Augmented Dissection

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Abstract: Dissection has long been the primary method to gain greater insight into the structures and functions of the human body. It requires careful step-by-step analysis, retrieval of stored information, and spatial navigation to successfully explore our inner makings. Many facilities and campuses nationwide are not equipped for cadavers, and in particular, online laboratory settings are often devoid of hands-on dissection altogether. Anatomy 4D is an augmented reality (AR) mobile application that allows for human body exploration through enhanced dissection. Its application in laboratory settings may be a viable means of resolving hands-on dissection limitations. To investigate this idea, college anatomy students utilized the AR mobile application to dissect the heart organ in an action research study. Students performed activities individually, by creating personalized deliverables to share, and collaboratively, by contemplating connections through discussion. In better determining the impact of AR dissection in enhancing identification of human body structures among learners, pre and post assessments were conducted. Overall results indicated AR utilization for human organ exploration was positive with a marked increase of recognition after lesson activities and numerous indications of personal satisfaction from the use of mobile learning technology, constructivist design, and peer collaboration.

Introduction

Laboratory science courses in human anatomy allow students to more deeply realize topics in human anatomy via dissection, experiments, and hands-on work. In particular, dissection is of central importance as it has long been the primary method to gain greater insight into the structures and functions of the body. It requires careful step-by-step analysis, retrieval of stored information, and spatial navigation to successfully explore the human body.

As an anatomy instructor, dissection of dry models and non-human specimens is employed as an instructional strategy. A human cadaver is the pinnacle model in anatomical dissection and would offer the most insight; it has long been the standard in advanced clinical professional programs. However, many facilities and campuses

nationwide are not equipped for cadaver, and in particular, online laboratory settings are often devoid of hands-on dissection altogether. Challenges also exist with the use of scaled anatomical models that are bland and fixed in nature as well as wet specimens that are costly and require special handling for on-campus laboratory courses. In an attempt to help students not only learn human body parts through enhanced dissection but to encourage other viable technological means of human body exploration, the laboratory environment was selected to create an action research project. The purpose of this action research study was to determine the impact of augmented reality dissection in enhancing identification of human body structures among anatomy students at Kapiolani Community College.

Literature Review

The use of augmented reality (AR) technology has been previously reported as an useful aid to help increase motivation and spatial comprehension alongside independent studies for students studying anatomy (Ferrer-Torregrosa et al., 2015). Kucuck made positive comments to its application and benefits for anatomy learners upon receiving student emphasized feedback on how it "generated sense of reality and was beneficial for independent study by providing a flexible learning environment" (Kucuk et al., 2015). In his further studies, the mobile AR approach helped "abstract information become concrete, increase interest, and students learn anatomy topics better by exerting less cognitive effort" compared to students who did not supplement learning with mobile AR technology (Kucuk et al., 2016). AR based applications were also found to help with increased engagement of the visual senses for enhanced experience-oriented learning of visually oriented learners, as it attractively captured their attention, and required their greater interactivity (Von Jan et al., 2012).

AR applications have been found to serve as useful learning tools when used with existing teaching models and setups as well (Lewis et al, 2014). As a cognitive tool and pedagogical approach, "AR is primarily aligned with situated and constructivist learning theory," positioning learners for authentic inquiry, active observation, authoring of products, and reciprocal teaching (Dunleavy et al., 2013). A multimodal approach combining multiple resources, ranging from medical imaging to 3D visualization technology to computer based anatomical representations, that complement one another, may also enable learners to learn more effectively (Estai et al., 2016). One study found combining traditional dissection activities, such as viewing and identifying structures, with technological resources produced improved exam scores over traditional dissection activities only (Biasutto et al., 2006). Another study concluded coupling mobile AR application with collaborative active learning strategies conferred "greater efficacy in achieving a broad range of learning outcomes" (Prince and Felder, 2006).

Learners in anatomy education settings have responded favorably to such learning

strategies across multiple studies. Attitudinal questionnaires revealed increased learner engagement, clarity of dissection objectives, and achievement with mobile technology use (Mayfield et al., 2013). Additionally, positive enhancement and growth in laboratory skills, and attitudes towards science laboratories ensued upon implementing AR technology (Akçayır et al., 2016). From these overall findings, AR technology is a tool which anatomy educators can consider utilizing to create a stimulating learning environment in modern anatomy education. Furthermore, this action research project was designed to meld mobile learning technology, constructivist design, and peer-to-peer collaboration to bring about a learning space, which conducively optimizes learner pathways, towards precise recognition and deeper appreciation for the underlying structures and processes which imbue us all.

Project Design

After realizing a need to help anatomy learners overcome the limitations of facilities, cost, quality, and distance in online anatomy laboratory settings, a novel approach of executing dissection practices with flexibility and physical transcendence was sought. After reviewing the literature, it became evident that other researchers and practitioners advocated the use of mobile AR technology as a powerful tool in anatomy understanding, due to its growing favor and ubiquity. It also became clear that coupling multiple education resources in a focused learning strategy would offer the most benefit to learners, and more likely be effective. In light of these factors, an online dissection lesson integrating AR technology via a constructive learning approach was surmised as an ideal resolution to overcome limitations and allay concerns of all those invested. The e-Dissection lesson would allow learners to see the unseen anytime or anywhere, encourage active efforts in completing tasks, and foster intercommunication between peer learners.

A total of four mobile applications were reviewed: “Essential Anatomy Skeleton” by 3D4Medical, “Edulus VR” by Experiential Learning, “The Brain” by Harmony UK, & “Anatomy 4D” by DAQRI. Ultimately, Anatomy 4D was selected due to its total augmentation, high level of detail, zero cost, and content found therein that directly correlated to course-specific topics covered in the featured anatomy lab. Additionally, it covered all existing body systems and offered one specific anatomical model marker on the heart organ itself. After careful review, organs and structures were found to be easily discernable and proportionally accurate, screenshot capable, and lacking structure labels. This last requirement was of greater importance, as it would require learners to cross reference and selectively label visible structures on their own, allowing for higher cognitive processing over pre-labeled or given identifiers. Test runs with various mobile devices also demonstrated app functionality in both iOS and Android devices without issues.

With mobile application selection finalized, a lesson was designed that incorporates sensory experience and real time interaction with environment. The goal was to provide a learning experience that grabs their attention, enables structuring of their own knowledge, relates to them personally, and satisfies their desire to understand their own biological design on a deeper level. The lesson also encouraged multiple content creation avenues utilizing mobile and Web 2.0 photo editing and presentation tools to capture learner experience, annotate burgeoning thoughts, and colorfully share what they saw through their own eyes and mobile devices.

The college's existing learning management system, Sakai 10.7, was selected as the digital delivery medium and primary vehicle to state learning objectives, outline general procedures, and provide background reference within a weekly module (Appendix A). It also featured a convenient forum area which students could upload AR dissection presentations, access peer deliverables efficiently, and provide peer-to-peer feedback.

An overview demo presentation was developed (Appendix B) as a guide and made available in the same forum area students would be submitting dissection presentations. It provided background on assignment description and goals, methods, Anatomy 4D features, Google Slides tutorial, commenting guidelines, presentation examples, and conclusion with purposes. Assignment description and numbered list of instructions for the augmented dissection were formulated (Appendix C) and made available in the same forum area. Grading rubric on content and presentation areas were provided too (Appendix D).

In organizing assignment activities for easier digestion by learners, the assignment was designed to be completed in three phases: augmented dissection, presentation creation, and peer-to-peer feedback, sequentially. In the first phase, learners completed the dissection by taking screenshots of structures viewed with the Anatomy 4D application corresponding to a specifically assigned body system. The structures in the images were named and labeled. Google Draw and Skitch were recommended as labeling editors. In the second phase, slide presentations were generated containing previously annotated screenshots. Further information such as locational and physiological descriptors and clinical connections (role as landmark in procedure, common disorders) were required remarks in slides. Google Slides and Microsoft Powerpoint Online were recommended. In the third phase, learners posted shared links or directly uploaded presentations to a designated forum area for giving as well as getting feedback and reviewing other work. The assignment was designed to be completed within a timeframe of one week from the release date.

For the pre- and post-dissection tests and post survey, Google Forms was selected as the delivery system to create separate pretest, posttest, and post survey. It was chosen because of its ease of accessibility and usablity with a high variety of question and

answer options. Correct answers to posttest questions were provided for immediate feedback only. The data from each of the forms was converted to Google Spreadsheets for further analysis.

Data was analyzed using descriptive statistics and organized into common themes and areas when possible. Means of individual responses and grand means for five pre-determined post survey inquiry areas: Engagement, Effectiveness, Benefits, Usability, and Learning Spaces, were calculated and compared. Comments drawn from open-ended responses were analyzed for commonalities. Tests were compared based on correct response percentages, and the survey was analyzed in better determining the impact of AR dissection activities to enhance understanding and confidence in related human anatomy and physiology.

Methods

A total of 39 adults participated in this study (Table 1). It consisted of 33 females and 6 males, all above the age of 18 with the largest group between the ages of 18-25 (41%). Majority of participants were also undergraduate (77%) in regards to educational level and represented diverse ethnicities including Asian (46%), Mixed; Other (31%), Caucasian (18%), and Native Hawaiian/Pacific Islander (5%). All participants were actively registered college students.

Table 1.

Participant Age, Education Level, Ethnicity, & Gender

Characteristic	Number	Percentage
Age		
18-25	16	0.41
26-30	8	0.21
31-40	13	0.33
41-50+	2	0.05
Education		
Undergraduate	30	0.77
Graduate	1	0.03

Post-Baccalaureate	6	0.15
Undeclared	2	0.05
Ethnicity		
Asian	18	0.46
Caucasian	7	0.18
Native Hawaiian/Pacific Islander	2	0.05
Mixed; Other	12	0.31
Gender		
Male	6	0.15
Female	33	0.85

Participants were notified about their participation in the project one week prior to the augmented dissection lab via an email announcement (Appendix E). Students received instruction on dissection content via an online lesson module (Appendix A) which outlined activities to be completed in sequence. For those who would participate in the study, the pretest was to be completed prior to required augmented dissection activities and followed up with a posttest then post-survey, afterwards. A total of 57 individuals were invited to participate with up to 39 responding to study assessments.

Prior to beginning the pretest, participants were required to agree to the terms of the consent form (Appendix F). The consent form contained information about activities and time commitment, benefits and risks, confidentiality and privacy, voluntary participation, and researcher contact information. Participants were also informed that completed tests and surveys would be considered their consent to participate in the study.

Links were provided in the module for direct access to all study related assessments as well as a referencing to a required e-Dissection forum. By clicking the link, participants were provided direct access to an external form. Data from submitted forms were automatically aggregated into individual Google Spreadsheets via Google Forms. The pre and post tests (Appendix F) consisted of identical 15 multiple choice, picture questions derived from five main sources. They included visuals from Anatomy 4D, photographic atlas images, cadaver images, anatomical models, and hand-drawn illustrations. Three questions were presented in each of these sourced areas. The post-survey (Appendix G) consisted of 50 questions scaled attitudinal questions and 8 open-ended response questions. Each area contained approximately 10 questions.

Demographic information and dissection experience was also included as part of the survey.

Responses were required for all questions in all three assessments with the exception of open-ended questions in the post-survey. Failure to complete a test or survey of its required entirety prevented the participant from submitting the form. Once forms were submitted, participant identifiers were discarded to maintain anonymity during data aggregation.

Results

To assess participant anatomy qualifications and technology backgrounds, participants were initially asked questions regarding previous anatomy course experience and use of general augmented and educational mobile applications. Post-survey analysis revealed all 39 participants (100%) had taken at least one anatomy course before with the majority, 30 participants (77%), having little to much prior dissection experience. As shown in Figure 1 below, 14 participants (35.9%) had little or much prior experience using AR technology compared to the larger majority of 25 participants (64.1%) who had never utilized AR technology.

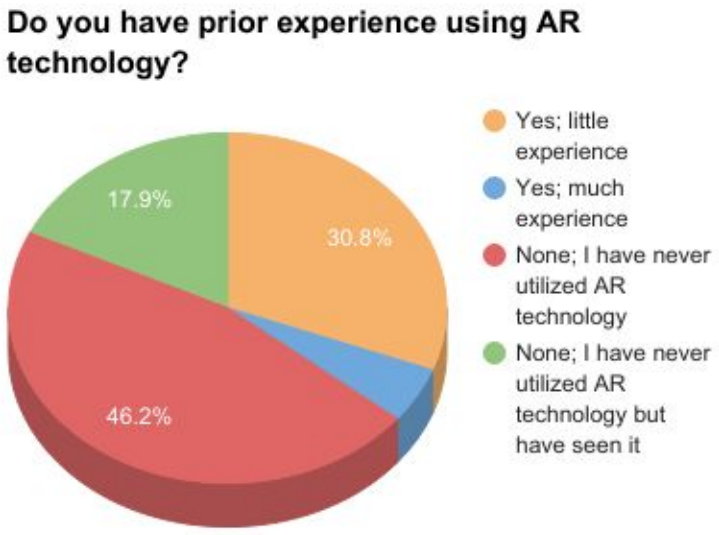

Figure 1. Post survey question regarding prior AR technology experience.

In Figure 2 below, 11 participants (28.2%) had little experience using other apps for human body visualization compared to the larger group of 22 participants (56.4%) who had never utilized an anatomy mobile application or the 6 participants who only utilized other study applications (15.4%).

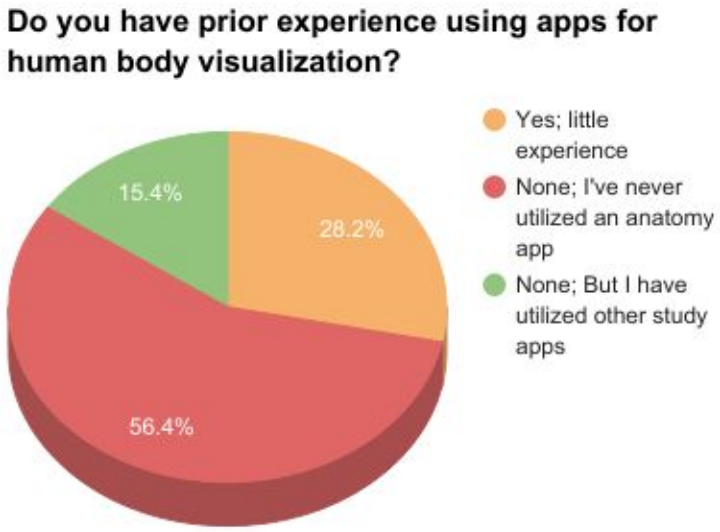

Figure 2. Post survey question on prior human body visualization experience.

Participants were asked which area they felt most improved after augmented dissection (Figure 3). Responses were open-ended and categorized into four common response areas that became evident upon analysis. Of those who responded, 12 out of 24 answering participants (50%) felt organ knowledge was most improved followed by 8 participants (33%) in identification & visualization followed by 2 participants (8.5%) each in both navigational capabilities and technology skills.

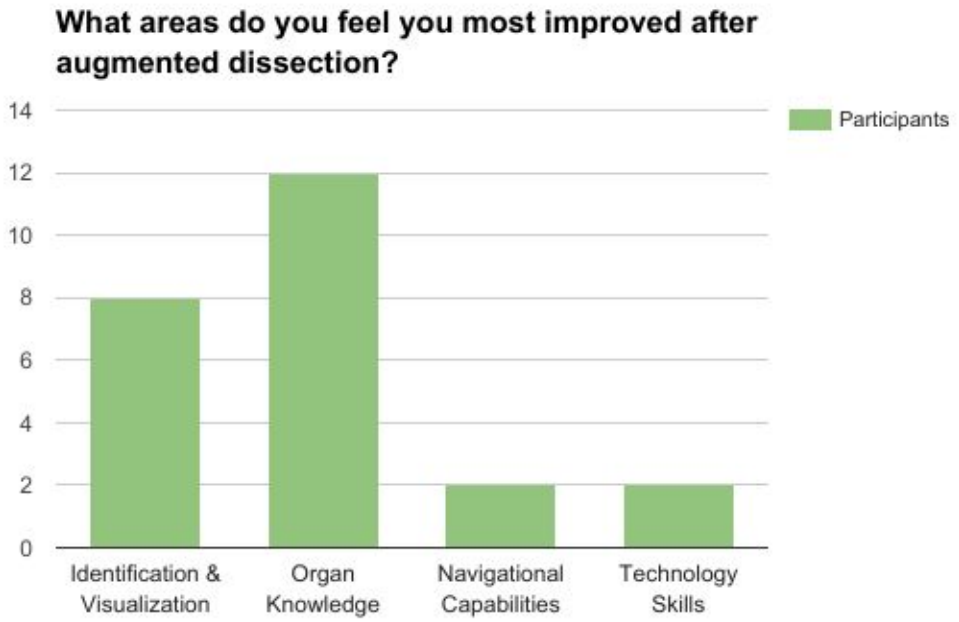

Figure 3. Post survey question gauging user's satisfaction with the experience of using a web-based lesson module.

In better determining what specific factors lead to improvements in perceived areas, participants were asked to state improvement factors. Responses were again open-ended and sorted into common response areas after analysis. The area with the highest attribution was augmented modeling with 12 out of 31 answering participants (39%) which was a positive indication. It was trailed by coupling resources (16%), mobile access (13%), time and repetition (13%), observation and feedback (9.5%), and creating presentations (9.5%).

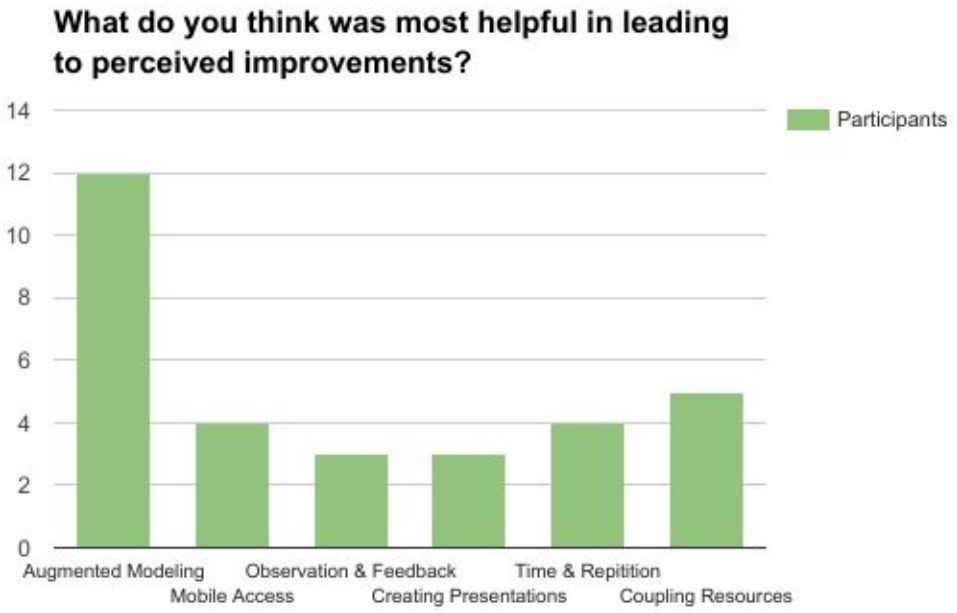

Figure 4. Post survey question gauging user's experience in utilizing aides that supported successful augmented dissection activities.

To determine which dissection format participants would choose should they be given the choice, 13 out of 39 participants (33%) selected traditional closely followed by 12 participants (30%) selecting combination, 8 participants (20%) selecting augmented, 6 participants (15%) selecting picture, and 1 participant (2%) selecting observation only.

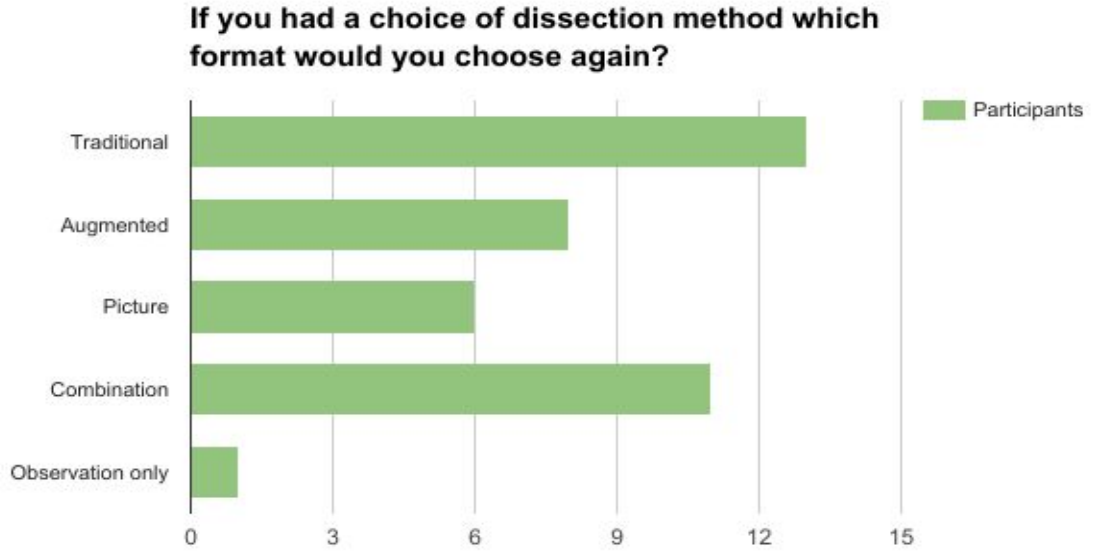

Figure 5. Post survey question gauging user's satisfaction with the experience of undertaking a web and mobile-based augmented dissection.

A number of factors can be attributed to the participants' satisfaction with the experience of performing AR dissection. For this study, a total of five categories were assessed: Engagement, Effectiveness, Benefits, Usability, and Learning Spaces (Figure 6). The grand means of each category exceeded 3 on a 5-point Likert scale (1 = Not at all, 5= Very much) indicating a positive learner experience. The highest result was Benefits with a grand mean of 4.1, while the lowest result was Effectiveness with a 3.21.

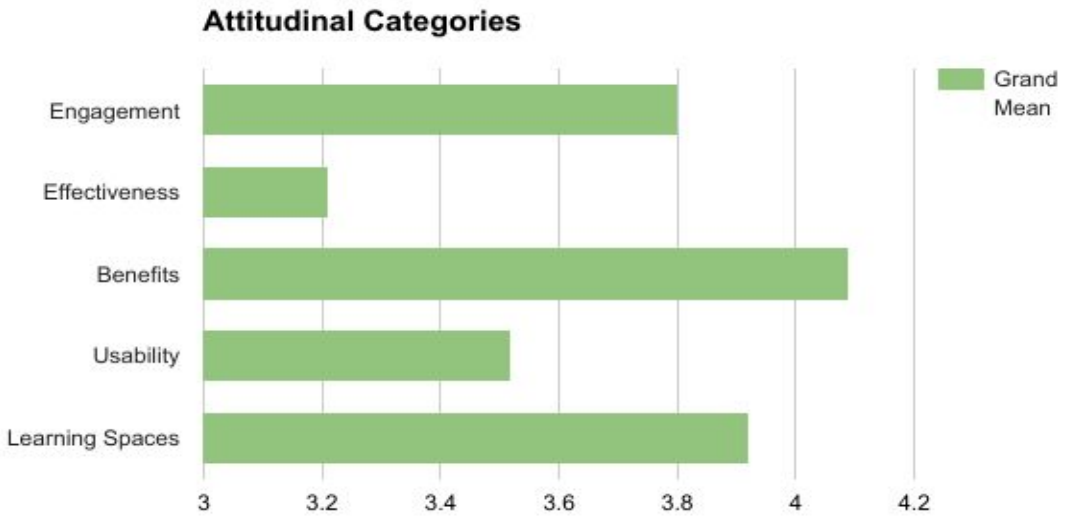

Figure 6. Grand means for the five categories of the attitudinal post survey.

The five categories are further examined in Table 2. Each of the categories consisted of five to eleven elements. Dissection of the categories reveals an explanation for the lower grand mean for Effectiveness. Participants were overall neutral about the statement, "I think augmented dissection was more engaging than traditional dissection," with a score of 3.05. The comparatively high response for Benefits can be attributed to 33 participants selecting "Much" and "Very Much" for a mean of 4.49 in response to the statement "Having materials in various formats."

Table 2. Post-Survey Attitudinal Results and Grand Mean (GM) Scores.

Item: 5 point Likert Scale	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean
Engagment						**GM=3.80**
I was comfortable with the augmented dissection.	3	2	9	10	15	3.82
What I needed to do for the augmented dissection was clear.	1	3	10	9	16	3.92
I enjoyed working in the augmented dissection lab class.	4	2	10	8	15	3.72
I was satisfied with the format of the augmented dissection.	4	1	11	8	15	3.74
I think the augmented dissection was effective.	3	2	12	11	11	3.64
I think the augmented dissection was efficient.	2	2	11	12	12	3.77
I think the augmented dissection was engaging.	2	1	9	10	17	4.00
Effectiveness						**GM=3.21**
I think the augmented dissection was more motivating than a traditional dissection.	5	8	9	10	7	3.15
I think the augmented dissection was more engaging than a traditional dissection.	5	8	11	10	5	3.05
I think the augmented dissection was more effective than a traditional dissection.	5	7	10	11	6	3.15
I think the augmented dissection was easier than a traditional dissection.	3	4	10	11	11	3.59
I learned more in the augmented dissection than a traditional wet specimen disseciton.	7	3	13	10	6	3.13
Benefits						**GM=4.09**
Working at my own pace.	0	0	6	10	23	4.44
Having materials in various formats - video - text - web.	0	1	5	7	26	4.49
Having the ability to see structures and capture them as images or recording.	0	0	7	11	21	4.36
Having more class time to work with my group.	3	1	14	9	12	3.67
Having the instructor help with our projects in class.	1	2	14	9	13	3.79
Having time to reflect on my learning.	1	1	12	10	15	3.95
Not having to wear gloves, use tools, make physical cuts, and poke around a real physica	4	2	9	3	21	3.90
Usability						**GM=3.52**
Obtaining a mobile device to utilize the Anatomy4D app was effortless.	6	3	2	4	24	3.95
Downloading the Anatomy4D app was effortless.	3	3	5	3	25	4.13
Getting familiar with the Anatomy4D app was effortless.	5	9	4	7	14	3.41
The user interface and touch controls for Anatomy4D were effortless.	5	6	6	9	12	3.36
The organs and structures seen in the Anatomy4D app were more detailed than those se	7	3	15	3	10	3.08
Absence of tactile stimulation and sensory input was uncomplicating.	5	5	14	4	11	3.28
Spatial navigation within an augmented environment on a mobile device screen was effor	4	4	14	5	12	3.43
Viewing augmented organs and structures on a mobile device screen was effortless.	4	4	9	7	15	3.64
Ability to accurately realize correct proportions of structures relative to each other was tro	2	3	14	8	12	3.64
Augmented dissection, presentation, and peer-sharing allow you to ask questions or get	8	3	14	4	10	3.13
The step-by-step procedures for the augmented dissection laboratory were straightforwa	4	4	8	6	17	3.72
Learning Spaces						**GM=3.92**
Anatomy 4D app was useful	1	2	10	10	16	3.97
Recommended resources (textbook, atlas, etc) were useful	0	0	9	9	21	4.31
Presentation creation was useful	2	1	15	8	13	3.74
Personal annotation/reflection was useful	2	1	14	9	13	3.77
Peer sharing and feedback was useful	2	2	12	10	13	3.77
Sharing your work in Laulima Discussion was useful	1	2	11	11	14	3.90
Seeing other group work in Laulima Discussion was useful	1	2	9	12	15	3.97

In order to measure the impact of AR dissection, a pretest was to be taken prior to dissection activities to establish an initial reading. The results were then compared to a posttest that was taken after completing dissection work. Both tests contained identical questions and content. Figure 7 below shows the results.

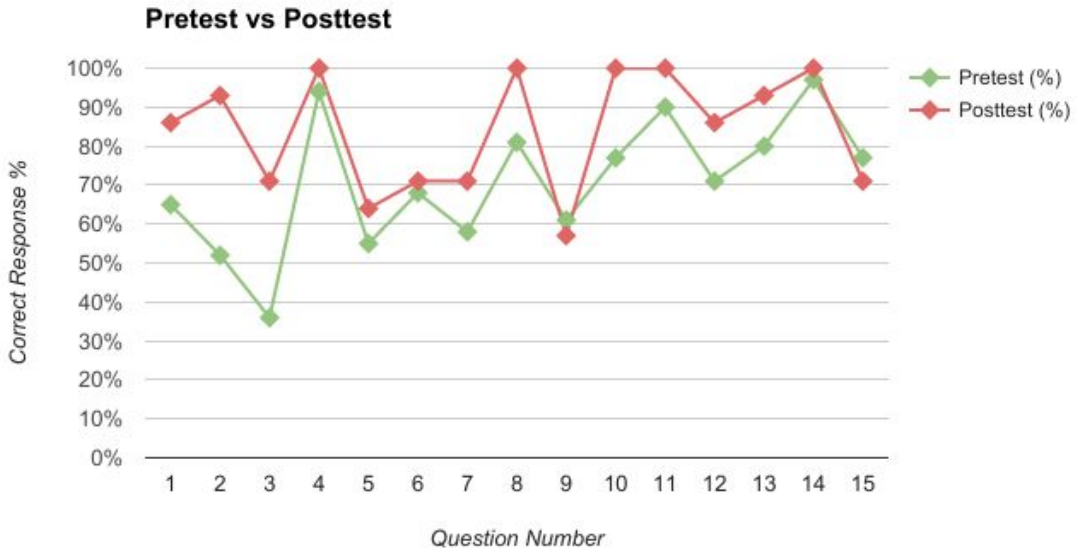

Figure 7. Pretest vs. posttest grades (%).

31 participants completed the pretest resulting in a 71% mean score, and 39 participants completed the posttest resulting in a 82% mean score. Participants overall scored higher on the posttest after dissection activities with the exception of question number 9 and 15. Greatest gains were observed in two question areas, augmented visuals and anatomical models, with the largest increase from 52% to 93% on question 2 and a moderate increase from 77% to 100% on question 4, respectively. Five posttest questions were perfectly answered by all participants.

Discussion and Conclusion

Dissection is an essential method of study and application of human anatomy and physiology. The learning process of dissecting involves tactile, spatial, and visual cues which better enables us to recognize and navigate all vertebrate morphology. The augmented dissection process sought to emulate those traditional learning cues through the use of an AR mobile application which re-animated the human body. Its goal was to allow learners to distinguish and differentiate anatomical organs, regions, and structures in the human body, similar to activities performed in a live dissection lab.

Findings from this study suggest traditional dissections are still touted by many due to a more highly perceived degree of connection to the human senses, especially in the areas of visual and tactile feedback. Anatomy 4D lacked sufficient spatial detail for some but

participants commended the platform in allowing them to recognize and identify the larger, major structures with greater ease in shared presentations and solidifying images seen in other texts. Overall, Anatomy 4D is a strong complementary resource to enhance learning strategies. Majority of participants made comments that Anatomy 4D was a beneficial aide, but its learning power was better realized by teaming it with other learning tools and strategies within a purposed learning package rather than by itself alone. Though it may not be a one-all solution for entirely replacing dissection, its capability as a potent learning tool and visual-spatial mobile learning application enable it to be a viable learning platform. Online learners may particularly benefit from its integration with learning strategies due to the prevalent scenario in which dissection activities are often absent altogether in distant e-learning environments.

In the area of instructional design, students particularly commented the ability to work at their own pace with mobile access, see from multiple perspectives, and share their personal findings with feedback from peers, was conducive to increased motivation and innovative. The practice of dissection - analysis, referencing, and review - is often performed independently within the cognitive and psychomotor learning domains. Thus, the novel approach employing constructivist and peer-to-peer efforts seems to have positively affected their attitudes regarding the dissection experience, while also providing further reinforcement for activities involving other learning domains.

Augmented dissection also did seem to allow for transfer of human body identification skills to other areas (i.e. printed illustrations, photographs, physical models, organs *in situ*) equal or better than traditional dissection. A content related concern regarding two posttest questions in which correct response percentage decreased by four and six points compared to the pretest did arise. Upon examination, this decrease may likely be attributed to the fact that specific content therein had yet to be covered in the semester.

Modifications to instructional aspects to further enhance learner benefits are planned. The first is the implementation of a specific structural identification list to ensure pivotal structures were being identified. A synchronous workshop session to help students overcome barriers of physical absence and provide “just-in-time” information for successful utilization of Anatomy 4D and presentation creation is also planned as a foundational dissection segment. Storification of dissection to arouse learner curiosities and promote investigate mindsets in this science based laboratory will also be considered.

In conclusion, by providing a structured dissection lesson module integrating AR technology, anatomy learners can be better prepared to distinguish and describe human body structures. The potential rewards of lucid visualization, proper scaling, and accurate navigation during enhanced human body exploration for anatomy learners everywhere is immense with the right tools, strategy, and instructional delivery. Further exploration is vital to the progression of anatomical studies in academic settings in this modern age.

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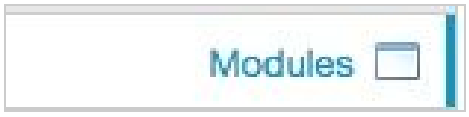
APPENDIX A
Lesson Module



M1: Cardiovscular & Endocrine Labs
Heart Dissection

Learning Objectives

- Describe major functions and processes of heart chambers, major arteries and veins, coronary circulation

- Identify and describe gross & microscopic of the heart organ, contraction phases, and integral role in circulatory system

- Envision clinical scenarios in which real heart dissection and identification may be significantly relevant (open-heart surgery, coronary bypass, aortic stent, EKG reading, etc.)

- See the unseen via augmented learning technology in place of hands-on organ dissection

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Dissection Procedure

1.) Complete voluntary pre-dissection test *prior* to beginning assignment to check your current understanding

2.) Download app - Anatomy4D [see forum]

3.) Take screenshots; label and edit screenshots in Skitch app or upload to web based editor such as Google Draw

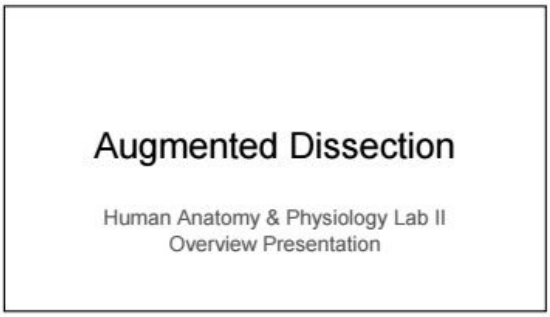
4.) Create final dissection deliverable with web tools [Powtoons, Slides, Piktochart, Voicethread etc.] by Sunday, February 12, 11:59 PM.

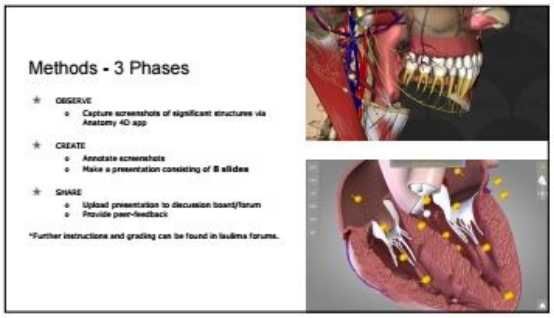
5.) Upload a shared link to your final deliverable to Virtual dissection forum by Sunday, February 12, 11:59 PM.

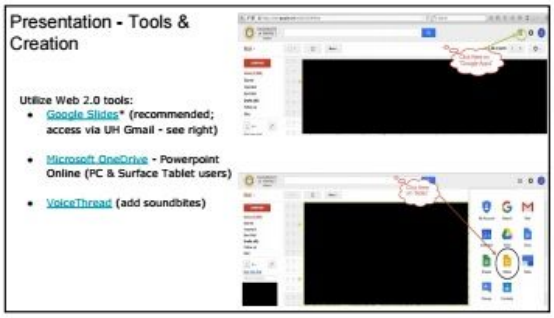
5.) Respond to **two** peer dissections and provide feedback on perspectives gained, shared, or expanded by Sunday, February 12, 11:59 PM.

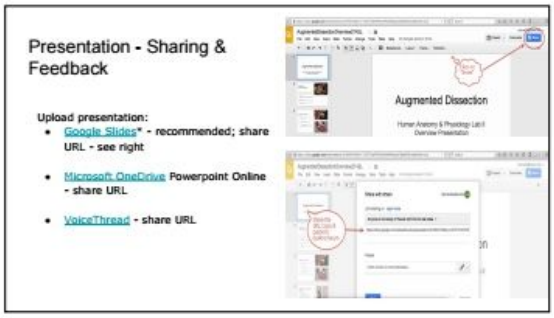
6.) Complete voluntary post-dissection survey and post-dissection test by Sunday, February 19, 11:59 PM

APPENDIX B
Overview Presentation









Presentation - Sharing & Feedback

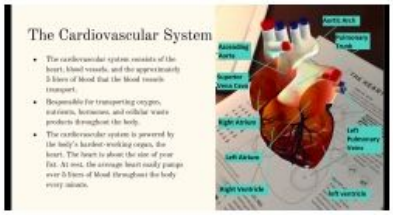
Comments should be:

- Critical and constructive
- Offering an outside perspective; furthering the argument
- Agreeing/disagreeing in professional fashion

Consider utilizing:

- "I heard, I saw, I wondered..." comment approach

Models & Examples



Google Slides

Models & Examples

Microsoft OneDrive Powerpoint Online

- ★ Construction of new knowledge - learning by synthesizing, creating, and collaborating actively
- ★ Research Study Participation (Voluntary)
  - o Pre- and post-dissection Quiz (15 questions, 15 minutes)
  - o Post-dissection Survey (50 questions, 20 minutes)
- ★ Explore, discover, and enjoy - Remember, it's all about Your very own human body... Know thyself to the benefit of your family, friends, and future generations to come.

APPENDIX C
Assignment Directives

Description: Dissection is an essential method of study and application of human anatomy and physiology. The learning process of dissecting involves tactile, spatial, and visual cues which better enables us to recognize and navigate all vertebrate morphology. This virtual dissection will seek to emulate those traditional learning cues through the use of an augmented reality mobile app which re-animates the human body. It will allow you to distinguish and differentiate anatomical organs, regions, and structures in a human body similar to activities performed in a live dissection lab.

INSTRUCTIONS:

PREPARATION & TOOLS

1. Download and install Anatomy 4D app by Daqri development to your personal mobile device (phones, tablets) from Google Play Store or Apple App Store; no costs involved
2. Print paper markers for recognition with Anatomy 4D app directly from web link or within mobile app by selecting "Target Library" from in app Menu list

AUGMENTED DISSECTION

1. Open Anatomy 4D app and aim your mobile device's camera at paper marker of human body outline
2. Click on the bottom right screen to toggle different systems and male/female configurations; move your device or paper marker to change positioning and navigate image
3. Identify all renal/urinary system structures visible and compare to atlas as needed
4. Capture TWO screen shots of prominent renal/urinary system structures (i.e. bladder, ureters, renal artery/vein, adrenal glands)

5. Capture THREE screenshots of structures related to systems discussed this semester in Z142L (i.e. respiratory, immune, digestive, reproductive)
6. Capture TWO screenshots of cardiovascular/heart structures by utilizing second cardiovascular paper marker

PRESENTATION

1. Annotate and edit screenshots (SEVEN total) by drawing, circling, highlighting, pinpointing all recognizable structures in each screenshot; consider MS Paint, Google Draw, Skitch, etc.
2. Insert all screenshot images into a presentation format; consider MS Powerpoint, Google Slides, iMovie, Voicethread
3. Provide details on physical characteristics, functions, clinical connections, personal insights on slides in text, audio, or video; bullet points are helpful
4. Create a minimum presentation of **8 slides** = 1 Introduction slide + 7 screenshot slides

SHARED FEEDBACK

1. Upload completed slide presentation to this Virtual Dissection forum in a single posting; give your posting a creative title
2. Paste the shared URL (Google Slides, Voicethread, etc.) or attachment (Powerpoint, iMovie) in your posting
3. Review two peer presentations and provide feedback on their personal augmented dissection insights
4. Provide critical, constructive, communal comments throughout your responses

APPENDIX D
Grading Rubric

CONTENT

	LEVEL 4	**LEVEL 3**	**LEVEL 2**	**LEVEL 1**
Identification of the Main topics	Identifies and understands all of the structures and functions	Identifies and understands most of the structures and functions	Identifies and understands some of structures and functions	Identifies and understands few of the structures and functions
Analysis of the related Anatomy & Physiology	Insightful and thorough analysis of all the A&P involved	Thorough analysis of most of the A&P involved	Superficial analysis of some of the A&P involved	Incomplete analysis of the A&P involved
Comments on further connections and identifies strategies	Well documented, reasoned and pedagogically appropriate comments about structural locations, use of anatomical directional terms and further connections (clinical, health, career, scientific)	Appropriate, well thought out comments about structural locations, use of anatomical directional terms and further connections (clinical, health, career, scientific)	Superficial and/or inappropriate solutions to some of the A&P involved in the dissection	Little or no action suggested, and/or inappropriate terms throughout the dissection
Links to Course Readings and Additional Research	Excellent research into the issues with clearly documented links to class (and/or outside) resources	Good research and documented links to the material reviewed	Limited research and documented links to any resources	Incomplete research and links to any resources

PRESENTATION

	LEVEL 4	LEVEL 3	LEVEL 2	LEVEL 1
Delivery and Enthusiasm	Very clear and concise flow of ideas. Demonstrates passionate interest in the topic and engagement with the class.	Clear flow of ideas Demonstrates interest in topic and engagement with the class.	Most ideas flow but focus is lost at times Limited evidence of interest in and engagement with the topic	Hard to follow the flow of ideas. Lack of enthusiasm and interest.
Visuals	Visuals augmented and extended comprehension of the issues in unique ways	Use of visuals related to the material	Limited use of visuals loosely related to the material	No use of visuals.
Response to Class Queries	Excellent response to student comments and discussion with appropriate content supported by learned A&P knowledge and research	Good response to class questions and discussion with some connection made to learned A&P knowledge and research	Satisfactory response to class questions and discussion with limited reference to learned A&P knowledge and research	Limited response to questions and discussion with no reference to learned A&P knowledge and research
Technology Tools	The individual chose technology tools that best illuminate the concepts/chal-lenges laid out in the dissection. These tools serve as a model for how these challenges were met	The individual chose technology tools that more than adequately illuminate concepts/challenges laid out in the dissection	The individual chose technology tools that are satisfactory with the concepts and challenges laid out in the dissection	The individual chose technology tools that minimally connect or do not connect with the concepts and challenges laid out in the dissection

APPENDIX E
Study Announcement

January 30, 2017

Aloha A&P Learners,

Welcome to Human Anatomy & Zoology course here at the University of Hawaii Kapiolani Community College campus. We're off to a great start this semester now that we've introduced the course and got you settled with your new A&P friends whom you'll be working closely with this Spring 2017 semester. It's also a special time for this particular time around as I will be conducting an action research study on A&P learning strategies as a master's candidate in the department of Learning Design & Technology at the University of Hawaii Manoa.

I would appreciate your assistance with this research project on the impact of augmented dissection practices in anatomy and physiology education. The results will be presented at a global learning technology conference this April 2017 and help educational practitioners gain greater perspective on employing new learning technologies in academic settings. This research will help me understand how information presented in augmented environments combined with constructive learning and peer feedback strategies can better prepare students for identification of human body structures and processes in real world settings and propel them towards greater joy in realizing the ins and outs of our amazingly intricate yet organized human body. Moreover, the virtual and augmented visuals that are computer generated for study will be compared to traditional methods of human body exploration which may allow for greater spatial and tactile sensory perception and inputs.

Should you decide to participate in our first laboratory dissection in week three, all you need to do is complete a questionnaire and two quizzes which should take approximately 50 minutes total. If you do not wish to participate, you are still required to complete the dissection assignment by creating a presentation of your augmented dissection which you will annotate and share with your peers for feedback as well as an individual worksheet. However, you may disregard the quizzes and questionnaire. Responses will be completely anonymous and your name will not appear anywhere on research items.

If you have any questions regarding the research, contact me via my contact information below or catch me in person after lab. If you have any questions regarding your rights as a research participant, you may also contact the UH Human Studies Program at 808-956-5007 or uhirb@hawaii.edu

Sincerely,
J. Jeong

APPENDIX F
Dissection Pretest and Posttest

Augmented Dissection - Pre Quiz

My name is Joshua Jeong and I am a UH Manoa Learning Technology graduate student conducting a research project. The purpose of my research study is to evaluate the impact of augmented dissection laboratory activities in better understanding human body systems in distance learning courses. You are being asked to participate in this project because you are at least 18 years old and you are enrolled as an Anatomy & Physiology student at Kapiolani Community College.

Activities and Time Commitment: If you decide to take part in this project, you will be asked to fill out a pre- and post-dissection quiz and survey. The quiz and survey questions are mainly multiple choice. However, there will be a few questions where you may add an open-ended response. Completing a quiz will take approximately 15 minutes and the survey 20 minutes. It is expected 20 people will take part in this project.

Benefits and Risks: Your feedback is valuable. The findings from this project may help create a better understanding of how augmented technology is perceived by A&P students to further improve A&P courses. The benefits of your participation may include increased awareness of virtual and augmented technologies in learning spaces, realization of constructive learning processes in enhancing information retention, and understanding of personal learning styles and habits. However, I cannot guarantee that you personally will receive any benefits from this research. There is little risk to you in participating in this project.

Confidentiality and Privacy: I will not ask you for any personal information such as your name or address. Please do not include any personal information in your survey responses.

Voluntary Participation: You can freely choose to take part or to not take part in this survey. There will be no penalty or loss of benefits for either decision. If you do agree to participate, you can stop at any time. Additionally, your decision whether or not to participate will not affect your relationship with the instructor and Kapiolani Community College. Grades or class standings will not be affected upon participation or declining to participate.

Questions: If you have any questions about this study, please call or email me: Joshua Jeong, M.S. 808-734-9264, joshua30@hawaii.edu. If you have any questions about your rights as a research participant, you may contact the UH Human Studies Program at 808-956-5007 or uhirb@hawaii.edu. AB

Accessing Quizzes & Survey: Pressing the links provided will take you to the respective quizzes and survey and instructions for completing it. Completing the quizzes and survey will be considered as your consent to participate in this study.

Mahalo for your time and participation.

Your email address (**joshua30@hawaii.edu**) will be recorded when you submit this form. Not **joshua30**? Sign out
* Required

Screenshots

Augmented Dissection - Post Quiz

Quiz Purpose: Evaluating the impact of augmented dissection laboratory activities in better understanding human body systems and the connections that exist between structures and functions.

Please fill out this post-dissection quiz which will take approximately 15 minutes and share your thoughts. Your feedback is voluntary and will be kept confidential. Be assured that the data collected will be handled with the required level of confidentiality and all data will be aggregated.

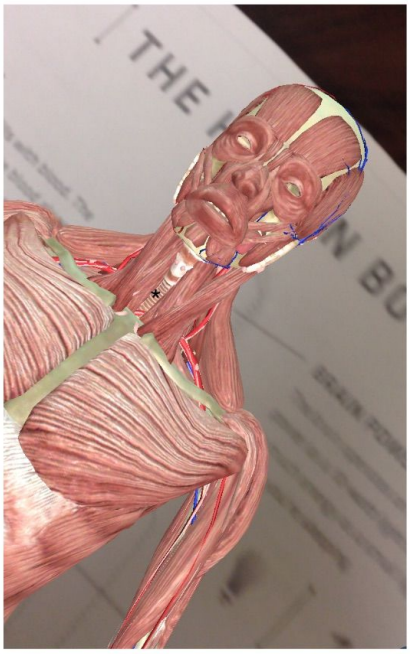
This quiz is closed book - outside texts and resources should not be referenced during the completion of this quiz.

Your email address (**joshua30@hawaii.edu**) will be recorded when you submit this form. Not **joshua30**? Sign out
* Required

Screenshots

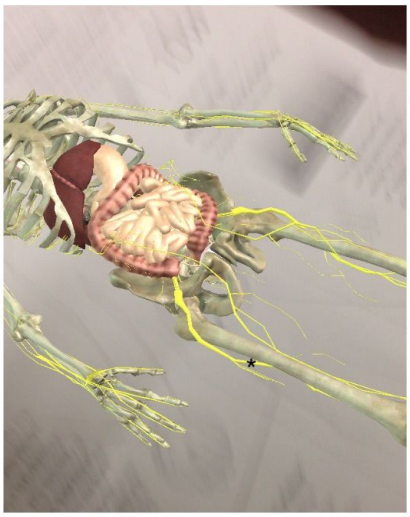
1. **Identify the system to which the marked structure below belongs.** *
   Mark only one oval.

   - ◯ Cardiovascular
   - ◯ Lymphatic
   - ◯ Respiratory
   - ◯ Urinary



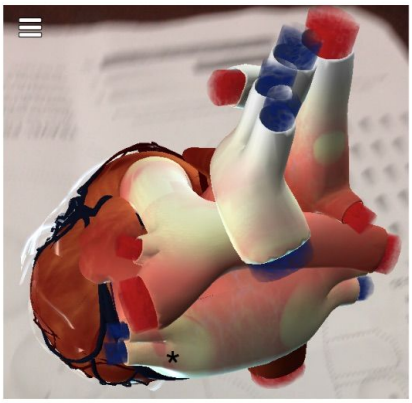
2. **Identify the system to which the marked structure below belongs.** *
Mark only one oval.

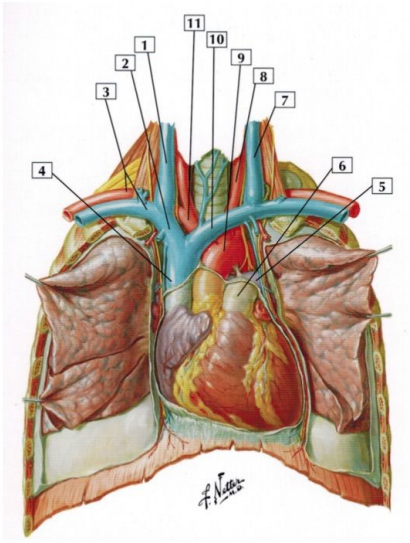
- Muscular
- Integumentary
- Nervous
- Skeletal



3. **Identify the structure marked below by the asterisk.** *
Mark only one oval.

- Ventricle
- Aorta
- Pulmonary Veins
- Seminlunar Valves





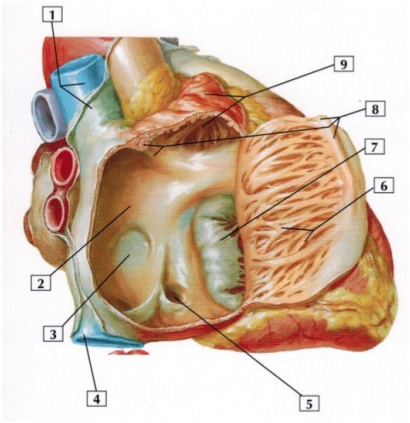
Illustrations

4. **Identify the system that structure marked below (#1) belongs.** *
Mark only one oval.

- Cardiovascular
- Lymphatic
- Nervous
- Urinary

5. **Identify the structure marked below (#7)** *
Mark only one oval.

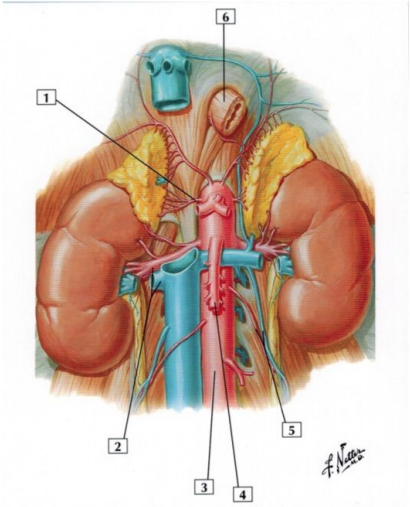
- Atrioventricular Valve
- Superior Vena Cava
- Pulmonary veins
- Interventricular Septum



6. **Identify the system to which #6 below belongs** *

Mark only one oval.

- Respiratory
- Reproductive
- Cardiovascular
- Digestive

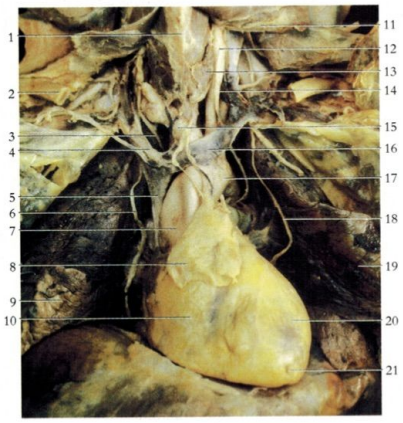


Organs

7. **Identify the structure marked below as #7.** *

Mark only one oval.

- Aorta
- Pulmonary Trunk
- Pumonary Veins
- Superior Vena Cava



8. **Identify the structure marked below as #9.** *

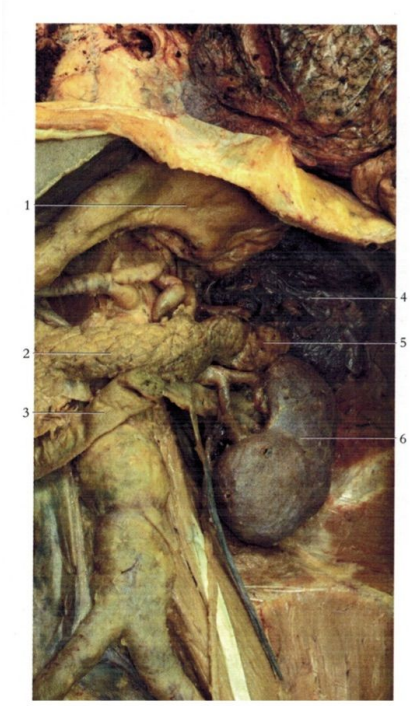
Mark only one oval.

- Trachea
- Esophagus
- Bronchus
- Aorta

9. **Identify the system marked below as #5.** *

Mark only one oval.

- Digestive
- Urinary
- Lymphatic
- Endocrine
- Muscular



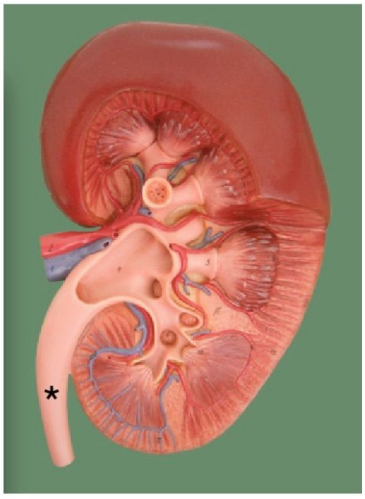
Anatomical Models

10. **Identify the system to which the marked structure below belongs.**
Mark only one oval.

- ◯ Digestive
- ◯ Respiratory
- ◯ Urinary
- ◯ Nervous
- ◯ Reproductive

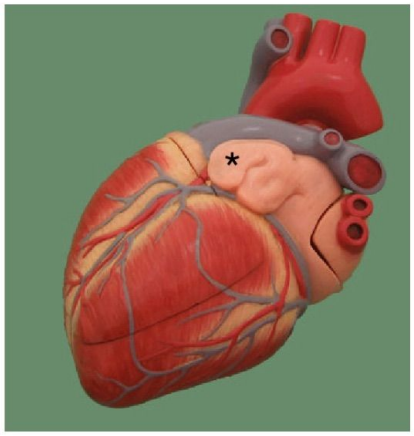
11. **Identify the structure marked by the asterisk below.**
Mark only one oval.

- ◯ Colon
- ◯ Pancreas
- ◯ Fallopian Tube
- ◯ Ureter
- ◯ Esophagus



12. **Identify the structure marked by the asterisk below.**
Mark only one oval.

- ◯ Atrium
- ◯ Ventricle
- ◯ Cornary Sinus
- ◯ Vena Cava

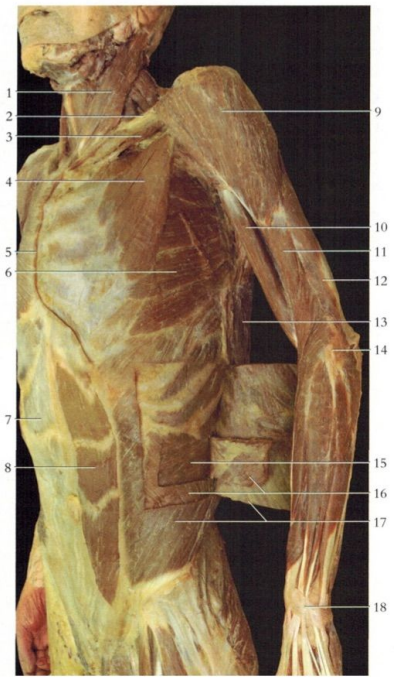


Atlas [Cadaver]

13. **Identify the structure #10 below.** *

Mark only one oval.

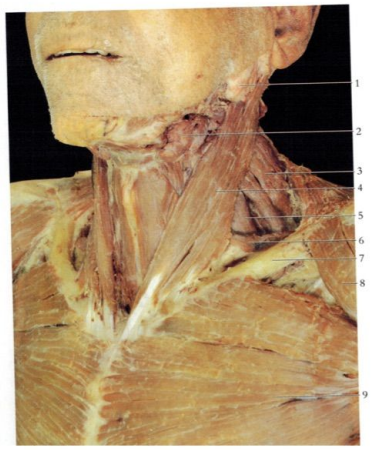
- ( ) Triceps Brachii
- ( ) Pronator Teres
- ( ) Brachioradialis
- ( ) Biceps Brachii
- ( ) Extensor Digitorum



14. **Identify the structure #4 below.** *

Mark only one oval.

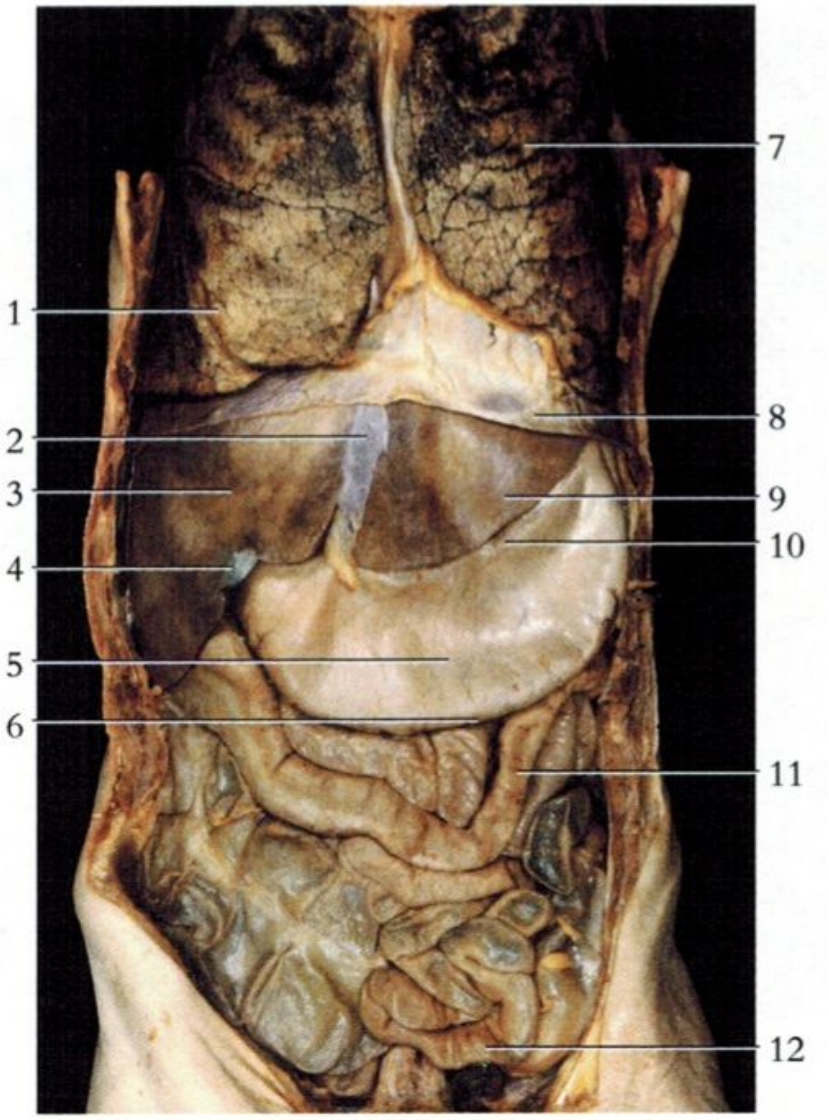
- ( ) Sternocleidomastoid
- ( ) Sternohyoid
- ( ) Subclavius
- ( ) Thyrohyoid
- ( ) Deltoid



15. **Identify the structure #11 below** *

Mark only one oval.

- ( ) Colon/large intestine
- ( ) Small Intestine
- ( ) Rectum
- ( ) Sigmoid colon
- ( ) Pancreas



Post-dissection quiz is now complete!

APPENDIX G
Dissection Post-Survey

Augmented Dissection - Post Survey

Research study purpose: Evaluating the impact of augmented dissection laboratory activities in better understanding human body systems and the connections that exist between structures and functions.

Please fill out this survey which will take approximately 20 minutes and let us know your thoughts (your answers will be anonymous). Your feedback is voluntary and will be kept confidential. Be assured that the data collected will be handled with the required level of confidentiality and all data will be aggregated before reporting.

* Required

1. **What is your student classification?**
   Mark only one oval.
   - ◯ Undergraduate
   - ◯ Graduate
   - ◯ Post-Baccalaureate
   - ◯ Other

2. **What is your current course load this semester?** *
   Mark only one oval.
   - ◯ 0 - 5 credits
   - ◯ 5 - 10 credits
   - ◯ 10 - 15 credits
   - ◯ 15+ credits

3. **Have you taken an anatomy course before?** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

4. **If yes, what type of course was it? [check all that apply]** *
   Check all that apply.
   - ☐ Online lecture
   - ☐ Online lab
   - ☐ On-campus lecture
   - ☐ On-campus lab

5. **Do you have prior dissection experience?** *
Mark only one oval.

- ◯ Yes; little experience (~1-3 dissections)
- ◯ Yes; much experience (4+ dissections)
- ◯ None; I have never performed hands-on dissections
- ◯ None; I have never performed them but have observed them

6. **Do you have prior experience using Augmented Reality technology?** *
Mark only one oval.

- ◯ Yes; little experience
- ◯ Yes; much experience
- ◯ None; I have never performed hands-on dissections
- ◯ None; I have never performed them but have observed them

7. **Do you have prior experience using an app for human body visualization?** *
Mark only one oval.

- ◯ Yes; little experience
- ◯ Yes; much experience
- ◯ None; I've never used an anatomy app
- ◯ None; But I have utilized other study apps

8. **Please describe what an "augmented dissection" is briefly in your own words.** *

_____

9. **If you had a choice of dissection method which format would you choose?** *
Mark only one oval.

- ◯ A traditional dissection - use of wet specimens, gloves, tools, googles
- ◯ An augmented dissection - use of augmented technology to "slice & dice"
- ◯ A picture dissection - use of illustrations and images for visual imprinting
- ◯ A combination or another dissection method
- ◯ Other: _____

10. **Any additional comments or suggestions about your experience with augmented dissections?**

_____

Engagement

Please respond to how much you agree with each statement below on a scale of 1 to 5 with 1 being NOT AT ALL and 5 being VERY MUCH for you as a student in these A&P courses.

11. **I was comfortable with the augmented dissection.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

12. **What I needed to do for the augmented dissection was clear.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

13. **I enjoyed working in the augmented dissection lab class.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

14. **I was satisfied with the format of the augmented dissection.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

15. **I think the augmented dissection was effective.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

16. **I think the augmented dissection was efficient.** *
Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

17. **I think the augmented dissection was engaging.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

Effectiveness

Please respond to how much you agree with each statement below on a scale of 1 to 5 with 1 being NOT AT ALL and 5 being VERY MUCH for you as a student in these courses.

18. **I think the augmented dissection was more motivating than a traditional dissection.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

19. **I think the augmented dissection was more engaging than a traditional dissection.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

20. **I think the augmented dissection was more effective than a traditional dissection.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

21. **I think the augmented dissection was easier than a traditional dissection.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

22. **I learned more in the augmented dissection than a traditional wet specimen disseciton.** *

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very Much

23. **Any comment or suggestions on the comparison of the effective of the augmented dissection vs. the traditional dissection.** *

Benefits

Rank the following on a scale of 1 to 5 with 1 being NOT BENEFICIAL and 5 being VERY BENEFICIAL for you as a student performing augmented dissections in these courses.

24. **Working at my own pace.**

Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneificial

25. **Having materials in various formats - video - text - web.**

Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneificial

26. **Having the ability to see structures and capture them as images or recording.**

Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneificial

27. **Having more class time to work with my group.**
Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneficial

28. **Having the instructor help with our projects in class.**
Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneficial

29. **Having time to reflect on my learning.**
Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneficial

30. **Not having to wear gloves, use tools, make physical cuts, and poke around a real physical specimen.**
Mark only one oval.

	1	2	3	4	5	
Not beneficial	◯	◯	◯	◯	◯	Very beneficial

31. **Do you have any other benefits, comments or suggestions?**

Challenges

PLEASE NOTE THE SCALE CHANGE!

Rank the following on a scale of 1 to 5 with 1 being NOT AT ALL CHALLENGING and 5 being VERY CHALLENGING for you as a student using augmented technology [Anatomy4D app] in this course.

32. **Obtaining a mobile device to utilize the Anatomy4D app.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

33. **Downloading the Anatomy4D app took more time and effort.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

34. **Getting familiar with the Anatomy4D app took more time and effort.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

35. **The user interface and touch controls for Anatomy4D took more time and effort.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

36. **The organs and structures seen in the Anatomy4D app were less detailed than those seen in a textbook, atlas, or physical model.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

37. **Absence of tactile stimulation and sensory input.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

38. **Spatial navigation within an augmented environment on a mobile device screen.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

39. **Viewing augmented organs and structures on a mobile device screen.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

40. **Ability to accurately realize correct proportions of structures relative to each other.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

41. **Augmented dissection, presentation, and peer-sharing don't allow you to ask questions or get clarification.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

42. **The step-by-step procedures for the augmented dissection laboratory were confusing.**
Mark only one oval.

	1	2	3	4	5	
Not at all challenging	◯	◯	◯	◯	◯	Very challenging

43. **Do you have any other benefits, comments or suggestions?**

Learning Spaces

Rank the following on a scale of 1 to 5 with 1 being NOT AT ALL USEFUL and 5 being VERY USEFUL for you as a student using the augmented dissection learning model in this course.

44. **Anatomy4D app**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

45. **Recommended resources (textbook, atlas, etc)**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

46. **Presentation creation**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

47. **Personal annotation/reflection**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

48. **Peer sharing and feedback**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

49. **Sharing your work in Laulima Discussion**

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

50. **Seeing other group work in Laulima Discussion**
Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

51. **Do you have any additions, comments or suggestions about the usefulness of individual learning space?**

Further comments and suggestions

52. **In what areas of anatomy and physiology do you feel you improved most during the augmented dissection lab?**

53. **What do you think was most helping in leading to this improvement?**

54. **Do you have any suggestions for improvement of the augmented dissection lab?**

55. **Do you have any other opinions, comments, or suggestions?**

Demographics

56. **What is your sex?**
Mark only one oval.

- ◯ Male
- ◯ Female

57. **What is your age?** *
Check all that apply.

- ☐ Under 20
- ☐ 21-25
- ☐ 26-30
- ☐ 30-40
- ☐ 41-50
- ☐ 50+

58. **What is ethnic group?** *
Check all that apply.

- ☐ White or Caucasian
- ☐ Black of African American
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Prefer not to answer
- ☐ Other:

Mahalo for your participation in this survey!