An Interactive System for Deaf and Hearing Impaired Children

New Mexico

SuperComputing Challenge

Final Report

April 1, 2015

Team Number: 108

Las Cruces YWiC

Team Members:

Hiba Muhyi

Kaitlyn Mason

Sponsoring Teachers:

Rebecca Galves

Daniela Miranda

Project Mentor:

Esperanza Medina

Table of Contents

Abstract

Research shows there is a great need for the development of interactive and creative tools for deaf and hearing-impaired children to motivate and develop their cognitive skills. Spelling and developing language systems and expressing thoughts for deaf and hearing-impaired children have been and still are challenging subjects. In this project a human computer interactive 3D system was developed based on Computational and Engineering principles and open source microcontroller platform to help deaf and hearing impairment children learn and understand the geographic terminology and language system for developing and expressing thoughts. The project compared the existing traditional ways to learn and practice spelling and understand geographic terminology with the developed Robo-Glove. The system concept is based on the natural movements of the user's hand as the input device to interact with the application and provide visual 3D feedback by programming the robot to navigate on the map to reach the spelled location. Twelve deaf and hearing impaired students were tested. Quantitative and qualitative data were collected. NASA TLX was used to measure the subject's frustration and cognitive load. Pre-test and Post-test were conducted and showed a significant increase in their performance by 80%, system usability and frustration low were also was measured. The system was rated 90% success by the subjects to measure their engagement and 100% for helpful feedback. The system is an innovative human computer interaction framework for many different learning applications for deaf and hearing impaired that is affordable, easy to use, accurate, and very engaging.

Problem

All children have many attributes they need in order to be successful throughout their lives. This includes basic skills, such as spelling and geography. For children who are hearing impaired or deaf spelling it is often overlooked. In this project a glove device has been created with an application for children to use in order to improve their spelling abilities. The device will be introduced at a young age to instill in them a motivation to continue to excel in spelling.

Hypothesis

The Robo-Glove system has a better effect on student's engagement that is more efficient and accurate.

Variables

Independent Variables:

o Flashcards/maps

o Robo-Glove

Dependent Variables:

o Number of Correct (Accuracy)

o NASA TLX

The Testing Process

1.Observation of the classroom, teachers, and students

2. Students have already gone through geographic terminology using traditional methods.

3. Then given a Pre-test, NASA TLX, and Questionnaire.

4. Students were taught how to use the Glove with the Spelling Application.

5. Students go over the same geographic terminology except this time using the Robo-Glove (same amount of time used with traditional method)

6. Given a Post-test, NASA TLX, and Questionnaire.

1-Introduction

1.1 Deaf Education

Though todays spell checking programs make spelling less of an important skill to have, there is still a need for individuals to have the ability to spell properly. It has been proven that an adult's spelling skills are considered important markers and attainments [6].Spelling is especially hard for deaf and hearing impaired individuals to grasp and it is best to lay a good foundation for spelling and implement good spelling habits at a young age so in the future they can be ready for the workforce. The importance of spelling is not only essential to success as an adult, but can be just as important for young children For children, spelling is critical not only for academic progress but it also contributes to a student's knowledge of their language. Spelling goes hand and hand with good reading skills and most of todays' tests require fast reading and understanding of the words so it is in the best interest for all students to have good spelling skills. Children that are hard of hearing or deaf have an increased difficulty for learning how to spell because of they are constantly battling their disability while also attempting to learn how to spell. "The employers of these deaf graduates were surveyed: 93% of the employers reported that good writing skills were necessary for promotion and that poor spelling was one of the most serious problems they saw in their deaf employees" [6]. If a teacher would give out a spelling test to a student without a hearing disability all the student needs to do is use phonics to figure out which letters make up the word. For a deaf or hard hearing impaired student they cannot hear the teacher, so the teacher must sign the word. However American Sign Language (ASL) is its own language it does not have a sign equivalent for every word in the English language so many words have to be described in order for the deaf student to be able to understand the teacher.

1.2 Human Computer Interaction (HCI)

Human–computer interaction is the intersection of computer science and behavioral sciences. This field involves the study, planning, and design of the interaction between people (users) and computers. Attention to human-machine interaction is important, because poorly designed human-machine interfaces can lead to many unexpected problems [11]. Technology is getting more and more common and teachers are seeing electronic devices as tools to help students learn. Experts say the future of education may eventually revolve around this technology. When creating teaching tools the human–computer interaction is an important part of system design. Quality of the system depends on how it is represented and used by the user. The direction of the research is to replace common regular methods of interaction between student and teacher and incorporate more technology. In this research a device or in this case a glove was developed to use the natural movements of the user's hand as the input device to interact with the program. There are three unimodal HCI systems they are visual-based, audio-based, and sensor-based. The visual- based human computer interaction is probably the most widespread area in HCI research. The commonality of these different areas is that at least one physical sensor is used between user and machine to provide the interaction [9]. Some common sensors would be the mouse, keyboard, joysticks, motion tracking sensors, haptic sensors, and pressure sensors. Both visual-based and sensor-based human computer interaction were used in this project.

1.3 Learning Techniques and Deafness

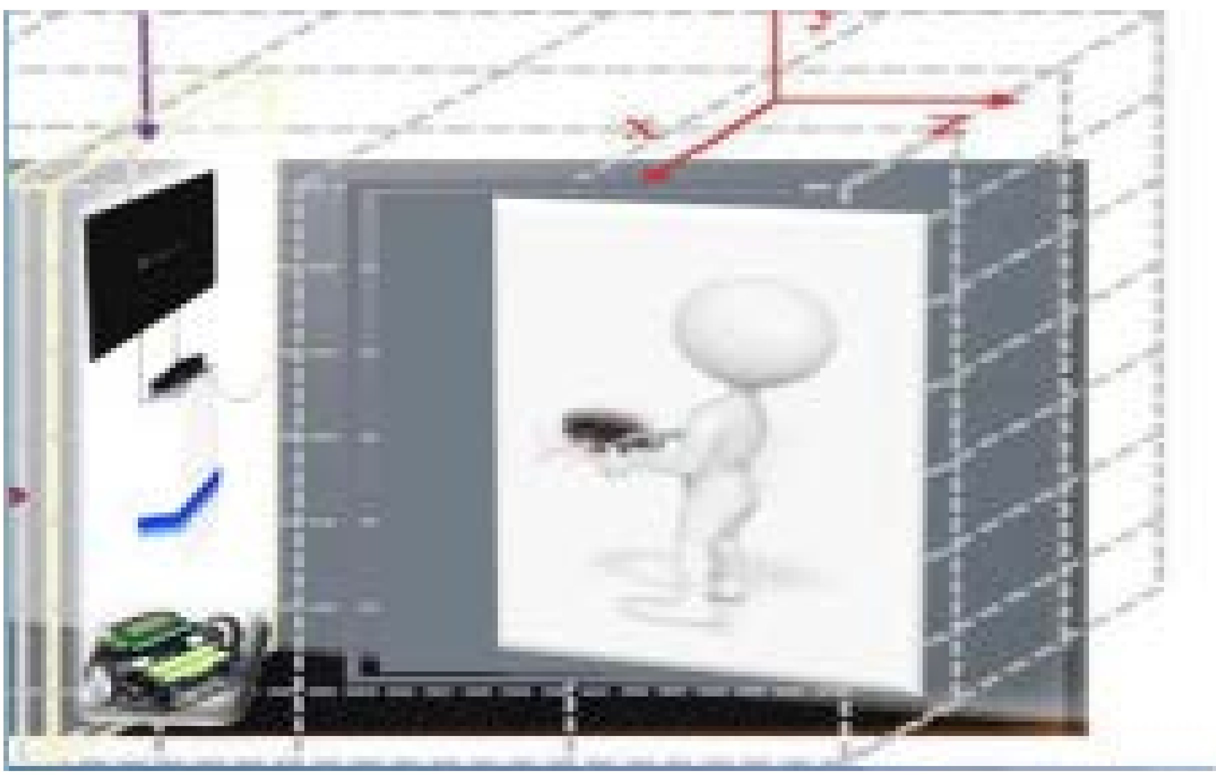
"The brains of Deaf people process sign language in the left hemisphere of the brain just as hearing people process spoken language" [1, 8]. Visual techniques work to enhance thinking, learning, and problem solving according to academic psychological studies as explored by popular psychologists [4]. These visual techniques include maps and diagrams that tap into the spatial and rational capabilities of the brain to create meaning. The mind establishes relationships between the elements of a diagram based more on color, shape, and spacing than from text alone. Maps are not tied to linear structures, so they more accurately reflect and mirror the structure of the brain, which is a mass of interconnected neurons that allow for a nonlinear processor of commands, in which information goes in one direction. Maps clarify content by removing unnecessary words that can be misleading and unnecessary.

Seeing, touching, and smelling are all short term memory uses. Research shows that people who are born being deaf process touch differently than people born with hearing [10]. With deaf people they use their auditory cortex to process touch stimuli and visual stimuli to a much greater degree than occurs in hearing people [10]. Research even shows that deaf focus more on touch than on vision. Some say that different people focus on different on certain senses and that is what makes us "a type of learner" like kinesthetic, auditory, or visual. The first of the main three are visual learners, who learn through their eyes. Visual learners need to see the teacher's body language and facial expressions to understand what is going on. When a class of deaf students was observed the desks were placed so no one desk was in front of another and students were usually brought up to a big table for every lesson. As visual learners prefer pictures and visual displays including: diagrams, illustrated text books, overhead transparencies, videos, flipcharts, and handouts. There are also auditory learners who learn through listening they learn best through verbal lectures, discussions, talking things through and listening to what others have to say. Written information may have little meaning until it is explained or heard. These learners often benefit from reading aloud or using a tape recorder. The third and final is Tactile/Kinesthetic Learners who learn through, moving and touching. Tactile/Kinesthetic people best learn through hands-on approach and physical activities[4].

1.4 3D Spatial and Gestural Interaction

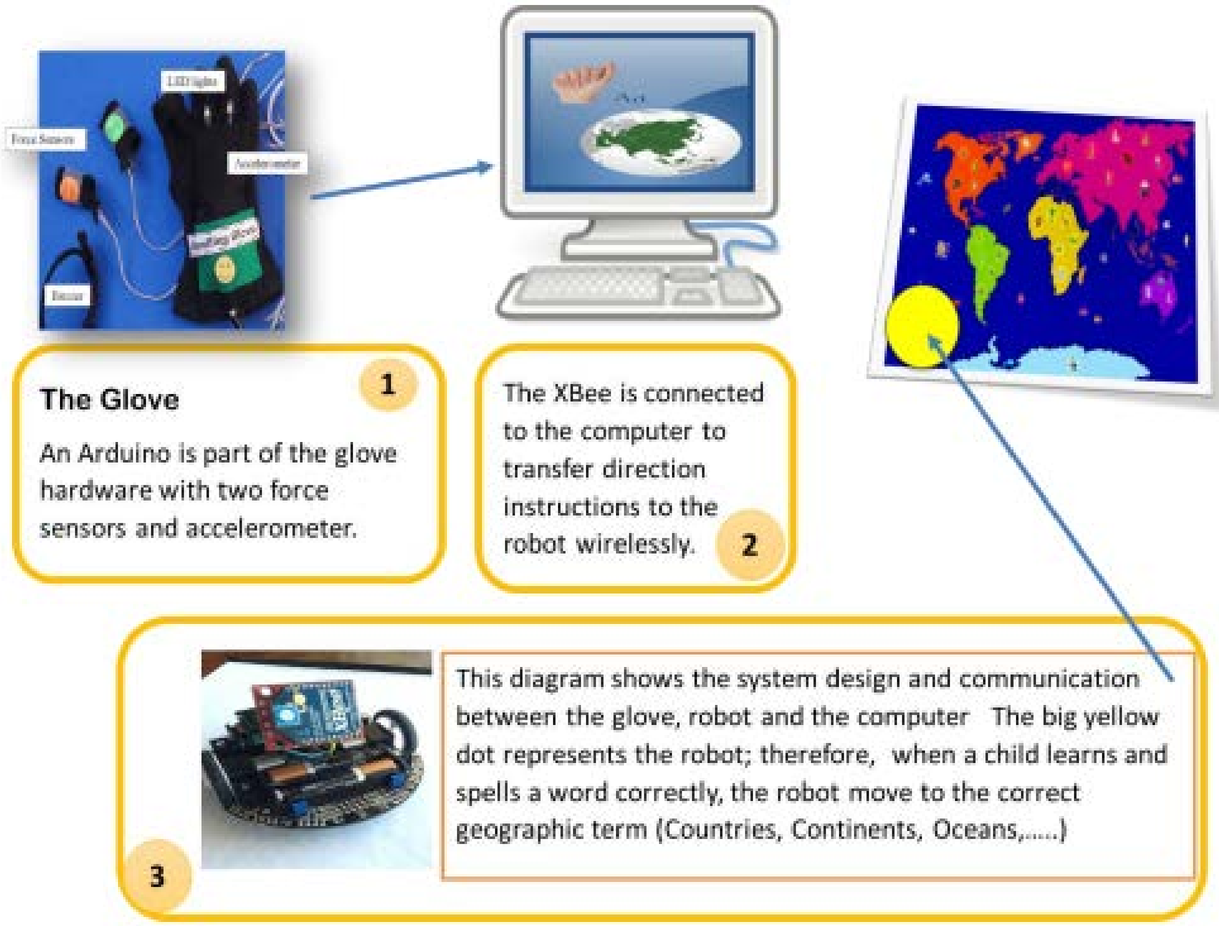
According to La Viola, 3D gestural interaction is “Interaction that provides a powerful and natural way to interact with computers using the hands and body” [12]. Gestural interaction is the movement of the body. For this particular system the movement of the students fingers and hand would be the gestural interaction/input.

The area that surrounds the student and the objects in that area is the 3D spatial interaction. Human computer interaction involves 3D spatial interaction through user interfaces where the user performs tasks with 3D spatial context and 3D input devices or 2D input devices with direct mappings to 3D. In other words, “3D user interfaces involve input devices and interaction techniques for effectively controlling highly dynamic computer-generated contents.” [13]



The Robo-Glove user space in 3D

2.0 System Design



In this project a robot based on Arduino platform is integrated with a XBee module to generate the wireless communication between the computer (the application) and the robot.

Code

The visual Basic .net code: (Please reference to the Flowchart)

By loading the form the code checks if the serial ports are available to enable the timers to start reading input from the Arduino via serial port COM 7, it will also enable timerport1 to send a serial write to the robot (COM 15).

```
Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles MyBase.Load

        xval = 0

‘ initial value

        pd = "s"

        feedback.Visible = False

        Label1.Text = "Press New Game button to start"

        Try

            If Port1.IsOpen = False Then

                Port1.Open()

                SerialPort1.Open()

                Timer2.Enabled = True

                Timerport1.Enabled = True

            End If

        Catch exp As IO.IOException

            Me.Text = " - COM port not found!"

        End Try

    End Sub



Public Function checkdir(ByVal d As String)
```

This function checks the input from the glove (serial port) and also check for correct answers.

This section check for correct answer when user press on force sensors and send a serial write to the glove to turn the green light on and send another write to the robot to move to destination.

```
If cv <> pd Then
            pd = cv
            ca = i

            For j = i To 16
                ' TextBox2.Text = i
                If cv = "2" Then
                    ' Correct answer
                    If sbi = c - 1 Then
                        '  If ff = 1 Then
                        Call SetInput(sb, i, Color.Green)

                        '  PictureBox9.Visible = True
                        For k = 1 To 1000
                            Port1.Write("2")   ' glove port

                        Next
                        If (m = 0) Then  'move robot to asia
                            SerialPort1.Write("rfffrr") ' robot port
                            PictureBox2.BackgroundImage =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\asiaw.png")

                        ElseIf (m = 1) Then  'move robot to africa
                            SerialPort1.Write("ffsrrff")
                            PictureBox2.BackgroundImage =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\africaw.png")
                        End If

                        Exit For
                    Else
                        ' not correct answer
                        SetInput(A(i), i, Color.Red)
                        ' sad face visible
                        PictureBox7.Visible = True
                        Port1.Write("11")

                        Exit For
                    End If
                End If
```

If the input from the glove is r or 0 then move the courses to the right and check for boundary. Check the button's background color and go back and check another input.

```
 ' Right

                '   If cv = "1" Or cv = "r" Then
                If cv = "0" Or cv = "l" Then
                    i = j + 1
                    If j + 1 = 17 Then
```

```
                        ' check for border
                        i = j
                        Exit For
                    Else
                        If A(j + 1) = sb Then


                            Call SetInput(sb, i, Color.Orange)
                            Exit For


                        Else

                            i = j + 1
                            SetInput(A(i), i, Color.Orange)
                            Exit For

                        End If

                    End If
                End If


 ' Left direction
                ' If cv = "0" Or cv = "l" Then
                If cv = "1" Or cv = "r" Then
                    i = j - 1
                    If A(j - 1) < 1 Then
                        i = j
                    Else
                        If A(j - 1) = sb Then

                            Call SetInput(sb, i, Color.Orange) ' then exit

                            Exit For

                        Else
                            i = j - 1
                            Call SetInput(A(i), i, Color.Orange)
                            Exit For
                        End If
                    End If

                End If
```

Same for all directions.

By pressing on new game button a new game gets generated randomly, using the case statement

the code with the check the correct pattern for each word.

```
Private Sub Button17_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles Button17.Click
        Dim k As Integer
        feedback.Visible = False
```

```
        PictureBox8.Visible = False
        PictureBox7.Visible = False
        Call ResetLeds(Color.Blue)
        ff = 0
        c = 1  ''  the counter for the answer array
         irandom = R.Next(4).ToString()

        i = 1
        For ff = 0 To 10
            s(ff) = 0
        Next

        Button1.BackColor = Color.Yellow
        Select Case irandom
            Case 0
                xval = 8
                yval = 12
                zval = xval / yval
                ' correct answer
                ' sb = zval
                sbi = 4
                m = irandom ' flag the image
                s(1) = 1
                s(2) = 2
                s(3) = 3
                s(4) = 1
                ' s(5) = 1

                PictureBox5.BackgroundImage =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\asia.png")

                Button2.Image
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\s.png")
                Button1.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\a.png")
                Button3.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\i.png")
                Button6.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\o.png")
                Button4.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\f.png")
                Button9.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\j.png")
                Button14.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\h.png")
                                Button16.Image =
Image.FromFile(My.Computer.FileSystem.SpecialDirectories.MyPictures & "\hiba\new
buttons\x.png")

                A(1) = 42 : A(2) = 3 : A(3) = 45 : A(4) = 14 : A(5) = 16
```

```
A(6) = 8 / 12 : A(7) = 15 : A(8) = 19 : A(9) = 23 : A(10) = 67
A(11) = 61 : A(12) = 8 : A(13) = 1 : A(14) = 64 : A(15) = 1 : A(16) = 88
```

```
Call SetInput(sb, i, Color.Green)
```

Programming the glove based on Arduino Uno platform:

These are the main two functions in the code, the main challenge was to create the serial communication between the windows environment and the two devices (the glove and the robot). We also programmed the Glove using c language, based on Arduino platform, please see attached code in C and the flowchard.

Programming the robot based on Arduino platform:

The Robot added the xbee to make it wireless and programmed the robot moving direction by controlling the motors speed such as motor(0,0) to stop and moter (50,50) to move forward , motor (0,50) to move left,…

2.1 System Development

The Spelling Application (software) was created in Visual Basic with Microsoft Visual Studio 2010 that incorporated more visual cues we were able to assist the students by helping them learn in a more formatted and entertaining way while also helping the teachers detect and correct their students common mistakes. The Spelling Application (Figure 1) has a simple design with an image of what the student is to spell on the right and the a bank of letters (in ASL and English) for the student to choose from on the left.

2.2 The Hardware Development

The Robo-Glove (Figure 2) was constructed using an Arduino Microcontroller, touch sensors and accelerometer. In this project the Robo-Glove was developed to help the deaf students' use their touch sense in spelling out a word by seeing an image containing the object the student needs to spell out. The Robo-Glove was constructed to enable them to use their hand, having some free movement. The Robo-Glove is communicating with a laptop computer via a serial port to send and receive signals from and into the Glove. Because of the accelerometer students are able to navigate throughout the software using the natural and free movement of the Robo-Glove. When the student is ready to select they press their index and thumb together and when they are done spelling out the word they press their middle finger and thumb together. If they answer correctly they receive visual feedback through LED lights flashing green located on top of the glove as well as the 3pi robot heading to whatever country, ocean, continent, etc. the student has spelled. But if they answer incorrectly then a buzzer wrapped around their wrist buzzes.

2.3 The Engineering Design of System

Low Cost Microcontroller Technology (Arduino):

Arduino Microcontrollers (at the bottom of Figure 2) are single-chip, integrated circuit devices that can be programmed to read electrical signals (input) and send electrical signals (output). Microcontrollers are designed for embedded control applications, and are pervasive in consumer and industrial products. Electrical and computer engineering are professions most commonly associated with the design and use of microcontrollers. However, as microcontrollers have become inexpensive and ubiquitous, the systems for programming and deploying them have become easier to use.

Arduino is an open-source hardware and software platform. The electrical design, programming software, and a large set of tutorials and examples are freely available. There is an energetic and idealistic community of open-source hardware participants who contribute to improvements in the platform, the creation of add-on circuits and components, and in providing instructional materials. This leads to rapid innovation and diffusion of innovation.

The 3pi Robot (Arduino-compatible):

The 3pi robot makes a great platform for people with C programming experience to learn robotics, and it is a fun environment for ambitious beginners to learn C programming. At its heart is an Atmel ATmega328P microcontroller running at 20 MHz and featuring 32 KB of flash program memory.

Figure 1 Spelling Application

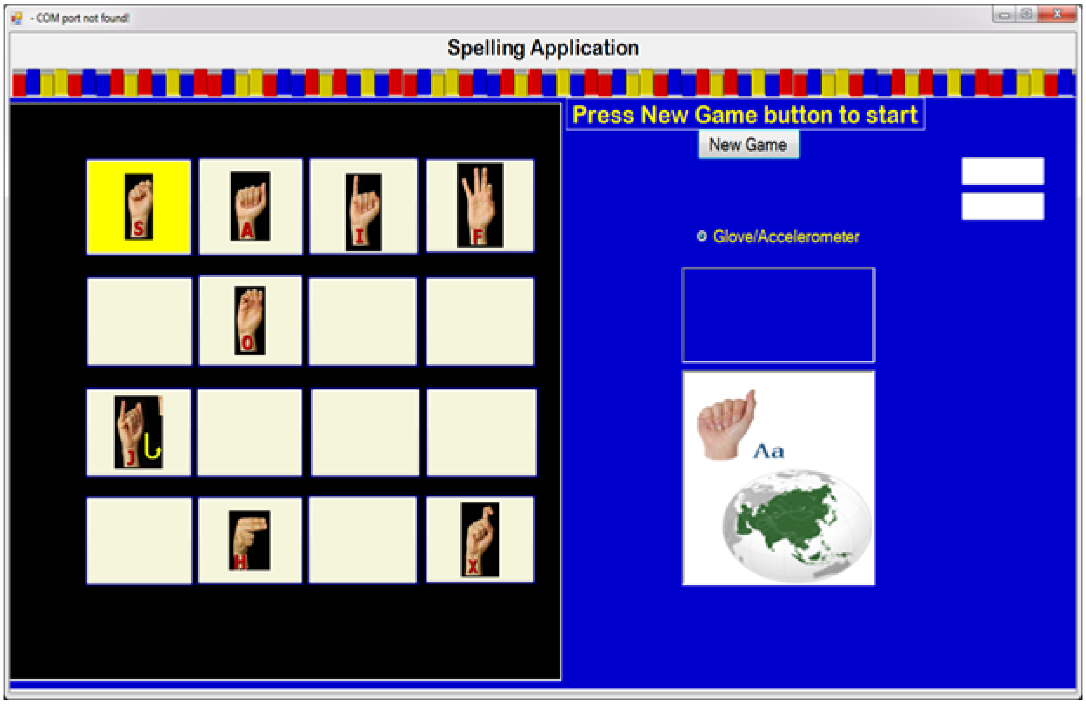
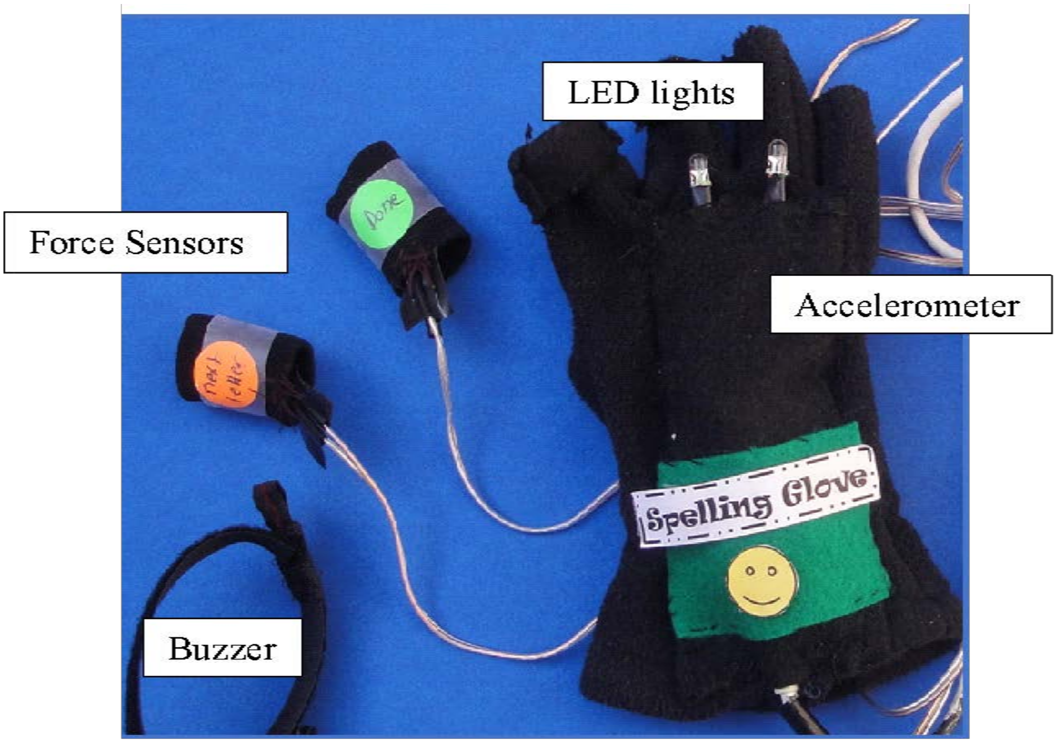
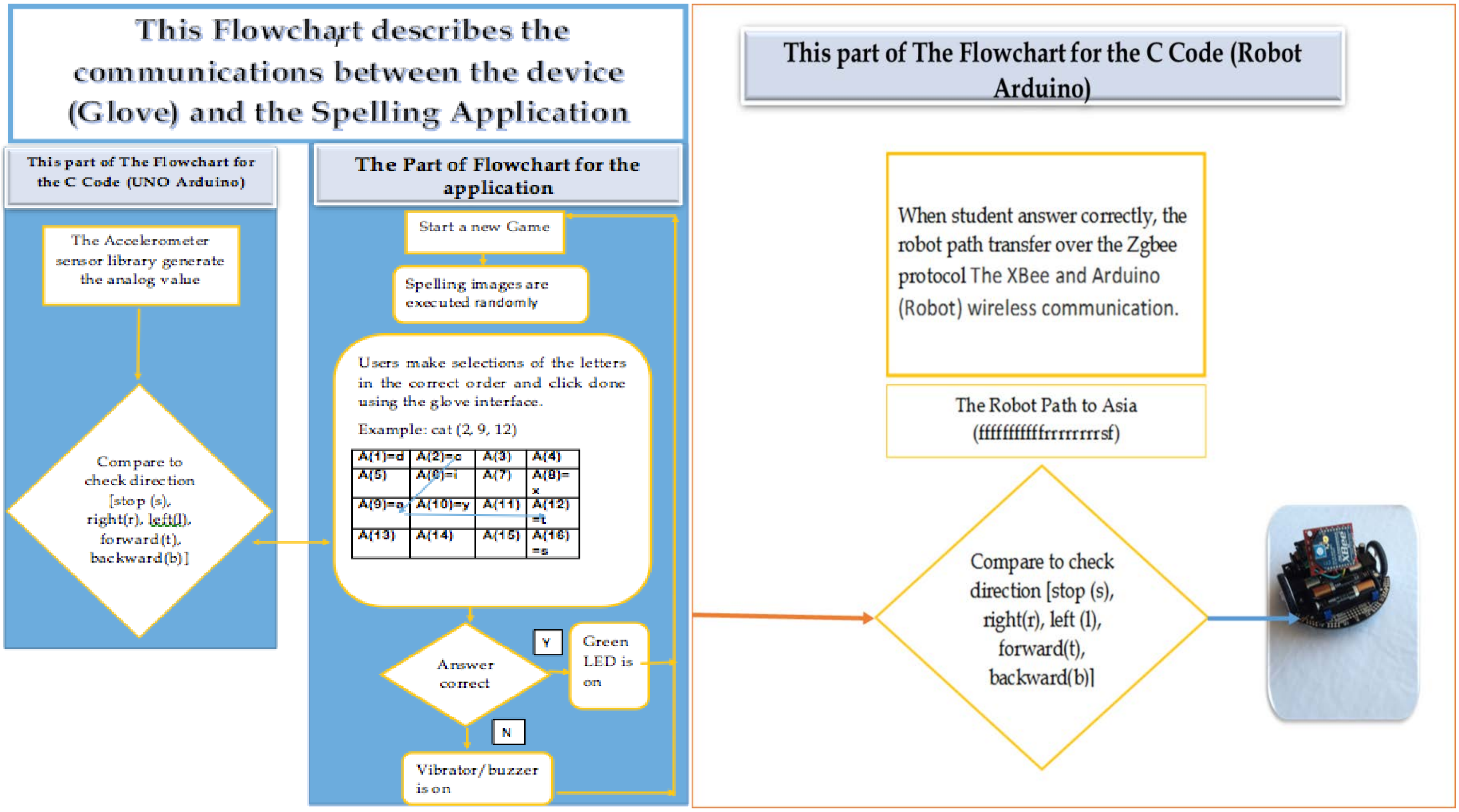


Figure 2 The Robo-Glove

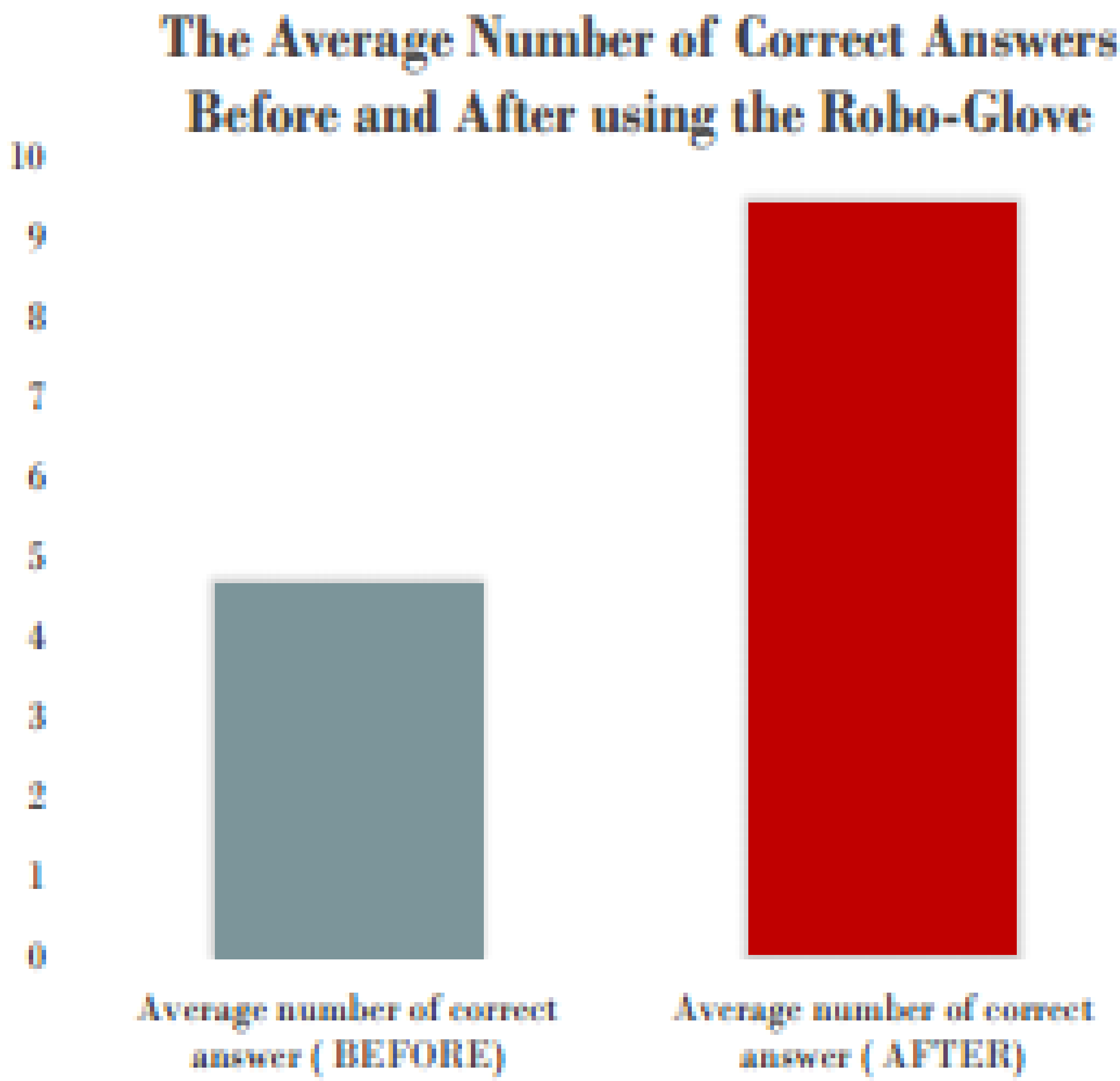


<u>The Flowchart and Computer Code Architecture:</u>



Data

A Pre-Post test was presented to the students to measure the number of correct answers (accuracy) before and after using the glove.

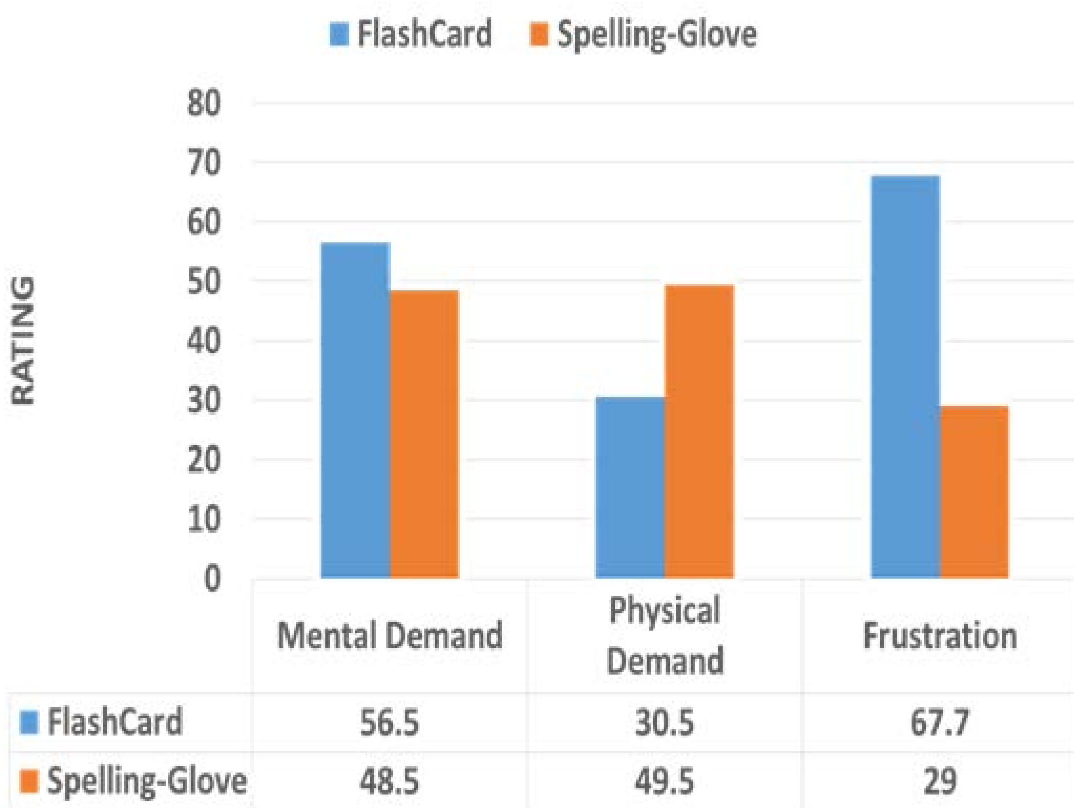


Workload Analysis-NASA TLX (Task Load Index)

o Questions were modified to adapt to the subjects by adding happy/frowny face.

o Mental demand (thinking, calculating, remembering).

o Physical demand (pushing the sensors or moving hand).



Evaluation Questionnaires

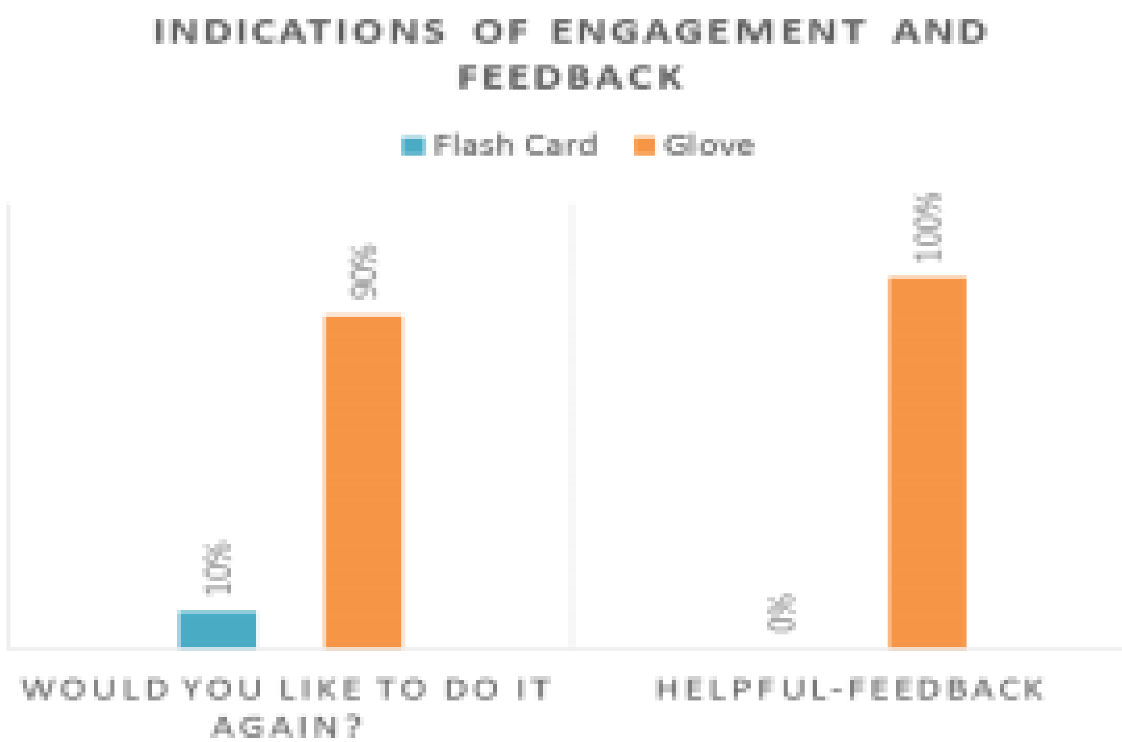
o In HCI, it is concerned with making

systems easy to learn and use.

o Easy to remember, effective, accurate,

safe to use and enjoyable to use.

o Designed for kids



Conclusion

In this project a human computer interactive 3D system was developed based on Computational and Engineering principles and open source microcontroller platform to help deaf and hearing impairment children learn and understand the geographic terminology and language system to develop their expressing thoughts. Pre-test and Post-test were conducted and showed a significant increase in their performance by 80%, system usability and frustration low were also was measured. The results, system rated 90% success by the subjects to measure their engagement and 100% for helpful feedback. In conclusion, using the Glove, robot, and the visual and haptic feedback allows the deaf/hearing impaired children to engage and participate more than traditional methods. The visual/haptic feedback allows users the ability to expand upon the traditional means of human-computer communication so there is more interaction.

Future Work

As a very near future work is add Xbee to the glove. Analyze the user's gesture hand movement to increase the adaptation and the intelligent of the interface. Continue investigate a more innovative ways to add intelligence to the way children interact with the interface.

Significant Achievement

Our most significant achievement was being able to come together and combine efforts to create the Robo-Glove system. It was truly a great experience from getting to go to the school to creating the tool to expanding on our knowledge of code.

Acknowledgements

We would like to thank Las Cruces YWiC for the support and the working space. Thank you to our sponsoring teachers Rebecca Galves and Daniela Miranda and our mentor Esperanza Medina. Also thank you to our parents and family members for being there for us through this year long project.

References

1. Author Anonymous. *Deaf people: "psychology of deafness?"* Retrieved from: http://www.lifeprint.com/asl101/pages-layout/psychologyofdeafness.htm

2. Cao, A., Chintamani K. K., Pandya K. A., Darin R. E. (2009). *Nasa tlx: software for assessing subjective mental workload.* 41 (1), 113-117 doi:10.3758/BRM.41.1.113 Wayne State University, Detroit, Michigan.

3.Casamassina, M. (2005). *Understanding the revolution controller*. IGN. Retrieved from: http://cube.ign.com/articles/651/651559p1.html

4. Farwell, T. (2000-2015). *Visual, auditory, kinesthetic learners.* Pearson Education, Inc. Retrieved from: http://school.familyeducation.com/intelligence/teaching-methods/38519.html

5. Figueredo, L., & Varnhagen, C. K. (2005). *Didn't you run the spell checker? Effects of type of spelling error and use of a spell checker on perceptions of the author*. *Reading Psychology*, 26(4-5), 441-458. doi:10.1080/02702710500400495

6. Hayes, H., Treiman, R., Geers, A. E. (2011).*Spelling in deaf children with cochlear implants: implications for instruction.* Washington: University School of Medicine. 1-17p.

7. Mirabella, F. and Casamassina, M. *Hands-on the revolution controller*. (2005). IGN. Retrieved from: http://cube.ign.com/articles/651/651275p1.html

8. Neville, Hellen (1988) [Interview] "The Mind: Language" [film]. The Mind Series, Vol. 7. WNET/New York: Educational Broadcasting Corp.

9. Saleh A. J, Karray F., Alemzadeh M., Arab N. M. (2008). *Human-computer interaction: overview on state of the art.* University of Waterloo, Waterloo, Canada.

10. Latham R. (2012). *Nih study shows the deaf brain processes touch differently*. NIDCD Office of Health Communication and Public Liaison. Retrieved From: www.nidcd.nih.gov/news/releases/12/Pages/071012.aspx

11. ACM SIGCHI Curricula for HCI (Hewett et al. 1992)

Verplank, W. , Hewett, T. T.,Baecker, R. , Card, S., Carey, T. , Gasen, J., . . . Strong, G. (1992). *ACM SIGCHI Curricula for Human-Computer Interaction.* New York, NY, USA

12. La Viola, J. J., (2013). *3D gestural interaction: the state of the field.* International Scholarly Research Notices. Volume 2013. Article ID 514641. Retrieved from: http://www.hindawi.com/journals/isrn/2013/514641/

13. Mat Deris, M., Herawan, T., & Abawajy, J. (2014). *Proceedings of the first international conference on advanced data and information engineering (daeng-2013). 410-414* Doi: 10.1007/978-981-4585-18-7. Retrieved from: https://books.google.com/books?id=kQvFBAAAQBAJ&pg=PA410&lpg=PA410&dq=3D+Spatial+Interaction&source=bl&ots=EmFcculHh_&sig=PnCZjN3LkhaH_H7wmmY3At5wA8w&hl=en&sa=X&ei=nO0SVcyFMYrcoASQ8YGADg&ved=0CCUQ6AEwAjgU#v=onepage&q=3D%20Spatial%20Interaction&f=false