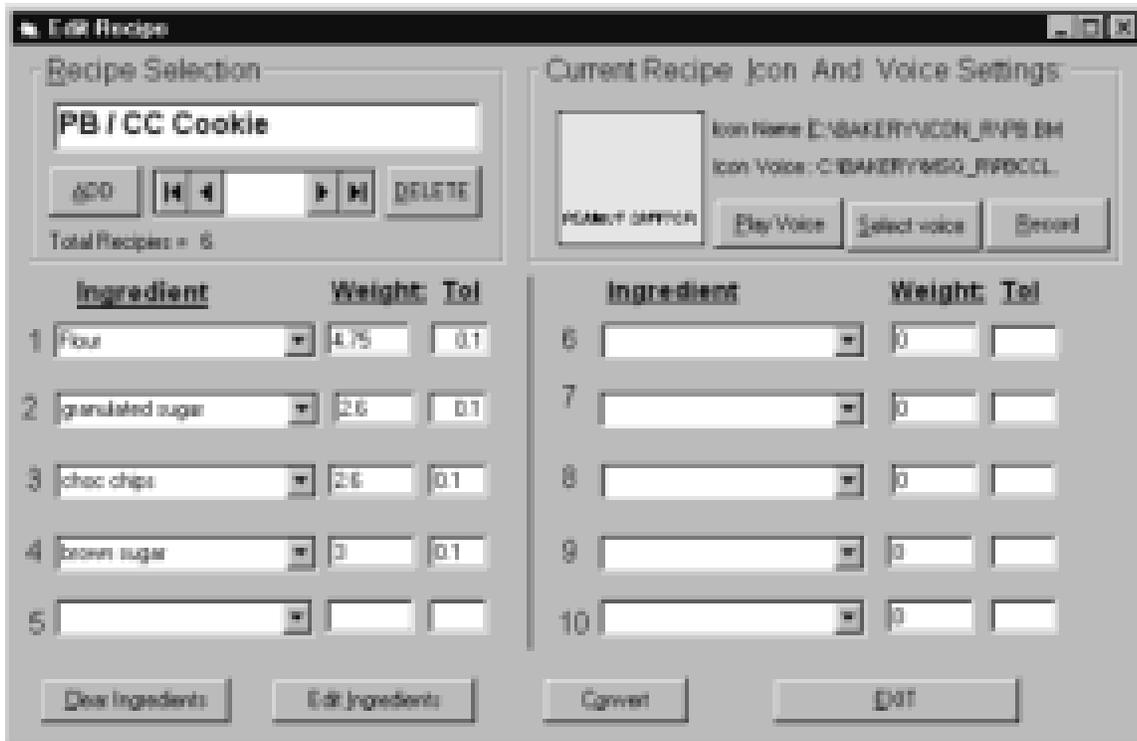


Figure 20.28. Bakery 98 Recipe Editor.

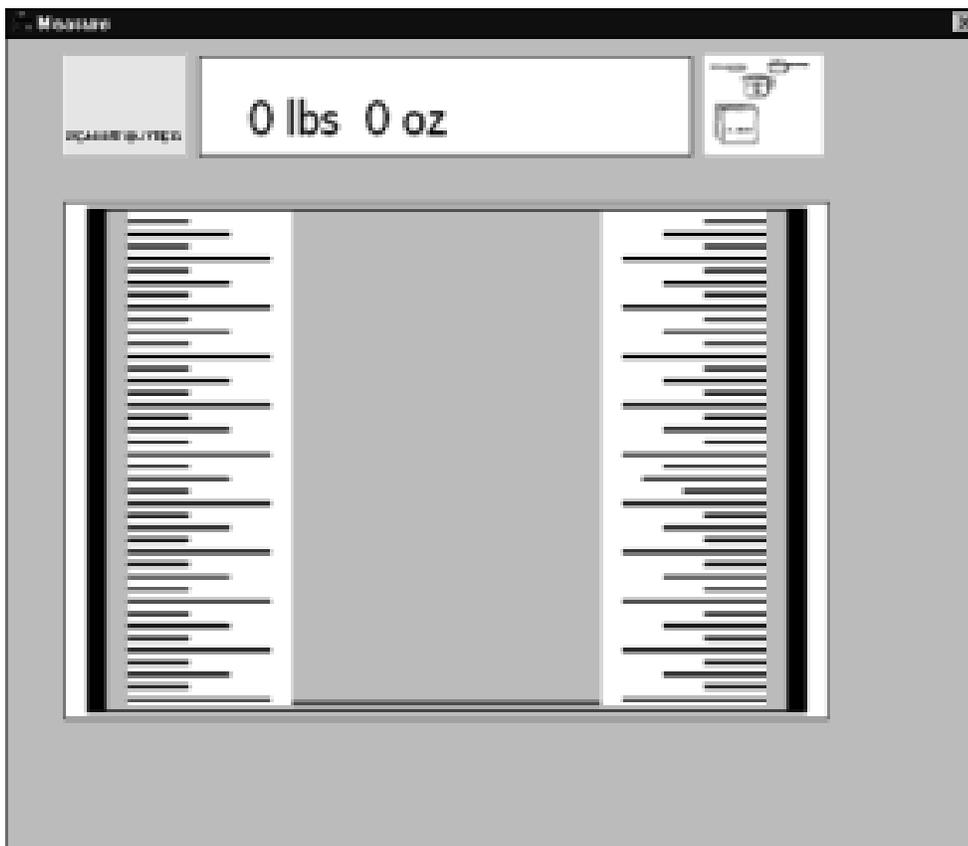


Figure 20.29. Visual Display of the Weighing Process.

