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Using AR to Teach AR: Learning Outcomes of a Guided, Augmented Reality Hearing Loss and Auditory Rehabilitation Simulation with SLP Graduate Students

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Abstract

Recent research has found that practicing speech-language pathologists report feeling underprepared to provide services for individuals with hearing loss. At the same time, graduate SLP programs report that students have fewer training opportunities with low-incidence populations. This study examines learning outcomes for a cohort of graduate SLP students using a novel application of an immersive, augmented reality, hearing loss simulation. Results show encouraging outcomes for the simulation experience's effects on empathy, knowledge, and clinical skills. This simulation offers a unique way to provide training related to auditory rehabilitation in SLP.

Keywords

simulation, augmented reality, hearing loss, auditory rehabilitation, speech-language pathology, Immersive Hearing Loss Prosthetic Simulator, i-HeLPS, Speech Perception Instructional Curriculum and Evaluation, SPICE

Introduction

The Scope of Practice of Speech-Language Pathology (American Speech-Language-Hearing Association [ASHA], 2016) includes nine broad disorder areas in communication and swallowing. One of these nine is the area of hearing. Hearing is the foundation of spoken and written communication. Training in this area is an important component of the certification process for speech-language pathologists, and graduate programs that do not have access to many clients with hearing loss may need to look for alternative or supplemental options to provide students with needed clinical experiences. Simulations can be an effective tool to provide this experience. The current study sought to describe learning outcomes encompassing knowledge, clinical skill, and disability awareness in first-year graduate speech-language pathology (SLP) students at the University of Montevallo who participated in a guided, augmented reality, hearing loss and auditory rehabilitation simulation.

Need for SLP training in hearing. The American Speech-Language-Hearing Association (ASHA, n.d.) and Ray et al. (2021) describe the distinct role of SLPs in assessment and intervention of auditory skills; yet, Henton and Glade (2023) showed that only 52% of accredited SLP programs have a required course related to auditory rehabilitation in their graduate curricula. This deficit is also reflected in that practicing SLPs report feeling less prepared to provide auditory rehabilitation services (Luckhurst, 2008; Page et al., 2018). Dudding and Nottingham (2018) reported that 63% of accredited programs noted that their students had “difficulty in obtaining clinical hours with low-incidence populations, with patients across the life span and across disorder types” (p.74). While hearing loss may not be considered low-incidence across the general population, the diagnosis may be an area of opportunity for graduate programs to broaden the clinical exposure for students.

According to the 2020 Schools Survey Report (ASHA, 2020), almost half (45%) of school-based SLPs reported that they have children with hearing loss on their caseloads and that they see this diagnosis more frequently than they see acquired brain injury, voice disorders, or selective mutism and equally as often as fluency disorders and childhood apraxia of speech. The National Institute on Deafness and Other Communication Disorders (2021) reported that half of adults have some degree of hearing loss by age 75. Additionally, the World Health Organization (2018) reported 460 million people with hearing loss worldwide and estimated that number would increase to 900 million by 2025. These statistics indicate that it is likely that most SLPs will see clients with hearing loss as either a primary or secondary diagnosis (Henton & Glade, 2023).

Simulations in CSD. Simulations have become accepted educational tools across healthcare training programs, and are increasing among SLP and audiology programs. They are often described according to the type of simulation and the degree of fidelity. Types of simulations include role play, standardized patients, computer-based applications, mannequins, augmented reality, or virtual reality. Choice of simulation varies depending on factors such as the desired student learning outcomes, the clinical population, and the availability of simulation technologies; Dudding et al. (2019) and Dudding and Nottingham (2018) provide a good overview of simulations in CSD. Fidelity is the level of realness of simulated experience. Low-fidelity simulations such as students role-playing and interaction in a classroom are further removed from an authentic patient-clinician interaction; whereas, digitized mannequins and immersive augmented or virtual reality simulations have the potential to be higher-fidelity simulations.

Dudding and Nottingham (2018) conducted the first comprehensive survey of accredited CSD programs' simulation practices and found that 51% use simulations of some type in their clinical education. Standardized patients were used most often, followed by computer-based simulations, then digitized mannequins, while only one program reported use of *immersive virtual reality*, and no programs reported using *augmented reality*. Andre et al. (2021) surveyed audiology graduate programs to investigate their use of simulations. Their results describe that eight surveyed programs used a "hearing aid and/or hearing loss simulator, such as the Verifit Skull Simulator" (p. 300); however, there was no indication of any use of immersive or augmented reality simulations. Alanazi and Nicholson (2023) conducted a systematic review of simulation use specifically within the discipline of audiology education. Their review found studies using standardized patients, video-recorded simulations, manikins, computer-based simulations, and virtual reality.

Virtual reality simulations have been used to develop empathy with various disability populations (Ahn et al., 2013; Embøl et al., 2021; Sri Kalyanaraman et al., 2010); however, at the time of this writing, only three studies were identified that used virtual reality in CSD. Embøl and colleagues (2021) described their novel technology to create a virtual environment to simulate the experience of children wearing cochlear implants in a classroom environment. Kelly and colleagues (2023) described a virtual reality simulation of an oral musculature assessment for SLP students. Bakhos and colleagues (2020) described a virtual reality simulation for audiometry training with audiology students. Although some consider augmented reality to be a form of virtual reality, the two are distinctly different; the differences between virtual and augmented reality have been defined by Lioce (2020) and are illustrated in Table 1.

Dudding and Nottingham (2018) found that a majority of simulation users and nonusers in CSD believe simulations can "benefit students in the following ways: (a) increase confidence and reduce anxiety, (b) provide repeated practice in a safe environment, (c) increase preparedness for off-campus placements, and (d) provide access to a broader range of experiences and client types" (p.76). Even with the broad acceptance of the benefits of simulations for students' clinical and academic development, faculty have reported that lack of expertise or unfamiliarity with existing technology is a primary barrier to incorporating simulations into their clinical and academic programs (Andre et al., 2021; Dudding & Nottingham, 2018). At the time of this writing, no research was identified regarding the use of immersive augmented reality simulation of hearing loss nor the particular software technology used in this study within communication sciences and disorders. The simulation design in this study combines the concepts of augmented reality, immersive virtual reality, and immersive simulation from Table 1. This study presents the outcomes of using this novel simulation application with graduate students in SLP.

Table 1

Definitions of Key Terms

Key Term	Definition
Augmented reality	"A type of virtual reality in which synthetic stimuli are superimposed on real-world objects, usually to make information that is otherwise imperceptible to human senses perceptible (M&S Glossary)" (as cited in Lioce, 2020, p. 11)
High-fidelity simulation	"In health care simulation, high-fidelity refers to simulation experiences that are extremely realistic and provide a high level of interactivity and realism for the learner (International Nursing Association for Clinical Simulation and Learning [INACSL], 2013)" (as cited in Lioce, 2020, p. 23)
Immersive virtual reality	"[P]articipants fully engage in a virtual environment through wearable technology (e.g., headsets, computer software) without interacting in the real world (Sherman & Craig, 2018)" (as cited in Towson et al., 2021, p. 3)
Immersive simulation	"A real-life situation that deeply involves the participants' senses, emotions, thinking, and behavior" (Lioce, 2020, p. 25)
Simulated patient	"An individual who is trained to portray a real patient in order to simulate a set of symptoms or problems used for health care education, evaluation, and research (Society for Simulation in Healthcare)" (as cited in Lioce, 2020, p.45)
Simulation fidelity	"The level of realism associated with a particular simulation activity." (Lioce, 2020, p.47)
Situated learning	"A theory that posits that learning occurs within authentic activity, context, and culture. Social interaction and collaboration are considered essential components (Lave and Wenger, 2008). This is opposed to a classroom learning activity that is abstract and out of context." (as cited in Lioce, 2020, p. 50)

Simulation Design and Rationale

Study Design. The simulation described in this study began as a way to address graduate SLP students' needs for competencies and clinical clock hours in assessment and treatment of hearing and incorporated augmented reality simulation technology. This project was designed to assess the learning outcomes among first-year graduate students in SLP after completing a guided, immersive, augmented reality, hearing loss simulation experience. The study used both quantitative and qualitative analyses of student learning, disability awareness, and students' perceptions of learning. This hearing loss simulation was a required component of the clinical rotations for the first-year graduate SLP students at the University of Montevallo. All students in the cohort completed the same simulation but were given the option to participate in the study. Students who gave consent to participate in the study took pre-simulation (pre-sim) and post-simulation (post-sim) tests with quantitative and qualitative questions. Participants were paired and completed the simulation in two-week rotations across the Fall 2022 and Spring 2023 semesters. This study was approved by the Human and Animal Subjects Research Committee at the University of Montevallo, which serves as the university's Institutional Review Board (IRB).

Definitions from Dudding and colleagues (2019) were supplemented with those from Lioce (2020) to describe the current simulation-based learning experience as accurately and thoroughly as possible while being consistent with recent terminology trends. The definitions selected are provided in Table 1.

The paired participants alternated being client and clinician for their partner. The *guided*, *situated learning experience* used in the current study allowed for unique experiences in both roles. The clinician provided assessment and treatment for their client or *simulated patient* which allowed the clinician to have a real-time, evolving interactive experience with their client. Simultaneously, the client experienced an immersive augmented reality (distinct from immersive virtual reality), which allowed them to both experience authentic environmental sounds and participate in communication attempts in real-time through the synthetic lens created by the hearing loss simulation technology.

The Immersive Hearing Loss and Prosthesis Simulator (I-HeLPS) device shown in Figure 1 was worn by the client. "The I-HeLPS algorithm for simulating hearing loss is designed to produce for the listener the absolute detection thresholds (i.e., hearing levels) and sensation of loudness recruitment that correspond to a specified hearing loss" (Sensimetrics, 2013, p.11). The simulator uses an automatic gain control which has been shown to "[produce] generally good agreement of speech-reception tests between listeners with actual hearing losses and listeners with simulated losses matched to actual losses" (Sensimetrics, 2013, p. 12). While wearing the device, participants heard all sounds in the environment (e.g., the clinician's speech, noises from outside the room) presented by air conduction through the headset and modified through the I-HeLPS software to simulate the hearing loss indicated by the audiogram configuration. The listener's perception of the stimulus is augmented by the I-HeLPS simulator. For example, an audiogram could be created for any configuration and most degrees of air conduction loss providing a wide array of possible augmented listening experiences. Rather than filtering out particular frequencies and intensities, the software masks the sounds affected by the hearing loss with white noise. The software is designed to limit the greatest intensities that can be presented, and therefore, the severities that can simulated.

The software provides real-time feedback that shows the speech and other sounds in the environment in relation to the detection thresholds of the audiogram. This is shown in the two display boxes in the lower right-hand portion of Figure 1. The red and the blue waves show the frequencies (horizontal axis) and the intensities (vertical axis) of the stimuli to the right and left ears, respectively. The gray waves in these boxes represents the audiogram thresholds. The auditory stimuli that fall within the gray sections are less intense (softer) than the indicated thresholds; the stimuli that rise above the gray sections are more intense (louder) than the thresholds. Participants were seated at a table with approximately 2 feet between them in a sound booth, so during the simulation they used this visual feedback to keep their live-voice stimuli productions in the 55-60 dB range for normal conversational speech.

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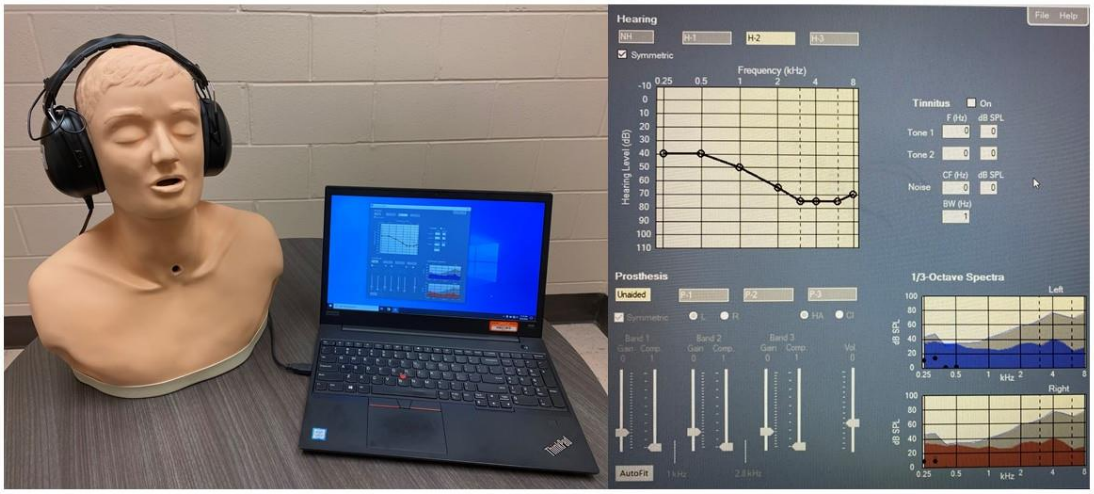
Figure 1

Image of I-HeLPS Simulation System with Enlarged Screenshot of the Desktop View



Kneebone (2005) proposed four key considerations for simulated learning experiences. These considerations included the following:

> (1) Simulations should allow for sustained, deliberate practice within a safe environment, ensuring that recently-acquired skills are consolidated within a defined curriculum which assures regular reinforcement; (2) simulations should provide access to expert tutors when appropriate, ensuring that such support fades when no longer needed; (3) simulations should map onto real-life clinical experience, ensuring that learning supports the experience gained within communities of actual practice; and (4) simulation-based learning environments should provide a supportive, motivational, and learner-centered milieu which is conducive to learning. (p. 549)

This simulation experience addressed each of these, respectively, by (a) allowing participants immediate reflection and feedback, followed by additional opportunities to practice new skills and apply new information; (b) providing 100%, side-by-side, one-on-one supervision with feedback and support tailored so that instruction was increased or decreased according to each participant's understanding and needs; (c) creating an interactive augmented reality experience for participants as client and as clinician to have novel communication exchanges in real time in an authentic environment; and (d) offering a developmental, supportive, conversational space where incorrect responses or lack of understanding were treated as learning opportunities.

The Council of Academic Programs in Communication Sciences and Disorders (CAPCSD) established a task force to consider the best practices for implementing simulations (Dudding et al., 2019). The current study includes a pre-brief, scenario, debrief, established learner outcomes, student performance evaluation, and simulation experience evaluation as recommended by the task force. Each is described in detail in the sections below.

Supervision was provided using strategic questioning as in the supervision-question-feedback model (Barnum, 2008; Dalessio et al., 2021). In Dalessio and colleagues (2021) this approach was determined to be most appropriate here due to the guided nature of the simulation sessions. This model of supervision emphasizes the experiential, dynamic nature of clinical learning, and encourages the supervisor "to act as a guide, providing support, direction, challenges, and feedback as needed to move the student through the experience" (Dalessio et al., 2021, p.3). Within this model, questions are varied to support a student's level of knowledge and skill and increase in complexity as a student's confidence and competence increase.

Clinard (2020) described processes to assess learning outcomes for simulations and offered five key outcomes to consider for simulation-based learning experiences. Using Clinard's terminology, the current study's participants' *attitudes and perceptions* were assessed from their open-response post-sim reflections; their *confidence* was measured using their pre-sim and post-sim self-ratings on a Likert scale developed by the principal investigator (PI); their *knowledge* was measured using pre-sim and post-sim responses to a clinical scenario; their *clinical skills* were measured against a program-defined rubric based on the PI's observations during the guided simulation; and their *clinical thinking skills* were measured using their pre-sim and post-sim responses to a scenario.

Research questions.

1. Do the participants have better knowledge of the role of the SLP and the scope of practice with regard to children and adults with hearing loss (HL) after they complete the hearing loss simulation?
2. Do the participants have increased understanding of the effects of hearing loss on communication after they complete the hearing loss simulation?
3. Do participants have higher self-perception ratings regarding their knowledge and skills for working with a client with hearing loss after they complete the hearing loss simulation?
4. Do the participants report greater empathy and disability awareness for significant hearing loss after they complete the hearing loss simulation?

Methods

Participants. At the beginning of their first graduate semester, all students in the cohort were invited to an introductory meeting where the study was explained, and they were given the opportunity to either provide their consent or decline to participate in the study, according to the IRB guidelines. All students in the cohort provided their consent. Participants were required to pass a hearing screening before beginning the simulation. Simulation rotations occurred across the Fall and Spring semesters of a single academic year. Of the initial 25 participants, one participant withdrew from the graduate program before completing the simulation, three participants completed the simulation but did not complete the post-sim test within the required five-day window, and one participant was eliminated due to a failed hearing screening; therefore, 20 participants (n=20) completed all study requirements. Pre-sim and post-sim data were compared for only these 20 participants.

Simulation Materials. This simulation experience involved two tools. The first tool was the software and wearable technology to create the simulated hearing loss, the Interactive Hearing Loss and Prosthesis Simulator (I-HeLPS; Sensimetrics, 2022). This system includes over-the-ear headphones that connect via USB cable to a personal computer housing the software; the computer display shows the audiogram plus a real-time spectral display of the input signal with respect to the audiogram. Sensimetrics (2022) described I-HeLPS as “a wearable headset system for simulating the auditory communication difficulties associated with hearing loss” (para. 3) that shifts the auditory thresholds of the listener according to the degree and configuration in a specified audiogram. Sensimetrics (2022) explained that “(t)he listener is immersed in the soundscape that is the input to the simulation so that he or she will be able to experience a simulated hearing impairment for the everyday sounds in the environment” (para. 4). The PI identified this tool early in the pandemic as a way to provide graduate SLP students clinical hours needed after many clinical rotations were cut short. This tool was originally selected because it was interactive and engaging, provided real-time spectral feedback, allowed for hearing loss configurations to be adjusted, and provided cochlear implant and hearing aid simulations.

The second tool, Speech Perception Instructional Curriculum and Evaluation (SPICE; Central Institute for the Deaf [CID], 2022b), provided the participants with a consistent structured protocol across all groups. SPICE is a criterion-referenced auditory training program for assessment and intervention for auditory skills including detection of speech sounds; discrimination of suprasegmental, vowel, and consonant features; and comprehension of connected speech. A significant portion of the program focuses on the critical detection and discrimination skills that are essential speech perception foundations for building speech production and spoken language skills. The kit includes all materials needed to implement SPICE, as well as a manual which provides detailed instructions, explanations, and activity suggestions. The Central Institute for the Deaf (CID) Professional Development website (CID, 2022a) provides free online videos (SPICE videos) explaining and demonstrating how to administer SPICE. SPICE is designed for auditory training for children with hearing loss. It is structured, well-organized, and easy to follow and understand. Because the SPICE kit contains all the materials necessary, the participants used session time during the simulation to focus singly on clinical thinking and problem solving by analyzing and understanding their clients’ errors with respect to the audiogram, rather than also needing to also devote efforts to creating and designing their own novel plans.

Pre-Simulation Procedures. The participants completed the pre-sim test (Appendix A) at the end of the introductory meeting. The pre-sim test included quantitative and qualitative questions that covered participants’ knowledge related to the role of speech-language pathologists in assessment and treatment of hearing loss, participants’ disability awareness related to hearing loss, and participants’ application of knowledge and skills to a case study involving hearing loss. Two additional questions, which were unique to the pre-sim test, were open responses regarding the participants’ prior experiences with the deaf or hard-of-hearing populations and their expectations of the simulation experience. All responses were anonymous, and randomized participant numbers were assigned so that within- and across-participant changes could be analyzed.

Participants were paired and scheduled for this simulation rotation by the clinic director, according to their already-determined clinical assignments and diagnostic team rotations. Each pair of participants was scheduled for a 2-week simulation rotation. Each pair received written and video recorded instruction (i.e., the SPICE manual, links to the SPICE videos) and hands-on review time with the complete SPICE kit prior to beginning the simulation. Each pair of participants began and completed this instruction and review within seven days before their first day with the simulation. Participants were instructed to avoid discussing their simulation experiences or the materials with anyone in their cohort other than their assigned simulation partner to preserve the validity of the simulation experience within the study.

Simulation Session Procedures. Each pair of participants had two 2-hour sessions with the simulator with one week between each session. The first session focused on assessment and the second session on intervention, using SPICE as a guide and structure. Within each pair, participants were randomly assigned as Participant A or Participant B. The audiogram for Participant A was different from the one assigned to Participant B, but the same pair of audiograms was used consistently across each participant pair. During each session, Participant A began as the clinician for the Participant B who began as the client who wore the simulator for one hour; then, the participants switched roles and Participant B became the clinician for the Participant A client who wore the simulator. The simulation was guided, meaning the PI was with each pair for 100% of the simulation time and used a predetermined set of prompt questions and cues to guide the clinicians through the simulation.

Participants administered portions of each section of the SPICE protocol. The restricted time for each pair to complete the simulation necessarily prevented the participants from administering the full SPICE as recommended in the program's manual; therefore, participants administered portions of the three key sections of speech detection, discrimination of suprasegmentals, and discrimination of vowels and consonants. The rate of progression through each section, the number of client skills measured, and the number of contrasts or trials per skill varied for each participant according to their questions and level of understanding. After participants had assessed their clients during the first sessions, they were instructed to use their resources (i.e., SPICE manual, CID videos) during the following week to select treatment targets for their clients and prepare intervention for those targets to be implemented at their second sessions.

Particular attention during the sessions was given to differentiation among the four levels of the listening hierarchy (i.e., detection/awareness, discrimination, identification, and comprehension) and to assessment and treatment at each of those levels across SPICE. For example, at the beginning of the session when the client was wearing the I-HeLPS headphones, the PI reviewed the listening hierarchy with the clinician, and discussed the connection between those stages and the design of SPICE. The PI and clinician looked together at the first part of the protocol, detection of speech, and the PI asked, "We have just defined detection, so how can you determine if your client can detect these sounds listed on the protocol?" If the clinician named a task that was better associated with discrimination, identification, or comprehension, the PI and clinician would further discuss the differences across those stages to help clarify the skill and assessment of detection. Similarly, for the second section of suprasegmental discrimination, the clinician was asked to define suprasegmentals and describe how they are created within spoken language. If the clinician was incorrect or unsure, then the PI guided the discussion to help the clinician understand the task. As the clinician administered each portion of the assessment, the PI continually asked questions such as "Why do you think your client missed that?" or "How do you expect your client will respond to this prompt?" or "How is this deficit going to affect the client's speech, communication, or academic performance?" to check the participant's understanding and to encourage critical thinking.

A portion of each participant's second session included additional scenarios and questions designed to extend their knowledge and skills to other populations beyond the recommended parameters of SPICE. Each participant responded to the same scenarios; however, the order of the questions and prompts varied slightly across the participant group. These variations were because the one-on-one, individualized nature of the sessions led some participants to spontaneously consider these alternate scenarios at different times. Also, the PI allowed the conversational flow and focus to guide the presentation as much as possible. Participants were guided to use their new knowledge about and experiences with speech perception and discrimination to consider how the hearing loss would affect children and adults in contexts beyond what the simulation demonstrated. The specific scenarios the participants considered were the following:

- How participants could modify the SPICE protocol to accommodate a patient with a significant vision loss which limited the ability to discriminate images in picture cards;
- How participants could modify the SPICE protocol to accommodate a patient with a significant motor impairment which limited the ability to reach across the table and point to picture cards;
- What circumstances could lead to an adult needing auditory training for discrimination skills such as those targeted by the SPICE?
- How participants could assess or teach detection or discrimination skills with a child in early intervention, younger than the lower limit recommended for SPICE protocol, who is not developmentally ready to sit at a table and look at picture cards;
- How participants could assess or teach detection or discrimination skills with an adult who needed auditory training support;
- How a hearing loss similar to the one used in the simulation would affect a school-aged child's detection of environmental sounds, other than speech, in a school environment; and
- How a hearing loss similar to the one used in the simulation would affect a school-aged child's academic performance in a typical school environment.

Post-Simulation Procedures. Each pair of participants completed the post-sim test questions (see Appendix A) within five days after the conclusion of their second session with the simulation. The post-sim test was identical to the pre-sim test, with the following exceptions. The one question regarding their expectations was removed from the pre-sim test and was replaced with one open-ended question and two Likert scale questions on the post-sim test. The added post-sim questions concerned the participants' general reflections and beliefs regarding the effects the simulation had on the participants' knowledge, skills, and disability awareness.

All participants received clinical clock hours for their time as the clinician during the simulation (that is, one clinical clock hour for hearing assessment and one clinical clock hour for hearing intervention) to support their program and certification requirements. Participants' competencies were recorded in Clinical Assessment of Learning Inventory of Performance Streamlined Office Operations (CALIPSO LLC, 2014) under hearing evaluation and hearing treatment. Question prompts were designed to target as many of the skills from the graduate program's CALIPSO rubric as possible through the simulation (a list of competencies credited to the participants is included in Appendix B). Added questions included analysis of adult scenarios to predict whether those individuals would be appropriate for auditory training for the types of skills targeted in SPICE, adaptation of the protocol for clients with hearing loss as well as motor and visual limitations, and consideration of sounds other than speech in a client's environment with respect to the given audiogram configuration. All participants received scores corresponding to minimal, entry-level competency on all skills that were scored. These scores were not factored into the participants' semester clinic grades so that the controlled simulation did not artificially inflate or deflate a student's semester grade. A minimal level of competency was chosen, in consultation with the clinic director, with the intent that participants could focus on being engaged in the simulation without any added angst to perform at a particular level for the sake of a grade or grade-point average.

At the end of the Spring 2023 semester after all participants had completed the simulation experience and the post-sim test, the PI conducted a debriefing session with the cohort. The debriefing session allowed the PI to review with all participants the simulation's audiograms, the listening hierarchy, key aspects of SPICE, and the added scenarios. The participants were also given the opportunity to discuss their observations, ask questions, offer feedback, and provide anonymous written comments.

Statistical Analysis. Statistical analysis for this study included comparison of pre-sim data to post-sim data using Pearson's correlation and paired two-tailed *t*-test. Data compared included the questions related to pre-simulation experience with hearing loss, scope of practice, and participant understanding of communication and hearing loss. All statistical analyses were completed using IBM SPSS Statistics (Version 20).

Results

Quantitative data were collected on a series of questions related to participants' understanding of certain aspects of the SLP scope of practice, the participants' confidence regarding assessment and intervention for individuals with hearing loss, and the participants' knowledge as applied to a case study. Most pre-sim and post-sim questions remained the same so that within-participant as well as across-cohort trends could be observed; the questions that were different from pre-sim to post-sim involved the participants' pre-sim expectations and post-sim reflections.

Both the pre-sim and post-sim tests also contained qualitative questions. These questions did not contain any prompts which could steer the participants' comments, beyond *in your role as client* versus *in your role as clinician* so that natural trends in participants' responses could be observed. A participant's lack of comment on any area should not be assumed to be indicative of either a positive effect, a negative effect, or no effect.

Question 1: Do the participants have better knowledge of the role of the SLP and the scope of practice, with regard to children and adults with hearing loss, after they complete the HL simulation? Prior to assessing the primary study-related questions, it was important to determine whether previous experience with hearing loss impacted pre-simulation knowledge of scope of practice or study-related assessment questions. Pearson's correlation was used to assess if any relationship existed between pre-simulation experience with hearing loss (self-reported as having or not having previous experience) and pre-simulation test outcomes. Analysis revealed that no significant relationships were present. These correlation data are available in Table 2.

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Table 2

Correlation Between Participants' Report of Prior Experience with Hearing Impairment and Pre-Simulation Measurements

	Student Reported Previous Experience		
	Yes (*n*=16)	No (*n*=4)	
Variable	Mean (*SD*)	Mean (*SD*)	Pearson's *r* (*p* Value)
Speech Diagnosis	1.0 (0.0)	1.0 (0.0)	- (-)
Speech Therapy	.94 (.25)	1.0 (0.0)	-.115 (.630)
Language Diagnosis	1.0 (0.0)	1.0 (0.0)	- (-)
Language Therapy	.94 (.25)	1.0 (0.0)	-.115 (.630)
Speech Perception Diagnosis	1.0 (0.0)	1.0 (0.0)	- (-)
Speech Perception Therapy	.94 (.25)	1.0 (0.0)	-.115 (.630)
Hearing Loss Diagnosis	.25 (.44)	1.0 (0.0)	.250 (.288)
Prescribe Amplification	.13 (.34)	.25 (.5)	-.140 (.556)
Troubleshoot Hearing Aids	.31 (.47)	.25 (.5)	.055 (.819)
Assessment of Communication Needs in D/HH Child	2.31 (1.07)	1.75 (.5)	.230 (.330)
Assessment of Communication Needs in D/HH Adults	2.44 (1.26)	1.75 (.5)	.240 (.308)
Intervention for D/HH Children	1.94 (.77)	1.75 (.5)	.107 (.653)
Intervention for D/HH Adults	1.88 (.80)	1.75 (.5)	.069 (.773)
Name Phonemes from Ling 6-Sound Test*	1.94 (2.08)	1.0 (1.41)	.195 (.409)
List 5 Sounds	1.5 (1.6)	1.0 (1.41)	.064 (.789)
Which Ling Sounds*	.13 (.34)	.25 (.5)	-.140 (.556)
List 5 Environmental Awareness Problems	1.50 (1.67)	1.25 (1.5)	.064 (.789)
List 3 Academic Problems	1.50 (1.03)	1.25 (1.5)	.109 (.648)
List 2 Objectives	.38 (.61)	.25 (.5)	.087 (.714)

Note. n=20, $p<.05$, (*SD*) Standard Deviation, (-) unable to compute, (D/HH) Deaf/Hard of Hearing
*Ling (1989)

To assess research question 1, participants were asked to indicate whether each of nine tasks was part of the SLP Scope of Practice. These questions were on both the pre-sim and post-sim tests. Four of the tasks were related to speech and language diagnosis and treatment. The remaining five tasks were related to hearing. Statistical analysis using paired *t*-test for the pre- and post-simulation data for scope of practice-related questions revealed no significant difference for any variable. Three comparisons (Speech Diagnosis, Language Diagnosis, and Speech Perception Diagnosis) were unable to be completed because pre- and post-simulation data were identical. The data in Table 3 represent the mean percent correct by category (1.00=100% of participants responded correctly). Further examination of the data revealed that on the pre-sim test, five participants (25%) answered all nine questions correctly. On the post-sim test, nine participants (45%) answered all nine questions correctly. Only one participant missed any of the speech and language questions post-sim. All other incorrect responses were within the area of hearing. One participant (5%) responded incorrectly pre-sim regarding speech perception treatment; all participants responded correctly to this question post-sim. Pre-sim, 20% of participants (*n*=4) responded incorrectly regarding hearing loss diagnosis; post-sim 10% of participants (*n*=2) responded incorrectly to this question. Interestingly, both of the participants who responded incorrectly on the post-sim test had responded correctly on the pre-sim test. On the pre-sim test, 15% of participants (*n*=3) responded incorrectly regarding prescribing amplification; post-sim, 5% (*n*=1) responded incorrectly to this question. On the pre-sim test, 70% of participants (*n*=14) responded incorrectly regarding troubleshooting hearing aids; on the post-sim test, 50% (*n*=10) responded incorrectly to this question.

Table 3

Pre- and Post-Simulation Outcome Comparisons for Scope of Practice Data

Variable	Mean (*SD*)		*t* Value (*df*)	*p* Value
	Pre-Sim	Post-Sim		
Speech Diagnosis	1.00 (.000)	1.00 (.000)	-	-
Speech Therapy	.95 (.224)	1.00 (.000)	-1.000 (19)	.330
Language Diagnosis	1.00 (.000)	1.00 (.000)	-	-
Language Therapy	.95 (.224)	1.00 (.000)	-1.000 (19)	.330
Speech Perception Diagnosis	1.00 (.000)	1.00 (.000)	-	-
Speech Perception Therapy	.95 (.224)	1.00 (.000)	-1.000 (19)	.330
Hearing Loss Diagnosis	.20 (.410)	.10 (.308)	.809 (19)	.428
Prescribe Amplification	.15 (.366)	.05 (.224)	1.453 (19)	.163
Troubleshoot Hearing Aids	.30 (.470)	.50 (.513)	-1.710 (19)	.104

Note. Paired *t*-test n-20, $p<.05$, (*SD*) = standard deviation, (*df*) = degrees of freedom, (-) = unable to compute

Question 2: Do the participants have increased understanding of the effects of hearing loss on communication after they complete the HL simulation? The participants were asked to list the six Ling sounds, then they were asked a series of questions centered around a case study of a school-aged child with a hearing loss with a corresponding audiogram. This audiogram was comparable but not identical to the audiograms used during the simulation experience. The scenario and the associated questions were the same for the pre-sim test and the post-sim test. Participants were asked a series of open-response discussion questions. Answers were scored according to the number of appropriate responses on each question.

Statistical analysis using paired *t*-test of the pre- and post-sim data related to question 2 revealed significant improvement across all variables. These data are available in Table 4. Participants' ability to name 6 Ling sounds (Ling, 1989) increased from a mean of 1.75 to 5.9 (*p*=.000). Further examination of the data found that on the pre-sim test, 10% of participants listed all six sounds, 10% listed four sounds, 10% listed three sounds, 10% listed two sounds, 25% listed one sound and 35% did not list any of the sounds. On the post-sim test, 90% listed all six Ling sounds, and 10% listed five Ling sounds. Ten percent of the participants listed all six sounds on the pre-sim test; therefore, 90% of the participants improved on this task after completing the simulation session.

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Table 4

Pre- and Post-Simulation Outcome Mean Raw Score Comparisons of Participant Understanding of Hearing Loss and Communication-Related Data

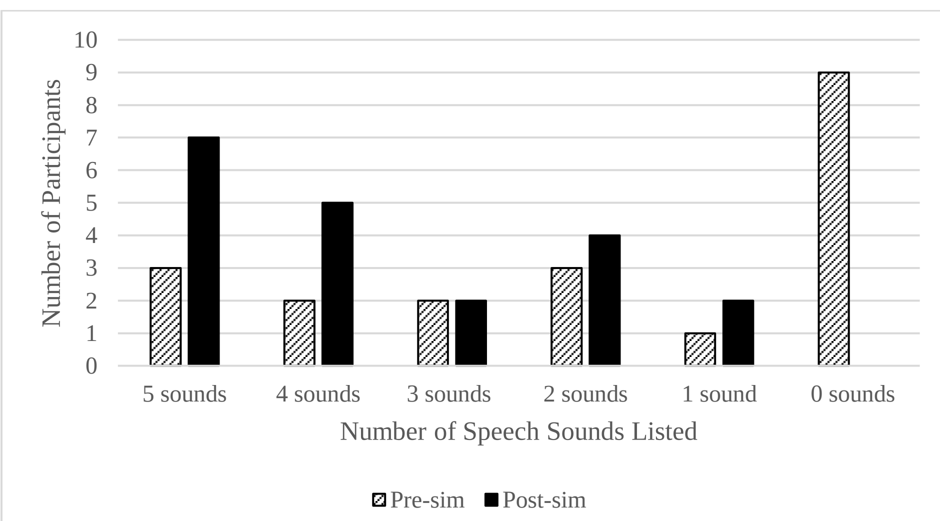
Variable	Mean (*SD*)		*t* Value (*df*)	*p* Value
	Pre-Sim	Post-Sim		
Name 6 Ling Sounds	1.75 (1.97)	5.9 (.30)	-9.246 (19)	.000
List 5 Sounds	1.8 (1.96)	3.6 (1.35)	-4.046 (19)	.001
Which Ling Sounds	.15 (.36)	.95 (.82)	-4.000 (19)	.001
List 5 Environmental Awareness Problems	1.45 (1.60)	2.55 (1.60)	-3.317 (19)	.004
List 3 Academic Problems	1.45 (.94)	1.95 (1.05)	-2.364 (19)	.029
List 2 Objectives	.35 (.58)	1.65 (.58)	-7.935 (19)	.000

Note. Paired *t*-test n=20, $p<.05$, (*SD*) = standard deviation, (*df*) = degrees of freedom.

Participants were asked to list five speech sounds they would expect this child to have difficulty detecting. Participants showed significant pre- to post-sim improvements with a pre-sim mean of 1.8 compared to a post-sim mean of 3.6 (p=.001). On the pre-sim test, 25% of the participants listed five sounds appropriate for the HL represented, and 45% of the participants did not list any appropriate sounds. The remaining 30% of the participants listed one to four appropriate sounds. On the post-sim test, 100% of the participants listed at least one appropriate sound, and 35% listed five appropriate sounds. Seventeen participants (85%) showed improvement on their post-sim test compared to their pre-sim test, two participants (10%) showed no change, and 5% showed a decrease from five sounds to four sounds. Taken together, after the simulation sessions, 95% of the participants made accurate predictions for this case study (see Figure 2)

Figure 2

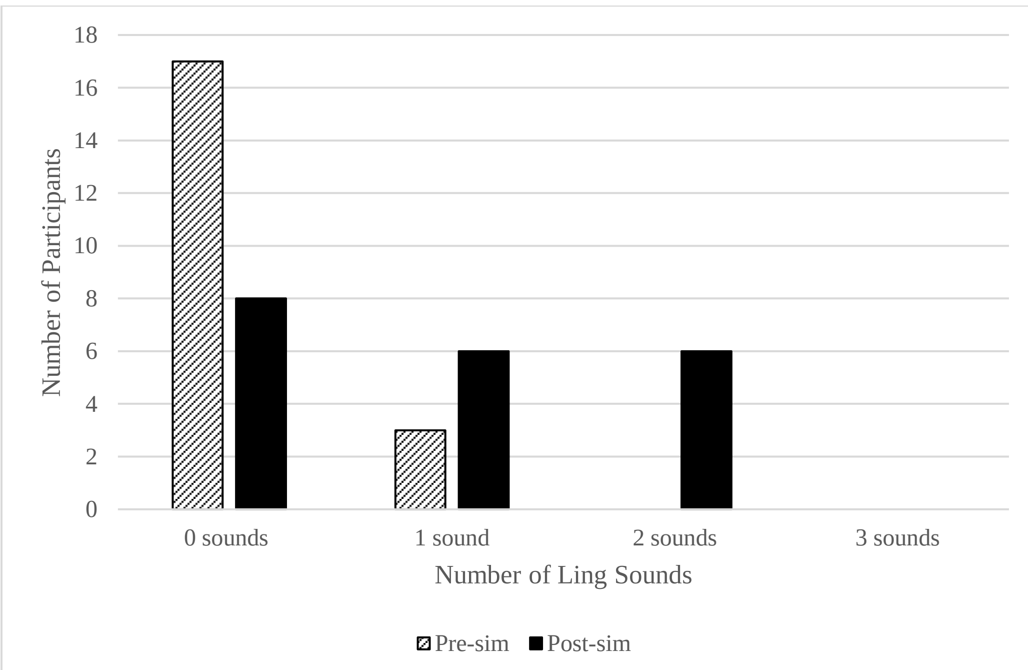
Number of Participants and Number of Speech Sounds Listed from Pre- to Post-Simulation



Participants were asked to list which of the six Ling sounds they would expect the child to have difficulty discriminating. Participants demonstrated significant improvements in the ability to identify the expected Ling sound post-sim with a pre-sim mean of .15 and a post-sim mean of .95 (p=.001). On the pre-sim test, 0% of the participants listed more than one correct sound, and 85% did not list any of the correct sounds. On the post-sim test, 30% of the participants did not list at least one correct sound, 30% listed two correct sounds, and 40% did not list any correct sounds. Fifty-five percent showed an increase on their post-sim test compared to their pre-sim test, 40% showed no change, and 5% showed a decrease (see Figure 3).

Figure 3

Number of Participants and Number of Ling Sounds Listed as Difficult for Child in Case Study to Discriminate



Participants were asked to list five ways they would expect for the child's environmental awareness to be affected by the HL represented. Because awareness of environmental sounds other than speech was discussed during the sessions, the following criteria were used to evaluate participants' responses. Responses were counted as correct if they indicated awareness or detection of specific high frequency or soft sounds. Responses were counted as incorrect if they included terms such as discrimination, understanding, or following directions, or referenced social relationships, speech sounds, or hearing teacher/peers. Statistical analysis revealed significant improvement with a pre-sim mean of 1.45 and a post-sim mean of 2.55 (p=.004). Further examination of the data revealed that on the pre-sim test, only 5% of participants listed five appropriate environmental sounds, and 45% did not list any appropriate environmental sounds. On the post-sim test, 10% listed five appropriate environmental sounds, and 15% did not list any appropriate environmental sounds. Twenty-five percent showed no change compared to their pre-sim test, and 15% showed a decrease (see Figure 4).

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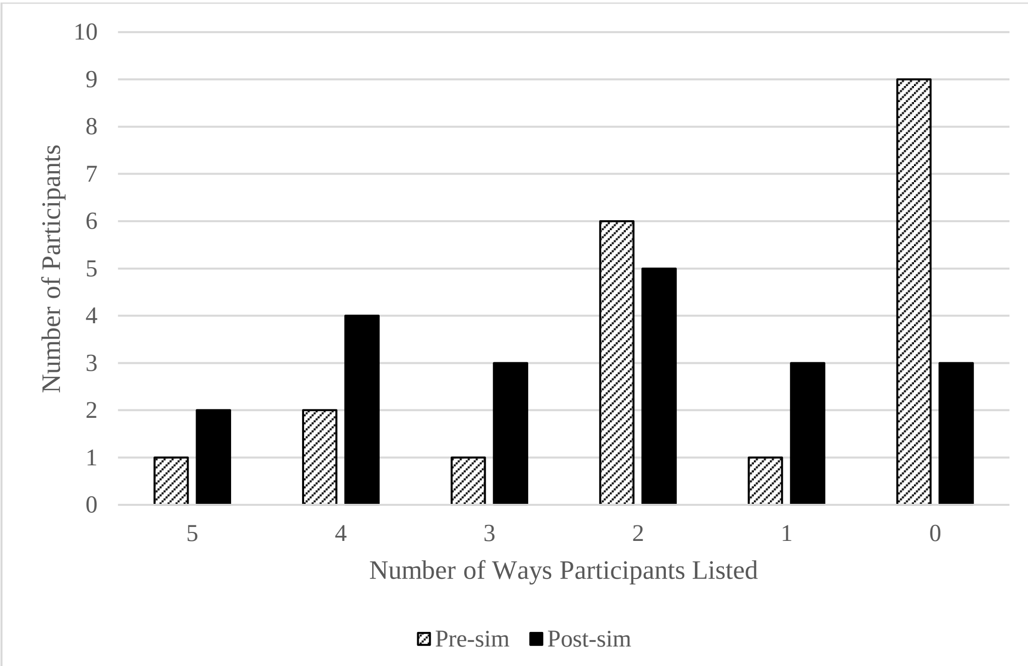
Figure 4

Number of Participants and Number of Ways Environmental Awareness Is Expected to Be Affected in Case Study



Participants were asked to list three academic problems they would expect this child to encounter in the classroom based on the HL represented. Responses were counted as correct if they referenced particular linguistic concepts (e.g., plural versus singular, word endings), following directions, participating in group activities, hearing teacher or peers in the presence of noise, reading, writing, or spelling. Responses were counted as incorrect if they indicated awareness of environmental sounds (e.g., hearing bells, alarms) or social relationships (e.g., making friends). Statistical analysis revealed a significant improvement in this area with a pre-sim mean of 1.45 and a post-sim mean of 1.95 (p=.029). Additional examination of the data found that on the pre-sim test, 85% of participants listed at least one appropriate academic problem, 15% listed three appropriate responses, and 15% did not list any appropriate responses. On the post-sim test, 45% listed three appropriate responses, and 10% did not list any appropriate responses. Thirty-five percent showed an increase, 45% showed no change, and 10% showed a decrease on their post-sim test compared to their pre-sim test (see Figure 5).

Participants were asked to list two objectives that would be appropriate to target speech perception with the child. Statistical analysis demonstrated significant improvement in this area with a pre-sim mean of .35 and a post-sim mean of 1.65 (p=.000). On the pre-sim test, 5% listed two speech perception behavioral targets, and 70% did not list any appropriate behavioral targets. On the post-sim test, 70% listed two appropriate targets, and only 5% did not list any appropriate behavioral targets. Eighty-five percent of the participants showed improvement, and 15% – including one participant who listed two correct targets on the pre-sim test – showed no change (see Figure 6).

Figure 5

Number of Participants and Number of Academic Problems Listed for Case Study

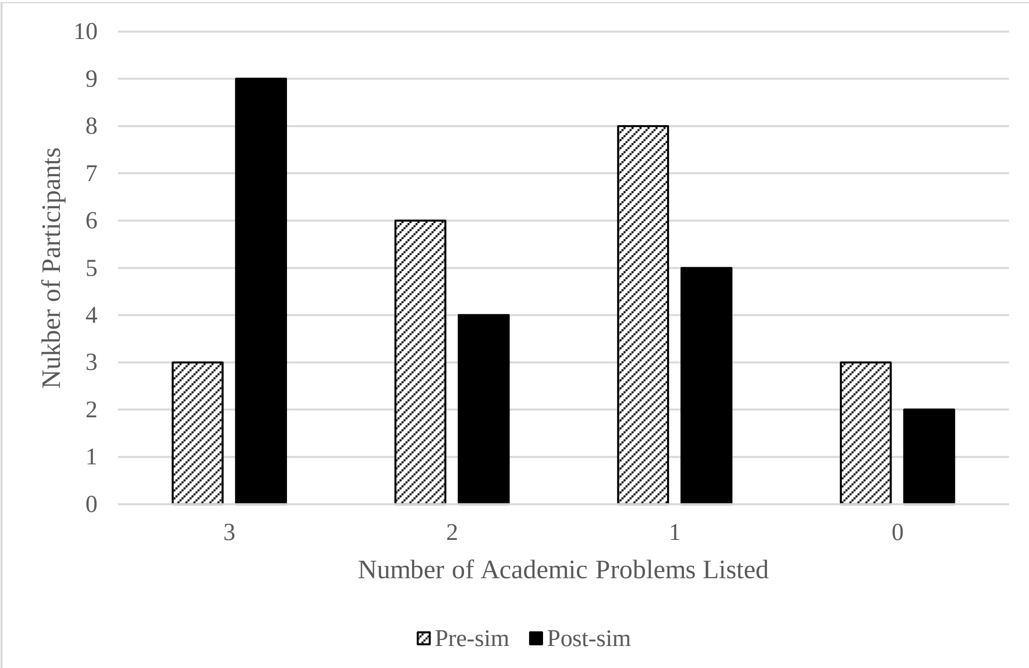
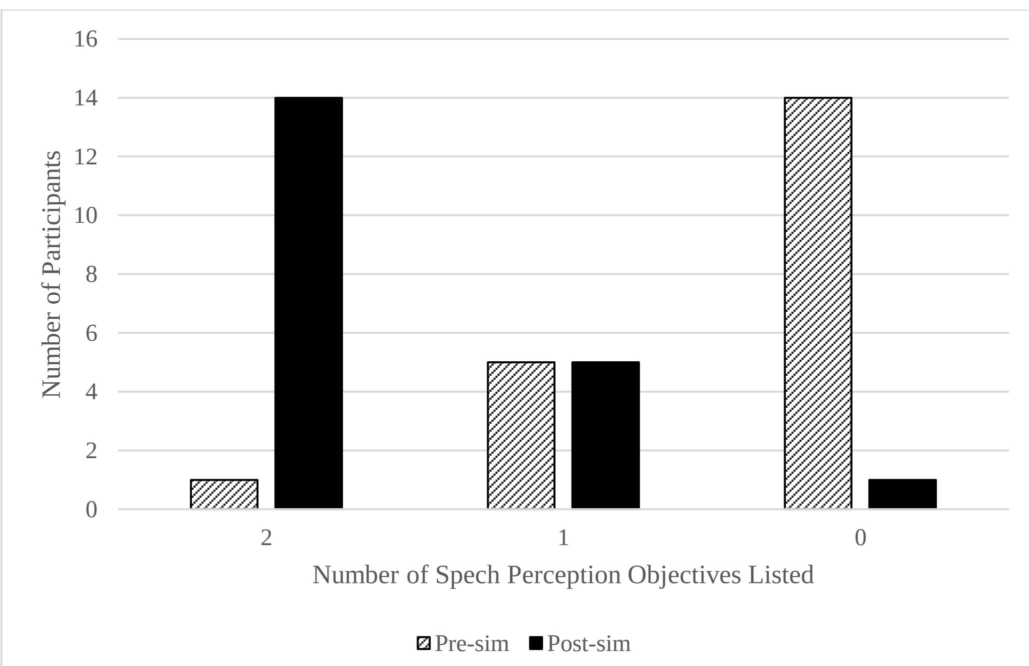


Figure 6

Number of Participants and Number of Speech Perception Objectives for Case Study



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Question 3: Do participants have higher self-perception ratings regarding their knowledge and skills for working with a client with hearing loss after they complete the HL simulation? All graduate students were required to have completed two undergraduate courses in hearing (typically an introduction to audiology course and an aural rehabilitation course) prior to beginning the graduate program at the University of Montevallo; therefore, all participants were assumed to have foundational knowledge in hearing. Participants were asked pre-sim to describe any additional experience or exposure with the deaf/hard-of-hearing (D/HH) population, such as through academic courses, personal or social connections, or volunteer or work experiences. Sixteen of the participants described some type of experience. Eight participants reported family or friends with hearing loss or deafness, three participants reported additional academic courses such as American Sign Language or Deaf Studies, and four reported some type of employment or shadowing experience with individuals with hearing loss. On the post-sim test, participants were asked to respond on a 5-point scale of strongly disagree (1), disagree (2), neutral (3), agree (4), or strongly agree (5) to the following statement: *The simulation experience increased my knowledge and skills for working with a client with HL*. Seventy-five percent of participants responded with *Strongly Agree*, and 25% responded with *Agree.*

Participants rated their confidence in providing services to children and adults who are D/HH on a 5-point Likert scale of Not at all confident (1), A little confident (2), Somewhat confident (3), Fairly confident (4), or Extremely confident (5). A total of four questions were asked on both pre-sim and post-sim tests to analyze their self-confidence with assessment and treatment of communication needs in children and in adults who are D/HH. No participants rated themselves as "extremely confident" on any of the four questions. Statistical analysis using paired *t*-test of the pre- and post-sim data related to question 3 revealed significant improvement on all four items. These data are available in Table 5. Regarding assessment of children, 10% of the participants on the pre-sim test and 40% on the post-sim test responded as "fairly confident;" 65% rated themselves more confident on post-sim test than they did on the pre-sim test (mean increased from 2.20 to 3.30, p=.000). Regarding assessment of adults, 25% of participants on the pre-sim test and 40% on the post-sim test responded as *fairly confident*; 60% rated themselves more confident on the post-sim test (mean increased from 2.30 to 3.35; p=.003). Regarding intervention with children, 20% on the pre-sim test responded as *Somewhat confident*, which was the highest level of confidence among the response for this item; 10% responded as *Fairly confident*, and 55% responded as *Somewhat confident* on the post-sim test. Seventy percent of the participants rated themselves as more confident on the post-sim test (Mean increased from 1.90 to 2.70; p=.000). Regarding intervention with adults, 20% of the participants on the pre-sim test responded as *Somewhat confident*, which was the highest confidence level among the responses; on the post-sim test 45% responded as *Somewhat confident* and 10% as *Fairly confident*. Sixty-five percent of the participants rated themselves as more confident post-sim (mean increased from 1.85 to 2.60; p=.000).

In their open-response post-sim reflections, several participants offered comments that showed increased confidence. No participants provided comments that indicated a decrease in confidence. Some participants commented that portions were “hard for me” or “difficult;” however, these cannot be assumed to be indicative of any increase or decrease in post-sim confidence. Participants’ post-sim reflections related to confidence are included in Table 6.

Table 5

Pre- and Post-Simulation Outcome Mean Raw Score Comparisons of Participants' Confidence Self-Ratings

Variable	Mean (*SD*)		*t* Value (*df*)	*p* Value
	Pre-Sim	Post-Sim		
Assessment of Communication Needs for D/HH Child	2.20 (1.00)	3.30 (.65)	-4.222 (19)	.000
Assessment of Communication Needs for D/HH	2.30 (1.17)	3.35 (.58)	-3.462 (19)	.003
Intervention for D/HH Children	1.90 (.71)	2.70 (.73)	-4.660 (19)	.000
Intervention for D/HH Adults	1.85 (.74)	2.60 (.75)	-4.265 (19)	.000

Note. Paired *t*-test n=20, $p<.05$, (*SD*) = standard deviation, (*df*) = degrees of freedom.

Question 4: Do the participants report greater empathy and disability awareness for significant hearing loss after they completed the HL simulation? On the post-sim test, participants were asked to respond on a 5-point scale (strongly disagree, disagree, neutral, agree, or strongly agree) to the following statement: The simulation experience increased my understanding of the communication experiences of a person with HL. Eighty-five percent (*n*=17) responded with "Strongly Agree," and 15% (n=3) responded with "Agree."

In the qualitative reflections, several participants offered responses that showed increased empathy for this population as a result of this simulation experience. Responses were unprompted and analyzed for themes based on word choice and tone of the responses. Comments which included terms such as *made a connection*, *eye-opening*, *put things into perspective*, *new insight*, and *opened my mind* were counted as empathy-related reflections; terms such as *I liked*, *interesting*, *I appreciated*, *helpful*, and *beneficial* were not counted as empathy-related comments. Fifteen (75%) of the participants provided comments on the post-sim test that indicated increased or improved empathy or understanding of the communication experiences for individuals with a significant hearing loss. None of the participants made comments that suggested no effect or a loss of empathy or awareness of hearing loss. Additional comments were collected from participants during the sessions and the debrief. Related comments are listed in Table 6.

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Table 6

Post-Sim Qualitative Responses

Question	Selected Quotations from Participants
Question 3 Regarding Participants' Self-Confidence After Completing Simulation	I had a better understanding of how the frequencies of speech sounds are altered for D/HH individuals.
	I feel pretty confident that I could come up with an intervention plan for an adult or child with a HL.
	I am confident in abilities to learn and sympathize with HL clients.
	I learned a lot in the sim. As the clinician I learned how to help assess and provide intervention to someone with a HL. I will be able to use this information in the future with potential clients.
	As the clinician, at first it was challenging to decide what kind of activities to choose to provide helpful intervention. Once I got the hang of it, I became more confident.
	It was helpful being the clinician and critically thinking through areas I wasn't comfortable with.
Question 4 Regarding Participants' Empathy or Disability Awareness After Completing Simulation	I could see how HL negatively impacts an individual's life.
	It makes more of a connection (empathy) for my future client.
	This really put things in perspective for me on what all someone with a D/HH diagnosis goes through.
	I have new insight for what it's like to have hearing difficulties.
	As the client, I experienced what it was like to experience significant hearing loss and how it might feel to learn how to communicate.
	It opened my mind to new experiences especially seeing what it was like to have a hearing loss.
	Opened my eyes to how hard living with a hearing loss must be
	Because I know several people with hearing loss, this was especially impactful.
	As a client, I realized how difficult it is to maintain attention when hearing is impaired. I also realized how tired I was after being the client and having to focus so hard.
	As the client, it made me aware of how much a hearing loss affects overall effectiveness of communication.
	Was slightly frustrating not being able to hear when conversation was happening around me
	I think allowing us to experience a hearing loss will make us more aware of clients who have an actual hearing loss.
	Eye-opening to experience hearing loss (I was tapping and fiddling constantly and had difficulty maintaining attention)

Discussion

Question 1. Analysis of the participants' self-reported pre-sim experiences with hearing loss compared to their pre-sim test responses showed no existing relationship between any pre-sim experience and study outcomes; therefore, any gains evidenced by post-sim data can be assumed to be related to the simulation experience itself. The ASHA scope of practice for SLP was not discussed in detail during this simulation. It was, however, referenced as appropriate, as in determining which client errors indicated auditory skills that the client had not yet learned (and therefore fell within the SLP scope of practice) and which indicated that the client did not have access to particular frequencies or intensities and should be referred back to their audiologist (and therefore outside the SLP scope of practice). These topics were targeted during the simulation sessions for two primary reasons – because those related aspects of SLP and audiology scopes of practice are typically included in the undergraduate audiology courses which were prerequisite courses for all of this study's participants and because their exclusion from the discussions allowed the PI to better determine whether participants' understanding of the role of the SLP with respect to hearing improved from participating in the simulation.

Although not reaching statistical significance, percentages of correct responses on all scope of practice questions increased across the participant group from pre-sim to post-sim. All participants responded correctly to the questions regarding speech diagnosis and treatment and language diagnosis and treatment, which was expected because they were enrolled concurrently in a variety of didactic graduate courses in SLP; these topics were not discussed at all during the simulation. All participants responded correctly post-sim to the questions regarding speech perception diagnosis and treatment. which was one of the original objectives of using this simulation with graduate SLP students. The incorrect responses on the post-sim test were on the questions regarding diagnosis of hearing loss (n=1; 5%), prescribing amplification (n=1; 5%), and troubleshooting devices (n=10; 50%). These errors are not entirely surprising because these were not explicitly targeted during the sessions. While any increase in untargeted knowledge and skills remains encouraging, these results suggest participants did not gain this knowledge from inference during the simulation; therefore, more direct, intentional teaching is warranted in this area. For these participants, these questions were addressed clearly during the debrief session so that all participants understood the SLP scope of practice with respect to hearing.

Question 2. Participants were asked to list the six Ling sounds and to respond to a series of questions regarding a case study scenario and accompanying audiogram. Knowledge of the Ling six-sound test may have come from the participants' prerequisite audiology courses for some participants, but, for all, these six sounds were key components of several sections of SPICE and therefore targeted directly during the sessions. For the case study, participants were asked to make predictions for a client based only on the information on the audiogram, which required them to apply their knowledge of the speech sound audiogram, acoustic characteristics and differences across the U.S.-English phonemes, their own experiences as the simulation client, their knowledge of the progression of listening skills, and the session discussions regarding awareness of environmental sounds and access to academic environments.

Participants demonstrated significant improvement on each aspect of this question: naming the six Ling sounds, predicting phonemes a client may have difficulty detecting and discriminating based

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solely on a given audiogram, describing effects of a hearing loss on non-speech environmental awareness and on academic skill acquisition, and writing clinical targets for a client with hearing loss. These results show that participants did have an increased understanding of the effects of hearing loss after completing the simulation than they did prior to the simulation. This demonstrated that the simulation provided the participants with knowledge, skills, and applications regarding the diagnosis of hearing loss that they did not have based only on their undergraduate courses and any related life experiences.

Some of the question prompts warranted closer analysis and explanation. One was the question prompt regarding environmental sound awareness. Many participants responded to this prompt with broad, non-specific statements about the child's decreased awareness or with comments about speech discrimination in background noise. Although these responses could have accurately been associated with the case study, the criterion for this question was narrow, based on the guided discussions during the sessions aimed to increase their recognition of environmental sounds other than speech. These were counted as incorrect responses to this question because they lacked specificity or could not be distinguished from academic concerns in the following question which had been a key difference discussed during the sessions. The participants' errors on this question suggest that either the distinction was not made clear during the sessions, the question prompt was poorly worded, or both. This lack of improvement is not concerning because their responses were largely accurate for the case, had the criterion not been so narrow.

Similarly, when asked to list academic problems the child would likely have, some participants responded with comments about environmental awareness (e.g., hearing bells and smoke alarms). These responses were counted as incorrect because of the distinction that was made during the sessions (described above). Other participants provided broad statements such as *trouble understanding* or *learning problems*. These were counted as incorrect because they were too non-specific or made inappropriate assumptions about the child's cognitive or learning abilities.

On the post-sim test, a majority of participants (70%, *n*=14) listed two appropriate behavioral target predictions for the child in the case study, which is a notable increase from the pre-sim results of one participant who listed two targets and 14 who did not list any. The original question prompt told the participants to use the behavior-condition-criterion structure for writing clinical objectives, which is what they are taught in their graduate clinical courses. However, because these components were not discussed explicitly during the simulation, credit was given for accurate behavioral targets even in the absence of other components of a formal objective. Also, this criterion was deemed inappropriate because the participants completed the simulation at varying points across their first two semesters in the graduate program and, therefore, had differing amounts of training and practice related to this structure for clinical objectives. Pre-sim responses that were scored as incorrect included wording such as *using speechreading, using lipreading, using an AAC device* or broad concepts such as *work on voiced sounds, use technology*. Many did not offer any potential objectives on the pre-sim test. On the post-sim test, more participants showed understanding of the types of targets appropriate for speech perception. Their correct responses included wording such as *discriminate between sounds or features* or *identify monosyllabic words.* The errors demonstrated in writing the objective components do raise the question of whether the participants who had difficulty in this context also showed difficulty composing objectives for their other clinical assignments. That analysis was beyond the scope of this study and could not have been determined due to the anonymous participant data; therefore, it is impossible to know whether the weaknesses that remain reflect the simulation or if they are participant-specific discrepancies.

Question 3. All participants responded that they had increased self-confidence after completing the simulation, with 75% indicating "strongly agree" and 25% indicating "agree." Although confidence should not be conflated with competency, this result is encouraging especially considering the previous studies (Luckhurst, 2008; Page et al., 2018) that found that practicing clinicians feel underprepared to provide services for individuals with hearing loss. Participants in this simulation study reported in their qualitative responses on the post-sim test, in their comments during the debriefing, and in their reflections and feedback following the debriefing that they felt much more confident in their abilities to assess, diagnose, and treat children and adults with hearing loss.

Question 4. Both the quantitative and qualitative data show that participants felt increased empathy for and awareness of hearing loss after completing the simulation. Because the ideas contained in the participants' reflections were unprompted, reflections that did include comments related to empathy or awareness should not be interpreted as a lack of or negative effect.

Evaluation of simulation experience. This simulation experience encompassed the best practice components described by Dudding et al. (2019), including pre-brief, simulation scenario, and debrief sessions and the four qualities originally described by Kneebone (2005). The inclusion of alternate scenarios allowed participants to think critically and extend their new knowledge and skills beyond their simulated client, which allowed them to demonstrate more competencies across more standards within the domain of hearing. The I-HeLPS tool provided a unique immersive, interactive, and authentic hearing loss experience for both client and clinician roles, with documented improvements across qualitative and quantitative assessments. The incorporation of SPICE provided exposure to and practice with a current, evidence-based assessment and intervention tool.

During the debrief session, participants were encouraged to contribute to open discussion or provide anonymous or self-identified written feedback about their perceptions of the simulation. Overall, this simulation was incredibly well-received by the participants. The two-hour rotations as clinician provided a considerable amount of gain for the participants but a minimal clock hour benefit in an often-needed disorder area. A longer simulation rotation would allow more opportunity to meet participants' suggestions to experience different degrees and configurations of hearing loss, to listen to speech through the hearing aid and cochlear implant simulators contained in I-HeLPS, to practice more of the SPICE protocol or even different instruments, and to watch others administer SPICE. Participants responded that they were appreciative of the one-on-one support and feedback and of the experiences as both clinician and client. Comments in Table 7 were collected from the participants during the simulation sessions and the debrief.

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Table 7

Feedback from the Participants After Completing the Simulation

Question/Prompt	Selected Responses from Participants
What do you still want to know more about?	Doing some activities with the CI implementation (cochlear implant filter of I-HeLPS) What it would have been like with a variety of hearing losses Getting to observe someone giving the SPICE Give the client something to do while the clinician was talking to the supervisor More activities to do for intervention
Participants' Reflections on the Simulation, from Both Client and Clinician Perspectives	I enjoyed it! I think I can hear colors right now! Loved the one-on-one w/Dr. Henton and the experience It was really cool! It was hard pulling my undergrad knowledge back for the sim I found it very interesting! I think it was executed well. I liked being the client and getting to experience what a hearing loss was like. That was really cool and interesting. As the client it was interesting to hear and experience the speech perception of someone with hearing loss I learned a lot in the sim. It gave me lots of new information of how to help of assess children who are deaf or hard of hearing. I really appreciated the experience of the hearing loss simulation and being able to listen with a simulated hearing loss. I thought the study was interesting from the viewpoint of the clinician. It was so interesting to experience what the world would sound like if I had hearing loss I learned/refreshed my knowledge about hearing losses. It was helpful being the clinician and critically thinking through areas I wasn't comfortable with. I felt it was extremely informative. It's important to understand what someone with a hearing loss goes through to better treat them in therapy. I enjoyed using and learning about SPICE! This simulation was beneficial to my skill set as a clinician. This was the first time I had been able to go in-depth into an auditory training protocol and it both challenged and encouraged me in my skills as a clinician. It challenged me to think critically about how to assess auditory skills. The calm environment of the simulation encouraged me to take time to think critically about effectively assessing children who are D/HH.

Limitations and Next Steps. Although positive outcomes and encouraging student feedback have been evidenced from use of I-HeLPS and SPICE in this study, qualitative and quantitative data are limited to this single cohort; therefore, replication of this study is warranted to establish outcomes from a larger pool of participants. The use of a one-group pretest-posttest design is another limitation of this study; conclusions would have been stronger had it been feasible to employ a control group design. It must also be acknowledged that the PI was also the instructor leading the simulation and, thus, not blinded to the study design, may have inadvertently been a motivating factor in the simulation process which may have affected student outcomes. A larger pool, a control group, and outside replication of the study could strengthen future study outcomes. The use of Likert scales within the study must also be considered as a potential limitation, and their use may have introduced measurement error, including central tendency bias. Another practical consideration to note with the methodology is that the high number of supervisor hours required compared to the number of student clock hours earned could make this a less-sustainable model for most graduate programs.

Future iterations of this simulation could use small group sessions rather than simulation pairs to allow more learning opportunities, additional clinical hours, and the benefit of watching as well as participating in the simulation and from group discussions and problem-solving. Question prompts and scenarios used during this study were also narrow in order to maintain consistency of the experience across participants; however, future implementations of this simulation should consider the wording of prompts and questions and the type and extent of guidance provided to participants to ensure greater understanding of concepts including academic needs versus awareness of general environmental sounds. Additionally, related scenarios could be expanded to include other populations to encourage participants to consider factors such as the social and vocational effects of hearing loss on adults with hearing loss.

For this study, data were not collected regarding the participants' actual performance on SPICE. Similarly, there were no measurements of how the participants performed across the listening hierarchy of detection, discrimination, identification, and comprehension of sounds, although these concepts were discussed with respect to the listening skills across SPICE to support the participants' evaluation and intervention of particular skills and their analysis of their partners' responses. This study focused on the experiences of the participants as listeners with the simulated hearing loss and on the clinical skills and clinical thinking of the participants, rather than on the listening skills demonstrated by the listeners. Additionally, interpretation of listeners' performance data could be problematic as comparisons could only be made with adult populations with sudden-onset hearing loss because the effects of learned acoustic cues would not be available to an individual with a pre-linguistic onset of hearing loss. Analysis of listening skill performance could be explored in future studies.

Conclusions

Existing research shows that practicing clinicians often feel underprepared to provide services for individuals with hearing loss. Graduate programs have also expressed interest in using simulations to provide students with broader range of experiences and clinical populations than their local facilities may be able to access. Although simulations may not be able to provide identical experiences to working with live patients, they can still serve as a powerful learning tool and modality, supplementing live clinical experiences. The results of this study suggest that I-HeLPS and SPICE work well together to provide students with experiences that support building empathy and clinical skills with this clinical population which some graduate clinicians may have difficulty accessing. This combination of I-HeLPS and SPICE is a viable option for graduate CSD programs that are seeking to increase their students' knowledge, skills, and experiences with hearing loss.

This study represents the first documented application of I-HeLPS within SLP or audiology programs. The learning outcomes and participant feedback from this study are highly encouraging that this simulation design provided needed skills and knowledge for this cohort of graduate SLP participants. Additional research is needed to demonstrate repeated effect across cohorts of students. Future studies should explore use of alternate auditory training programs in combination with I-HeLPS. A broader and deeper investigation of any changes in empathy and critical thinking is also warranted. Participant feedback and test data suggest that the current iteration of this simulation experience would benefit from explicit instruction on writing behavioral objectives and on the value of non-speech environmental stimuli.

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Appendix A

Pre-sim and Post-sim Test Questions

Questions on Both Pre-Sim and Post-Sim Tests
Indicate whether it is within the scope of practice for SLPs to provide each of the following services for clients with hearing loss (HL).

	Yes	**No**
Provide speech (articulation, voice, resonance) assessment for clients with HL		
Provide speech (articulation, voice, resonance) intervention for clients with HL		
Provide language assessment for clients with HL		
Provide language intervention for clients with HL		
Provide speech perception assessment for clients with HL		
Provide speech perception intervention for clients with HL		
Diagnose hearing loss		
Prescribe amplification		
Troubleshoot hearing aids		

Rate your confidence in your own knowledge and skills in each of the following areas.
Not at all confident (1) – A little confident (2) – Somewhat confident (3) – Fairly confident (4) – Extremely confident (5)

	1	**2**	**3**	**4**	**5**
Assessing communication needs in children who are D/HH					
Assessing communication needs in adults who are D/HH					
Designing and implementing intervention for children who are D/HH					
Designing and implementing intervention for adults who are D/HH					

Name the sounds in the Ling 6-Sound test.

Case Study
A 7-year-old child in your school or clinic has the congenital, sensorineural hearing loss shown in the audiogram below. Use specific examples and your knowledge of the relationship between speech / environmental sounds and the audiogram to answer the questions below.

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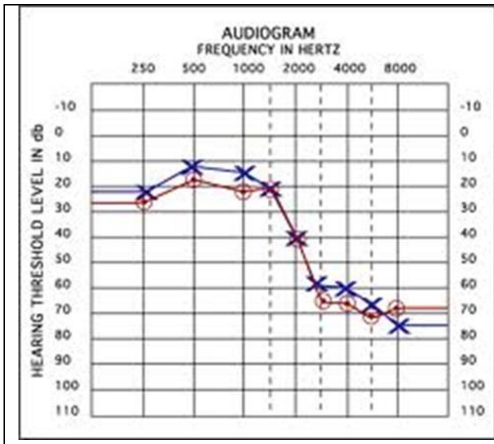

List 5 speech sounds this child will most likely have difficulty detecting.

Which of the 6 Ling sounds will this child most likely have difficulty discriminating?

List 5 ways this child's environmental awareness is likely to be affected.

List 3 academic problems this child will likely encounter in the classroom.

List 2 specific objectives (using do-condition-criterion format) that would be appropriate to target speech perception with this child.

Question Only on Pre-Sim Test

You were required to have taken both an audiology course and an auditory rehabilitation course prior to beginning this graduate program. Describe any additional exposure to or experience with the D/HH population that you have had, either through academic courses, personal or social connections, or volunteer or work experiences.

Questions Only on Post-Sim Test

Write a reflection of your experience in this simulation, both as the client and as the clinician.

This simulation experience increased my knowledge and skills for working with a client with HL.

Strongly disagree – Disagree – Neutral – Agree – Strongly agree

This simulation experience increased my understanding of the communication experiences of a person with HL.

Strongly disagree – Disagree – Neutral – Agree – Strongly agree

Appendix B

Clinical Competencies

Competencies Participants Received After Completing the Simulation

Evaluation, Area of Hearing

- Demonstrates current knowledge of the principles and methods of prevention and assessment, including consideration of anatomical/physical, psychological, developmental, and linguistic and cultural correlates (CFCC IV-D)
- Administers non-standardized and standardized tests correctly (CFCC V-B, 1c)
- Adapts evaluation procedures to meet the needs of individuals receiving services (CFCC V-B, 1d)
- Demonstrates knowledge of communication and swallowing disorders and differences (CFCC IV-C)
- Interprets, integrates, and synthesizes all information to develop diagnoses (CFCC, V-B, 1e)
- Interprets, integrates, and synthesizes all information to make appropriate recommendations for intervention (CFCC V-B, 1e)
- Completes administrative and reporting functions necessary to support evaluation (CFCC V-B, 1f)
- Refers clients/patients for appropriate services (CFCC V-B, 1g)

Treatment, Area of Hearing

- Develops setting-appropriate intervention plans with measurable and achievable goals that meet client/patient needs, demonstrating knowledge of the principles of intervention and including consideration of anatomical/physiological, developmental, and linguistic cultural correlates. Collaborates with clients/patients and relevant others in the planning process (CFCC V-B, 2a)
- Implements intervention plans that involve clients/patients and relevant others in the intervention process (CFCC V-B, 2b)
- Selects or develops and uses appropriate materials and instrumentation (CFCC V-B, 2c)
- Measures and evaluates clients'/patients' performance and progress (CFCC V-B, 2d)
- Modifies intervention plans, strategies, materials, or instrumentation to meet individual client/patient needs (CFCC V-B, 2e)
- Completes administrative and reporting functions necessary to support intervention (CFCC V-B, 2f)
- Identifies and refers patients to services as appropriate (CFCC V-B, 2g)

Additional Clinical Skills

- Sequence tasks to meet objectives
- Provides appropriate introduction/explanation of tasks
- Uses appropriate models, prompts, or cues. Allows time for patient response.
- Practices diversity, equity, and inclusion (CAA 3.4B)
- Addresses culture and language in service delivery that includes cultural humility, cultural responsiveness, and cultural competence (CAA 3.4B)