CHAPTER 19
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PACKAGING AND ASSEMBLY FIXTURES AND SHIPPING KIT DESIGN

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INTRODUCTION
Our design is for a small business that employs people with disabilities. The business produces a product line of hand painted tools with wooden handles, including kitchen and garden tools, hammers, and screw drivers. A screwdriver is shown in Fig. 19.1. The tools are distributed worldwide through gift stores and as promotional items for companies.

Unfinished inventory is sent to special education vocational classes for sanding and priming of the wooden handles. The prepared tools are then sent back for artists to paint. The finished products are packaged for shipment. Packaging involves: 1) folding cardboard frames and supports that hold the tools in place; 2) affixing a tool to the holding supports; and 3) inserting the cardboard frame into a stiff plastic sleeve. It is important that the plastic sleeve not be scratched or deformed so that the product is nicely displayed.

Previously, there was no standardization of the production process or quality control at the different schools involved. Also, the method of shipping unfinished tools and materials to schools and back was not cost effective and tools were often marred or ruined. The first goal of the project was to design fixtures to standardize the fabrication and packaging processes. The second goal was to design a shipping kit to standardize the shipping process as a way to prevent damage to the tools.

SUMMARY OF IMPACT
A kit was designed for shipping all materials and inventory required by the special education classes. Fixtures were created for improving the sanding and paint priming process. Fixtures were also created for improving cardboard folding and insertion of cartons into plastic sleeves. After training with the kits, the students were able to independently and efficiently unpack the shipping materials and organize them. They were also able to repack their finished products to be sent back. Students with physical and cognitive disabilities were able to perform the associated tasks faster and with fewer errors. Based on the initial success of the fixtures provided, the client company has built ten more fixtures like them. They use some at their facility and have shipped others to the participating schools.
TECHNICAL DESCRIPTION
A team of student engineers and occupational therapists worked with special education teachers at a vocational training school to design a collection of jigs to help improve the productivity and quality of participating students. A prototype shipping kit was also designed and is being field tested.

Fig. 19.2 shows an unfinished screwdriver handle (steel portion removed) on a jig that can hold four handles for the sanding and priming operations. Fig. 19.3 shows a folding jig for the shipping/display boxes.

Fig. 19.4 shows a packaging jig to aid in error-proofing, quality control and productivity. The jig is a wedge-shaped block of wood with metal clamps on the end. The clamps are stiff enough to hold the box while the wedge is inverted and pushed through the plastic cover. The rectangular shape of the wooden jig forces the plastic cover to open to the correct shape as the box is inserted.

The estimated cost of all the materials is $140.
FACILITIES ANALYSIS AND WORKSTATION DESIGN

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INTRODUCTION
A client business produces a product line of hand-painted decorative tools, as described in the previous project report. The business is experiencing a rapid growth phase in terms of increasing orders and expanding business opportunities. The business required operations and facilities that can accommodate this growth. The goals of this project were to: 1) conduct an analysis of facilities requirements; 2) make recommendations for improvements; and 3) design a prototype workstation to serve as a standard workstation for the facility. The work area was overcrowded. There

Fig. 19.5. Redesigned Shipping Area.
were materials stored on the floor in a receiving area, a shipping area that doubled as the packing area, and donated furniture and shelving spread about the facility. Workers in wheelchairs could not access most of the work area. Workers with mobility or balance problems had trouble negotiating the work area. Material flow and handling were inefficient and limited because of worker's navigation difficulties.

**SUMMARY OF IMPACT**
A detailed facilities analysis was performed and several alternative scenarios were presented to personnel. Discussion among the design team, participating faculty, and staff resulted in a consensus strategy. Additional space was rented adjacent to its current facilities. The team set up shelving, established new shipping and receiving areas, and created an organized storage area. A new mobile wheelchair-accessible workstation was designed and built. The work area was reorganized into U-shaped work cells with defined tasks in each cell, i.e., sanding in one, priming in another, and final decorative painting in another.

As a result of these changes the entire work area became more accessible. Workers in wheelchairs and those with mobility or balance issues can now safely navigate the work area, allowing these workers to assume more responsibilities for material handling, stocking and inventory control.

**TECHNICAL DESCRIPTION**
The first step was to conduct an analysis of storage space, shipping areas, material handling practices, work areas, and task analyses. Brainstorming with owners and staff led to more clearly defined business and operational objectives. Based on these a 5S program was implemented. The 5Ss are: sort, set in order, shine, standardize, and sustain. AutoCad was used to display the original facilities layout as well as alternative layout strategies. BlocPlan was used to analyze facilities layout options. A more organized inventory system using the A-B-C approach was designed and implemented. Fig. 19.5 shows the new shipping area.

A prototype version of a mobile workstation was designed based on agile assembly principles. The workstation was built from Creform, a pipe and joint technology used extensively in manufacturing and assembly. There is a pegboard top and a pegboard divider extending up from the center of the workstation table. Hangers can be attached to the pegboard to hold freshly painted tools. The pegboard serves as a holder for many of the tools. They are simply inserted in the holes and securely positioned for priming, decorative painting, or a final protective coating of varnish.

The estimated cost for the mobile workstation is $350.
MATCHING CORRESPONDENCE COUNTER: COUNTING AND PACKAGING

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Client Coordinator: Jane Resutek, Occupational Therapist, Warren Woods Tower High School
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INTRODUCTION
A special education vocational training class has a mini-business that supplies teachers throughout the local school district with a variety of decorative paper cutouts. The Matching Correspondence Counter (MCC) was developed to help special education students count and package paper cutouts that have been ordered by teachers throughout the district. The MCC consists of 10 instrumented bins communicating with a control PC. It communicates to the PC the status of the bins (empty or containing an object) via an indicator light.

SUMMARY OF IMPACT
The MCC is ideal for counting light paper cutouts because of the sensing bin structure. It turns the counting task into a pattern recognition task with system monitoring and multi-modal feedback to the students. The MCC enables students who cannot count to engage in the packaging activity.

TECHNICAL DESCRIPTION
The program is written in Visual Basic 6. It uses the MSCOMM control variable in Visual Basic to communicate with the MCC. Fig. 19.7 shows the splash screen that appears when the program starts. Fig. 19.8 shows the system configuration screen. The teacher can specify a prompt time. The prompt time is the amount of time the system will wait for a user response before issuing a voice or sound message. The teacher can record a customized prompt message and can add new pictures to the display. The pictures are of the paper cutouts to be counted. Fig. 19.9 shows the job set-up screen. Here the teacher selects the cutout to be counted and the number of pieces to be counted. These are displayed on the screen. Fig. 19.10 shows the counting screen. As the cutouts are added or removed, an image is added or removed to keep track of the MCC bin contents.
Fig. 19.9. Job Setup Screen for Selection of Cutout and Number of Pieces to be Counted.

Fig. 19.10. Counting Screen Reflecting Number of Items in the MCC Bins.
MATCHING CORRESPONDENCE COUNTER: MATHORAMA MATH GAME

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INTRODUCTION
A universal design approach was used in creating a game for pre-school, kindergarten and early elementary students and those with comparable cognitive abilities. It is a manipulative activity that makes use of the Matching Correspondence Counter (MCC). The MCC consists of ten instrumented bins communicating with a control PC. The MCC can be programmed to perform a variety of tasks. The MathORama game involves users adding objects to and removing them from the bins, guided by visual and voice prompts from a PC. The activity has two levels, a practice level (level zero) and a grading level (level one).

The practice level prompts the user to fill the bins until all of them are full and then prompts him or her to remove the cards from the bins until all of them are empty. In the grading level game the student is given ten questions and is graded on a ten-point scale. The questions can be addition, subtraction or a combination of both. The teacher is given an option to select a category. Scores are shown in percentages on a graph. The prompt time, the duration for which the system waits without a user response before presenting another auditory prompt, can be set by the teacher according to each student’s ability.

SUMMARY OF IMPACT
Students with cognitive disabilities can benefit from this educational activity.

TECHNICAL DESCRIPTION
The game was developed using Visual Basic 6.0 with a PIC 16F876 microcontroller on the MCC to provide the communications interface between the PC and the MCC sensing and display elements.

The backbone of the MCC program is the Visual Basic MSCOMM control, version 6.0.81. This control integrates both hardware (RS232 port) and the MathORama software to produce an integrated gaming activity that interfaces smoothly with the MCC and user responses. The MSCOMM control accomplishes this communication utilizing OnCommEvent, RThreshold, and InBufferCount. The OnCommEvent, for example, invokes the PC and updates it with user movements or interactions. As the user fills the bins or removes items from the bins, the microcontroller polls the bins and detects the status of the bins via the sensors. The microcontroller then sends the data to the PC. The OnCommEvent receives the data and signals the PC, which then reacts accordingly.

Fig. 19.11, 19.12, and 19.13 provide sample screen images. Fig. 19.11 shows the splash screen, which is present as the program starts. Fig. 19.12 shows the teacher set-up screen wherein she can select the game level (1 or 2) and enter the player’s name. When the game starts the player is prompted both
verbally and visually. Fig. 19.13 shows an addition example where the player is asked to add three and six together to get nine. The player places objects one at a time into the MCC bins. With each placement the player receives a prompt. A prompt also indicates when the sum number is reached (three in this case) and then provides another verbal and visual prompt to add six more. When that is done the prompt provides a reward message stating the answer, nine in this case. A voice recording utility is provided so that teachers can create their own customized prompt message.

Fig. 19.12. Set-up Screen.

Fig. 19.13. Addition Example.
ACCUCUT MANUAL DIE MACHINE CONVERSION
TO SWITCH OPERATED

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INTRODUCTION
The staff at a high school special education vocational training program uses a mini-business model for vocational activities. A goal of the program is to engage as many students as possible in work activities. One successful mini-business produces paper cutout decorations for classrooms throughout the school district. Teachers place orders for decorative cutouts, e.g., 25 hearts for Valentines Day, 12 flowers for spring, etc. The students are using manual AccuCut Die cutting machines to create the cutouts. Fig. 19.14 illustrates use of the manual device. The physical demands of the task preclude use by students with poor upper extremity functioning.

The goal of this project was to design and build a switch-controlled version of the AccuCut Die machine. The staff requested that this device be mounted on a wheelchair-accessible mobile workstation with enough storage space for all the materials necessary for the job.

SUMMARY OF IMPACT
The staff was pleased with the final design and eager to start using the system.

TECHNICAL DESCRIPTION
Conversion of the manually operated device to a switch-operated device required that the manual crank be removed and an electric motor coupled to the shaft. The manual device was inherently safe in that it was impossible for a student to turn the crank and get his or her fingers into the die press rollers. With switch control, safety is a primary concern.

Fig. 19.15 shows the completed system. The AccuCut is positioned on a custom-designed Creform workstation. Creform is a pipe and joint technology ideally suited to rapid prototyping yet durable enough to be used as the final product. The workstation is wheelchair accessible and has storage units for the job's required materials.

First, the dies must be placed into the movable tray. Then the tray must be positioned so that an edge of the tray and the cushion material are engaged with the press rollers. It does not matter on which side the tray starts, as system sensors detect the position and move the tray accordingly. One or more sheets of paper are then placed over the dies and the start switch is pressed. The press rollers pull the tray through. The roller pressure pushes the paper into a metal cutting blade in the die. As the tray moves through the rollers the paper cutouts are produced. Sensors detect when the dies have passed through the rollers and the device stops. A worker can then remove the cutouts and the residual scrap paper, place new paper on the dies, and push the start switch. The tray then moves through the press rollers in the opposite direction, completing the cycle.
Fig. 19.16 shows the various safety mechanisms. The stop bars block fingers or larger objects from entering the rollers. If the bars are engaged and move toward the rollers they activate a limit switch, which stops the rollers. Two switches must be sequentially pressed to restart the device. The rollers move the tray away from the press section when activated again. This clears the object from the safety bars. Multiple limit switches and a timer add redundant safety measures.

The cost of the system was about $1,500.