CHAPTER 16
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RFID TAG BASED LAUNDRY SORTING SYSTEM

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INTRODUCTION

Cooke School is an educational center for students with cognitive impairments. The school serves nearly 150 students from 16 school districts in Western Wayne County, Michigan. The students may be severely cognitively impaired, severely multiply impaired, and dual diagnosed with emotional and cognitive impairments. Staff at Cooke School wanted to redesign and enhance their laundry oriented vocational training activities.

Staff wanted students to collect used smocks, aprons, coveralls, and other articles of clothing that needed to be washed from the twenty-one (21) classrooms in the building. After washing and drying the articles of clothing, the clothing must sorted and returned to the correct room. Based on discussions with Dr. Case, an Occupational Therapist at Cooke School, and her colleagues, the laundry area would need to be wheelchair accessible, with mobile and adjustable workstations to accommodate the physical demands of the students and the relatively small space available for the laundry operations. Additionally, any cognitive aid for sorting would have to eliminate the need for reading or number recognition. The system should provide the environmental support required for a worker with cognitive impairments to independently perform sorting based on color, size, names, destination of the clothes (a laboratory, classroom, or business), or any other requirement.

These requirements resulted in a redesigned laundry room, incorporating a number of inter-related design projects. These inter-related projects are briefly described within the context of the overall laundry room project. The key decision was to use a passive RFID tag system for clothing identification and sorting. This decision drove the design requirements and needs for the rest of the facility. The project spanned two consecutive semesters.

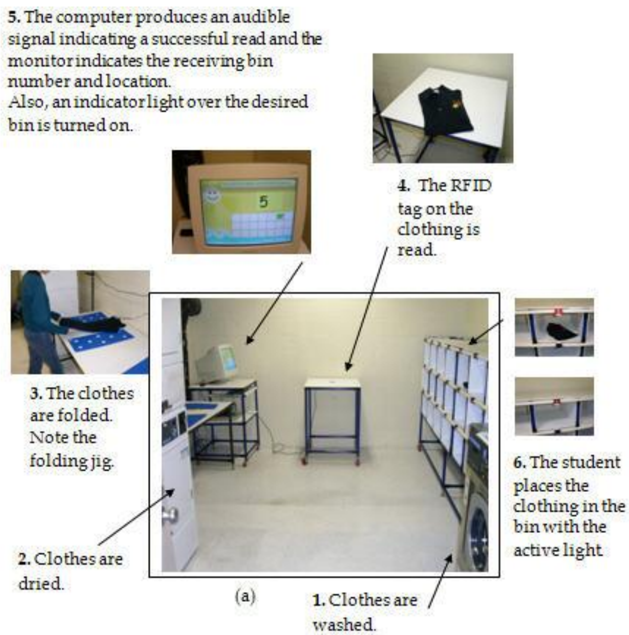

Fig. 16.1. The overall process.

SUMMARY OF IMPACT

The new laundry facility has been fully operational for over six months. Students are eager to work in the laundry, and the system supports the variety of physical and cognitive disabilities presented by the Cooke student population. Staff like the system and appreciate the level of independence it provides the students.

TECHNICAL DESCRIPTION

The goal of the project is to design a laundry sorting system that enables the students to independently perform the laundry sorting operation. The system provides the necessary environmental supports, both physical and cognitive, for independent work. Agile workstation design, coupled with CREFORM technology, provide the physical support and RFID passive tag technology provide a method to achieve the desired cognitive support.

Every garment has an RFID tag that is read (identified) by a reader, which communicates the tag's ID to a control computer. Special computer software associates the tag ID with a specific article of clothing through a database system. Once the association is established, sorting by classroom informs the worker as to the designated bin to place the garment.

There needs to be 21 classroom bins. Each bin requires an indicator light to instruct the worker where to place the garment. To eliminate long cable runs, a wireless Zigbee protocol is used to communicate between the control computer and a Bin Controller Module, mounted on the bin rack, to control the LEDs.

The room's plumbing dictated placement of the washer and power and venting options dictated placement of the dryers. An adjustable and mobile cloths folding workstation was designed and built as was a mobile RF reader cart, a mobile PC controller cart, and of course, the mobile instrumented bin frame that housed the 21 storage bins.

Figure 16.1 shows the overall process. Step 1 and Step 2 show the washer and dryers in the laundry room. Just behind the dryer, along the left wall, is the folding and sorting workstation. Behind that is the PC controller cart with computer. The RFID tag reader is mounted under the top of a mobile workstation. It is straight ahead as you look through the laundry room door in the central image. As a folded article of clothing is passed over the top of the reader workstation, the RFID tag affixed to the clothing is read and information passed to the PC controller. The controller provides visual and auditory feedback to the worker, but also sends a wireless message to the Bin Controller Module, which turns off the previous light and turns on an indicator light over the bin where the clothing needs to be placed.

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Fig. 16.2. A CAD 3D representation from CATIA and the actual rack at Cooke School (from top to bottom: A and B, respectively).

Workstation Design:

The workstations are all constructed from CREFORM, which is a pipe and joint technology [1]. CREFORM is used worldwide in industrial material handling, workstation, and storage systems. CATIA was used to design four devices; a clothes folding table, computer cart, reader cart and bin frame. CATIA is a powerful CAD system and produces all of the CAD documentation required for replication of the devices [2].

All the devices have casters and are mobile. Only the folding table is required to be height adjustable for improved wheelchair accessibility. Students do not use the computer or access the computer cart, and the reader cart is accessed by someone in a wheelchair since it is relatively small. The collection bins are all wheelchair accessible. Figure 16.2a shows a CAD 3D representation from CATIA and Figure 16.2b shows the actual rack at Cooke School.

Software–Operating System:

An application program was written using VB 2005.net. Figure 16.3a shows the main screen. The program has two major sections: setup and operation. Upon starting, the program checks all 21 bin light control modules to make sure they are operational. If the system is OK, the second screen appears, Figure 16.3b. In the Setup mode, the users can add a new RFID tag and make a bin assignment, edit a current tag Assignment, or delete a tag ID. Figure 16.3c shows the add tag screen.

To add a tag the user scans the tag from the reader. A dialog box shows its vendor supplied ID number and requests a bin assignment and description. When this information has been added, the user saves the data into an Access database. After all Setup functions are done, the user returns to the 2nd screen (Figure 16.3), and activates the Start window. The operational window will be shown in a subsequent section.

RFID tag Electronic Components:

The electronic components include: the Bin Light Controller Module, a PC Communications Module, a Bin Controller module, and the wiring harness that supplies the bin light power and "on" "off" control signals. Altium Designer, an electronic CAD system, is used to design the circuit, run simulations, and layout the printed circuit board (PCB). The printed circuit boards are fabricated by a professional vendor using files provided from Altium Designer. All PCBs are visually inspected for defects prior to assembly.

RFID Reader/Antenna:

A Texas Instruments TRF7960 RFID High Frequency reader is used to detect the garment tags [3]. The TI reader is mounted in a box under the top of the reader cart. This interrogator transmits a 13.56 MHz signal to the passive tags sewn into the garments, and charges the tags using inductive coupling. The tag then transmits a unique code to the reader using the information contained in its sidebands. The reader is connected to the computer through a USB connection. It also has the capability of adding an external antenna through a SMA connector.

Fig. 16.3. The main screen, the second screen and the add tag screen (from top to bottom: A, B, and C, respectively).

Bin Light Controller Module:

Twenty one (21) of these modules are required – one for each bin. These modules use a simple circuit containing two connectors, a flip-flop, a resistor and LED. A temporal assignment of clock and data pulses will turn the bin LED "on" and "off." The PCB's are populated then individually tested using the power supply and frequency generator functions. Once they are found to function properly, the light modules are connected to the ribbon cables and the bin light controller and tested.

Figure 16.4 illustrates the design power of the CAD systems. Once the PCB is complete, a 3D rendering of the PCB is created in Altium and exported to the CATIA package. The CATIA system handles the mechanical and packaging design. Figure 16.4a shows the 3D PCB from Altium inside the case in a 3D CATIA rendering. All the electronic circuits are designed in this way.

Wiring Harness:

As seen in Figures 16.4b and 16.4c, ribbon cables connect the Bin Light modules together. The wiring harness consists of 22 individual ribbon cables with connectors. The cable has four signal lines, ground, VCC (5 volts to power the bin LEDs), a clock signal and a data line. After assembly each cable is tested.

Zigbee wireless transmitter/receiver:

The bin destination data is transferred from the PC Communication Module to the Bin Controller through the Jennic JN5139 wireless communication module [4]. The Jennic is a high performance 2.4GHz transceiver with Zigbee wireless protocol capabilities. The modules are a low cost, low power solution for transmission of bin destination data.

PC Communications and Bin Controller Modules:

Both the PC Communications and Bin Controller modules are basically the same circuit. Both contain a Jennic 5139 chip, but differ on additional functional components. Because of the similarities we designed one schematic and one PCB configuration. The PCBs are populated differently to yield different functionality. Use of common structures is a standard industrial approach to reduce fabrication costs.

The PC Communication module communicates information from the control computer to the Bin Control Module, i.e., which bin LED to turn “on” and which to turn “off.” At the Bin Controller the Jennic receives the information, constructs the series protocol that is sent over the wire harness and then sends the appropriate clock and data signals.

[1] CREFORM, "CREFORM North America Home Page," http://www.creform.com/defaults.asp, 2008.

[2] Dassault Systèmes, "CATIA, the Dassault Systèmes flagship PLM solution," http://www.3ds.com/products-solutions/plm-solutions/catia/, 2007.

[3] Texas Instruments, "TRF7960 Evaluation Module - TRF7960EVM, Status: ACTIVE ", 2007.

[4] Jennic, "Jennic: enabling the emerging market for wireless sensor networks," http://www.jennic.com/, 2007.

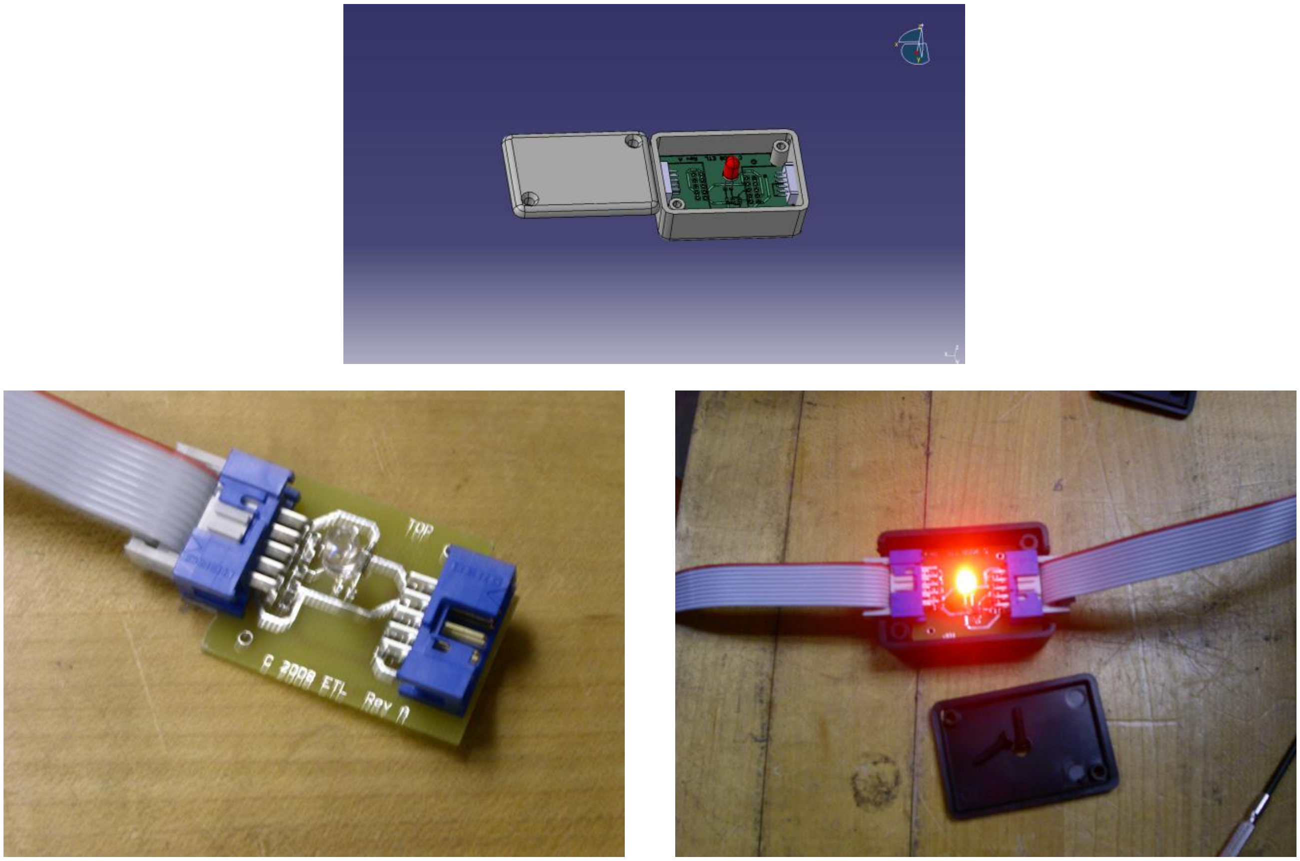

Fig. 16.4. The design power of the CAD systems (top: A; bottom: B and C from left to right, respectively).