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Can the Use of Art and Active Learning Improve Retention and Observational Skill Confidence Among Audiology Graduate Students

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Abstract

Human anatomy and physiology is considered one of the most difficult courses a student can take in a pre-health professional major in the US (Slominski, et. al., 2017). Research has revealed benefits of the use of art and anatomy within medical education, including improved clinical observational skills, greater understanding of disease and patient perspectives, and greater ability to empathize (Bell & Evans, 2014). Bell and Evans (2014) argue that observational skills are often overlooked in medical education. Use of art assignments in a graduate anatomy and physiology course will be discussed with reference to design and learning outcomes. The purpose of this study was to evaluate the relationship between art and medical education for audiology students. This study aimed to incorporate STEAM education (art assignments, the teaching effect, and community outreach) into audiology curriculum. Auburn University's Au.D. class of 2022 participated in this study, consisting of 10 students. The Student Assessment of Learning Gains (SALG) questionnaire was conducted and provided qualitative and quantitative evidence supporting the integration of art in the Doctor of Audiology curriculum. BASE (pre) and SALG (post) outcomes assessed that the use of STEAM assignments can help improve the retention of the anatomy and physiology within of the auditory system. Cross-tabulations of pre and post course responses show a positive increase in student understanding of course material. A positive perception that art assignments enhanced student confidence and clinical observation skills related to the course was observed. Many students felt they had a great gain in understanding covered topics. The effects of utilizing the teaching effect and community outreach were also positively seen by student participants. Students' opinions following coursework and cross-tabulations support a place for art in health education and healthcare.

Keywords

Art, Audiology, Otoscopy, KASA, STEAM, SoTL

Cover Page Footnote

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Introduction

Research has shown that using art within medical education may improve clinical observational skills, increase understanding of disease, encourage better patient perspectives, and increase clinician empathy (Bell & Evans, 2014). Educators have stated that students should be provided with multiple opportunities to obtain learning goals within highly structured environments (Emanuel et al., 2013), such as integrating art into medical education.

Slominski and colleagues (2017) argued that human anatomy and physiology is one of the most difficult courses a student can take in a pre-health professional major in the United States. A survey from the American Medical Association of Doctor of Audiology (Au.D.) curricula suggested 0-9 credit hours were required in biological sciences (American Medical Association, 2009). A website-level curriculum search conducted in 2020 indicated that 56% (45/81) of Au.D programs had an Anatomy course pre-requisite [15=Not required; 23=Not specified on published requirements, see individual program websites details (Weaver, 2019)]. Across the 81 Au.D. programs reviewed in 2020, the mean was 6.64 credits hours offered across 1-6 courses. Those include, but are not limited to, the following: Neuroscience, Anatomy and Physiology, Auditory System or Bioacoustics, and Medical Aspects of Hearing Disorders. These core knowledge subjects serve as a foundation to many other courses in the Au.D. It is unclear if the use of art assignments and active learning would improve observational skills and confidence of students enrolled in a clinical Au.D. program. It has yet to be determined if art and active learning to improve student retention of anatomy and physiology of the auditory system enhance gains in confidence, as well as anatomical observation skills of audiology students.

Au.D. Curriculum. A disconnect has been observed between a health care professional's knowledge and the ability to convey that knowledge to patients in a manner that can be easily understood. Bardes and colleagues (2001) stated that clinical diagnosis involves the observation, description, and interpretation of visual information. This is often referred to as the "craft" of clinical care, which requires translating the complex medical knowledge of human anatomy and physiology into lay language that can be digested by patients and caregivers (Bardes et al., 2001). Areas of practice within audiology, as listed by the American Speech and Hearing Association (ASHA), include "audiologic identification, assessment, diagnosis and treatment of individuals with impairment of auditory and vestibular function, prevention of hearing loss, and research in normal and disordered auditory and vestibular function" (ASHA, 2004). Schematic representations of the auditory system are often used by audiologists when counseling patients. While there is limited research related to the extent that sketching and/or other art assignments are used for Au.D. students to acquire such anatomical knowledge, labeling anatomy is common practice during the assessment of anatomy (Slominski et al., 2017).

Art and Anatomy – Observational Skills. Recent literature identified an association among art and specific medical education skills (Bell & Evans, 2014; Chun et al., 2022). Shapiro and colleagues defined observation as the identification of key pieces of data, pattern recognition, and integration of significance and meaning. The authors argued that clinical observation is taught primarily through preceptor modeling during the all-important clinical years. Though there is no single method that exists for communicating these skills, medical educators have periodically experimented with art-based training to hone observational acuity. Shapiro and colleagues (2006)

used three different groups to participate in training: clinical photographs and cases, sketching, and mixed media of art, and dance. The authors concluded that students who received sketch training showed greater accuracy with medical conditions that had clearly observable manifestations and could better describe clinical photographs of patients when compared to peers using the standard curriculum (Shapiro et al., 2006). These students revealed better understanding of different concepts of observations, patterns, empathy, and emotions, which provided them with a more holistic picture of each patient. Ultimately, the incorporation of art in medical coursework helped students learn and think in new ways (Shapiro et al., 2006).

Bell and Evans (2014) argued that observational skills are often overlooked in medical education curriculum because students "look" rather than "draw." After an "art in medicine" course given to first year medical students, feedback displayed a strong association between feedback and skills necessary for art, medical education, and medical assessment. In another art in medicine workshop study, Master of Fine Arts students were paired with first year medical students to draw various anatomical figures (Moore et al., 2011). Students combined their perspectives to further their overall understanding of the relationship of structures and increase their ability to draw the structures observed. This workshop helped to aid understanding and provided an outlet for emotional expression of dealing with disease and mortality (Moore et al., 2011).

To explore student knowledge of human anatomy and physiology throughout an undergraduate course, students were instructed to draw neurons and their synapses (Slominski et al., 2017). Before the course, students were able to draw anatomy more accurately than physiology; after completing the coursework, however, both anatomy and physiology skills demonstrated by the students were improved. The drawing assignments served as a tool to reveal student content knowledge about neuroanatomy and neurophysiology (Slominski et al., 2017). In addition, prior work in the field of teaching and learning in audiology has demonstrated that students' perceived confidence in otoscopy skills may be misleading and need additional instruction in otoscopic inspection (Kaf et al., 2013). Prior work related to observations skills in both medical students and audiology students has suggested supplementary education (e.g., simulation, additional training) are merited to improve students' competence and/or confidence in otoscopy (Bhat et al., 2022; Davies et al., 2014; Davis et al., 2015; Higgins et al., 2019; Kaf et al., 2013; Sebothoma & Khoza-Shangase, 2021). At least one prior attempt to incorporate art without integration resulted in mixed student feedback (Weaver, 2019).

One of the authors of the current study participated in an *Art and Pathology* course as an undergraduate pre-med student (TR artist of Figure 1). The authors discussed this coursework, while working on a pathology image for a publication on otitis media (Weaver & Barnett, 2019). The course was created as an art elective for science majors and was co-taught between instructors from the biology and fine arts departments. A typical class was divided into a lecture from the biology professor that covered anatomy and physiology of various human body systems (e.g., internal organs, bones, muscles, connective tissue) followed by instruction on drawing techniques by the fine arts professor. Early drawing lessons focused on basic techniques of drawing such as line weights, shading techniques, value shifts, etc., and later lessons coincided directly with the content of the anatomy and physiology lecture.

One of the memorable activities consisted of a pathological condition (e.g., bone fracture) followed by timed sketches of the condition that decreased in length; for example, a ten-minute sketch of a bone fracture, five-minute, two-minute, one-minute, and thirty-second sketch. The purpose of this activity was to train the students on how to take a complicated topic and determine the key components necessary for conveying a meaningful visual message in the amount of time that one might have in a clinical appointment setting. The goal to engage students that were not particularly artistic found the activities to be helpful in learning the material and developing at least a fundamental understanding of how to draw or sketch anatomical features. For the authors of the current study, courses using art sparked a passion for anatomical drawing that has remained to this day. The authors of the current study believe that the skills developed in such courses have been useful in both audiological clinical settings as well as in the classroom for teaching audiology lectures.

Lerner durch Lehren Method. Lerner durch Lehren (LdL), described by Martin (1985), is a German teaching method that means *learning by teaching* when translated to English. LdL is referred to in literature as the *teaching effect* (Stollhans, 2016). This approach enhances collaborative learning by placing students in the position of teaching course content, which requires a deeper level of understanding on a given topic . In Stollhans' study, students were given an opportunity to use the knowledge they had been taught in a real-world scenario. The LdL method was used, requiring students to develop materials in order to teach their fellow classmates. The result of the study showed that the students benefitted from applying this strategy as they were able to work with other classmates to improve their communication skills, creativity, and abstract thinking. The survey responses were positive, and many students reported that they enjoyed LdL and would like to apply for it more often. The study concluded that teaching a concept to others is a valuable form of learning for adult learners.

In addition to the LdL, other studies have shown that implementing service learning in undergraduate audiology education has been highly effective. One study from the American Journal of Audiology (AJA) involved undergraduate students applying their clinical knowledge by providing band members with free hearing screenings. After completing the screenings, the undergraduate students were given the opportunity to practice counseling by explaining the importance of wearing hearing protection (Krishnan et al., 2015). The results of this opportunity were overwhelmingly positive from both groups of students (Krishnan et al., 2015). This hands-on experience allowed the students to not only raise awareness about hearing protection, but also fostered clinical confidence and critical thinking skills. This study illustrated that service-learning techniques not only enhance academic and civic learning, but also have the potential to benefit the community (Krishnan et al., 2015). This work suggested that service-learning projects are beneficial when integrated into undergraduate courses in communication sciences and disorders.

Measuring learning gains. Regional and professional accreditation agencies require Au.D. programs to provide detailed documentation regarding learning outcomes as well as formative and summative assessment tools used in curriculum (Emanuel et al., 2013). The Student Assessment of Learning Gains (SALG) system is an NSF-funded tool used to develop and test pedagogy and curricula for undergraduate courses (Student Assessment of Learning Gains [SALG], n.d.). It has been implemented by thousands of instructors to evaluate student learning gains across Science, Technology, Engineering and Mathematics (STEM) fields, and has been reported to have good

content validity and reliability (Seymour et al., 2000; Sheardy, 2010). The SALG systems' baseline (pre-course) assessment allows a student to report their perceived confidence in the course content area before a course begins, and then allows them to report their final ability or gains in their knowledge following the completion of a course (Sheardy, 2010; Weaver et al., 2018).

In the field of audiology, faculty encounter a diverse academic skill set in students. To address this diversity, educators must focus on enhancing individual learning, whether that be through visual, kinesthetic, or auditory modalities (Emanuel et al., 2013; Jenkins, 2010). Science, Technology, Engineering, Arts and Mathematics (STEAM) education is commonly understood as the use of arts in teaching other subjects (Liao, 2016). On the other hand, STEM varies from STEAM, and is often referred to as the hard sciences that enforce transdisciplinary classroom pedagogy. The National Art Education Association (NAEA) defines STEAM as "the infusion of art and design principles, concepts, and techniques into STEM instruction and learning" (Liao, 2016, p 45). Liao suggested that this arts-integrated approach leads to an innovative society. STEAM education supports kinesthetic learning as it is a way of applying creative problem solving through art making (Liao, 2016).

Based on empirical SoTL findings in other fields, making use of different forms of learning, such as hands-on, visual, and community-based teaching assignments, may benefit retention of knowledge and skills acquired throughout coursework for Au.D. students learning medical aspects of the auditory system (Liao, 2016; Slominski et al., 2017). Reflection is a key aspect of successful forms of engagement, and at the root of structured reflection is critical thinking (e.g., exploring and evaluating relationships) related to the course content from readings, lectures, and discussions to student experiences in their community (Ahmed, 2010). While most literature discusses reflection in reference to service learning, all graduate studies in health professions can apply reflection to the clinical community they serve and often do. The clinic to classroom environment in most communication sciences and disorders (CSD) graduate programs allows rich learning opportunities from reflection.

Additionally, evidence supports that otoscopy skills benefit from supplemental education opportunities (Kaf et al., 2013); therefore, inclusion of art assignments to facilitate anatomical observational may prove beneficial. The current study describes the curriculum offered, as well as the student's assessment of their learning gains to evaluate the use of STEAM, LdL, and reflection to related to a medical course covering anatomy and physiology of the auditory system and the disease processes that can occur.

The Current Study. The purpose of this study was to evaluate the relationship between art and medical education for audiology students. The study aimed to utilize art and active learning to improve student retention of anatomy and physiology of the auditory system and enhance gains in confidence and anatomical observation skills. In the course *Medical Aspects of Hearing Disorders*, art assignments, peer-presentations, and a community-based art lesson were used to engage students with hands-on learning. The art lesson required students to apply the knowledge they gained throughout the semester by presenting art and anatomy lessons to elementary-aged children in the local Auburn, Alabama area. This planned lesson functioned as an opportunity to serve the community, as well as benefit the graduate students by facilitating their knowledge acquisition and understanding in the science of the ear. This STEAM approach was applicable to both first-year Au.D. students and kindergarten and first grade (K-1) students. Through active

learning, graduate students engaged in new skills, thoughtful reflections, and applied the knowledge they had learned in the classroom.

The SALG questionnaire was administered and provided qualitative and quantitative evidence supporting the integration of art in the Doctor of Audiology curriculum. Additional questions related to the ASHA Knowledge and Skills Acquisition (KASA) standards for the course were incorporated in the baseline assessment and SALG. Baseline assessment and SALG outcomes were administered in the current study to determine if STEAM assignments can help improve the retention of anatomy and physiology within auditory system. Three areas of student perspective were investigated, including: KASA understanding, specific learning gains, and opinions related to STEAM education and art in health education [for complete 2012 KASA standards see Audiology Standards crosswalk (ASHA, 2020)].

Curriculum Objectives. During the academic Spring semester, first year Au.D. graduate students enrolled in the Medical Aspects of Hearing Disorders course. This course was designed to address the symptoms, incidence and prevalence, etiology and pathology, site of lesion, audiological evaluation and management, and medical evaluation and management of peripheral and central auditory disorders. As part of the course syllabus, knowledge of normal anatomy, physiology, and bases of human communication provided a foundation for appreciating, assessing, and treating disordered communication. Thus, the material learned in this course is also foundational for further studies relevant to ASHA KASA standards IV-A, IV-C, IV-D, and other various clinical skills.

KASAs are ASHA outline areas used to monitor student knowledge and skills acquisition that are necessary for graduation. Of the 16 KASAs listed on the course syllabus, the purpose of this study was to evaluate the following KASA items: (a) A1: Embryology and development of the auditory and vestibular systems, anatomy and physiology, neuroanatomy and neurophysiology, and pathophysiology; (b) A3: Normal aspects of auditory physiology and behavior over the life span,; (c) C4: Otoscopy for appropriate audiological assessment/management decisions, determining the need for cerumen removal (based on art activities); (d) A22: Oral and written forms of communication; and (e) A10: Pathologies related to hearing and balance and their medical diagnosis and treatment. The remainder of the KASA were not were not directly linked to the Art and LdL activities investigated [i.e., A2, A4, A8, A14, A26, C1, C3, C5, C9, C11, and D1, see list (American Speech-Language-Hearing Association, 2020)].

The first hypothesis (H1) of the study was that understanding on the five KASA specified will show increased gains over remaining KASA based on the curriculum design. More specifically, (H1a) students will perceive that processing classroom information in a hands-on and spatially oriented way will enhance the students' understanding of anatomy (KASA A1, A3: related to Anatomy & Physiology; and C4: related to otoscopy); and (H1b) students will perceive enhanced learning gains related to pathologies of hearing and balance (KASA A10) and oral communication (KASA A22) due to incorporation of LdL and reflection.

In addition to KASA enhancements, , the second hypothesis (H2) was that curriculum choices would enhance specific learning gains and skills: (H2a) the use of the LdL method will improve their professions skills related to working effectively with others and preparing and giving oral presentations; and (H2b) students will report that the STEAM approach improved their confidence and observation skills (KASA C4: related to otoscopy). Lastly, opinions related to STEAM in

audiology were evaluated, with the hypothesis (H3) that following coursework, students' perceptions related to art use and the place for art in health education and healthcare will increase positively. Bell and Evans (2014), stated there are additional benefits of art in medical education other than observational skills that include gaining a greater understanding of disease, patient's perspective, and a greater ability to empathize. Integrating art into the audiology curriculum may be beneficial to students enrolled in a clinical Au.D. program. However, many of the studies that support the use of art in medical education have not used validated forms of student perceived learning gains. Therefore, the current study aimed to use the validated baseline assessment and SALG systems to measure student confidence gains after completion of coursework containing the incorporation of STEAM and active learning.

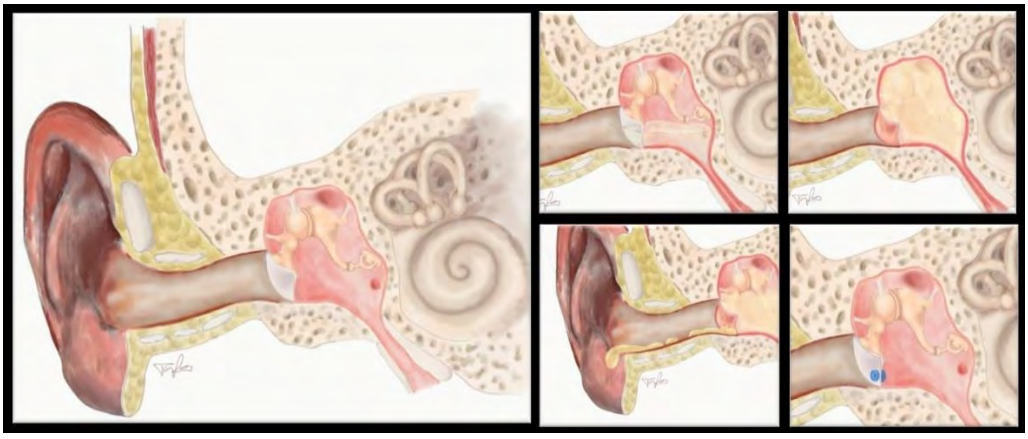
Methods

Participants. Ten students from Auburn University's Au.D class of 2022 participated in this study, completing all surveys, assignments, and reflections (individual and group) related to the study. The study was approved by the Auburn University IRB (Protocol # 19-298 EX 1907) and an information letter was sent out during the first and final weeks of the course in lieu of documented informed consent for students to volunteer their opinions.

Art Assignments. Seven art projects were assigned to align with the topics covered over each two-week period in the semester, per the course syllabus. Students were encouraged to spend time drawing, sketching, or creating representations of audiology anatomy, while also reading course textbooks or listening to the recorded lectures provided. The goal of these assignments was to integrate STEAM and critical reflection for all KASAs listed for the course. Certain KASAs (A1, A3, and C4), however, were hypothesized to be more enhanced by art assignments than others. Materials including canvas, paper, modeling clay, and iPads were provided to foster creativity for the art assignments. Figure 1 illustrates a cross section of the temporal bone, as well as four stages of otitis media, used in the course as an example of how art can help students visualize pathophysiology (Travis Riffle, 2018).

Figure 1

Anatomical Art used in Instructor Lecture

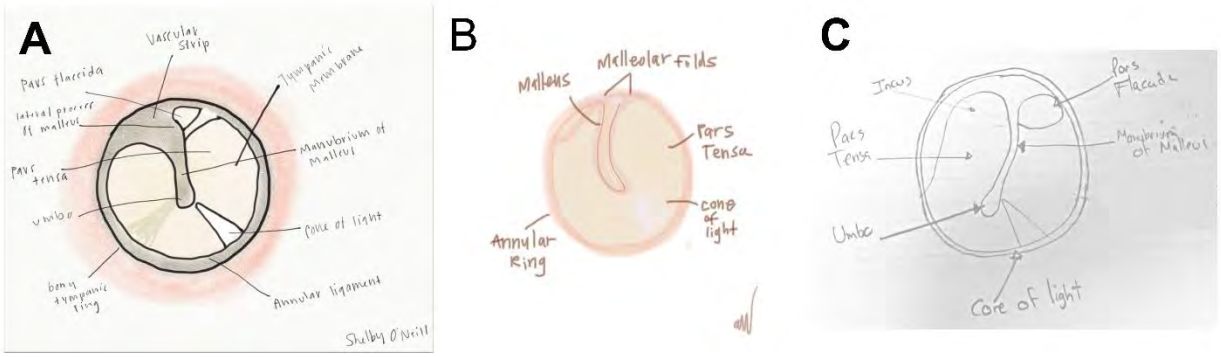


Note. Art work created by Travis Riffle, Au.D., Ph.D., CCC-A for lecture on stages of otits media for CMDS 8210.

The art assignments comprised ten percent of the students' overall grade, and individual due dates were linked with exams throughout the semester (see Figure 2 for examples of artwork submissions linked with Exam 2 covering the outer and middle ear). Additionally, students were required to submit a written reflection that described three aspects of the assignment: (a) the relevance of the piece submitted (including the structure and function/dysfunction within the auditory system); (b) what was learned from completing the assignment; and (c) what could have been done differently to better learn from the assignment. These graded assignments served as a form of individual reflection on the course material and were not used as data in the current study. The art assignments were also integrated into formative assessments requiring students to draw an anatomical figure on four exams throughout the semester. For example, one of the test questions stated, "Draw what you could visualize with Otoscopy for a patient with at least five landmarks visualized during otoscopy" (see Figure 2C). These formative assessments provided students with ongoing feedback regarding their mastery of the knowledge and skills taught throughout the course (Emanuel et al., 2013).

Figure 2

Student Art Submissions



Note. Artwork created by Au.D., students labeled A & B as an assignment; whereas C was completed in a formative assessment when asked to draw and label at least five landmarks visualized during otoscopic inspection. Permissions obtained for use in this manuscript.

LdL Method. Students were required to prepare and provide five oral presentations on topics throughout the semester. The first three were individual presentations in class to their peers on specific pathologies of the auditory system, including one presentation per topic area covered in the lectures (i.e., hereditary and congenital hearing loss, outer and middle ear pathologies, and inner ear and retrocochlear pathologies). The purpose of the fourth presentation was to share with the class what small groups learned and observed for their surgery observation (i.e., either CI implantation, mastoidectomy, or tympanostomy). Because not all students could observe all three surgeries, small groups researched the approach or surgery beforehand, and presented a grand rounds-style case to the class. The fifth presentation was a group assignment that involved community outreach in collaboration with a local kindergarten and first grade art teacher (Au.D. Class of 2022). The goal of each assignment was to integrate the LdL and reflection into course materials; however, certain KASAs covered (A3, A10, A22) were hypothesized to be more enhanced.

Both the peer-presentations and the community outreach project allowed Au.D. students to participate in LdL by using their knowledge on the anatomy and physiology of the auditory system, and pathophysiology to educate both graduate-level learners as well as elementary-age students. This community outreach project also served to enhance the Au.D. students' understanding of the material and introduced STEAM to K-1 students. The lesson plan utilized the STEAM approach by using the Au.D. students' art to explain how the brain hears.

The Lesson Plan. Prior to developing a lesson plan, students first met with the elementary art teacher (e.g., community partner) to discuss classroom curriculum and objectives for the K-1 students. The Au.D. students then brainstormed the best art medium to incorporate into their plans that would not only be entertaining, but also meet the curriculum and objectives. The topic of the lesson plan was to explain how the brain hears. The lesson plan organized the auditory system into ten parts – one section per student. Each student had to create a monologue about how their assigned portion of the auditory system contributes to how the brain hears. The professor provided each student with feedback on their assigned section and then created a correlating homework assignment to aid their project. The homework assignment was to create a handout to be used as visual aids for the presentation. The lesson plan and handouts were approved by both the course instructor and community partner (e.g., elementary art teacher), and permissions were obtained from Auburn City Schools administration.

On K-1 presentation day, the graduate students introduced the auditory system to the elementary students through a guided story time by reading "The EAR Book." Next, the elementary students participated in an interactive presentation of "How the Brain Hears." The entire Au.D. cohort participated in this activity titled "All Aboard the Hearing Train" reciting their scripted monologues. For the remainder of the art class, elementary students were divided into small groups for a hands-on art activity (i.e., the elementary class colored in prints that the Au.D. students had created throughout the semester, while the Au.D. students talked about the specific anatomy).

To assess the children's knowledge of the presentation, they were asked to line up before leaving the class based on the order of how sound travels. This met the Art Standard in the scope sequence, to create works of art using a variety of subject matter, to create and develop skills by following a sequence of steps, and to create works of art on subjects that are real or imaginary (Arts Education State Course of Study Committee and Task Force, 2017). The Au.D. students were engaged in both formal and informal reflection opportunities, to facilitate critical thinking related to course material. As there were three lessons throughout the day, the Au.D. students were provided feedback and guided in a peer-reflection by both their instructor and community partner, following each lesson. Feedback facilitated the Au.D students building fast rapport with the young children across lessons. Following the completion of the community project, the community partner met informally with the cohort and hosted an art and anatomy mural event where the Au.D. students used the art from their lesson to create a mural painting. During this time, an informal group reflection on the community LdL and course reflection engaging with the community outreach project was completed as a final reflection (see Figure 7).

Measurement of Student Assessment of Learning Gains. The SALG system was used to collect students' de-identified assessment of their learning expectations referred to as baseline assessment

SALG, n.d.). Baseline/pre-course assessments were collected during the first week of class, and the post evaluations were used again in the last week of class to collect students' perceived learning gains for the course were used again in the last week of class to collect students' perceived learning gains for the course.

Pre-Course Topic Self-Assessment Distribution. Access to the baseline assessment survey was e-mailed to each graduate student enrolled and remained open for seven days following the course start date. This timeline aided in capturing the students' confidence in their understanding, skills, and attitudes prior to course work, in addition to a question about their major. The baseline assessment template includes six sections related to the topics covered in the course:

- Section 1: Understanding
- Section 2: Skills
- Section 3: Attitudes
- Section 4: Integration of Learning
- Section 5: Major
- Section 6: Grade point average (GPA)

For the current study, Sections 5 and 6 were removed from the template, while an additional section was added to the baseline assessment and SALG (i.e., consisting of STEAM questions). Figure 3 provides a flow chart to indicates how a question under Section 1: Understanding would be framed on the baseline assessment survey using confidence scale (left), re-coded values bottom left), as well as the gain scale (bottom right) used in the SALG survey (post-instruction). Note, while not intended for analysis purpose, the confidence scale was re-coded for ease of interpretation of descriptive data.

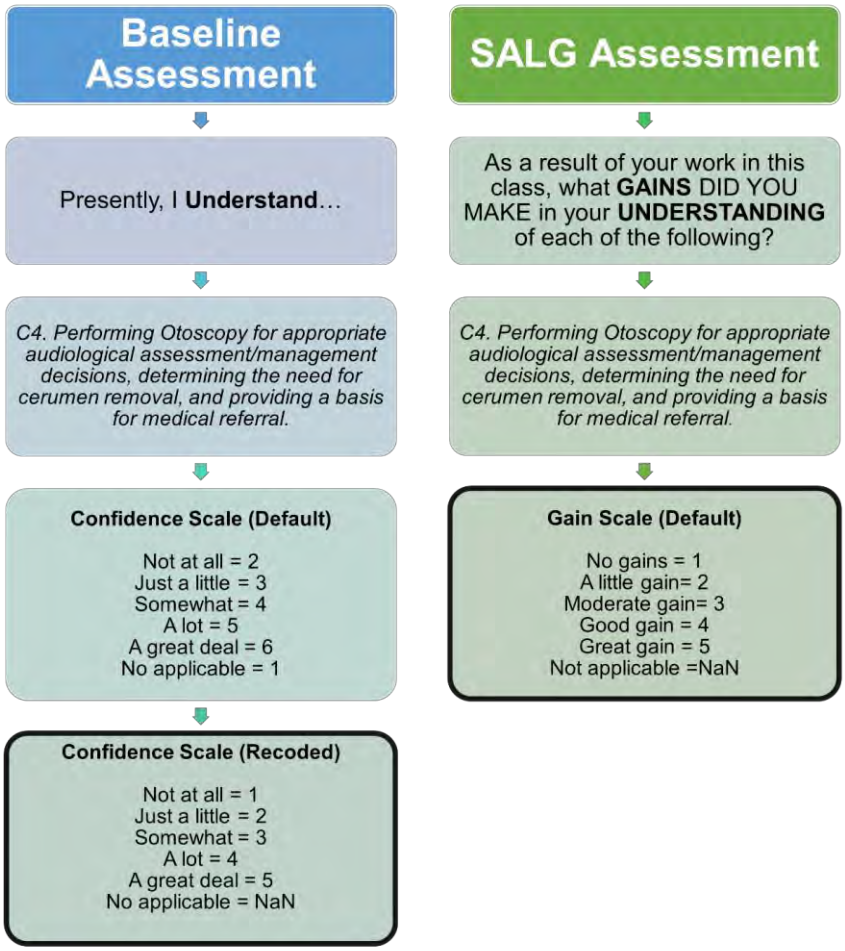
Long Format Responses. Each section of the baseline assessment and SALG offered a long format response (i.e., comment box) for students to express their current understanding of a given topic. Baseline assessment and student comments can be used by instructors to facilitate realistic expectations for course learning outcomes or to modify the curriculum to address students' current understanding of topics covered (SALG, 2000). Long format responses on the SALG allowed students to express in their own words that aspects of the coursework facilitated their learning. (See the Supplemental Content for baseline and SALG long format responses; examples are paired with descriptive findings in the results and discussion sections.)

Post-Course Topic Self-Assessment Distribution. During the last week of the spring semester, the link to the SALG post assessment survey was distributed via email to the students and remained open for 7 days. At this time, sections 1-4 were asked, and responses were requested using a gain scale related to KASA and overall learning gains (see Figure 3 for an example of how Section 1 was framed using both the baseline assessment and SALG surveys). Sections 5 and 6 used a help scale (no help = 1, a little help = 2, moderate help = 3 much help = 4, great help = 6, and not applicable = not a number) to address specific aspects of the course. Section 7 was included to ask students about their beliefs regarding art and audiology as a tool following coursework and projects using a 5-point Likert agreement scale (strongly disagree = 1, disagree = 2 neutral = 3, agree = 4, strongly agree = 5, and not applicable = not a number). STEAM questions 5-11 were altered on the SALG to relate the art assignments and coursework more closely to the current study. The SALG asked the students to re-evaluate their understanding of each topic to measure how much

each student felt they gained from the general and specific aspects of the course, including opportunities for long format responses. The SALG system generates cross tabulations, to facilitate interpretation across different scales, highlighting the trends in responses with density shading.

Figure 3

Baseline and SALG Assessment question prompts and scales for section 1-Understanding



Note. NaN= not a number. Flow chart on the Left provided the confidence scale for the baseline assessment whereas flow chart on the right provides the Gain scale used in the SALG. The values associated with the descriptive scale are assigned within the SALG system.

Data Analysis. The baseline assessment used both 5-point confidence scale with the additional "not applicable" option and long answer format. The SALG assessment used a 5-point gains scale; the STEAM questions used the 5-point agreement scale, ranging from strongly disagree to strongly agree. Descriptive statistics are reported without parametric comparisons due to the recommended use of different scales used for baseline assessment and SALG and to the response anonymity designed within the SALG system (SALG, n.d.). Results are organized based on the italicized hypotheses.

Long Format Comments. On both the baseline assessment and SALG, students provided direct insight related to their experience with hands-on learning and how specific activities and teaching approaches influenced their learning experience. For example, when asked "What would you expect to understand at the end of the class that you do not know now?" one anonymous student commented, *"I wish to be able to evaluate, test, interpret and diagnose pathologies according to what is expected with a substantial knowledge and well-developed skills."* These comments were not used for analysis in this study; however, some are reported in the results and discussion to supplement the descriptive results. (See Supplemental Content for all submitted comments.)

Results

In the Spring of 2019, 100% of the students enrolled in the course Medical Aspects of Hearing Disorders completed both the baseline assessment and the SALG assessments. The first research question sought to examine if the teaching methods used enhanced learning gains for certain KASA. It was hypothesized that KASA understanding on the five KASA specified will show increased learning gains over remaining KASA based on the curriculum design (e.g., Anatomy and Physiology Art assignments linked to KASA A1, A3: and LdL assignments linked to KASA A10 and A22).

Hypothesis 1: Enhanced KASA Understanding. The overall mean on the baseline assessment 5-point confidence scale across the 16 KASA Understanding questions was 2.55 (*SD* = 0.85; minimum 1.10, maximum 4.20). This score reflects confidence across topics to range from 1 = "not at all" to 4 = "a lot" of confidence in the KASA topics (see Figure 3 for question prompt format and scales descriptions). On average, students reported 2 = "just a little" to 3 = "somewhat" confidence in KASA A1 and A3 related to physiology. Students reported 1 = "not at all" to 2 = "just a little" confidence in KASA A10 related to pathologies of the hearing and balance system, whereas 4 = "a lot" of confidence was reported related to their oral and written forms of communication (KASA A22). Lastly, students reported on average 3 = "somewhat" to 4 = "a lot" of confidence in KASA C4 related to otoscopy (see Table 1 for results).

A 5-point gain scale ranging from 1 = "no gains" to 5 = "great gains" was evaluated using the descriptive statistics from the SALG. Following coursework, the overall mean across the 16 KASA understanding questions was 4.28 (*SD* = 0.51; minimum 3.40, maximum 5.00). This mean reflects students that reported 4 = "good" to 5 = "great" learning gains. The means and standard deviations for KASA of interest (A1, A3, A10, A22, and C4) fell above this average, reflecting 4 = "good" to 5 = "great gains" (see descriptive statistics provided in Table 1). Please note that the scales are different across the baseline assessment and SALG, and cannot be statistically compared. Baseline assessment scales were ordered nominally from 2 = "Not at all" to 6 = "A great deal" with 1 = "Not applicable," while SALG scales were ordered nominally from 1 = "No gain to 5 = "Great gain" with NaN being "Not applicable." For clarity, the values on the baseline assessment were recorded to match the SALG scale values (see Figure 3 for details).

KASA Cross Tabulations. The SALG system generated cross tabulations to facilitate interpretation across different scales, and the system highlighted the trends with density shading (i.e., greater frequencies are represented in darker shades of grey). Cross-tabulations visualized the individual and overall trends in gains that resulted in the descriptive statistics reported in Table 1.

Figure 4 plotted individual data in a matrix; please note that the cells with higher response frequencies are designated with greater density of grey (darker grey). Therefore, the darkest shade of grey represents the mode for each crosstabulation. Baseline assessment confidence scale (rows) for Section 1: Understanding in KASA A1, A3, A10, A22 and C4 (listed in column 1) are cross tabulated with the SALG gains scale (columns 2-6) for each respective KASA. Ideal student responses were plotted on the right of the table, indicating that regardless of their confidence prior to instruction, students perceived greater gains in their understanding following instruction.

Table 1

Descriptive statistics for KASA Understanding for Baseline assessment and SALG

KASA (prior to 2020 updates) Understanding	**Baseline Assessment** *(confidence)*		**SALG Assessment** *(gains)*	
	M	*SD*	*M*	*SD*
A1: Embryology and development of the auditory and vestibular systems, anatomy and physiology, neuroanatomy and neurophysiology, and pathophysiology	2.7	0.82	4.4	1.35
A3: Normal aspects of auditory physiology and behavior over the life span	2.8	0.92	4.7	0.48
A10: Pathologies related to hearing and balance and their medical diagnosis and treatment	1.6	0.70	4.8	0.42
A22: Oral and written forms of communication	4.2	0.79	5.0	0.00
C4: (Performing) otoscopy for appropriate audiological assessment/ management decisions, determining the need for cerumen removal, and providing a basis for medical referral	3.7	0.95	4.8	0.63
A2, A4, A8, A14, A26, C1, C3, C5, C9, C11, and **D1:** KASA's covered in course, but not targeted by teaching approached investigated	2.2	0.75	4.1	0.46

Note. The default baseline assessment uses a 5-point confidence scale from 2-6, with 'not applicable' designated a value of 1, as it can hold meaning. This was recoded to match the 5-point values used in the scale as not applicable was not used. The SALG uses a 5-point gains scale, which not-applicable is not given a score. The different scales across the Baseline assessment and SALG cannot be compared with parametric statistics.

Across the five KASAs, the trend reported by the density shading (see Figure 4) of the responses reflect what any educator would desire: regardless of students' confidence of a topic prior to the course, they perceived greater gains in the topic area (represented by the majority of responses plotted to the far right of Figure 4). Students reported that their confidence in their understanding for KASA A1 (related to embryology and development) on the baseline assessment as follows: one student reported they were 1 = "not at all" confident, two students reported 2 = "just a little" confidence, six students reported they 3 = "somewhat" had confidence, and only one student reported 4 = "a lot" of confidence in their understanding of embryology and development of the

auditory and vestibular systems, anatomy and physiology, neuroanatomy and neurophysiology, and pathophysiology. Following the course, eight out of ten students felt they had 5 = "great gains" in KASA A1, one student reported 3 = "moderate gains," and one student reported 1 = "no gains."

Figure 4

Cross-tabulations for KASA Baseline assessment to respective SALG outcomes (N=10)

Baseline Confidence	**Student Assessment of Learning Gains (SALG)**				
KASA A1	No gains (1)	A little gain (2)	Moderate gain (3)	Good gain (4)	Great gain (5)
Not at all (1)	0	0	0	0	1
Just a little (2)	1	0	0	0	1
Somewhat (3)	0	0	1	0	5
A lot (4)	0	0	0	0	1
A great deal (5)	0	0	0	0	0
KASA A3	No gains	A little gain	Moderate gain	Good gain	Great gain
Not at all (1)	0	0	0	0	1
Just a little (2)	0	0	0	1	1
Somewhat (3)	0	0	0	2	3
A lot (4)	0	0	0	0	2
A great deal (5)	0	0	0	0	0
KASA A10	No gains	A little gain	Moderate gain	Good gain	Great gain
Not at all (1)	0	0	0	1	4
Just a little (2)	0	0	0	1	3
Somewhat (3)	0	0	0	0	1
A lot (4)	0	0	0	0	0
A great deal (5)	0	0	0	0	0
KASA A22	No gains	A little gain	Moderate gain	Good gain	Great gain
Not at all (1)	0	0	0	0	0
Just a little (2)	0	0	0	0	0
Somewhat (3)	0	0	0	0	2
A lot (4)	0	0	0	0	4
A great deal (5)	0	0	0	0	4
KASA C4	No gains	A little gain	Moderate gain	Good gain	Great gain
Not at all (1)	0	0	0	0	0
Just a little (2)	0	0	0	0	1
Somewhat (3)	0	0	1	0	3
A lot (4)	0	0	0	0	3
A great deal (5)	0	0	0	0	2

Note: For each KASA, the Baseline Assessment Confidence scale (reported in rows) are cross tabulated with the SALG gains scale (reported in columns) from each respective KASA. Numeric Values in parenthesis were designated for each Likert level. The matrix cells with higher response frequencies are designated with darker densities of grey.

For KASA A3, students reported that their confidence in their understanding related to normal aspects of auditory physiology and behavior over the life span on the baseline assessment as

follows: one student reported they were 1 = "not at all" confident, two students reported 2 = "just a little" confidence, five students reported they 3 = "somewhat" had confidence, and two students reported 4 = "a lot" of confidence in their understanding. Following the course, seven out of ten students felt they had 5 = "great gains" and three reported 4 = "good gains" in their understanding of normal auditory physiology. On the baseline assessment for KASA A10 (pathologies and their medical diagnosis and treatment), five students reported they were 1 = "not at all" confident, four students reported 2 = "just a little" confidence, and one student reported they 3 = "somewhat" had confidence in their KASA A10 understanding. Following instruction, eight students reported 5 = "great gains" and two students reported 4 = "good gains" in their understanding of pathologies related to hearing and balance and their medical diagnosis and treatment. For KASA A22 (oral and written forms of communication) on the baseline assessment, students reported greater confidence in their abilities prior to the course, with two students reporting they were 3 = "somewhat" confident, four students reporting 4 = "a lot" of confidence, and four students reporting 5 = "a great deal" of confidence. All ten students reported they perceived 5 = "great gains" in the KASA.

Lastly, on the baseline assessment for KASA C4 (related to otoscopy, and Standard IV-C: Assessment), students tended to report higher levels of confidence in their understanding of performing otoscopy for appropriate audiological assessment/management decisions, determining the need for cerumen removal, and providing a basis for medical referral. One student reported they had 2 = "just a little" confidence, four students reported they 3 = "somewhat" had confidence, three reported 4 = "a lot" of confidence, and two reported 5 = "a great deal" of confidence in their understanding of this KASA. Following instruction, nine out of ten students reported 5 = "great gains" in their understanding and one student reported 3 = "moderate gain."

Hypothesis 2: Specific Curriculum Gains. The second research question sought to examine if the curriculum choices would enhance specific learning gains and skills. It was hypothesized that a) the use of the LdL method will improve their professional skills related to working effectively with others and preparing and giving oral presentations; and b) students will report that the STEAM approach improved their confidence and observation skills (KASA C4: related to otoscopy). Descriptive statistics were calculated from all ten students, reported in Tables 2 and 3. Means and standard deviation of the student responses on the baseline assessment and SALG obtained for overarching gains in student understanding, skills, attitudes, integration of learning are reported from sections 1-4 (see Table 2), which used the gain scale. Sections 5 and 6 of the SALG assessment (see Table 3) asked students to report "***How*** *much* did each of the following aspects of the class *help your learning*?" These sections (Class Overall, and Class Activities) used a Help scale, where 1 = "no help," 2 = "a little help," 3 = "moderate help," 4 = "much help," and 5 = "great help." The general results are reported relative to the reflective education questionnaire, which asked questions related to model/approach to coursework, or specific curricular activity (e.g., art or LdL). Note authors bolded items in Tables 2 and 3 that were mapped to H2a-LdL, and italicized items mapped to H2b-Art. The remainder of the items were included as part of the SALG template and are reported in reference to the overall reflective educational model.

Educational Approach. On average, students reported 4.2 - 4.8 across the general approaches to curriculum and specific activities listed in this section, reflecting "much" to "great help." The overall instructional approach taken in this class was reported to be 5 = "great help" to 50% of the students; 4 = "much help" to 30%; 3 = "moderate help" to 10%; and 2 = "little help" to 10% of the

students. Seventy percent of students reported that doing hands-on classroom activities was 5 = "great help," and 30% reported it was 4 = "much help." When asked about the pace of the class, half reported it was 4 = "much help" and the remaining half reported 5 = "great help." When asked overall about opportunities for in-class review/reflection and specifically about class reflections, referred to as maintenance, 80% of students said both were 5 = "great help," 10-20% reported 4 = "much help," and 0-10% reported 3 = "moderate help." Students reported on average 2 = "just a little" confidence in understating the relationships between the main concepts prior to the course, whereas they reported 4 = "good" to 5 = "great gains" (mean = 4.6) following coursework. Specifically, 70% of the students reported 5 = "great gains," 20% reported 4 = "good gain," and 10% reported 3 = "moderate gain." When asked about their understanding of how ideas from this class relate to ideas encountered in other classes prior to instruction, on average, the class reported they were 3 = "somewhat" confident. Following instruction, on average, the class reported 5 = "great" to 4 = "good gains" (mean = 4.8); with 90% reporting 5 = "great gains" and 10% reporting 4 = "good gains."

Table 2

Baseline and SALG for Sections 1-4: Class Activities (n=10)

Baseline Confidence vs. SALG: Question Prompts	Baseline Mean (*SD*)	SALG Mean (*SD*)
Understanding		
The relationships between the main concepts	2.2 (±1.0)	4.6 (±0.7)
How ideas from this class relate to ideas encountered in other classes	3.2 (±1.2)	4.8 (±0.4)
Skills (I can)		
Working effectively with others	**4.5 (±0.5)**	**4.8 (±0.4)**
Preparing and giving oral presentations	**3.4 (±0.4)**	**4.9 (±0.3)**
Attitudes (I am)		
Enthusiasm for the subject	4.6 (±0.5)	4.8 (±0.4)
Interest in discussing the subject area with friends or family	4.4 (±0.7)	4.9 (±0.3)
Interest in taking or planning to take additional classes in this subject	4.1 (±1.2)	4.5 (±0.7)
Confidence that you understand the material	2.7 (±0.4)	4.4 (±0.7)
Confidence that you can do this subject area	3.5 (±0.4)	4.6 (±0.5)
Your comfort level in working with complex ideas	4.5 (±0.4)	4.5 (±0.7)
Willingness to seek help from others when working on academic issues	5.0 (±0.0)	4.8 (±0.4)
Integration of Learning: (I'm in the habit of)		
Connecting key class ideas with other knowledge	**3.8 (±0.4)**	**4.8 (±0.4)**
Applying what I learned in this class in other situations	**3.8 (±0.6)**	**4.7 (±0.5)**
Using systematic reasoning in my approach to problems	3.5 (±0.9)	4.6 (±0.7)
Using a critical approach to analyzing data and arguments in my daily life	3.4 (±0.8)	4.6 (±0.7)

Note. Items with asterisk indicate questions added to the SALG template. See Supplemental Content for questionnaire prompts, slight tense alterations across the formats were merged for the table.

Questions on the baseline assessment targeting student habits related to integrating their learning with other knowledge, other situations, and systematic reasoning, and critical approaches in daily life, students reported 3 = "somewhat" to 4 = "a lot" of confidence. Following coursework, students reported 4 = "good" to 5 = "great" gains (mean = 4.6 - 4.8, respectively) when asked "as a result of your work in this class, what *gains did you make in integrating* the following?" with 70-80% reported 5 = "great gain," 20-30% reported 4 = "good gain," and 0-10% reported 3 = "moderate gain."

Educational Attitude. Across the baseline assessment questions targeting the attitudes related to the course, the students on average reported 4 = "a lot" of confidence to the questions: *I am…*

a) …enthusiastic for the subject interested in discussing the subject area,
b) …interested in taking or planning to take additional classes in this subject,
c) *… comfortable working with complex ideas.*

All students reported a great deal of willingness to seek help from others when working on academic problems/issues. On average, students reported 2 = "just a little" confidence in their understanding of the subject material, and 3 = "somewhat" to 4 = "a lot" of confidence that they can do this subject. Following coursework, students on average reported 4 = "good" to 5 = "great" gains in each of the areas related to their attitudes (4.4 – 4.9). Ninety percent and 80% reported 5 = "great" gains, on enthusiasm and interest to discuss the subject, respectively. Fifty percent and 60% reported 5 = "great" gains in their confidence to understand the material and confidence that they can do this subject, respectively, while 40% of students reported 4 = "good" gains in each area, and 10% reported 3 = "moderate" gains in their confidence to understand the material.

Specific Activities. This coursework made use of recorded lectures in a blended classroom modality from 2016 to 2020. Seventy percent of the students reported 5 = "great gains," 20% reported 4 = "good gains," and 10% reported 2 = "a little gain" from watching recorded lectures. Authors note only one course in their program was blended modality, prior to COVID precautions wherein most coursework was restructured into blended format due to COVID precautions. When prompted, "Please comment on how *the way the class was taught* helps you *remember* key ideas," five of the eight comments reported positive views of learning using the recorded lectures. One student commented "recorded lectures ROCK, it was great to be able to refer back to a lecture and relisten to things that I didn't quite understand the first time" while another student commented "having to listen to the lectures online and take notes caused me to pay more attention." Another student commented that "the class was taught in a very hands-on way, which I really appreciated. I really enjoyed the many different teaching styles and learning opportunities that were provided to us." Because lectures were recorded, each class period was spent either working on activities (e.g., embryology timeline, medical binders, art, or attending a surgery, student presentations, and preparing for the group K & 1st Grade presentation on "how the brain hears"), oral reflections (e.g., surgery case presentations, meetings with community partners), reviews and exams. Across the 12 items listed, students on average reported "much" to "great help" (4.2 - 4.9).

Hypothesis 2a – LdL. Specific to the LdL activities listed on the SALG questionnaire, 80% of students reported that the LdL presentations throughout the course was 5 = "great help," whereas 60% responded that the K & 1st Grade presentation on "how the brain hears" was 5 = "great help." Seventy percent reported the surgery observation and case presentation was a 5 = "great help", and 30% reported it was 4 = "much help." Across the seven aspects of that class related to LdL, the

means approximated "great" gains and "a great deal of help" (*M* = 4.71; *SD*= 0.20). Additionally, students on average reported a 4.9 and 4.8 for gains in the skill related to in preparing and giving oral presentations, and working effectively with others throughout the course, indicative of "great gain."

Figure 5, Panel C cross tabulated the baseline assessment confidence related to KASA A22 (oral and written professional forms of professional communication to the gains in the skill of preparing and giving an oral presentation). Panel D demonstrated the correlation among post-course (SALG) reported gains in KASA A22, and gains reported by students related to the skill preparing and giving and oral presentation.

Table 3
SALG for Sections 5 & 6: Class Activities (n=10)

SALG Help (gains) Question Prompts		
	M	***SD***
Class Overall (How much Help)		
Instructional approach taken in class	4.2	1.0
How the class topics, activities, readings, and assignments fit together	4.7	0.4
The pace of the class	4.5	0.5
Opportunities for in-class review/reflection	4.7	0.7
Class Activities (How much Help)		
Listening to recorded lectures*	4.5	0.9
Participating in class discussions	4.7	0.5
Listening to discussions during class	**4.7**	**0.5**
Participating in group work in class	4.5	0.5
Doing hands-on classroom activities	*4.7*	*0.5*
K & 1st Grade preparation and presentation*	***4.3***	***1.1***
*Embryology timeline**	4.3	1.0
Class "Maintenance/Reflections"*	4.8	0.4
Surgery Observation/Case presentation *	*4.7*	*0.4*
Medical binder*	4.8	0.6
*Individual and Group art assignments**	*4.2*	*1.2*
Presentations (all)	**4.8**	**0.4**

Note. Items with asterisk indicate questions added to the SALG template, items in bold are mapped to H2a – LdL and items italicized are mapped to hypothesis 2b – Art. See Supplemental Content for questionnaire prompts; slight tense alterations across the formats were merged for the table.

When asked on the SALG, "Please comment on what *skills* you have gained as a result of this class," seven out of eight students commented on speaking in front of a group or presenting. For example, one student stated, "I feel more comfortable giving presentations about topics that I am newly learning as I feel as if I know how to find appropriate information that helps me to gain a better understanding of the topic." Additionally, when asked to "Please comment on how the class activities helped your learning," a student reported, "I really enjoyed the K and 1st grade presentation. I love working with kids and having the opportunity to do so was really exciting for me. I felt like explaining the auditory system in such a simplistic was really helped engrain in my

head how the brain hears." (See Supplemental Content for Long Format responses.) This activity overlapped with H2b – Art as the LdL used art to facilitate an anatomy and physiology lesson.

***Hypothesis 2b – Art Activities*.** Across the five aspects of the curriculum examined on the SALG, the mean was 4.4 (*SD* = 0.24), reflecting "much" to "great help" (see Table 3; doing hands-on classroom activities, surgery observation, individual and group art assignments, K and 1st grade anatomy lesson/presentation, and the embryology timeline with made use of the student's individual art assignments). When asked, "Do you think the art assignments improved your observational skills for otoscopy," nine out of the ten students strongly agree art assignments improved their observational skills for otoscopy on the SALG (see Table 4, Question 7.3). Inspection of the cross tabulation in Figure 5 gives more insight to student responses about their learning, because these results were suspected to be influenced based on the student perception of their own creativity. Figure 5, Panel A, targeted the general incorporation of STEAM as it cross tabulates the confidence scale (rows) for the baseline assessment question, "Do you consider yourself to be artistic/creative?" with the agreement scale (columns) from the SALG STEAM question, "Did the art assignments prepare you to label a figure on an exam?" Perceived artistic abilities spanned from "not at all (1)" to "a great deal (5)" artistic/creative on the baseline assessment. Regardless, nine of the ten students still reported ideal trends that they strongly agree the art assignments prepared them to label figures on an exam (see Figure 5, Panel A).

In Figure 5 Panel B, KASA C4 (related to performing otoscopy) was cross tabulated with the agreement scale from the SALG STEAM question "Do you think the art assignments improved your observations skills for otoscopy?" The cross-tabulation density plot highlighted the difference students may have in their confidence prior to the course, with five students reporting "just a little (2)" to "somewhat confident (3)," and five reporting "a lot (4)" to "a great deal (5)" of confidence in their understanding of performing otoscopy for appropriate audiological assessment and management decisions, determining the need for cerumen removal, and providing a basis for medical referral. They also strongly agreed on the SALG that the art assignments improved their observational skills for otoscopy (see Figure 5, Panel B). Regardless of their confidence, 90% "strongly agreed (5)" the art assignments improved their observations skills for otoscopy.

Hypothesis 3: **Perceptions on Art in Health Education and Healthcare.** The third research question investigated students' perceptions related to art use and the place for art in health education and healthcare. With the hypothesis (H3) that perceptions will increase positively, following coursework. The content in Table 4 reported Section 5 of the baseline assessment and Section 7 on the SALG surveys, and provided the proportion of students' perception of STEAM, as well as art and audiology, specifically. Table 4 provided the percentages (columns 2-6), the means, and standard deviations (column 7) across students. STEAM questions were modified to determine if the art activities facilitated student learning gains and 90%-100% strongly agreed to each question following coursework (see lower half of Table 4).

These results aligned with long format responses students submitted. Following coursework, in response to the SALG long format question, "Is there a place for art in healthcare?" nine out of nine students, that provided responses to that question, reported yes. One connected their assignments to their training by stating, "YES! Drawing out the concepts from each of the lectures was SO helpful for me on the exams. It helped me better visualize what I was learning and not just trying to memorize facts." (See Supplemental Content for full list of student feedback).

Figure 5

Cross-tabulations for STEAM Baseline assessment to respective SALG outcomes (n=10)

Baseline Confidence	**Student Assessment of Learning Gains (SALG)**				
Panel A	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
Not at all (1)	0	0	0	0	3
Just a little (2)	0	0	0	0	1
Somewhat (3)	0	0	0	1	3
A lot (4)	0	0	0	0	0
A great deal (5)	0	0	0	0	2

Panel A, the confidence scale (rows) for the BASE question "Do you consider yourself to be artistic/creative?" were cross tabulated with the agree scale (columns) from the SALG STEAM question "Did the art assignments prepare you to label a figure on an exam?"

Panel B	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
Not at all (1)	0	0	0	0	0
Just a little (2)	0	0	0	0	1
Somewhat (3)	0	0	1	0	3
A lot (4)	0	0	0	0	3
A great deal (5)	0	0	0	0	2

Panel B confidence scale (rows) for KASA C4 (related to performing otoscopy) cross tabulated with the agree scale (columns) from the SALG STEAM question "Do you think the art assignments improved your observations skills for otoscopy?"

Panel C	No gains (1)	A little gain (2)	Moderate gain (3)	Good gain (4)	Great gain (5)
Not at all (1)	0	0	0	0	0
Just a little (2)	0	0	0	0	1
Somewhat (3)	0	0	0	0	1
A lot (4)	0	0	0	1	3
A great deal (5)	0	0	0	0	4

Panel C cross tabulates the Baseline assessment confidence related to KASA A22- Oral and written professional forms of professional communication to the gains in the skill of preparing and giving an oral presentation

Panel D	No gains (1)	A little gain (2)	Moderate gain (3)	Good gain (4)	Great gain (5)
A lot (4)	0	0	0	0	0
A great deal (5)	0	0	0	1	9

Panel D demonstrated the correlation among gains in KASA A22 (rows), and gains reported by students related to the skill preparing and giving and oral presentation (columns)

Note: For panel A-D, each Baseline Assessment Confidence scale (reported in rows) are cross tabulated with the SALG agreement of gains scale (reported in columns). The matrix cells with higher response frequencies are designated with density (darker) shades of grey. Numeric Values in parenthesis were designated for each Likert level

Table 4
STEAM Questions and Student Responses (N=10)

Section 5 – Baseline assessment: STEAM Question prompts	**Baseline Confidence Scale**					
	Not at all	Just a little	Some -what	A lot	A great deal	*M* (*SD*)
5.1 Do you consider yourself to be artistic/creative?	30%	10%	40%	0%	20%	2.7 (1.5)
5.2 Have you ever been required to draw a figure…						
5.2.1. for a class on assignment?	0%	10%	70%	20%	10%	3.2 (0.8)
5.2.2. on a quiz	0%	30%	40%	20%	10%	3.3 (1.0)
5.2.3 on an exam?	0%	30%	40%	20%	10%	3.3 (1.0)
	Agreement Scale					
	SD	D	N	A	SA	*M* (*SD*)
5.4 Do you believe there is a place for art in science?	0%	30%	0%	20%	50%	4.1 (0.7)*
5.5. Do you believe creative work can improve your study habits?	0%	0%	30%	30%	40%	3.9 (1.4)*
5.6. Can creative work improve your memory for material covered in a graduate level course?	0%	0%	30%	20%	50%	4.1 (0.9)*
5.7. Do you believe art can improve your memory of anatomy and physiology?	0%	0%	20%	10%	70%	4.2 (0.9)
5.8. Is there a place for art in healthcare?	0%	0%	30%	20%	50%	4.5 (0.9)
Section 7 -SALG: STEAM Question prompts	**Agreement Scale**					
	SD	D	N	A	SA	*M* (*SD*)
7.1. Did the art assignments prepare you to draw a figure on an Exam?	0%	0%	0%	10%	90%	4.9 (0.3)
7.2 Did the art assignments prepare you to label a figure on an Exam?	0%	0%	0%	10%	90%	4.9 (0.3)
7.3 Do you think the art assignments improved your observational skills for otoscopy?	0%	0%	10%	0%	90%	4.8 (0.6)
7.4. Do you believe there is a place for art in science?	0%	0%	10%	0%	90%	4.8 (0.6)*
7.5 Do you believe creative work can improve your study habits?	0%	0%	0%	0%	100%	5.0 (0.0)*
7.6 Can creative work improve your memory for material covered in a graduate level course?	0%	0%	0%	10%	90%	4.9 (0.3)*
7.7 Do you believe art can improve your memory of anatomy and physiology?	0%	0%	0%	10%	90%	4.9 (0.3)

Note. Agreement scale SD= Strongly disagree, D= disagree, N= Neutral, A= Agree, SA= Strongly agree. Question 5.3 was omitted from the Baseline assessment due the statement being cut off/ incomplete: "Have you ever had to label a figure for:" see Supplemental Content for Questionnaire. Rather than use the agreement scale for Question 7.8; long answer format was used for the SALG
*Statistical significance alpha < 0.05; Mann-Whitney U.

Non-Parametric Analysis. Baseline Assessment questions 5.4, 5.5, 5.6 and 5.7 were repeated using the same agreement scale in the SALG questions 7.4, 7.5, 7.6, 7.7 (see Table 4 for means and standard deviations of student responses). A series of one-tailed Mann-Whitney U tests with the H1 baseline < SALG were conducted and analyzed to detect positive changes in beliefs about STEAM following coursework. Significant difference was found in responses to the question (5.4 and 7.4) "Do you believe there is a place for art in science?" with lower baseline scores (U=29.5; z = -1.87, p = .031). A significant difference was found for the question (5.5 and 7.5) "Do you believe creative work can improve your study habits?' with lower baseline scores reported *(*U=20.0 z = -2.76, p = .003). Additionally, a significant difference was found the question (5.6 and 7.6) "Can creative work improve your memory for material covered in a graduate level course?" with lower baseline scores reported (U=28.5; z = -1.96, p = .025). No significant difference was identified for responses to the question (5.7 and 7.7), "Do you believe art can improve your memory of anatomy and physiology?" (U=39 z = -1.14, p = .127).

Discussion

This study investigated student perception of their learning gains for a medical audiological course which focused on anatomy and physiology, as well as disease pathophysiology. STEAM curriculum was applied across several integrated assignments to determine if this curriculum could enhance the retention and learning gains of anatomy and physiology of the auditory system. In this study, there were three primary hypotheses based on the curriculum. The first hypothesis (H1) considered whether the STEAM curriculum design would yield gains in students' understanding of the five selected KASA (A1, A3, A10, A22, C4) while the second hypothesis (H2) determined if the overall and specific curriculum approaches (STEAM or LdL) facilitated students' perceived gains and confidence in specific skills linked to observational (KASA C4) and communication skills (KASA A22). The third hypothesis (H3) investigated students' overall perceptions, post-curriculum, of the utility for art in health education and healthcare.

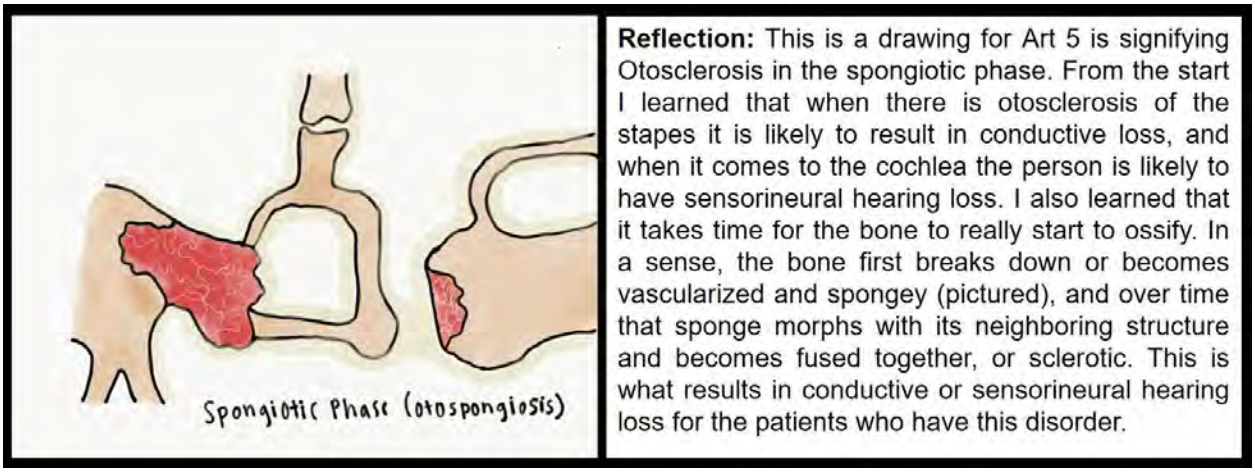
Based on the SALG post evaluation, all three hypotheses were data-supported. This aligned with prior work, which found that using art in medical education not only improved diagnostic accuracy (Shapiro et al., 2006), clinical observational skills, and increased understanding of disease, but also led to better clinical skills related to patient interactions (Bell & Evans, 2014). Additional findings from this investigation may be helpful to educators teaching CSD anatomy coursework. For example, on the baseline assessment survey, only 20% of the students enrolled in the course considered themselves "a great deal (5)" artistic, whereas all 10 of the students reported that they had been required to draw a figure for a class on a quiz, or on an exam in prior coursework (see Figure 5 Panel A). Based on the current outcomes, taking time to integrate STEAM as well as practicing required schematic or accurate anatomical/pathway art, was appreciated by graduate students, because these tasks trained them to observe and draw, rather than simply look (Bell & Evans, 2014). Despite students not identifying as artistic/creative, most students in this cohort did report beliefs that using STEAM in the classroom benefited their learning in the course, see Figure 5 (Panel A) and Table 4. The authors note that while baseline assessment outcomes are aimed to gauge students' confidence and potential need to adjust curricula, it can be used in reference to the SALG results to inspect trends. The remainder of the discussion will be focused on the SALG outcomes regarding the specific research questions.

Steam Curriculum. Slominski and colleagues (2017) identified anatomy and physiology to be one of the most difficult subject matters for pre-health professionals. Insufficient integration of assignments into curriculum, even when fun or engaging, can be viewed by students as a burden (Weaver, 2019); therefore, Emanuel et al. (2013) recommended providing student learning opportunities within a highly structured environment. Such empirical SoTL support contributed to the STEAM and LdL curricular activities reported in the current study (Ahmed, 2010; Emanuel et al., 2013; Krishnan et al., 2015). Clear curricular integration between art activities and learning outcomes for the course (KASA) were developed including the use of multiple opportunities for individual student and group reflection to foster critical guided learning opportunities on the topics covered.

Throughout the semester, students were assigned to create art related to the current topic of study. Students were asked to write a summary of each art project and address the questions "Did you learn from this assignment? If so, what did you learn? If not, what can you do/change to learn from this art assignment?" Often students wrote a few facts about the structure and why they chose it for the assignment (see Figure 6 for an example). Doing so integrated the art assignments with course material and student learning outcomes (i.e., KASA A1, A3, A22, and sometimes A10). Students were encouraged to pick topics that they did not understand fully during readings and lectures and incorporate new knowledge or content they were reminded of into the reflection.

Figure 6

Example submission for Art 5 related to Unit 2 pathologies of the middle ear. Permissions obtained to use for publication



The professor provided canvas, paper, modeling clay, and iPads for the students to use, and it was also encouraged for students to try a variety of art platforms throughout the semester. These reflections were typically brief (3-to-5 sentences) and graded for content accuracy, whereas feedback on art was provided only to clarify any anatomical errors (i.e., remediation).

Hypothesis 1: Enhanced KASA Understanding. The first hypothesis of this study focused on an overall enhancement of five specified KASAs based on the educational approach using STEAM, LdL, and reflection in the audiology coursework. Prior to coursework, student-reported

confidence in their understanding reflected "just a little to somewhat" (M = 2.55; SD=0.85). While the findings from suggested student self-reported confidence in otoscopy can be misleading, the SALG focus perceived gains following instructions. Each of the means for KASA of interest (A1, A3, A10, A22, and C4) reflecting 4 = "good" to 5 = "great" gains were higher than the gains reported for the remaining 11 KASA (M = 4.1; SD = 0.46). A downside of the SALG system is that educators must decide if waiving anonymity is worth the inability to reconstruct an individual's reports on the baseline and SALG without use of the system. This anonymity limits statistical analysis controlling for within-respondent repeated measures. The SALG system does reconstruct data by providing cross tabulations to visually inspect the trends. H1 can be investigated by examining the students' cross-tabulations for KASAs A1, A3, A10, A22 and C4, demonstrating both the initial confidence and gains reported in the KASA area by the students. These outcomes suggested that the curriculum met the need of students with varying confidence across the topics; gains reported are similar to reports within medical education (Davis et al., 2015).

For the question "Do you believe art can improve your memory of anatomy and physiology?" means were higher on the SALG (M = 4.9) than the baseline assessment (M = 4.5), however the statistical analysis failed to reject the null hypothesis. This result suggested that although students strongly agreed with this statement, on average, the students already agreed or strongly agreed with this belief prior to coursework. As indicated by the cross tabulations in Figure 4 (top panel labeled KASA A1), eight out of ten students felt they had 5 = "great gains" in KASA A1, while one student reported 3 = "moderate gains", and one student reported 1 = "no gains."

Gains related to KASA A1 is an area where further data on performance outcome would be helpful. Based on formative assessments in the class (mapped to KASA A1) all students met the instructors benchmark for "mature." Since embryology was covered in Unit 1, however, perception and/or retention of this information might have affected the perceived gains for KASA A1 more than the remaining KASA topics for the student that reported 1 = "no gains." Alternatively, because this course focused more heavily on hearing development and anatomy and physiology, therefore the student who reported "no gains" may have focused on their learning gains related to the vestibular system when reporting. This speculation is based on the overlap among KASA A1 and A3, for which all students reported 4 = "good" to 5 = "great" gains on A3. Additionally, due to this overlap, the Council for Clinical Certification in Audiology and Speech-Language Pathology of the merged these KASA in the 2020 updates (i.e., KASA A1 – Genetics, embryology and development of the auditory and vestibular systems, anatomy and physiology, neuroanatomy and neurophysiology, and pathophysiology of hearing and balance over the life span). While it's unclear why a student perceived "no gains (1)" on this KASA, they did report with the cohort (10/10) how the class topics, activities, readings, and assignments combined were 4 = "much" to 5 = "great help." These findings supported (H1a) STEAM education as an approach to student learning of KASA related to anatomy and physiology and (H1b) LdL as an approach related to pathologies and oral communication.

In reference to retention of KASA, one student reported on the SALG , "I will carry on my learning style to other classes. During this class I learned that learning can be done in a variety of ways. I really liked and felt like I learned a lot more by drawing out the anatomy." This comment aligned with the descriptive statistics and nonparametric analysis reported on perceptions related to how STEAM (approach and assignments) aided in retention of graduate coursework (see Table 4). For

example, while 50% of the students 5 = "strongly agreed" that creative work can improve their memory for material covered in a graduate level course on the baseline assessment, report for 9 = "strongly agreed" increased to 90% on the SALG.

Hypothesis 2: Specific Curriculum Gains. The second hypothesis explored curriculum gains reported by the students. Specifically, (H2a) focuses on the specific effects of curriculum on student learning gains when integrated with the LdL method, group art assignments, and community outreach project. Whereas (H2b) aimed to clarify if the STEAM assignments specifically enhanced gains related to the practice of otoscopic inspection (KASA C4).

Hypothesis H2a-LdL. Stollhans argued that LdL required a more in-depth level of understanding about any the given topic. Table 2 and 3 used bold font to highlight seven questions of the SALG that asked about aspects of LdL activities. The mean across these items demonstrated "great" gains and "a great deal" of help (M = 4.71; SD = 0.20). While the service-learning aspects of the LdL fell below this (M = 4.3; SD = 1.1), the majority of students (8/10) reported on the SALG that the K & 1st grade presentation was 4 = "much" or 5 = "a great deal" of help in their learning (see Table 3). Three of the LdL assignments were individually prepared peer-presentations on medical and audiological presentation and treatment of pathologies (i.e., hereditary and congenital hearing loss, outer and middle ear pathologies, and inner ear and retrocochlear pathologies). Outcomes on KASA A10 gains reported by students aligned with research that suggested the LdL requires a deeper level of understanding on a given topic, while enhancing collaborative learning.

The fourth presentation included pairs of two students that attended a surgery together. They were required to research the specific surgery prior to attending, attend the surgery, and then present a 10-minute reflection on their experience. This presentation aimed to make the surgery observation more integrated into the class. Both the fourth and the fifth LdL presentations required the Au.D. students to *work effectively with others* in the class to meet the assignment needs of *preparing and giving oral presentations* (Student Assessment of Learning Gains, n.d.). Overall, the cohort reported 5 = "great" gains in both skills respectively (see Table 2, Skills section). As mentioned in the results, seven out of eight students commented on speaking in front of a group or presenting, when asked on the SALG to "comment on what SKILLS you have gained as a result of this class," one student stated the following:

> "I have never seen a surgery before, so being able to go into the ER and see the power of modern technology can do it is pretty amazing. It showed me that we can make a difference in someone's life that is permanent in their life. Not that I loved making many different presentations, I really found that I learned so much from diving into one topic and exploring how it effects a person's life, so this class has taught me to continue to learn and find the answers."

For the community outreach art lesson, Au.D. students described how each part of the auditory system contributed to how the brain hears, using art they created for class. As part of the project, students were required to work as a group to prepare and implement a lesson to elementary students. This addressed the need to "give back" to the community partner that had provided the Au.D. students with art instruction, as well as created an opportunity for the Au.D. students to take graduate material and convey it in lay language to a young audience. The following student feedback captured their insights:

> "I really enjoyed the K and 1st grade presentation. I love working with kids and having the opportunity to do so was really exciting for me. I felt like explaining the auditory system in such a simplistic [way] was really helped engrain in my head how the brain hears."

Hypothesis 2b-Art and Observation. The other specific skill hypothesized to enhance perceived gains was otoscopic inspection (KASA C4). In a study by Shapiro and colleagues (2006), medical students that received sketching training showed greater accuracy with medical conditions that had clearly observable manifestations. It was hypothesized that students would report that the STEAM approach improved their confidence and observation skills. This question was directly assessed in a question in SALG question 7.3, as well as examining cross-tabulations. Nine out of ten students strongly agreed when asked "Do you think the art assignments improved your observational skills for otoscopy," in the SALG (see Table 4 Question 7.3). Cross tabulations further supported this hypothesis, regardless of how helpful the students feel creative work could be towards their memory for course material prior to engaging in the class (see Table 4, baseline assessment). These perceived gains support the use of art to enhance observational skills in audiology. Shapiro and colleagues (2006) defined observation as the identification of key pieces of data, pattern recognition, and integration of significance and meaning. On the SALG, students were asked to comment on "The *way this class was taught* helps you *remember* key ideas." Three out of ten students mentioned art, while others mentioned the hands-on approach and projects. One student reported, "One would be the art. I enjoy art and I feel like being able to draw structures, understand their shapes, and seeing the whole picture allows me to understand where the problem lies."

Hypothesis 3. Perceptions on Art in Health Education and Healthcare. There is a multitude of evidence that art is a useful tool in training, retention, and observational abilities of healthcare students including nursing, pre-med, and medical students' coursework (Bardes et al., 2001; Bell & Evans, 2014; Davis et al., 2015; Klugman et al., 2011; Moore et al., 2011; Naghshineh et al., 2008; Shapiro et al., 2006; Slominski et al., 2017). There is a lack of STEAM-SoTL literature in students seeking degrees in CSD; however, evidence does support the general use of STEAM in anatomical coursework. It is unclear if art is used less frequently in CSD education, or if SoTL investigations are underrepresented; however it is currently recommended for educators to focus on enhancing individual learning through diverse approaches (Emanuel et al., 2013; Jenkins, 2010). Future work surveying teaching techniques used in CSD anatomy courses would clarify if art and/or STEAM are currently used in CSD curricula.

Liao (2016) argued that art-making should be the center of the STEAM approach. In addition to their STEAM assignments, nine out of ten students participated in an optional art class to paint a mural inspired by their anatomy and physiology drawings of the ear (see Figure 7). Three questions related to overall beliefs of STEAM were found to be statistically significantly higher, indicating increased positive belief. On the SALG, 100% of the students reported that they "strongly agreed (5)" creative work can improve their study habits (Question 7.7, see Supplemental Content). Related to their retention of content, one student commented, "there definitely is a place for art in healthcare, it is so vital for clinicians to utilize this tool and it aids in the patient's understanding." Following coursework, when asked, "Is there a place for art in healthcare?" one student responded:

> "Yes. Prior to this class, I might not have because I have never thought about it before. However, after this class I think art can be used in many ways to enrich learning. I really enjoyed drawing the anatomy because it better engrains the information in my head."

Incorporating artwork into a curriculum that does not traditionally offer courses or material in this topic area could have benefits that extend beyond the classroom. The students in the current study reported that they feel that the artwork helps improve their own understanding of the material since it forces them to think of it in new ways which enriches their learning experience. These skills could be particularly useful outside of the classroom in clinical settings. As clinicians, healthcare workers are often tasked with explaining complicated concepts or conditions to patients that may have limited background knowledge of the topic being discussed. Being able to do a quick sketch or schematic drawing during a clinic visit could not only help clarify the patient's understanding of the appointment, but could also help to build rapport between the patient and the provider. Additionally, many of the courses in health sciences curricula are science-based, which do not often lend themselves to a great deal of creativity. Incorporating art-based courses and assignments provides an opportunity for students to be creative in an otherwise scientific, laboratory, or clinical environment.

Figure 7

Class of 2021 Anatomy and Physiology of the Ear Mural (left panel). Students used seven images they drew for class in the border of the mural during their LdL lesson plan (right panel)

Limitations. The cohort in the current study is small, reflecting the average class size in this program, which limited the generalizability of the results. Due to 2020 KASA updates, however, replication would create challenges in future data comparisons. Future work in this line could investigate larger sample sizes to afford additional analysis as well as improve the ability to generalize findings. Additionally, there were no formative assessments completed for observational skills prior to course instruction. For the coursework described in this study, formative assessments were completed for course credit; all participants met or exceeded KASA requirements. The performance measures, were not retained as records for this study. Future work should make use of pre-and post-otoscopic inspection formative assessments to corroborate perceived gains with improved accuracy (Kaf et al., 2013). While the approach to measuring confidence aligned with work conducted in this realm (Davies et al., 2014), educators should be cautious as students' perceived confidence ratings may not align with performance (Kaf et al., 2013).

One issue with pairing performance and student perceptions collected using the baseline assessment and the SALG is that the instructor must waive anonymity in student questionnaires to link them to performance outcomes or average them across the cohort. It is worth pursuing how a formative assessment may be integrated into tools that preserve anonymity. This would allow the exploration of the relationship between a student's *perception* of their confidence and/or learning *gains* in a topic compared with their actual performance. Further comparison of teaching strategies from a similar course with limited use of art assignments or LdL opportunities would be beneficial.

Baseline and SALG construction. As it related to the baseline and SALG construction, there was one omitted question on the baseline assessment related to "labeling figures on: …homework, …quizzes, or …exams" that was removed from the data analysis and the SALG as the delineations were missing. This question may have revealed insight as to how art has been required in prior CSD coursework, while not being embedded in the curriculum. Again, a future survey could clarify if or how art (i.e., STEAM) is used in instruction of formative assessments. Additionally, authors hypothesized (H2) that curriculum choices would enhance specific learning gains and skills. To do so, a SALG question directly asked about "Did you think the art assignments improved your observational skills for otoscopy?" There was not, however, a direct question related to LdL method and their professional skill gains (e.g., related to working effectively with others and oral presentations) or understanding gains (KASA A10 related to pathologies). Therefore, we inferred that reported skill gains were facilitated by the five presentations students prepared and provided during the course, as well as the ideas expressed in the long response format comments. In addition to not asking a specific question about LdL, a limitation of the current work was equating class presentations to teaching the material. Further work should clarify components of presentations or other assignments which lead to the most robust gains from LdL, for all students involved. Despite these limitations, the current outcomes align with prior work finding that incorporation of art in a medical coursework helped students learn and think in new ways (Shapiro et al., 2006)**,** which is important for future audiologist as hearing healthcare professionals. Additionally, when asked, "What is STEAM Education?" and "Does it apply to audiology students?" a student commented that, "STEAM is an approach to education that combines several disciplines including science, technology, engineering, the arts, and mathematics. I believe it can apply to all disciplines, including Audiology students. Being able to incorporate several disciplines makes for a well-rounded student and future professional."

Conclusions. It was evident that STEAM assignments helped improve retention and understanding of the anatomy and physiology of the auditory system. The integration of STEAM education in this course allowed students to experience LdL by processing classroom information in a hands-on and spatially-oriented way. After the course, eight out of ten students felt they had a greater understanding of the topics related to KASA A1: Anatomy and physiology of the auditory system. The data from this study supported a positive perception that art assignments enhanced confidence and clinical observation skills related to the course. Lastly, students' opinions following coursework supported a place for art in health education and healthcare. As clinical care requires translating the complex knowledge of human anatomy and physiology into lay language that can be digested by patients and caregivers our findings supported the use of STEAM education for future professionals in the field of audiology.

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There are no author financial relationships to disclose. Aurora J. Weaver, Au.D., Ph.D. is on the board of directors for the Educational Audiology Association, and Larry Molt, Au.D., Ph.D. is the professional relations chair of the National Stuttering Association and the VP of Finance for the American Speech-Language-Hearing Association financial planning board.

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