ADDING VISUAL SIGNALS TO MACHINE SHOP EQUIPMENT: A CASE STUDY OF DEAF GAIN IN ENGINEERING EDUCATION

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Abstract

Deafness has historically been portrayed as a disability in engineering culture. Deaf engineers are portrayed as needing additional support to obtain communication access to engineering classrooms and to "overcome" communication barriers with hearing colleagues. Medical device engineers design technologies such as hearing aids and cochlear implants that are intended to help Deaf people fit into the hearing world. This paper proposes an alternative viewpoint that Deaf culture, with its rich traditions of visual/tactile/non-auditory communication, provides an unique context from which the (culturally hearing) engineering field can learn.

This paper explores one such contextual adaptation in the context of engineering education. Specifically, when Deaf engineers adapted a manufacturing machine to use visual signals in addition to auditory ones, their modifications were useful not only to users with hearing loss, but also for users with normal hearing in noisy environments. This is an example of "Deaf gain," a concept from Deaf studies that frames Deafness as a minority culture and a rich source of diverse thought as opposed to a stigmatized medical condition and disability.

In this paper, we contextualize Deaf gain theory as it applies to engineering education settings, then use that framing to narrate the events leading to the machine adaptations. After describing the impact of this environmental modification on Deaf and Hard-of-Hearing learners, the equipment vendor's reactions are described. This project narrative suggests that when a company designs a new product with auditory alerts, they should also add visual alert signals in order to benefit a wider range of users. In addition to following Universal Design principles, it is far more effective in terms of both cost and time to implement this in the original design instead of needing to make aftermarket modifications.

Background

In American culture, deafness has typically been portrayed with a negative stigma; it is a medical condition of being unable to hear, an impairment, and a disability [1]. Engineering culture shows signs of this medicalized view of deafness. For instance, (hearing) engineering students might work on technologies like sign language gloves with the intent of "helping" the deaf, even if their intended users repeatedly state that these technologies are not beneficial [2]. In the context of engineers and engineering students with hearing loss, deafness is often framed as a challenge or barrier to be overcome; one paper on "Enhancing the Educational Experience for Deaf and Hard of Hearing Students in Software Engineering" explains that "Deaf/HoH students are prone to losing a large amount of both verbal and nonverbal communication…" and describes their experience of teaching Deaf/HoH students as involving "significant hurdles" [3].

Deaf studies proposes an alternative view of Deafness as a culture, not a disability. Just as Americans typically would not call French people "disabled" because they use a different language and have a different culture, so too can Deaf culture be seen as a group of people with a distinct history, language, and traditions of art, theatre, education, and so forth [4]. This cultural attitude towards Deafness is denoted by using an uppercase "D" (Deaf) rather than a lowercase "d" (deaf), which signifies the medical condition of hearing loss [5]. Significantly, a cultural framing of Deafness opens up the possibility of seeing Deafness as a *benefit* -- as a different perspective through which the world can be imagined anew. This framing is known as "Deaf Gain," in contrast to "hearing *loss"* [6]. "Deaf Gain" is the English translation of an ASL concept that can variously be signed as "Deaf-benefit" (Deafness as a benefit or privilege), "Deaf-addition" (Deafness as something that adds, rather than takes away), or "Deaf-gift" (Deafness as a valuable contribution to the world).

Taking a Deaf Gain perspective in engineering education can lead to new insights that may not occur within a predominantly hearing context. In particular, approaching equipment design from the context of Deaf culture allows engineers and engineering educators to draw on rich traditions of visual/tactile/non-auditory communication. The resulting designs can benefit engineers regardless of whether they are Deaf, hard-of-hearing, or hearing. The remainder of this paper presents a case study that illustrates these principles.

I. The Problem: A CMM with Auditory Notifications

The National Technical Institute for the Deaf (NTID) has a 50-year tradition of educating Deaf and Hard-of-Hearing (DHH) students in technical fields. On February 12, 2013, their Department of Engineering Studies (DES) had a setback; their Coordinate Measuring Machine (CMM) broke down, and all attempts to restore it to working order were futile. Using a CMM was a critical skill in the DES curriculum, as students would have a difficult time understanding how to inspect parts without it. The DES therefore decided to purchase a new CMM machine (Figure 1), and settled on the Phoenix RB Model 112-102 DCC from Helmel Engineering Products, Inc.

Figure 1. *Coordinate Measuring Machine (CMM). CMM is a device for measuring the physical geometrical characteristics of an object. Photo courtesy of Helmel Engineering Products, Inc.*

Part of the quote from Helmel included training for the DES faculty who would be teaching students how to use the machine. Three professors teaching various courses in Computer Integrated Machining Technology went to the company during the January 2014 Intersession. One of the professors, Wendy Dannels, was Deaf; the other two were hearing.

The three-day training commenced at Helmel company headquarters. Partway through, Prof. Edward Schwenzer, one of the hearing faculty members attending, realized the CMM machine was producing various beeping noises to alert operators to various stages of the process. He and his hearing colleague could hear the machine in the relatively quiet training room;

however, their Deaf colleague Prof. Dannels could not, and their DHH students would similarly not be able to.

The Solution: Add Visual Notifications

Prof. Schwenzer returned to NTID and asked Prof. Gary Behm (Deaf) to investigate the issue in his laboratory, the Center on Access Technology. Prof. Behm proposed the project to another Deaf faculty member, Prof. Stanislow. Working with Deaf student employees Vasu Gupta and Matthew Ballerini, Prof. Stanislow retrofitted the CMM with a prototype sound detector (see Figure 2).

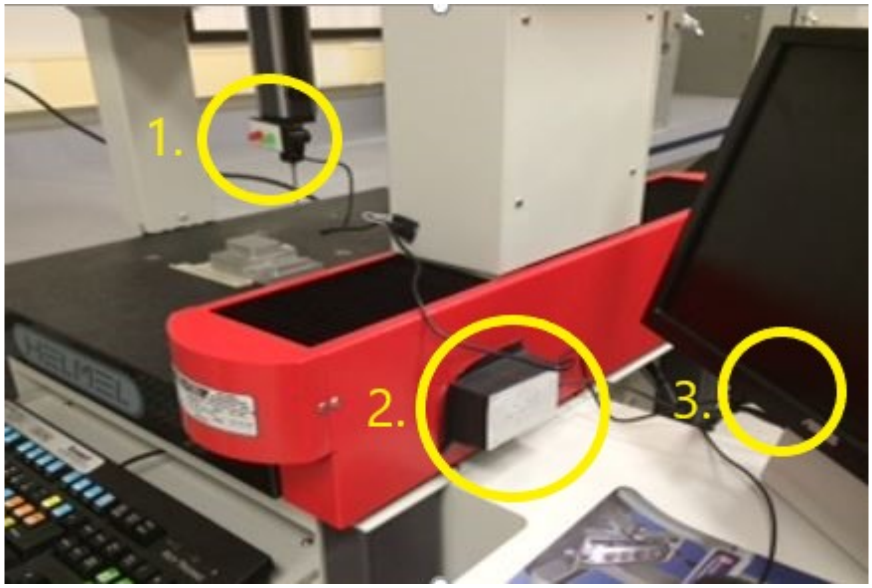

Figure 2. *CMM outfitted with a prototype sound detector, showing (1) notification LEDs, (2) the main processing unit for the sound detector, and (3) the audio notification hookup for capturing sound from the CMM monitor's speaker.*

The prototype sound detector for the CMM was based on a design for an earlier project with scientific lab equipment. Briefly in 2012, Dr. Raymond C. Merritt, Jr., a Gallaudet University professor, ran into issues with blood testing equipment in his genetics lab. One of his machines involved a time-sensitive process; blood samples needed to be removed as soon as the process was done, or the samples would be ruined. However, some of Dr. Merritt's students were Deaf, and the machine had no function for notifying them that the process was complete. The process completion passed unnoticed, and samples were often ruined. Prof. Stanislow had developed a visual notification sound detector for the blood testing equipment, and this design was improved and modified to fit the physical configuration and auditory alerts of the CMM.

The CMM version of the sound detector fit over the speaker where the audio notifications were playing (Figure 3) and listened continuously for the audio alerts when it was turned on. It then translated the different sounds into flashing lights of different colors that were mounted over the CMM probe head (Figure 4). Notably, the design, implementation, and administration of the project was carried out entirely by Deaf engineers.

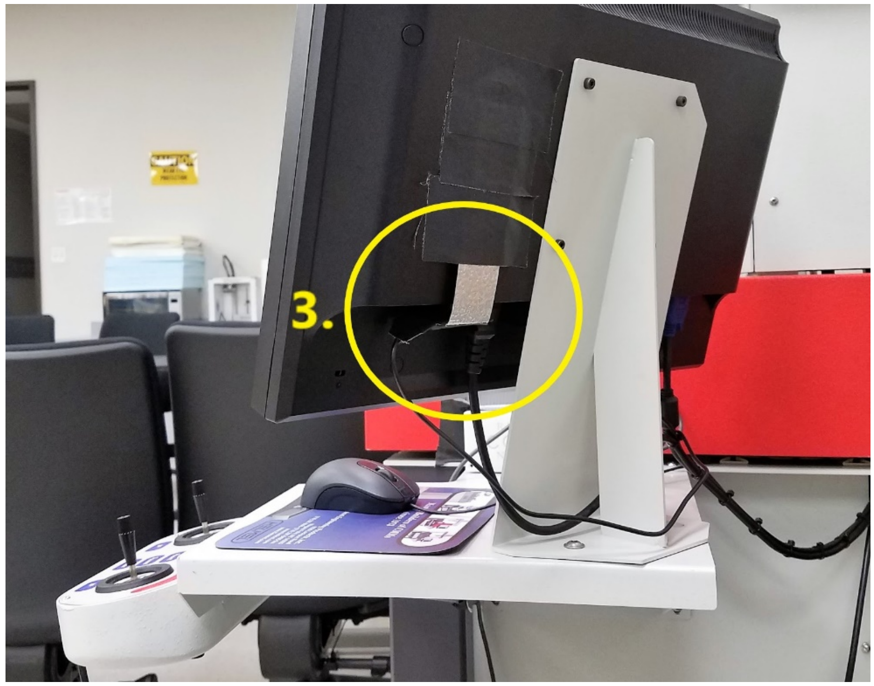

Figure 3. *Close-up of (3) from Figure 2. The audio notification hookup is attached near the built-in speaker on the monitor.*

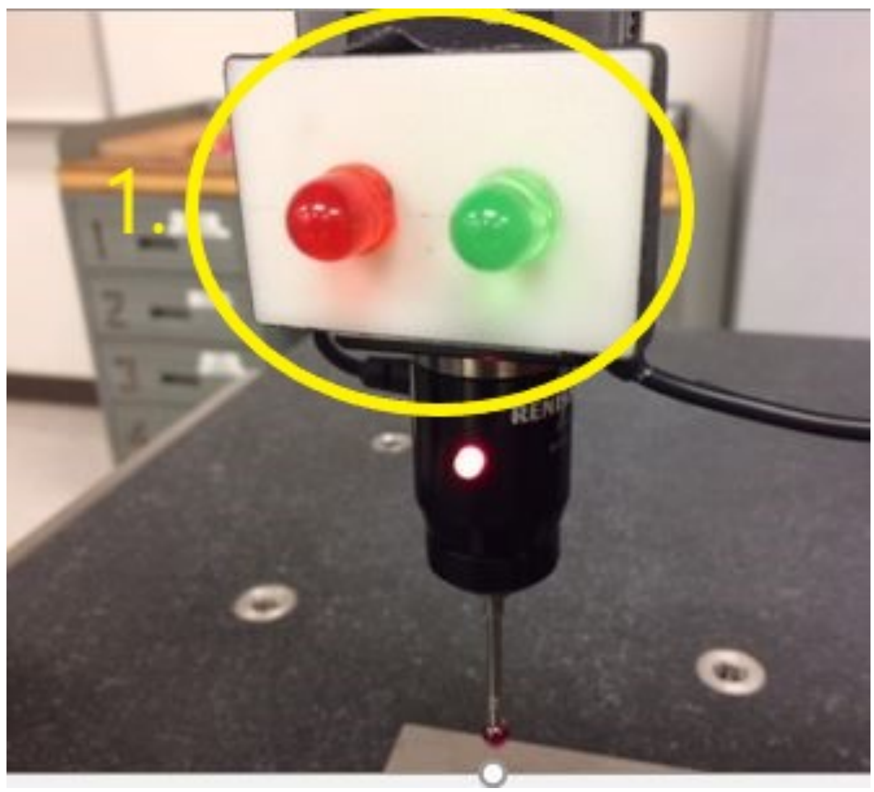

Figure 4. *Close-up of (1) from Figure 2 showing the notification LEDs mounted above the CMM probe head.*

The Impact: Student Learning and Industry Design Changes

The resulting prototype was tested with DHH students, who were randomly assigned to learn how to operate the CMM either with or without the visual notification modifications. The students using visual notifications performed significantly better than the students using auditory notifications only. Details of this preliminary study are forthcoming in a future publication [7].

After analyzing the study results, Prof. Dannels contacted the original device manufacturer and asked to meet with them. The Helmel Company agreed, and Prof. Dannels and Prof. Stanislow went to their headquarters with the study results and their modified machine. The Helmel's VP of Sales and Marketing (hearing) reacted with surprise and delight. He wrote to

Prof. Dannels and Prof. Stanislow with his realization that their visual signalling modifications would "...also be very beneficial to any user who works in a noisy environment and cannot hear the beeps…" and outlined their plans to incorporate NTID's visual signalling idea in all of their future device designs. Their current designs already had a red power indicator LED mounted above the CMM probe head, close to the location where Prof. Stanislow had mounted the lights on the modified version. It would be simple to swap that out for a tri-color LED and update the firmware to emit both auditory and visual signals during device operation.

Discussion and Conclusion

This case study provides a simple example of how a Deaf perspective led to design modifications that will benefit both Deaf and hearing engineers. In noisy environments, auditory signals become difficult to distinguish even for hearing engineers. However, regardless of the level of background noise, visual signals are still clear. This also allows hearing operators to use protective hearing equipment as recommended by OHSA.

This work also benefits future DHH students and their instructors by giving the field a better understanding of how lab equipment can be designed in an accessible manner, and the impact the lab equipment design has on student learning. Future work may include investigating the impact of visual signaling for hearing students, as well as modifications to the equipment to better accommodate low-vision, color-blind, left-handed, and/or physically limited operators. For instance, color-blind accessibility could be achieved by having the signals distinguished by both light color and the number of light flashes.

These modifications are not limited to CMM or machine shop devices. Principles of visual signalling can be applied to a wide variety of devices, such as household equipment. For instance, microwaves and ovens could have flashing light notifications to signal when cooking is finished to prevent food from getting cold and being wasted. Additionally, home equipment that is usually located out of sight (e.g. laundry machines) could be equipped with remote light signals for the main living space in addition to the auditory signals they already have, or send messages to mobile devices that users might already own. Generally, the practice of adding visual (and/or tactile) signalling options in the design and manufacturing phase of products is an example of employing Universal Design principles [8], which lead to cost savings compared to trying to incorporate accessibility later in the design process.

Incorporating Deaf perspectives into the machine shop does not only make the shop itself more accessible; it can help students see their workplace contexts as modifiable as well. DHH students in NTID classrooms can now see the results of Deaf engineering work affecting the devices they use, encouraging them to think of ways to modify other equipment they encounter in the workplace in the future. Exposing students to these kinds of adaptations now can empower them to advocate for better solutions in the future. In this way, Deaf engineering perspectives will continue to spread in society in ways that are applicable and beneficial to both hearing and DHH people.

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