A Comparison of Laboratory and Virtual Laryngeal Dissection Experiences on Preservice Music Educators' Knowledge and Perceptions

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Summary: Science-education literature is replete with studies examining how students learn anatomy most effectively and efficiently. Some researchers have found that students learn best through hands-on learning, whereas other investigators have concluded students rate both computer and hands-on learning as effective and enjoyable. No study to date, however, has examined anatomical learning of preservice music education students on anatomical and physiological knowledge of the larynx. Therefore, the purpose of this investigation was to examine the effectiveness of virtual versus laboratory dissection in learning anatomy of the laryngeal structure for preservice music educators in a vocal pedagogy course. University students ($N = 26$) were given a pretest on laryngeal physiology and anatomy. Thereafter, the first group ($n = 13$) attended five 1-hour sessions of laryngeal dissection in a cadaver lab. The second group ($n = 13$) attended five 1-hour sessions in a computer lab equipped with *Physiology and Anatomy Revealed, version 3.0* (McGraw Hill, New York, NY), a computer software program designed to simulate the dissection experience. Two days after finishing the laboratory or virtual dissection experience, each group was given a posttest. Perceptions were also gathered through a short questionnaire following the posttest. Results indicated that student knowledge and perceptions varied widely. All participants showed improved scores from pre- to posttest measures; however, scores were not significantly different between groups. Results are discussed in terms of feasibility of such a learning mode and importance of dissection experiences in understanding human anatomy as well impact on future music educators' teaching practice.

Key Words: Dissection–Larynx–Preservice music education–Anatomy–Vocal pedagogy.

REVIEW OF LITERATURE

Technology is prevalent in almost every aspect of education today. Whether online programs, virtual learning, hybrid classes, or digital libraries, technology infuses today's curricula with new possibilities for delivery of instruction and learning experience. As of 2010, each public school in the United States had an average of 189 computers with 93% having Internet access. In addition, 74% of districts enrolled students in technology-based distance education.[1] Schools spend large sums of money on technology to support and deliver instruction. Experiences that were once only available in person (such as dissection) are now available in a variety of formats through technology.

Many researchers have focused on the use of technology in the classroom. For example, DeBord et al[2] tested whether the use of technology in the classroom and the optional use of websites outside of class time would increase student performance. They found no effect on final examination scores when more technology was used. In another study of technology in education, Pemberton et al[3] assessed the effects of using an interactive, computer-based teaching tool (LearnStar) as an in-class exam review method. Students ($N = 377$) were divided into two groups—one that utilized LearnStar (computer software) for review and another that experienced traditional, non–computer-based review sessions. Satisfaction ratings indicated that LearnStar reviews were more enjoyable and conducive to participation than traditional reviews. However, review sessions with LearnStar did not lead to significantly higher student exam scores or course grades compared to traditional reviews.

Use of technology in education is a topic of interest in science education including online learning.[4] Others have examined such topics as learning anatomy through dissection. Comparison of dissection experiences often indicated one method to be more advantageous to students, whereas other investigations have concluded students rate both computer and hands-on learning as effective.[5]

While examining dissection experiences, researchers have found that a majority of students learn best through hands-on learning in comparison with digital/media learning such as website tutorials and educational software programs.[6,7] For example, Jamison[8] compared traditional and virtual rat dissections in high school students ($N = 311$). The students were divided into two groups. Each group completed a pretest, lab practicum, and a posttest. The groups were then switched and completed the opposite activity. Participants in the laboratory dissection group made significant gains on the posttest and indicated preference for the hands-on experience. In a similar study, Michel-Clark[6] also found higher scores in students performing traditional laboratory dissection. High school biology students ($N = 115$) participated in a 2-day laboratory frog dissection or a 2-day virtual frog dissection. Posttests were administered immediately following the dissection and again 2 weeks following the dissection. The laboratory dissection students scored significantly

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higher than the virtual students on both tests. In another study of frog dissection, Taeger[7] compared student's retention of knowledge when participating in laboratory verses virtual frog dissections. Students spent 1 hour in dissection (laboratory or virtual) and took a test immediately following with illustrations that neither group had seen. The traditional laboratory dissection students scored higher on the test; however, Taeger found no difference 2 weeks later on the same test.

Kopec[9] compared 218 biology students in three different course levels (foundations, general, and honors biology). Half of the students participated in a live frog dissection and half in a virtual frog dissection. Comparison of pre- and posttest scores found no significant differences among the three groups. Surveyed biology teachers perceived online dissection as a good option for students who do not want to perform traditional laboratory dissection.

Benefits of an online or virtual approach to dissection have also been found. Kuyatt[10] studied the effectiveness of Practice Anatomy Laboratory (PAL 2.0) software in a community college traditional classroom and hybrid online classroom. Results indicated that students effectively learned human anatomical spatial relationships with digital software tools. Interestingly, perceived learning was significantly higher in the online class environment.

Youngblut[5] also found benefits of virtual dissection. Youngblut compared students participating in laboratory and multimedia virtual frog dissections. The participants involved in the virtual dissection were given 44% less time, but results indicated that they scored higher on the posttest. These participants also spent more of their time on task than the laboratory dissection students. Participants perceived the virtual dissection as easier; however, teachers expressed that monitoring student progress in the virtual dissection was difficult.

Several researchers have also compared virtual and hands-on dissection in cadaver dissection programs. Some researchers found combining the virtual and laboratory dissection to be most beneficial to students. For example, Biasutto et al[11] examined laboratory and virtual dissection in first-year medical students (N = 1028) enrolled in a gross anatomy course. Group A (n = 698) studied cadavers that had been dissected for them. Group B (n = 330) followed the same coursework, but used dissection software. Five years later, group C (n =145) used both laboratory and virtual dissection with the same coursework and professor. Results indicated that group C (both) performed significantly better on posttests, followed by group A (cadavers), and finally group B (software). In another investigation of combined experiences, Jones et al[12] studied the effect of dissecting cadavers on student examination scores. Participants had dissection software (virtual component) at their disposal. All students (N = 75) participating in the program took part in laboratory dissection. Students dissected one section of the body and observed other students dissecting another section. The researchers then compared student performance on portions of the test that corresponded with the section dissected verses the observed. There was a small increase in performance on the National Board of Medical Examiners Gross Anatomy and Embryology Subject Exam, but findings were not statistically significant.

Other researchers have examined technology sources (computer-assisted instruction [CAI]) in anatomical learning have been examined as well. One study of CAI compared the use of traditional lecture supported by a graphics-enhanced CAI program to a traditional lecture without the CAI program[13]. They examined teaching anatomy, biomechanics, and path mechanics of the temporomandibular joint in physical therapy students. They found no significant difference between groups. In another study examining CAI, Ester[14] randomly assigned undergraduate students (N = 52) to three groups studying vocal anatomy in the following ways: via CAI using Hyper Vocal Anatomy software, via traditional lecture, and via combined CAI and lecture. The goal was to help students understand the function of the larynx through labeling of cartilage, muscle, and understanding the phonation process. Students in the CAI group were free to explore and learn at their own pace. Results indicated that students in the CAI group scored higher on the posttest than the lecture group, and were equal to the students in the combined group.

Some CAI programs are Internet based. For example, Ryder[15] created an Internet-based instruction program for choral students (N = 237) from three different high schools to study vocal anatomy, function, and health. Participants completed surveys measuring attitude toward Internet learning before and after the study. Pre- and posttest measures of knowledge and content were also given. Results indicated participants were comfortable with Internet learning and thought vocal anatomy was an important topic of study. Significant differences were found on mean test scores between pre- and posttest measures. Ryder concluded that all students gained knowledge as a result of using the program and a majority had a positive attitude toward Internet learning.

CAI is primarily an instructional technique in which computers are used to present the material and monitor the learning of students. Others have examined virtual reality in which computer technologies use software to generate realistic images, sounds, and other sensations that replicate a real environment or stimulate the imagination. In music education, researchers have examined the effects of virtual technology. Some studies have investigated learning music or instruments with the aid of virtual technologies.[16, 17] Still other researchers have examined training of music educators and conductors through the use of virtual reality.[18–20] Still other research has examined virtual field experience in preservice music educators[21, 22] as well as online music education.[23]

Many studies have compared virtual and laboratory dissection; however, no study to date has examined anatomical learning of preservice vocal music education students. Therefore, the purpose of this investigation was to examine the effectiveness of virtual, computer-simulated dissection versus traditional dissection in a laboratory on learning anatomy and physiology of the laryngeal structure for preservice music educators in a vocal pedagogy course. The following research questions guided this investigation: (1) Are there significant differences by group in pre- and posttest scores on a laryngeal anatomy and physiology test? (2) What do singer comments suggest about perceptions of virtual and laboratory dissection experiences?

METHODS

Participants

Singers

Singer participants ($N = 30$) constituted a convenience sample recruited by word of mouth from the undergraduate music education population in a vocal pedagogy course at a major southeastern university. There were 16 (54%) female participants and 14 (46%) male participants with a mean age of 22 years. Reported major instruments included voice ($n = 26$, 87%), piano ($n = 2$, 7%), euphonium ($n = 1$, 3%), and bass ($n = 1$, 3%). Self-reported choral singing experience included elementary ($M = 1.83$ years), junior high ($M = 1.79$ years), and high school/college ($M = 6.3$ years). Participants had studied private voice ($M = 5.42$ years) as well. Finally, 28 participants (93%) reported no prior knowledge of laryngeal anatomy or physiology.

Research assistants. Two doctoral students served as research assistants (one male and one female) for this study. Both had experience in vocal anatomy and physiology, and had previously experienced the traditional laboratory dissection. Prior to the study, each assistant spent time with the virtual dissection software until they felt comfortable guiding the undergraduate students in navigating as well as finding terms and definitions within the software. The assistants had experience in teaching voice, choir, and vocal pedagogy.

Test instrument

The pre- and posttest covered anatomy and physiology of the larynx. The test was piloted three times during the year prior to this study with undergraduate and graduate students. As a result of the pilots, the test was edited for clarity of images, question and answer consistency, length of test, and overall coverage of material. The final version of the test used in this study was divided into three sections: intrinsic laryngeal muscles, extrinsic laryngeal muscles, and cartilages/bone of the larynx. Total possible score on the test was 46. The extrinsic muscles of the larynx section consisted of anatomy labels and physiology or function answers. These included six different muscles (digastric, mylohyoid, thyrohyoid, sternohyoid, sternothyroid, and omohyoid). The second section covered the intrinsic muscles of the larynx and included anatomy labeling and physiology questions. These included five muscles (cricothyoid, throaryntenoid, transverse arytenoid, posterior cricoarytenoid, and lateral cricoarytenoid). The third and final section pertained to the cartilages and bone of the larynx. This section included labeling tasks and physiology questions, and included the epiglottis, hyoid bone, thyroid cartilage, cricoid cartilage, arytenoid cartilages, and corniculate cartilages. Anatomical representations employed in the study guide and test were gathered from online digital images based on those from *Anatomy of the Human Body*.[24] Images were altered only in darkness and shadow during photocopying for purposes of clarity.

Dissection laboratories

Cadaver laboratory

The cadaver laboratory was housed within the School of Veterinary Medicine and operated by the kinesiology department. The laboratory space was equipped with metal laboratory tables, stools, scalpels, probes, and scissors for performing dissection. One human cadaver head was disconnected from the body by the director of the laboratory at the base of the neck, just above the clavicle, for dissection purposes. The cadaver provided for this study was a deceased male with all neck and head structures intact. Dissection manuals were used to guide the dissection process (*Clemente's Anatomy Dissector*[25] and *Atlas of Human Anatomy*[26]).

Vocology laboratory. The vocology laboratory was housed in a quiet corner of a university building. The space was equipped with a Dell Precision T5600 workstation with a 22-inch Dell high-resolution monitor loaded with the Physiology and Anatomy Revealed Software (version 3.0, McGraw Hill). Students sat at desk chairs facing a large office desk with enough space for placing papers on which to take notes.

Procedures

All participants ($N = 26$) were given 1 hour in which to complete a pretest on laryngeal anatomy and physiology. Following this test, all participants took part in five training sessions (once a week for 5 weeks) either in a cadaver laboratory or a vocology laboratory equipped with dissection software (virtual experience). As the dissection was not a requirement of the degree program, participants self-selected one of the groups and were given a study guide. The study guide was based on the pre- and posttest and included diagrams, questions, and terms. Students were directed to take notes as they found information such that they could utilize their study guides to prepare for the posttest.

The virtual dissection group ($n = 13$) came to the lab once a week for 5 weeks. Students came into the lab with a partner and had 1 hour to work with the software program. Research assistants read a researcher-prepared task analysis to guide participants through opening and navigating the software. The two research assistants then answered student questions throughout the virtual dissection sessions as needed. The software included features enabling removal of parts, addition or subtraction of layers, and access to information on labels as well as physiology or function of the structures.

Students ($n = 13$) participating in the laboratory dissection were prepared for the experience with a short explanation of the setting including what to expect to see, hear, and smell. They were given directions to the laboratory and procedures set forth by the kinesiology department were reviewed. All participants in the laboratory dissection group were required to wear clothing that covered their feet, legs, torso, and arms. Surgical gloves and laboratory goggles were supplied for students. Students in the laboratory dissection group met at the cadaver lab for five 1-hour sessions led by the researcher and research assistants. This group utilized the same study guide as the virtual dissection group on which to take notes during dissection sessions.

Finally, 2 days after the final sessions all participants took a posttest identical to the pretest along with a post-study questionnaire on perceptions of the experience (the Appendix). Students had 1 hour to complete this paper and pencil task —the same amount of time given for the pretest. Pre- and posttest scores were then compared to measure change in student knowledge following dissection experience.

Test scoring

Tests were scored by research assistants and confirmed by the researcher. Scores were agreed upon with inter-rater scoring at 98%. Pre- and posttest scores as well as participant demographics and participant perceptual responses were entered into a spreadsheet for subsequent analysis.

RESULTS

Results are presented according to the two research questions posed for this study. An alpha level of 0.05 was used to determine significance on statistical tests. Analysis of mean scores and participant perceptions are presented below.

Research question 1: test scores

The first research question inquired as to differences in test scores by group. Posttest scores for each group (virtual dissection and laboratory dissection) were compared. A repeated measure ANOVA was run with group as the between subjects factor and pre-/posttest as within subjects variables to compare the effect of dissection experience on posttest measures. The results of the ANOVA indicated that test scores were not significantly affected by the type of dissection experience, F (1, 24) = 0.531, P = 0.472. Mean scores on each section of the test as well as total scores are given for each group (Table 1). All participants showed improvement between pre- and posttest scores.

The laboratory dissection group gained (M = +21.41) points from pre- to posttest scores. The group scores improved on all three sections of the test with the largest improvement on the cartilage section of the test (M = +9.18 points). Scores on extrinsic muscles (M = +6.91 points) and intrinsic muscles (M = +5.32 points) also increased from pre- to posttest measures. In the virtual dissection group, scores improved overall between pre- and posttests (M = +20.74 points). Scores improved in all three sections of the test (extrinsic muscles [M = +6.35 points], intrinsic muscles [M = +5.88 points], and cartilages [M = +8.43]) for the virtual dissection group as well.

Research question 2: participant perceptions

The second research question inquired as to singer perceptions of benefits or drawbacks regarding the dissection experience. Following the posttest, participants responded in writing to a short questionnaire. Questions included benefits and drawbacks of the experience (either laboratory or virtual dissection). Response rate was 100% (N = 26).

Research assistants sorted the two responses by participants into exhaustive and mutually exclusive categories. The first set of categories organized all responses on benefits and the second on drawbacks. Reliability was calculated using the formula [agreements/agreements + disagreements] × 100. Agreement between observers was 96% for response analysis.

Laboratory dissection group perceptions The most frequent responses from participants in the laboratory dissection group with respect to benefits of the experience had to do with uniqueness of the experience. Those who mentioned a unique learning experience (n = 6, 23%) wrote such comments as “I was exposed to something I typically would not have been exposed to” and “many people don't get this kind of experience.” Participants also gave responses categorized as having to do with learning style (n = 2, 8%) such as "I am a visual learner so it was helpful to see the real thing.” Another comment category had to do with getting the opportunity to see the structure/get an inside view (n = 3, 12%). Comments in this category were those such as ”getting to actually see our instrument,” and “I had the opportunity to see a real larynx.” Finally, participants (n = 3, 12%) commented on overall knowledge (understanding, application, or transfer of knowledge), saying “it was great learning how the voice works,” “I was able to directly transfer my knowledge to something tangible,” and “I finally get to see how my instrument works, maybe I can help my technique now and develop a freer sound.”

Participants in the laboratory dissection group also commented on drawbacks of the experience. The main categories were difficulty seeing the structures (n = 8, 31%), aversion to the structure/space (n = 4, 15%), and not enough time (n = 3, 12%). Participants commented that it was overall “really gross!,” “the smell of the laboratory was difficult at times,” and “seeing part of a human being was off-putting at times.” In terms of difficulty seeing the structure, participants’ comments included “it was hard to see certain parts of the anatomy because they are too small” and “there were a lot of people trying to see one thing.” Finally, participant comments regarding time with the material included such things as “I would have loved to have spent more time on chunking the information of the anatomy of the larynx.”

Virtual dissection group perceptions Participants in the virtual dissection group completed the same questionnaire following the posttest. Categories of benefits included increased knowledge (n = 4, 16%), ease of use of software (n = 8, 31%), and overall interest in the topic (n = 3, 12%). Comments having to do with increase of knowledge included “I know way more now than I did before” and “I

TABLE 1.
Pre- and Posttest Scores by Group

	Extrinsic Muscles	Intrinsic Muscles	Cartilage	Total
Laboratory dissection group (*n* = 13)				
Pretest *M* (SD)	0.45 (1.44)	0.73 (1.80)	2.18 (3.30)	3.36 (5.96)
%	3.75	4.87	14.53	8.00
Posttest *M* (SD)	7.36 (3.90)	6.05 (4.41)	11.36 (3.66)	24.77 (8.93)
%	61.33	40.33	75.73	58.97
Difference (*M*)	+6.91	+5.32	+9.18	+21.41
Virtual dissection group (*n* = 13)				
Pretest *M* (SD)	0.46 (0.96)	0.31 (0.63)	0.69 (0.63)	1.46 (1.76)
%	5.52	2.06	4.60	3.47
Posttest *M* (SD)	6.81 (3.30)	6.19 (5.37)	9.12 (3.69)	22.12 (10.16)
%	56.75	41.27	60.80	52.67
Difference (*M*)	+6.35	+5.88	+8.43	+20.74

learned more about the muscles and functions without actually having to dissect." Ease of use of the software was another category. Comments in this category included "the software was not too difficult to use, and had plenty of detailed images and information," "when you click on something it tells you the function and shows different angles which is really cool," and "it allows us to view each component in its proper place in relation to other parts of the body. The layering tool allows for some perspective on location of each component." Overall interest in the topic included comments such as "you learn a lot about the muscles that help you sing" and "it's very interesting to learn how many different parts make your voice work."

Perceived drawbacks of participants in the virtual dissection group were divided into three categories (lack of visual clarity, time with material, and missing aspects of the software). Comments pertaining to lack of clarity ($n = 5$, 19%) included "it is sometimes hard to tell where the pictures are pointing to. I feel like I could get a better understanding with a hands on dissection," and "while the software allows real life views, a model or cadaver lets you see in three-dimension where each muscle is and how it articulates with others, a benefit not seen in the software." Participants who commented on time with the material ($n = 7$, 27%) provided such comments as "I didn't feel like I had enough time to really learn the material," and "I wasn't able to retain much knowledge based on the few sessions." The final category of drawbacks was missing aspects of software ($n = 5$, 19%), "software didn't describe functions, sometimes no function at all," and "a software with more description of functions would be helpful. Animation would also improve understanding," and "the software, though lacking in some detail, provides a great visualization of the placement of the muscles/bones and cartilages."

DISCUSSION

The major finding of this study is that 100% of participant test scores improved after dissection experiences. However, student knowledge was not different according to the particular dissection experience (virtual or traditional laboratory). Similar to the findings of this investigation, past research has also found no significant difference in student knowledge based on dissection mode.[9, 10] However, in Youngblut,[5] the virtual students scored higher. Participant perceptions differed and offer insight into the experiences for future research.

As mentioned, all participant scores increased from pre- to posttest measures. As very few of the participants reported prior knowledge of anatomy or physiology at the time of the study, this finding indicates some measure of growth. It is, however, uncertain whether or not this can be attributed to a particular experience. Participant perceptions indicate that knowledge was gained in both experiences; however, the difference on test scores between the two was negligible.

Results also indicate that student perceptions vary widely. Students offered feedback on perceived benefits and drawbacks. Participants expressed some frustration with clarity of both the software and the cadaver. Images of the human body are very complex. Furthermore, the intricacy of the human structure can make it extraordinarily difficult to differentiate between structures at times. Laboratory dissection requires great care and patience in dissecting the layers of the structures. As this study occurred over only five 1-hour sessions, time was short. Perhaps elongating the sessions or including more sessions could aid in devoting the time to more effectively separate and identify all structures. Furthermore, because the software only allowed students to see the parts of the body in layers, and those layers changed based on the position of the virtual body, locating specific parts of the larynx was difficult or not always possible.

Participant comments also indicated that laboratory dissection cadavers were sometimes difficult to see. Space in the laboratory was limited because of number of students, number of cadavers present, and number of student groups in the space. Participants gathered around a table to view and work with the cadaver. The table was approximately 1 × 3 feet in size. With 13 participants, this sized space limits the opportunity to get a "front row seat" around the cadaver at times.

Further, the size of the human structure without magnification can be difficult the see clearly. Finally, challenges finding and seeing structures of the body clearly are common in dissection. In terms of the larynx, for example, if a person was intubated, the vocal folds can be torn, damaged, or pressed against the sides of the trachea making them very difficult to see. Fewer participants and/or magnification of the cadaver may be employed in future research to ameliorate difficulty in clearly viewing the vocal structure.

As another possible solution, participants noted that combining the experiences would be most fruitful to learning. Past research has found that combining experiences lead to increased learning and better retention of knowledge.[11, 12] Future study might employ a combination of experiences and examine the results in preservice music teachers. The combination of experiences might clarify and reinforce anatomy and physiological concepts more effectively.

Even as separate dissection experiences, there were marked gains in participant scores of knowledge in this study. Increased laboratory experiences could lead to better understanding. Vocal music education students rarely, if ever, have the opportunity to see their instruments. As vocalists, we depend on pictures or diagrams to learn about the structure of the instrument. Some singers and teachers have the opportunity to witness a laryngeal scope, seeing an inside view of the voice in action. However, many vocalists and teachers never see the complete structure of a human voice. Cadaver dissection offers the opportunity to not only see the vocal folds but the entire structure. Therefore, dissection enables singers to understand the complexity of the instrument in a different way. Participants in the laboratory dissection in this investigation were also afforded the chance to see the entire abdominal cavity, including a diaphragm, lungs, heart, and other musculature. This inside view can enable deeper and clearer understanding of the instrument, and consequently, sound production while singing.

Participants perceived their understanding improved over 5 weeks. Some participants commented, however, that this amount of time was not enough to learn the material. Through a pilot study, it was determined that five sessions with dissection would be a reasonable amount of time to learn the basic anatomy and physiology of the larynx. However, many vocal pedagogy courses or cadaver dissection laboratories are conducted over the timespan of a semester. This amount of time may produce more successful and lasting results. Retention of information has been the focus of previous studies in science education. However, the retention of information was not measured in this investigation but would be an area of interest for future research with preservice music teachers.

Participants commented that they had a better understanding of the voice, but application to singing was not a primary focus of this study. Knowledge transfer is a pertinent step. For example, participants commented that they had a better understanding of the voice because of this experience. Comments such as "I was able to directly transfer my knowledge to something tangible" and "I finally get to see how my instrument works, maybe I can help my technique now, and develop a freer sound" were indicative of students intending transfer of knowledge gained from the dissection experience to their practice. Future research into application of knowledge attained during dissection to the vocal music classroom would be of interest.

There are many limitations to widespread availability of this type of program because of legal issues associated with human cadavers, funding, laboratory space, and scheduling. Therefore, virtual dissection through computer software offers a reasonable alternative without extensive limitations. Some virtual dissection participants expressed disappointment in not being able to feel the structures. Interestingly, more recent computer interfaces are incorporating a sense of touch (haptics). This technology is being used to help surgeons perform traditional surgery from a great distance from the patient.[27] Technology is also being developed to incorporate a sense of smell in computer interfaces.[28] Smell was a factor in the present investigation with a few participants remarking that the smell of the cadaver laboratory was more difficult to overcome than the visual aspects of the experience. These new technologies may bring two more bodily senses, touch and smell, in to use along with those of sight and sound currently incorporated into many computer programs. This type of technology would provide a very different virtual dissection experience to future research.

Voice education has evolved over the years and many preservice teacher preparation programs incorporate vocal pedagogy, anatomy, and physiology in their coursework. Students who learn about anatomy and physiology of the larynx can later offer their own students a greater understanding of the vocal instrument. For some students, this type of understanding can increase success in the act of singing. For example, understanding that muscles of the larynx grow and change over time, just as muscles in the rest of the body do, can help singers in transition understand feelings such as vocal instability, range changes, and timbre differences.

Although dissection of human cadavers has many inherent limitations, technology can make this type of experience more readily available to a wider population. Anatomical software programs are now readily available. Websites and other videos can also help students to understand the inner workings of the larynx and are often free of charge. Students learn with and through technology often and may benefit from this type of learning in regards to singing as well.

This type of experience may assist vocal educators, developing and current, in understanding vocal pedagogy and practice. This type of greater understanding can benefit students and teachers such that both can healthfully sing throughout their lives. Understanding the voice, respiratory system, and overall structure of the human body assists in fully educating teachers of efficient singers.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jvoice.2018.06.012.

APPENDIX

Participant Number:__________

Participant Questionnaire

Please circle the experience you participated in: **Dissection** **Software**

Name:____

Age:_________years Major instrument:__________________________________

Major and year in school: ____

Gender—Circle one: Male Female

1. How many years have you been in the following type of choirs? (i.e. 0-10)

Pre-K through 5th Grade Choir Participation: ____________years

6th through 8th Grade Choir Participation: ____________years

High school – college ____________years

2. How many years have you been in private voice lessons? (i.e. 0-10) ____________years

3. Describe your background knowledge, prior to or during this study, in anatomy and physiology of the larynx (include specific classes, instruction, texts, etc.)

4. Benefits of the experience:

5. Drawbacks to the experience:

6. Other comments:

Thank you for participating!

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