APPLICATION OF RADIO FREQUENCY IDENTIFICATION TO AN ASSET CHECKOUT SYSTEM

By

MA'AYAN K. BENNAIM

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Graded By: _____________ Date of Submission: 
THANK YOU,

Dr. Tali Freed

Dr. Jose Macedo

Anton Slobodnik

Mandy Whitney
# Table of Contents

Abstract ................................................................................................................................. 4

Introduction ........................................................................................................................... 4

Background ............................................................................................................................. 6

Design ................................................................................................................................... 10

  - Problem Definition ......................................................................................................... 10
  - Hardware Requirements ................................................................................................. 10
  - Software Requirements ................................................................................................. 12
  - Reporting ......................................................................................................................... 13

Results .................................................................................................................................... 14

Conclusion ............................................................................................................................. 16

Bibliography .......................................................................................................................... 17

Appendices ............................................................................................................................ 19

  - Appendix A: Database Screen Shots ............................................................................ 19
  - Appendix B: Database Visual Basic Code .................................................................... 21
  - Appendix C: RFID Tag Specifications ......................................................................... 28
  - Appendix D: RFID Reader Specifications .................................................................... 30
  - Appendix E: Time Study Data ....................................................................................... 31
  - Appendix F: Project Cost Information .......................................................................... 32
ABSTRACT

Radio Frequency Identification (RFID) is a growing technology which is increasingly utilized throughout industry. This senior project identifies an RFID alternative to the checkout system in the tool crib of the Cal Poly Aero Hanger. A new database is designed and built to interface with an RFIDeas AIR enroll reader. The system realizes vast time savings in check in times and increases student accountability for the tools which are checked out by tagging tools.

INTRODUCTION

Radio Frequency Identification (RFID) has been around longer than many people are aware. In 1948, what is possibly the first paper discussing RFID was published by Harry Stockman, titled “Communication by Means of Reflected Power,” it discussed the problems which needed to be overcome to make a reflected power technology viable. Stockman did not realize how long it would take technology to develop and mature to enable his ideas. Fast forward to modern times and RFID has become a pervasive part of our everyday life, easing payments at the grocery store, and helping recover lost pets. However, the technology is still very young.

In the business world RFID has had a large impact. It helps companies manage their supply chains, control access to their facilities and track valuable assets. The tool shop in the "Aero" hanger at the east end of the Cal Poly campus is interested in RFID for this last reason. Facilities are maintained for students to work on projects and there is a token based checkout system currently in place, which allows students to borrow the tools they need, but it is cumbersome, and prone to error. Figure 1 shows the crib where students check the tools out. Dr. Tali Freed brought to my attention the possibility of improving the
system through an RFID retrofit. The goal of the retrofit will be to decrease the complexity and time required to check out a tool while increasing the amount of data which is collected during the checkout process.

Figure 1: The Tool Crib

The tool system currently in place at the hanger does not track tool check outs. It only tracks when students are checked in, and basic housekeeping task such as clean up shifts. Because it does not track tool checkouts it cannot keep records of how well tools are utilized nor can a tool shop manager tell a student what tool they are missing if they fail to return a tool at the end of the day. Additionally in order to check a student in or out, the shop tech must search a combo box with hundreds of entries for the specific student’s name.

By adding RFID tags to the tools, and utilizing the information stored on the Cal Poly ID’s a manager will be able to pull up a student’s name by swiping their card, significantly reducing the time required for a student to check a tool in or out. In addition to reducing the time required for the checkout process the system will allow the managers to track tool usage and loss accurately and automatically.
BACKGROUND

Throughout the world radio frequency identification technologies are allowing people and businesses to operate more efficiently. RFID is evolving at an increasing pace throughout as it is adopted in a wide spectrum of businesses. One function where RFID had almost completely displaced previous technologies is access control. It is visible anywhere physical security is an issue. The technologies RFID is generally used to replace are barcodes and magnetic stripes.

One area where the technology has proven its value is, Supply Chain Management. RFID tags are utilized to track inventory from the pallet level all the way down to the individual items. Even with the rise of RFID use throughout the business barcodes will remain as an alternative for the foreseeable future because of their minimal cost, ubiquity, and history of continuous improvement and innovation. (McCathie and Michael) Recently seeing the success of barcodes increasing numbers of companies are investigating if RFID can create a competitive advantage for their business. This drive to create a competitive advantage is leading those companies to phase out other technologies and systems for RFID.

There are two distinct areas where the technologies RFID replaces, barcodes and magnetic stripes, create a disadvantage. One, RFID is durable and can be ruggedized. Two, RFID, unlike these technologies does not need contact or line of sight to be read. In order for barcodes to be read the tag must be clean, and correctly oriented to the reader. Magnetic stripes, such as those on credit cards must be swiped, and both technologies are venerable to scratches. Depending on the needs of the application, RFID tags are available in Passive and Active forms which have maximum read ranges of an inch to more than 75 feet. It is also important to understand the weaknesses of RFID. Because it relies on the propagation electromagnetic fields, the presence water and metal make it very difficult to create
accurate systems. But even these weaknesses are being overcome as tags are developed for use in the steel industry. (Chen, Kuo and Lin) The reliability and time savings possible with RFID have led to its wide adoption in applications from passports to libraries and cars.

Some opponents to the permeation of RFID argue that anyone armed with a scanner can read the tag in your credit card walking by you in the street. Richard Stallman famously protested the use of RFID security cards during the UN world summit on the information society in 2005 by wrapping his card in aluminum foil and only uncovering it at security stations. This is being addressed by different industries in different ways. One example is that the International Civil Aviation Organization standard is changing to require a code from the inside page of the passport to be typed in to decrypt the data stored on the RFID chip. (Landt) The downside of this is that it severely diminishes the time savings which can be achieved by scanning the RFID tags alone. Fortunately in asset tracking security is not a major concern.

The current standard for tracking assets and inventory is the barcode, 2d barcodes and code128 are the most widely employed. (McCathie and Michael) Barcodes are good in that they are cheap, so cheap in fact that they have become ubiquitous; it is difficult to find an object without a barcode. This ubiquity occurs not only at the product level, boxes, pallets and even shipping containers employ barcodes as identification. (Manthou and Vlachopoulou) There are multiple reasons why RFID is slowly replacing them. Barcodes are read optically, this requires that the label is facing the sensor/scanner, while correctly oriented and free from dirt or grime. Additionally, the scanner can only read one code at a time. The barcode also becomes unreadable if it gets scratched.

Because RFID can be read through walls and in groups, instead of having to orient each item to the scanner, as one would do with a barcode, one can simply walk by the item, or a
group of items and scan them all at once. (Ferrer, Dew and Apte) Systems have even been
developed where entire warehouses are read by scanners mounted on forklifts. As the
forklift drives around the warehouse it is constantly and automatically taking an inventory.
Similar smaller handheld systems such as the NoxVault are becoming widely available to
smaller business (Brown). Warehouses and supply chains have demonstrated the viability
of RFID in their operations. The utilization of RFID in asset tracking is still very much in its
infancy.

Even in its infancy RFID technology has proven itself useful for asset management in a wide
variety of fields including airport operations and libraries. In the Frankfurt airport RFID is
utilized to keep track of maintenance schedules on important assets, to service breakdowns
and ease the tracking of preventative maintenance. The tags allow quick access to the
stored knowledge needed to overcome the problem and allow a real time transfer of
critical information (Legner and Thiesse).

The Construction industry has been investigating RFID for tracking asset. Current practice
in many firms is to buy an extra margin of hand tools to reduce search times when workers
need the tool. Some tool companies, such as Hitachi, have even started offering tools with
built in tags. These tags are being used to check out tools so that the extra margin is not
needed because locating the tool is simplified. This allows the companies optimize the use
of their resources and save time (Goodrum, McLaren and Adam). One study even found that
the tags could be read while in metal gang boxes (Kang). One difficulty in tagging tools is
making sure that the tags are durable enough to survive in the workplace. Tags must be
encased in the durable packaging or placed inside the tool body. If the tag is not properly
protected performance can be severely degraded if the tag is warped (Sidén, Jonsson and
Olsson). The use of RFID for tracking movable assets is one of the recent areas the
technology is proving itself. Utilizing RFID pertinent location, status, and usage information
can stored for individual items. Current systems do not adequately support inventory features. Employing RFID for movable asset management could be used to insure that an airplane mechanic does not forget a tool inside of an engine by utilizing a reader in the toolbox. Systems are also being tested to simplify checkout systems. By integrating a scanner into the countertop of a checkout window tools can be quickly and accurately checked out to operators identified with personnel badges (Lampe and Strassner). A checkout system which relies on RFID will reduce asset loss, increase accountability, and ease data recording, thereby reducing errors (Roussos).

Libraries provide another example of RFID revolutionizing a checkout system. Hundreds of Libraries nationwide have implemented RFID systems to manage security, ease checkout, and simplify inventory counts. The systems allow librarians to save time when checking books in and out by reading the tags without requiring the librarian to open the book and orient it, as is required by barcodes. Additional savings are realized from the ease of inventory updates, scanners can be used to inventory the library shelf by shelf, rather than book by book. Additionally the information is automatically checked against the database, no longer requiring a human to visually determine a books status (Boss).

In the past barcodes were the solution turned to for managing movable assets (Manning). As RFID matures it is being utilized for increasing numbers of solutions across a broad spectrum of businesses.
**DESIGN**

**PROBLEM DEFINITION**
This project was commissioned because the database currently in use in the Tool Crib was lacking in two key areas. It does not track tool use, and it does not track which tools a student has checked out. This second factor creates a problem in that tool utilization is not tracked and students are not held fully accountable for their tools leading to thousands of dollars of loss every year.

**HARDWARE REQUIREMENTS**
To fulfill the requirements hardware needed to allow tags to be scanned quickly and reliably. The tags need to be durable and securely attach to the wide variety tools in the crib. The most difficult part of the selection process was identifying a reader which could easily interface with Microsoft Access. Initially an Alien ARL9900 was considered, however the supporting software was not completely reliable and the interface with Access was highly complicated. The reader which was selected, the RFIDeas pcProx AIR Enroll\(^1\), interfaces easily with the software and provides visual feedback on the reader when the tag is read.

![MicroProx adhesive tag](image)

**Figure 2: MicroProx adhesive tag**

\(^1\) See Appendix D for full specifications
Once the reader was selected the tag selection process involved simply choosing from a list of compatible tags. A sample kit of tags was obtained from the manufacturer, HID Global, and two tags were selected. An adhesive tag with a durable plastic coating, the MicroProx 1391, this tag is shown in Figure 2. Additionally, a dangle tag was elected for attachment to tools without a surface for the MicroProx to adhere to; the ProxKey II 1346 is shown in Figure 3. Figure 4 and Figure 5 illustrate how the tags are attached to the tools.
The hardware for tracking the students is not covered by the previously mentioned items. HID Global offers access cards which could be given to the students; however every student already has a school ID (CPID) so these were utilized instead. This required the acquisition of a magnetic stripe reader. A Unitech MS241 was selected. The MS241 is a standard 3 track magnetic stripe reader.

Both readers interface with the system through a keyboard wedge, meaning that they act as a keyboard and “type” the read data to the computer. Because the same interface is employed in both readers RFID cards could be used for student identification without updating or modifying the system.

SOFTWARE REQUIREMENTS
The system currently in place was built and operates in Microsoft Access. This fact and the Shop manager’s familiarity with the program predisposed the new system to be created in the same environment. After meeting with George Leone, the shop manager, to determine the requirements the first step was to design the layout and graphical interface of the database. Three alternatives were considered, a single screen with multiple tabs, a home screen with links to multiple windows, and a single screen with a static area and a tabbed
area. The second alternative was dismissed because of the complexity to the user of having to constantly open and close multiple windows. Comparing the sketches of the other two alternatives it became clear that the third, with the static area, would be the most ergonomic. It allowed the most highly accessed functions of the database to be accessed immediately while also allowing for the flexibility, expandability, and organization offered by tabs. Screenshots of the final database are in Appendix A.

When laying out the graphical interface it is important to make sure that the most often used functions are in the top left corner. This is where we start our visual search when we look for a function (Christopher D. Wickens). For this reason the Student check in/out and tool lend/return functions are placed in the upper left hand corner. Below them is a display of the total number of students checked in and a list of the specific students. These features are always visible. All other features are located on tabs on the right side of the screen. This layout creates a simple interface which allows the user quick and straightforward access to the entire database. Another Human factors consideration is error handling and messages. Numerous custom error and status messages were created. The human factors consideration given to the database allows the user to interact more easily and minimize confusion.

**REPORTING**

The last requirement from the software was that it report statistics. To accomplish this all actions are recorded to history tables. Reports and graphs can be created from these history tables or the data can be printed or exported to Microsoft excel for farther analysis. Examples of the reports and graphs can be seen in below in Figure 4 and Figure 5.
RESULTS

The database created for the tool crib improves upon the current system in some key areas. The focus of the project was on reducing the amount of time it takes a tech to check-in a student, and collect lab use metrics. Additionally I was asked to look into what would be
required to implement RFID into the checkout system to reduce errors and farther streamline the process.

Table 1: Economic Analysis

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab tech's hourly rate</td>
<td>$11.00</td>
<td>per hour</td>
</tr>
<tr>
<td>Ave # of users per day</td>
<td>100</td>
<td>students</td>
</tr>
<tr>
<td>Days open per quarter</td>
<td>30</td>
<td>days</td>
</tr>
<tr>
<td>Original cycle time</td>
<td>32.8</td>
<td>secs</td>
</tr>
<tr>
<td>New cycle time</td>
<td>3.2</td>
<td>secs</td>
</tr>
<tr>
<td>Proposed system cost</td>
<td>$606.48</td>
<td></td>
</tr>
<tr>
<td>Current Quarterly Cost</td>
<td>$300.67</td>
<td></td>
</tr>
<tr>
<td>Future Quarterly Cost</td>
<td>$29.33</td>
<td></td>
</tr>
<tr>
<td>Simple* Payback Period</td>
<td>2.24</td>
<td>Quarters</td>
</tr>
<tr>
<td></td>
<td>6.71</td>
<td>months</td>
</tr>
<tr>
<td></td>
<td>0.56</td>
<td>Years</td>
</tr>
</tbody>
</table>

*Taxes interest and inflation are not taken into account

One of the key metrics investigated was the amount of time it takes to check a student in. With the current system students waiting to check in often back up due to the lengthy process. By conducting time studies\(^2\) of the current and proposed systems a vast reduction in this check in time was identified. The current system has an average check in time of about 32 seconds while the proposed system brings it down to just over 3 seconds. Utilizing these times to calculate a payback period it was determined that if the only savings came from the reduced check in time the system would pay for itself in just over

\(^2\) The time study data can be seen in Appendix E
four academic quarters. See Table 1 for more detail on the numbers used in the calculation. Additional saving will also be realized from reductions in tool loss. The proposed system tracks which students check tools out making them more accountable for the tools. This value is not included in the economic analysis because it would not be possible to calculate is to a sufficient degree of accuracy.

**CONCLUSION**

The proposed system improves on the current one in multiple areas. In order to take advantage of the improvements without driving up costs a partial implementation is recommended. This partial implementation would involve tagging three groups of tools. The first group, the yellow tag tools, should be tagged because they are hazardous and their use needs to be closely monitored and controlled. The Second group is expensive and delicate tools whose high replacement cost justifies the cost of the tags. The last is any tools who have a history of disappearing. These tools need the extra accountability offered by the system by individually identifying each tool. For tools which are not tagged the Techs will be able to check them out generically by name. By following these recommendations the tool crib will be able to better serve the students who work there, while simultaneously lowering costs by reducing losses.
BIBLIOGRAPHY


Brown, Carl. Asset Tracking with RFID. 3 October 2009. 15 1 2010 <http://support.simplyrfid.com/noxvault?gclid=CLj1ifH7xJ0CFRgawod1hMDrQ>.


APPENDICES

APPENDIX A: DATABASE SCREEN SHOTS

Figure 8: Screenshot with Student tab selected

Figure 9: Screenshot with Tools tab selected
Figure 10: Screenshot with Projects tab selected

Figure 11: Screenshot with Statistics tab selected
APPENDIX B: DATABASE VISUAL BASIC CODE

The following code is copied from the VB library of the database.

Option Compare Database

Private Sub Checkouts_Change()
'Refresh The form when the combobox value is changed
Me.Form.Refresh
End Sub

Private Sub Clock_Out_Click()

Dim rst As ADODB.Recordset 'Set .rst as recordset
Set rst = New ADODB.Recordset 'Setup new recordset
Dim cpid, Title, Message, NoTool 'Dimension variables
    Message = "Swipe Student ID Card" 'Set Prompt
    Title = "Enter ID Number" 'Set Prompt Title
    cpid = InputBox(Me.Message, [Title]) 'Open Messagebox with above prompt and title
    If cpid = "" Then 'Action if message box returns empty
        MsgBox ("Scan Failed") 'Display message
        GoTo emptyX 'Goto the end of the code and end the sub
    End If
    NoTool = True 'Variable to block checkout if tools are missing
    'The following line opens the Tool_Checkedout query for reading
    rst.Open "[Tool_CheckedOut]", CurrentProject.Connection, adOpenStatic, adlockoptimistic
    For i = 1 To rst.RecordCount 'checks all rows of the query results
        If rst("Stu_ID") = cpid Then 'Checks if row matches student being checked out
            If rst("ReturnTime") = "0" Then 'checks if student has any tools out
                NoTool = False 'Changes Variable so Checkout value is not modified
            End If
        End If
    Next i
End Sub
MsgBox ('Student has not returned ' & rst("Description")) 'msgbox with tool student has not returned
    End If
    End If
rst.MoveNext 'Advances loop to next row of the query
Next i 'Moves run back to For statement
rst.Close 'If NoTool = True Then 'If student does not have any tools check out then execute this code
    Me.CPIDout.Value = cpid 'Write CPID to invisible text box for storage
    rst.Open '[Lab_History]', CurrentProject.Connection, adOpenStatic, adlockoptimistic
    rst.MoveFirst
    For i = 1 To rst.RecordCount
        If rst("Time_Out") = '12:00:00 AM' Then 'Find tool which is not returned (12am is the default value in the table)
            If rst("Stu_ID") = cpid Then 'If the ID in the table matches the scanned ID then
                rst("Time_Out") = Now 'Write the current time to the tool returned field
                rst.Update 'Update table with new values
                GoTo Found 'Run
            End If
        End If
    Next i
    Found: 'Run moves to this point once it finds the matching entry
        rst.Close 'Close the table
        DoCmd.OpenQuery 'Student_ClockOut', acViewNormal, acEdit 'check student out
        MsgBox ('"Student Checked Out")
    End If

emptyX: 'Move to this point if combo box comes back empty
Me.Form.Refresh
End Sub

'Check In
Private Sub ClockIn_Click()

Dim rst As ADODB.Recordset 'Set .rst as recordset
Set rst = New ADODB.Recordset 'Setup new recordset
Dim cpid, Title, Message, chkout 'Dimension variables
Message = "Swipe Student ID Card" 'Set Prompt
Title = "Enter ID Number" 'Set Prompt Title
cpid = InputBox(Message, [Title])
If cpid = "" Then
   MsgBox ("Scan Failed")
   GoTo EmptyBox
End If
rst.Open "[Lab_History]", CurrentProject.Connection, adOpenDynamic, adlockoptimistic
rst.AddNew
rst("Time_in") = Now
rst("Stu_ID") = cpid
rst.Update
rst.Close
Me.StoreID.Value = cpid
'Runs Query which sets checked-in value to true
DoCmd.OpenQuery "Student_ClockIn", acViewNormal, acEdit
EmptyBox:
Me.Form.Refresh
End Sub

Private Sub Command116_Click()
check23 = InputBox(d, f)
toolcount = DCount("[Tool_ID]", "Tool_CheckedOutTo", "[Stu_ID]" = check23)
MsgBox (toolcount)
End Sub

Private Sub Hist_G_Lab_Click()
DoCmd.OpenForm "Lab_history_graph", acFormPivotChart, ac
Me.Form.Refresh
End Sub

' Lend Tool
' The new features in here do not work yet
Private Sub Lend_button_Click()

Message = "Swipe Student ID Card" 'Set Prompt
Title = "Enter ID Number" 'Set Prompt Title
cpid = InputBox(Message, [Title])
If cpid = "" Then GoTo Fail
'if the number of tools checked out is less then five then

toolcount = DCount("[Tool_ID]", "Tool_CheckedOutTo", cpid)

If toolcount < 6 Then

    Dim rst As ADODB.Recordset
    Set rst = New ADODB.Recordset

    ToolID = InputBox("Scan Tool", "Return Tool")

    rst.Open "[Tool_Hostory]", CurrentProject.Connection,
    adOpenStatic, adlockoptimistic

    rst.AddNew
    rst("Returntime") = Now()
    rst("Student_ID") = cpid
    MsgBox ("Number of tools student has checked out")

    rst.Update
    rst.Close

    If CkIn = False Then
        MsgBox ("Student is not checked in")
        GoTo EndOF
    End If

    rst.Open "select * from Tool_info",
    CurrentProject.Connection, adOpenStatic, adlockoptimistic

    rst.MoveFirst

    For i = 1 To rst.RecordCount
        If Me.TNChkOut.Value = rst("Tool_ID") Then
            ToolTag = rst("tag")
            GoTo Down1
        End If
        rst.MoveNext
    Next i

    Down1:
    rst.Close

    If StuTag = "yellow" Then
        ToolTag = "red"  'allows student to check out yellow tag
        End If

    If ToolTag = "Red" Then
        'checks that student is authorized for tool

            rst.Open 'select * from Tool_History",
            CurrentProject.Connection, adOpenDynamic, adlockoptimistic
            rst.AddNew
rst("Tool_ID") = Me.TNChkOut.Value
rst("Stu_ID") = cpid
rst("BorrowTime") = Time
rst.Update
rst.Close
MsgBox("Tool Lent Out")
Else
MsgBox("Student is not authorized to check out this tool")
End If
GoTo EndOF
Fail:
MsgBox("Scan Failed")
toolcount = DCount('[Tool_ID]', 'Tool_CheckedOutTo', cpid)
MsgBox(toolcount)
Else: MsgBox('Student already has five tools checked out.')
End If
EndOF:
Me.Form.Refresh
End Sub

Private Sub Stu_select_Click()
'Refresh form when a different student is selected
Me.Form.Refresh
End Sub

Private Sub ToolReturn_Click()
DoCmd.OpenQuery "Tool_Return", acViewNormal, acEdit
'Dim rst As ADODB.Recordset 'Set .rst as recordset
'Set rst = New ADODB.Recordset 'Setup new recordset
'Dim cpid, Title, Message, FN, LN 'Dimension variables

 rst.Open "[Student_Info]", CurrentProject.Connection, 
adOpenStatic, adlockoptimistic
 rst.MoveFirst
 ' For i = 1 To rst.RecordCount
 ' If Me.TNChkOut.Value = rst("Tool_ID") Then
 ' ToolTag = rst("tag")
 ' GoTo Down1
 ' End If
 ' rst.MoveNext
 ' Next i
 'Down1:
 'rst.Close
Me.Form.Refresh

' Adds New student
Private Sub Student_AddNew_Click() ' Add New entry to the student Table

Dim rst As ADODB.Recordset ' Set .rst as recordset
Set rst = New ADODB.Recordset ' Set new recordset
Dim cpid, Title, Message, FN, LN ' Dimension variables

rst.Open "select * from Student_Info", CurrentProject.Connection, adOpenStatic, adLockOptimistic
rst.AddNew

' Enter CPID Information
Message = "Swipe Student ID Card" ' Set Prompt
Title = "Add New Student" ' Set Prompt Title
cpid = InputBox(Message, [Title])
rst("Stu_ID") = cpid
If cpid = "" Then
    MsgBox ("Please try again. Failed to add new student")
    GoTo failure
End If

' Enter First Name Information
Message = "Enter First Name" ' Set Prompt
Title = "Add New Student" ' Set Prompt Title
FN = InputBox(Message, [Title])
rst("First_Name") = FN
If FN = "" Then
    MsgBox ("Please try again. Failed to add new student")
    GoTo failure
End If

' Enter Last Name Information
Message = "Enter Last Name" ' Set Prompt
Title = "Add New Student" ' Set Prompt
LN = InputBox(Message, [Title])
rst("Last_Name") = LN
If LN = "" Then
MsgBox ('Please try again. Failed to add new student')
    GoTo failure
End If

'Enter Tag Information
Message = "Choose Tag Color" 'Set Prompt
Title = "Add New Student" 'Set Prompt Title
FN = InputBox(Message, [Title])
rst("Tag") = FN
If cpid = "" Then
    MsgBox ('Please try again. Failed to add new student')
    GoTo failure
End If

MsgBox ('Student Successfully Added')
'Write Fields and Close Table
rst.Update
rst.Close
failure:
Me.Form.Refresh 'Refresh all views
End Sub

'Private Sub TNChkOut_Change()
'Me.Form.Refresh
'End Sub
### APPENDIX C: RFID TAG SPECIFICATIONS

**Microprox Tag**

<table>
<thead>
<tr>
<th>General Specifications</th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Manufacturer</strong></td>
<td>HID Global</td>
</tr>
<tr>
<td><strong>Manufacturer Part #</strong></td>
<td>1391</td>
</tr>
<tr>
<td><strong>Cost Central Item #</strong></td>
<td>10563501</td>
</tr>
<tr>
<td><strong>Product Description</strong></td>
<td>HID MicroProx 1391 - RF proximity adhesive tag</td>
</tr>
<tr>
<td><strong>Product Type</strong></td>
<td>RF proximity adhesive tag</td>
</tr>
<tr>
<td><strong>Product Material</strong></td>
<td>Lexan</td>
</tr>
<tr>
<td><strong>Approximate Dimensions (WxDxH)</strong></td>
<td>1.3 in x 0.1 in</td>
</tr>
<tr>
<td><strong>Manufacturer Warranty</strong></td>
<td>Limited lifetime warranty</td>
</tr>
</tbody>
</table>

**Extended Specifications**

**General**

<table>
<thead>
<tr>
<th><strong>Product Type</strong></th>
<th>RF proximity adhesive tag</th>
</tr>
</thead>
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<tr>
<td><strong>Product Material</strong></td>
<td>Lexan</td>
</tr>
<tr>
<td><strong>Approximate Width</strong></td>
<td>1.3 in</td>
</tr>
<tr>
<td><strong>Approximate Depth</strong></td>
<td>0.1 in</td>
</tr>
<tr>
<td><strong>Manufacturer Warranty</strong></td>
<td>Limited lifetime warranty</td>
</tr>
<tr>
<td><strong>Service &amp; Support</strong></td>
<td>Limited warranty - lifetime</td>
</tr>
<tr>
<td><strong>Service &amp; Support Details</strong></td>
<td>Limited warranty - lifetime</td>
</tr>
</tbody>
</table>
**ProxKey II Tag**

**General Specifications**
- **Manufacturer**: HID Global
- **Manufacturer Part #**: 1346LSSMN
- **Cost Central Item #**: 10564579
- **Product Description**: HID Proxkey II 1346 - RF proximity card
- **Product Type**: RF proximity card
- **Approximate Dimensions (WxDxH)**: 0.9 in x 0.4 in x 1.9 in
- **Approximate Weight**: 0.2 oz
- **Compliant Standards**: ISO 9001, RoHS
- **Manufacturer Warranty**: Limited lifetime warranty

**Extended Specifications**

**General**
- **Product Type**: RF proximity card
- **Approximate Width**: 0.9 in
- **Approximate Depth**: 0.4 in
- **Approximate Height**: 1.9 in
- **Approximate Weight**: 0.2 oz

**Miscellaneous**
- **Compliant Standards**: ISO 9001, RoHS

**Manufacturer Warranty**
- **Service & Support**: Limited lifetime warranty

**Service & Support Details**: Limited warranty - lifetime
APPENDIX D: RFID READER SPECIFICATIONS

Specifications for RFIDEas AIR Enroll

Typical maximum read range:
• 2.0” – 4.0” (5.0 – 10.0 cm) with PVC ID cards
• 1.0” – 1.5” (2.5 – 3.8 cm) with labels or tags
• 1.0” – 2.0” (2.5 – 5.0 cm) with MIFARE card

Dimensions: 3 3/8” x 2” x 0.6” (Models with RDR in part number only) 4.2” x 2.5” x 0.875” (10.6 x 6.35 x 2.2 cm)

Weight: 0.45 lbs. (12.7g)

Power supply and interface: USB self-powered; RS-232 model; 5V supplied by PS2 Keyboard pass-thru connector

Indicators: Tri-state LED, beeper

Transmit frequency: 13.56 MHz

Operating temperature range: -22° to 150°F (-30° to 65°C)

Operating humidity range: 5% to 95% relative humidity, non-condensing

Certifications: FCC, CE, C-tic, RoHS
APPENDIX E: TIME STUDY DATA

Note: All values are recorded in seconds.

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<th>PolyCard Check in</th>
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<th>Average</th>
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<tr>
<td>Standard Deviation</td>
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APPENDIX F: PROJECT COST INFORMATION

- **Inlays - HID Global HID MicroProx 1391**
  - $4.58 from Manufacturer, HID Global
    - Available for $2.18 from, CostCentral
- **Fobs - HID Global HID Proxkey II 1346**
  - $6.56 from manufacturer, HID Global
    - Available for $3.45 from, CostCentral
- **Reader - RFIDEas pcProx USB Reader**
  - CDW sells for $154.99
- **Reader - Unitech MSR-241-UG3**
  - Buy.com sells for $60.99

Totals:

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<tr>
<th>Item</th>
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<th>Price 2</th>
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<tr>
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<td></td>
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