Personalized Technical Learning Assistance for Deaf and Hard of Hearing

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Abstract

In this demonstration, we present a virtual reality classroom environment that is accessible to Deaf and Hard of Hearing (DHH) as well as hearing participants. The class will be conducted live through the Virtual Reality interface. The lecturer and the students will log in to the VR interface through Oculus Go and Rift devices. For the DHH individuals an interpreter will also log in to the VR classroom through a VR device. The video feed of the lecturer and the interpreter will be streamed live to each VR device of the participants. Participants can themselves reconfigure a classroom by muting, removing, and displacing other participants including the lecturer and the interpreter. This environment also enables seamless collaboration between the DHH and hearing individuals without a disclosure of the particular disability.

Introduction

Deaf and Hard of Hearing (DHH) representation in the labor force in the year 2014 was 48% (C.L., S., and M. 2016), which is 24% lower than the employment rate for hearing individuals. Out of the 100,000 deaf people between the age of 18 to 44 only 20% attend post secondary educational institutions each year (IES NCES 2019). Only a small subset will enroll in a computer science course. In Arizona, there were 2100 deaf people within the college going age range of 16 to 21 (US Department of Education 2017), out of which only 20 are currently enrolled in STEM courses at the undergraduate level at ASU, out of which only one is enrolled in Computer Science (According to statistics generated at the ASU DRC). While the total DHH enrollment in STEM courses for 4 year undergraduate college (≈ 17%) is nearly the same as hearing individuals (≈ 18%), only 0.19% of DHH students attend any postgraduate education as opposed to nearly 15% of hearing individuals (Gallaudet University 2012). This reduces the access of DHH individuals to high quality skilled jobs in technological fields that require postgraduate education where they may earn 31% more (Gerard G Walter 2010). This lack of access not only deteriorates the economic conditions for the DHH community but also reduces the potential STEM workforce by nearly 15,000 per year resulting in millions of dollars in lost tax revenue.

Driven by this need for inclusion of DHH individuals in STEM, a series of NSF projects were granted over the last decade including CNS-0837508, DBI 1062589, HRD-1127955, and MCB-1232380. A workshop for DHH integration in STEM education in the Gallaudet University (Gallaudet University 2012) held in 2012 summarized a set of research problems that should be optimally addressed to improve DHH integration. Alarmingly after 6 years or recommendations and implementations, a 2018 study from Gallaudet university on the experience of DHH students in University STEM education still lists very similar problems faced by the DHH community, suggesting that the improvements for DHH access to STEM education over the past 6 years was only incremental.

Accessibility Problem: Two main methods can be used by the DHH students to gain access to lecture materials in any class: a) American Sign Language (ASL), preferred by the Deaf and requires an in-class accompanying interpreter, and b) live transcription or captioning (CART), preferred by the hard of hearing, where a transcriber (typically court trained or a stenographer) takes notes in shorthand which is converted into text using a software. In the case where ASL is used, for a STEM class one of the main challenges is that many of the technical terms used in lectures may not have an associated gesture. In such cases, an interpreter can either meet the student before-hand to decide on an improvised gesture or fingerspell the English word in class. Research by Coppola et al at the University of Connecticut has shown that the usage of home signs (non-standard gestures developed in an improvised manner) or fingerspelling are good for short term memory, but have poor long term recall performance (Spaepen et al. 2011). This is especially problematic for technical education such as computer science, where the DHH student is required to utilize the concepts learned for long term in the field of employment. In addition, the absence of a standardized set of gestures hinders discussion and collaboration between peers, especially if they do not share the same home signs. The same problem also exists for transcription services such as CART where a shorthand may not be available for a technical term. The transcriber then has to carefully listen to the technical word and spell it...
out resulting in higher than normal delays. This may also introduce errors especially when the transcriber is not familiar with the technical terms.

It has also been reported that the DHH students accompanied by interpreters have significant problems with seating arrangements (Gallaudet University 2012). The interpreters typically are stationed to the front of the class so that they can not only observe the lecturer but also translate for in-class interactions. DHH students sitting in the front may have problems viewing lecture materials and student interaction simultaneously, while sitting at the back may result in a difficulty in viewing the Interpreter. On the other hand, transcribers only get the audio feed of the lecturer and hence cannot transcribe in-class interactions. Access to in-class interactions is significant for better learning outcomes for the DHH students. Several research studies such as (Griffin 1976; Dowaliby, Burke, and McKee 1983) have shown that a DHH individual learns best when they can collaborate and discuss with their peers (Chi and Wylie 2014). Hence a re-configurable classroom is of utmost importance.

The “Online” Conundrum: With the advent of mobile technology and increasing availability of cloud computing services, there is a significant drive towards online delivery of STEM education. At ASU, several undergraduate core courses in computer science are delivered online at an open scale reaching thousands of students each semester. Although the current paradigm of online course delivery in STEM education improves accessibility for a global hearing population, it can hinder the access of the DHH population to qualify education Courses that deliver content online eliminate the possibility of in-class interactions, which has been shown to be more essential for DHH students than for hearing students for better learning outcomes.

Our aim is to integrate the advances in Virtual Reality technology and cutting edge research on gesture recognition with high capacity computer and networking infrastructure for:

a) performing research on best practices for enabling success of the DHH community in graduate and post graduate computer science programs, and

b) developing online computer science courses for the global DHH community that provide a virtual in-class experience.

c) provide a platform to enable collaboration between DHH and hearing individuals

In this regard, this paper proposes CSAVE (Computer Science Accessible and Virtual Education) classroom, which is a VR enabled live class, where DHH individuals can interact with a lecturer and DHH or hearing peers through a remotely available interpreter. All the individuals can log into the classroom regardless of their physical location, and can have their chosen levels of identity disclosures. Although our focus is computer science, the infrastructure can be used for any STEM subject. We have chosen computer science as a case study to identify the salient challenges and provide concrete solutions.

Usage of VR in Technical Education for DHH

We built a virtual reality (VR) interface to provide in class experience for the DHH individual in online CS courses and a collaborative space to enable DHH to DHH and DHH to hearing interactions. Usage of VR can be especially beneficial for the DHH individual that allows them to improve their inductive learning skills (Pantelidis 2010; Passig and Eden 2000).

b) VR environment can be configured by the student to create optimal class configuration that enables the DHH student to give maximum attention to the lecturer, interpreter or transcription, and lecture material.

c) The immersive environment and lack of distractions in VR can result in increased cognitive engagement (Anglin, Sugiyama, and Liew 2017) as opposed to video conferencing. It can potentially improve learning outcomes, as cognitive engagement is seen to have a positive correlation with active learning outcomes (Chi and Wylie 2014).

d) VR can enable co-construction collaborations among DHH and their hearing peers, which can potentially improve learning outcomes (Viswanathan and VanLehn 2018) and prepare DHH students for their professional experience.

e) Through the usage of avatars the DHH students can control the level of disclosure of personal information to their peers during in class or collaborative activities. This is a significant advantage of this environment and can allow for seamless interaction between students leading to better social inclusion for the DHH community.

CSAVE architecture

CSAVE architecture enables both video conferencing and virtual reality options to the students. The student, instructor and interpreter setup is shown in Figure 1. The DHH student should be in front of a computer with a webcam and can additionally use a Virtual Reality headset. The webcam is used to
render the video of the DHH student either in the video feed or in the virtual environment of other students, instructors, and interpreters depending on their mode of access. The VR headset is used to provide a virtual in-class experience for the student. When a student wishes to participate in in-class interactions, the webcam feed is rendered. The video feed with gestures is accessed by the interpreter, who translates the signed communication into English (the language of instruction). On the student’s end, the video content includes the video feeds from the virtual classroom with the lecturer, other fellow students, and the interpreter. Each class offers choices between a default technically trained interpreter and other freelance interpreters who have different expertise as needed by the students. Students can choose their preferred interpreter feed to maximize accessibility with regard to different backgrounds. This can bring a paradigm shift in interpretation services by allowing geographically unconstrained availability for incentive based freelance interpretation service.

The Instructor is present in a recording studio, where the class is delivered live. The instructor can choose to wear a VR headset which provides an in class experience to the instructor as well. The video feed from the Instructor is rendered in the VR headsets or the video content for the students and the interpreter. The Instructors can use their video content or VR headsets to interact with the students and the interpreter. The instructors voice is streamed live to transcribers or Interpreters who have logged in to the CSAVE course.

The interpreter setup is very similar to the student setup, where the interpreter can use a VR system or the computer to watch the video feed from the instructor and the virtual class. The video feed from the interpreter is rendered to the students and the lecturer through their respective VR devices or computers. Through the video or VR interface, the interpreter continuously translates lecture into signed communication. Whenever a student has a question, the interpreter view is modified to facilitate communication with the specific student. The interpreter can also view the interactions of other students in class and may translate them into sign language for the DHH student. Figure 2, shows the overall architecture of a CSAVE course. The students, interpreters, and the lecturer are connected to a central CSAVE server.

There can be multiple technically trained interpreters that are virtually present at a time.

The components needed for different participants in the CSAVE architecture are listed in Table 1.

<table>
<thead>
<tr>
<th>Table 1: CSAVE components by participants</th>
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<tbody>
<tr>
<td>Students</td>
</tr>
<tr>
<td>VR Headset</td>
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<tr>
<td>Laptop</td>
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<td>Webcam</td>
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Through the VR interface the DHH student experiences an immersive classroom. The student is able to view the live lecture and the interpreter of his or her choice. This one way interaction is the most basic operation of the CSAVE architecture. However, if the student has any question or interjection, then the student can indicate either through an input from the computing system or by simply raising their hand. An automated course monitor then creates a log of such interjections and presents it to the instructor. If the instructor chooses to respond to any interjection, then the chosen interpreter for the respective DHH student is connected to the Student. The student can then ask questions in ASL enhanced with the technical gestures and the interpreter speaks out the question for everyone to hear or see.

The instructor view consists of a classroom filled with students. The students can choose to display their actual video feed or use an avatar to represent their presence. VR headsets are able to automatically track the orientation of the head of the wearer. This means that the instructor is not only aware of who is attending the class (their avatar will disappear if they switch applications or take off the headset) but is also subtly aware of who is paying attention by the direction their heads are facing in the classroom. The instructor also sees the default interpreter in his or her view.

The most unique component of CSAVE is the group collaboration or interaction module. Using this module, the DHH student can perform a face to face meeting with fellow students as well as other DHH students while being accompanied by a virtual interpreter. In addition the DHH student can also join group collaboration activities in separate virtual environments different from the classroom like immersive labs or demonstration rooms.

**Demonstration Setup**

In our demonstration, we will setup an instance of an online class, where an instructor will be lecturing live about an exemplary AI topic. Examples of topics include introduction to machine learning concepts and other high level topics that do not need mathematical background. The online classroom is setup in Altspace VR and is a virtual environment. The lecturer will remotely log in to the online classroom using the Oculus Rift VR device. There will be at least 2 DHH students logging in using an Oculus Go device. DHH participation will be ensured through collaboration with another event hosted by the authors in AAAI Diversity Activity.
For each deaf student a remote interpreter will also log in to the Altspace environment. The remaining 9 Oculus Go devices will be used by hearing participants to log into the class. The hearing participants can either explore the classroom or interact with DHH participants through their interpreters. The disability status of the participants will not be disclosed. This can potentially enable seamless collaboration between the DHH and hearing individuals overcoming the barriers of disabilities. The Altspace online classroom will be hosted on a server at the IMPACT Lab. Sample interfaces for the demonstration is shown in Figure 3.

**Discussion and Conclusions**

The presence of CSAVE infrastructure is only the first step towards making technical education accessible to DHH community. There are significant challenges which can be addressed in the future utilizing this infrastructure. For example, both undergraduate and graduate computer science courses require prior knowledge of concepts in secondary mathematics and logic. The DHH student enrolling in a 4 year college degree in computer science is expected to at least be familiar with the pre-requisite concepts or to take a 100 or 200 level computer science courses. However, this cannot be expected of the Interpreter or the transcriber which can impose significant problems with respect to interpretation or transcription of technical terms. Although the 100 or 200 level courses can be designed to re-introduce the basic prerequisite terms and theorems, this may not always be possible for the higher level undergraduate or graduate level courses. Often lecture discussions can depend on student interactions in class which may lead to the introduction of a new technical concept that was not previously planned. This is a bigger problem in advanced PhD level courses in Computer Science that have been very recently introduced. For example, in courses dealing with human computer interaction or cyber physical systems, often the discussion may require prior knowledge of fields traditionally unrelated to computer science such as psychology, human physiology, physics and mechanics. Even if the DHH individual has prior knowledge, this cannot be expected from the Interpreter or transcriber, leading to potentially erroneous communication or increased delays. Hence, a library of technical signs are essential which is lacking in recent times.

As an employee in the IT industry, every professional has to collaborate with peers to develop code, review, debug and testing. Often team members decide to work on different aspects in parallel, which requires careful planning and coordination. Such interactions are initiated early in computer science education through capstone projects, where students collaborate on different programming and implementation projects. Collaboration with fellow hearing students can be a significant hurdle for the DHH individual which is exacerbated by the online computer science education drive.

We believe that a careful design of the online course delivery infrastructure can actually increase accessibility to CS courses for the global DHH community while providing novel and effective solutions to the problems faced by the DHH student for computer science education.

**References**


Griffin, T. E. 1976. A comparison of the cognitive styles of deaf students with the cognitive styles of hearing students.


