Helping Deaf or Hard of Hearing (DHH) Students Participate in Group Work Setting

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Abstract

Certain colleges or universities provide only expensive or impractical assistive technology solutions to address specific needs of students with disabilities. This limitation demonstrates the lack of cost-effective and practical options to assist deaf or hard of hearing (DHH) students in participating in group discussion or more generally, collaborative learning environments. Active participation by a DHH student in these environments can be limited due to the fact that those students may struggle to understand what is being said while at the same time struggle to respond verbally, depending on the severity of their impairment. Solutions currently available, such as a live or a remote transcriber, may solve part of the issue, namely assisting the DHH student in understanding what is being said, but they may do so impractically due to the substantial communication delay and cost ($42,000 per student per academic year).

Our senior design capstone group proposes an efficient and cost-effective solution that a DHH student can utilize to realize near-natural communication with peers in group discussions. This solution involves the use of Bluetooth enabled headsets (microphones and earpieces) as well as mobile and laptop softwares (developed by our team) to create a chat room type environment. The non-DHH students in the group are able to communicate orally through the use of their headsets, while the DHH student will be able to see and respond to the non-DHH students communication through the laptop software. Our solution will be a deliverable prototype to Ohio Northern University's Disabilities Office for effectiveness live-testing by DHH students.

1.0 Introduction

The goal of this capstone project will be to develop an Assistive Technology Device that will aid a deaf or hard of hearing (DHH) student in their level of participation and comprehension in a group work setting, or collaborative learning environment. This device should assist the student in understanding what is being said as well as assist them in communicating themselves so that they can have a more active participation role at a reasonable cost.

2.0 Problem Description and Related Work

Nearly 20,000 DHH students in the United States currently attend some form of higher education [2]. Additionally, collaborative learning has become more common in these institutions, requiring students to work in a group of their peers. Solutions currently exist to assist DHH students in understanding what is being said in these environments, such as in-person or Skype based transcription services. However, these, along with the environment in general, still pose challenges to DHH students.

- First, transcription services, like those mentioned above, only solve one part of the problem in a collaborative learning environment, namely, they do not aid a DHH student in responding to what is being said to them, or at the very least do so inefficiently.
- Second, the transcription services can be quite inefficient, especially in Skype-based services. These services involve a transcriber transcribing what is being said, which they hear over a Skype connection, in an online document viewable to the DHH student. The fact that the transcriber is receiving audio and sending textual information over an internet connection provides no guarantee that they will hear all that is being said, whether due to connection issues or due to the quality of the audio being sent.

Additionally, the transcriber may miss information due to the fact that their rate of writing/typing may not match the rate that the audio is transmitted to them.

- Third, the cost of these services can be quite high. At Ohio Northern University, according to an interview with Ms. Tracey Harris, the school's Student Disability Coordinator, it will cost the school $42,000 for one student to use the transcription service over the course of a year. This can be extremely prohibiting, especially to institutions with smaller operating budgets, such as ONU.

Additionally, it is important to note that even The Ohio State University, a school with a large student body as well as an entire department dedicated specifically to students with disabilities, utilizes services such as the in-person or Skype-based transcription services*. This would seem to indicate that there is a lack of quality solutions for a DHH student in a collaborative learning environment. Furthermore, to our group's knowledge, there has been no national survey conducted to examine the technologies and the cost of such technologies used by the Disabilities Offices at universities to assist DHH students in a collaborative learning environment. Such a survey should be conducted in the future to better evaluate assistance solutions for DHH students.

3.0 Methodology

3.1 Solution Constraints

A few parameters must be considered if the DHH community is to be assisted in an collaborative learning environment. These parameters, the basis of which are described above, are considered appropriate constraints by the Accreditation Board for Engineering and Technology (ABET).

- Economic: As previously mentioned, transcription devices and services can be costly to students and universities - up to $42,000 per student per school year. Therefore, in order

*: This fact about OSU was confirmed through email correspondence with their Student Life Disabilities Services.

for a solution to be accessible to the largest demographic, **the cost of a solution should be considerably lower than $42,000.**

- Word Transcription Accuracy: It is important that words be accurately communicated in order that they be understood, regardless of a student's ability to hear. Therefore, a solution should **transcribe or communicate words with an accuracy of 94.1%**[1].
- Response Rates: In order to foster a more natural collaborative environment and to encourage a natural flow of conversation, the minimum rate at which **a DHH student should be able to respond should be 41.4 words per minute (wpm)**, which is considered the average typing speed according to Ratatype[10]. Similarly, the **non-DHH student should also be able to respond at a rate of at least 41.4 wpm**. Maintaining the same response rate for both groups will in a sense "level the playing field" and allow for a more natural conversational flow.
- Ethical: There arises situations in a collaborative academic environment where due to either the course subject or an off topic conversation between peers, sensitive or confidential information is shared. Therefore, in order for the solution to be effective in all settings, it will be **required that no audio or text recordings be stored on devices**. Additionally, **users** of the solutions should be **prohibited from saving any textual information from a session**, such as through screenshot or copy functions.

3.2 Solution Description

Our solution, shown in Fig. 1 will utilize a headset with a microphone for each non-DHH student connected to their phone via Bluetooth. The phones will then communicate with a laptop controlled by the DHH student, also through Bluetooth. To begin, the group of students will choose a group key, which is entered into the mobile (for non-DHH students) and laptop (for DHH student) applications, enabling all devices to recognize signals sent amongst one another.

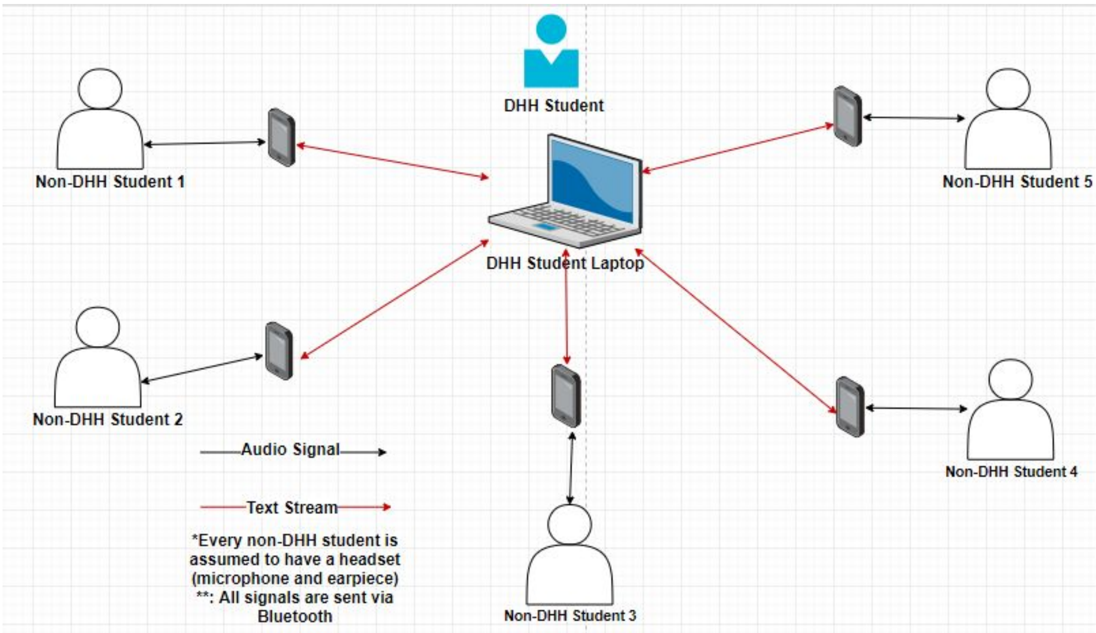

Figure 1: Communication Block Diagram

During conversation, each non-DHH student, after having activated their headsets microphone using a push to talk button, will speak into the microphone, which will send the audio to the mobile application on their mobile device. The mobile application will then transcribe this audio into text using Google's Voice-To-Text software (accessed via Wi-Fi) and will send that text to the laptop application. This transcribed text, through the laptop application, will be viewable to the DHH student. Further, the DHH student will be able to respond via typing in the laptop application, at which point they will be able to respond to either the group as a whole or to an individual student in the group. In the case that the student would communicate with the group as a whole, the text would be synthesized into speech in their laptop application, the audio of which would be played through the speakers of their laptop. In the case that the student would communicate with an individual student in the group, the text of their communication would be sent to the mobile application of the student they wish to respond to. That mobile application would then synthesize the text into speech and would send the audio to the headset of that student.

The laptop application (shown in Fig.2) will display a group name, along with a group code at the top the screen, which as previously mentioned, will be used by all students in the group to connect their devices to one another. This screen will display one dialog box for each non-DHH student, which will include the name of that specific student at the top of the box. Additionally, the speech of that student will then be displayed within their dialog box on the left side of the box along with the time that they spoke for one continuous stretch of time on the right side of the box. The DHH student will be able to respond to individual students by typing in the response box at the bottom of the dialog box of the student they wish to respond to. The DHH student will be able to respond to the group as a whole by typing in the Reply to All box at the bottom of the screen.

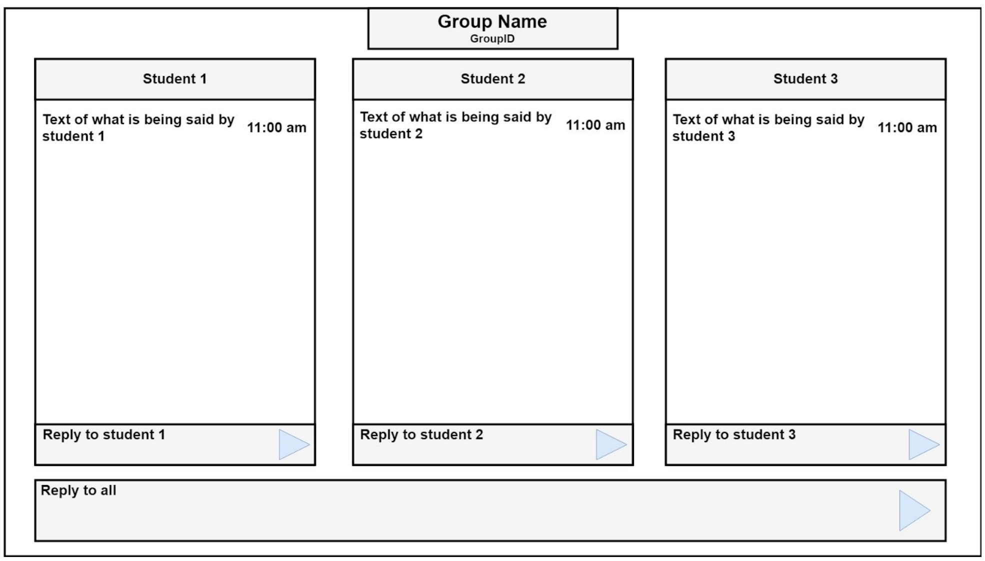

Figure 2: Laptop Application UI

The mobile application, shown in Fig. 3, will contain a login screen where the non-DHH student will enter the group key in order to authenticate the connection of their mobile device with the laptop application. This authentication will create a dialog box for that individual student on the laptop application.

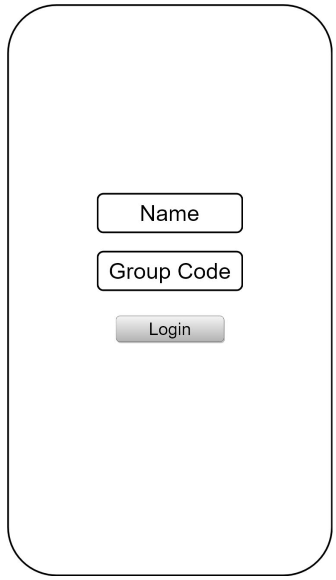

Figure 3: Mobile Application Login UI

Additionally, non-DHH students will be able to control the sensitivity of their microphone as well as the volume of the audio played through their earpiece through another user interface, shown in Fig. 4. The microphone sensitivity as well as the earpiece volume are controlled through sliders. A push to talk button is also included in this portion of the mobile application. The purpose of the push to talk button is to reduce the potential cost to the user due to the fact that Google's Voice to Text API will charge users as long as the microphone is transmitting audio, regardless of whether or not it is intended speech. By using the push to talk button, the system will only transmit audio to the VTT API when the button is pressed.

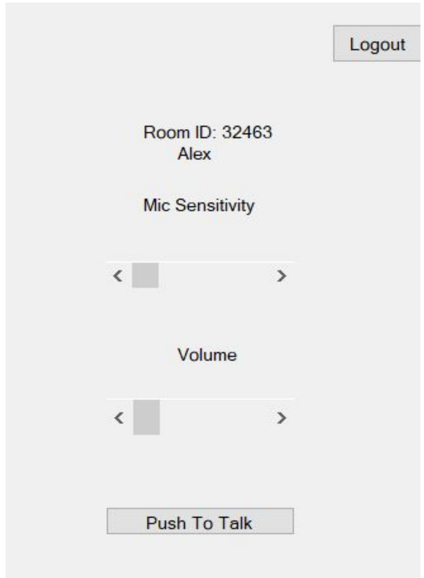

Figure 4: Mobile Application Parameter Adjustment and Push to Talk UI

All devices will communicate via Bluetooth connection. Each mobile device/headset pair will form a piconet, with the mobile application coordinating communication between the two devices. Audio will be sent to the mobile application as audio packets. The laptop and all mobile devices will form another piconet, with the laptop application coordinating communication between itself and the mobile devices. All text data sent between a mobile application and the laptop application will be in the form of character strings.

All text data sent between mobile devices and the laptop will be encrypted using public key encryption. All applications will also not store text or audio data and in addition, the laptop application will prevent the user from copying text data or taking a screenshot of the UI.

The applications will be developed in C# due to the fact that the language can be used on multiple devices as well as the fact that it includes a speech synthesis library. Speech transcription will be conducted using Google's Voice to Text software, as previously described. Headset microphones selected were chosen due to their high battery life and clear audio quality.

3.3 Solution Evaluation

The total cost for this proposed solution would be **$157.60**. This cost takes into consideration the cost for **5** Bluetooth headset microphones (**$107.20**) as well as 35 hours of voice to text transcription via Google Voice to Text software ($50.40)[8, 6].This price may be even lower depending on how often the solution is used, which would affect the use of the Google Voice to Text software. Because the solution will utilize Google's Voice to Text software, it will correctly transcribe words 95% of the time[3]. The communication of the non-DHH students would be transcribed at a rate of 150 wpm, as this is the average speaking rate[4]. The DHH student would be able to communicate at a rate of at least 41.4 wpm, as this is the average typing rate[10].

3.4 Testing and Refinement

A complete functional test of the system will be performed in order to evaluate the performance of the system in terms of how effective it is at assisting a DHH student in having a more active participation role in a group work setting. This testing, though not completed at the time of paper submission, will involve one DHH student as well as five non-DHH students in a simulated group work environment. As these tests will involve humans, it will be required that the test procedure, or protocol, be submitted to Ohio Northern University's Institutional Review Board (IRB) for approval. Other necessary documents to be submitted include a participant consent form, a questionnaire related to the user interface designs, a script to be used by the participants to simulate the group work environment, and a document describing the non-standardized and/or unpublished instruments to be used in the testing (per the instructions of the IRB).

Each functional test of the system will include the following segments:

1. System Set-up

a. Participants will be given the necessary equipment (headsets, access to mobile application, laptop with pre-downloaded software). Once the participants have the necessary equipment to use the system, they will configure the system by creating a group session, connecting all of their devices together over Bluetooth connections. This connection process will be done according to the system set-up description in Section 3.2. **The time that it takes the group to completely configure the system will be measured in seconds (s)** starting from the time that the non-DHH group members start to set up the system to when the system is able to be fully used by the group.

2. System Use Simulation
    a. The testing will include a simulated group work environment. In order to accomplish this, all participants will be given a script and assigned a role according to that script. Participants will read from that script while using the system according to the description in Section 3.2. Multiple measurements will be made during this portion of the test.
        i. **The time that it takes a non-DHH student to respond will be measured in seconds (s)**. These measurements will be made from the time that the non-DHH student starts talking (after having pressed the press to talk button on their mobile application) to when the transcription of their speech is displayed in the appropriate dialog box on the DHH student's laptop software user interface. These time measurements can be used to calculate the rate at which the non-DHH student is able to respond.
        ii. **The time that it takes the DHH student to respond will be measured in seconds (s)**. These measurements will be taken from the time the DHH student starts typing to the time that they press send on the laptop software as well as from the time that the DHH student presses send on the laptop software to the time that it is

heard through either the laptop speaker or through the earpiece of one of the non-DHH students. These times can be used to calculate the rate at which the DHH student is able to respond.

iii. **The accuracy of the system in transcribing the speech of the non-DHH students will be measured as a percentage (%) of words correctly transcribed**. These measurements will be made by saving the transcription of the conversation to a text file and comparing blocks of text in that file to the respective blocks of text in the script.

3. Questionnaire
   a. After the testing of the system is concluded, the participants will be given an anonymous questionnaire with questions related to the design and usability of the user interface.

Three complete functional tests of the system will be performed and after each test, the system will be adjusted in order to improve performance. After all tests and improvements are made, the system will be made available to the Ms. Tracey Harris, Student Disability Coordinator at Ohio Northern University. Headsets, access to the mobile application and laptop application, and a user manual will be provided and instructions on how to operate the system will be explained to Ms. Harris. Headsets, access to the mobile application and laptop application, and a user manual will be provided to Ms. Harris.

4.0 Conclusion

Colleges and other schools lack the ability to effectively and practically integrate deaf and hard of hearing students into collaborative learning environments. Our solution involves the non-DHH students in a group speaking into their own individual headset microphone, which sends audio to be translated into text. This text is then sent to the DHH student, who is able to view the conversation in a chat room format. Additionally, the DHH student is able to communicate with the non-DHH students through their laptop application. This solution mimics the natural flow of a conversation while allowing DHH students to seamlessly work in a group.

One major issue that could be present with this solution would be in regards to the potential delay involved in the response of the DHH student to any communication. This time delay should be smaller when compared to other available solutions, however, there is a possibility that there will be a delay in the time that it takes the DHH student to respond due to the fact that they would have to type out a response rather than speak their response. Therefore, one improvement that should be made in the future would be in the method in which the DHH student responds. Rather than waiting for the DHH student to completely type out a response before playing back the corresponding speech, it may be possible to convert the typed response into speech instantaneously, meaning that the text is converted to speech as soon as a word is typed.

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