HOW THE EXPERIENCES OF MEDICAL PROFESSIONALS AND HIGH SCHOOL STUDENTS INFORM IMPROVEMENTS TO HIGH SCHOOL HUMAN ANATOMY AND PHYSIOLOGY COURSES

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This project aimed to identify some of the most effective ways that students learn the human anatomical and physiological concepts in high school through medical school. This project looked at the effectiveness of learning human anatomy online versus hands-on learning and learning through simulations versus lecture and reading. This study considered different modes of instruction through the perceptions of medical professionals at University of California San Francisco and Sheridan High School human anatomy students. Medical professionals suggested best teaching practices for high school human anatomy and physiology teachers. The high school students shared their learning strategies that could lead to a successful high school course. Through interviews and surveys a group composed of high school students, medical students, surgical residents, fellows and surgeons shared their opinions on the effectiveness of different learning and teaching styles of human anatomy and physiology concepts. Data collection for this project not only included online survey questions, but also personal interviews. The results suggested that anatomy and physiology courses taught to pre-college level students should include a large portion of hands-on learning and teaching styles.

INTRODUCTION AND BACKGROUND

Sheridan High School, in Sheridan, Wyoming is located at the base of the Big Horn Mountains in northern Wyoming and has a town population of 17,400. The majority of Sheridan is made up of Caucasians (94%) the remainder is made up of mostly Hispanic or American Indian. The estimated median household income is $45,430 with construction/trade and health care as the two most common industries; Sheridan has a 4.8% unemployment rate (City Data Website 2013).

Sheridan High School (SHS) is located north of town near the hospital, two neighboring elementary schools and the fairgrounds. The current enrollment of Sheridan High School is 972, with the majority of students coming from within a radius of approximately twenty miles.

In order to graduate, students in the Sheridan High School science program are required to achieve a passing grade of 60% or higher for 9th grade Integrated Science and 10th grade Biology. In addition, students must also pass one year of an elective science; those options range from Chemistry, Physics, Human Anatomy and Physiology, Earth Science and the Advanced Placement options of Chemistry, Environmental Science and Biology. SHS Human Anatomy and Physiology (A&P) students are presumably motivated to take this course through several indicating reasons: they have *chosen* to take this course as it is not a graduation requirement; they are typically the older students in the high school (juniors and seniors) that are focused on their career path(s) and what courses will benefit them the most.

This project investigated the most effective way in which 53 Sheridan High School anatomy and physiology students learned human anatomical concepts. The students from three different human A&P sections were all administered a survey to voluntarily answer questions relating preferences in their human A&P course (Appendix D). From those surveys, I randomly selected students from each course to interview about their responses and the reasoning behind those responses. (Appendix E).

University of California- San Francisco (USCF) Medical School is located in the city of San Francisco, northern California with a metropolitan area population of 4.3 million and a university enrollment of 2,940 (USCF 2014). According to the 2010 Census, the approximate ethnic makeup of San Francisco was Asian (33%), White (48%), Hispanic-Latino (15%). Data taken from Fall of 2009 to Fall of 2013 at UCSF indicated that the medical student population consisted of the following makeup: African American (7%), Asian (27%), Hispanic (12%), White (40%).

With over one-third of San Francisco's population being born outside of the country, the largest percentage of L.G.B.T. in the USA and the highest percentage of same-sex households, San Francisco is very diverse (World Population Review Website, October 2014).

I conducted in-person research at University of California- San Francisco (UCSF) Medical School in June 2014 and web-based in January and February 2015. This part of my study focused on the medical professionals under the direction of Dr. Stanley Rogers, Associate Professor and Chief of Minimally Invasive Surgery. This group included UCSF

surgeons, fellows, nurses and residents that use their human anatomy and physiology educational background every day in their occupations.

I studied 67 medical professionals in June 2014 and 38 surgery residents in January-February 2015 at UCSF. During that time, I surveyed and interviewed individuals with a series of questions focused on their backgrounds in high school and collegiate human anatomy and physiology. They also provided me with insight on what they thought was the best way they learned human anatomical concepts from a series of choices and rankings (Appendix A, B, and C).

The data collection for this project not only included surveys and interviews about the subjects' preferences towards learning human anatomy and physiology via preferred methods but also included the subjects' history of science courses.

Focus Questions

This study focused on the following primary question, "How are the perceptions and learning methodologies of medical professionals (surgical residents, medical students, fellows and surgeons) at UCSF and students in human anatomy and physiology class at Sheridan High School related, and how can these related methods establish changes or improvements to maximize learning in high school anatomy and physiology-teaching methods?" From the main research question, I additionally included sub questions to clarify and categorize my research project as follows:

1. What educational experiences in human anatomy and physiology do medical professionals perceive as most helpful in their medical career development and success?

2. What teaching and learning suggestions do medical professionals have for high school anatomy and physiology students and teachers?

3. What interview information can high school students enrolled in a human anatomy and physiology course share about their learning styles and strategies respective to learning human anatomy?

CONCEPTUAL FRAMEWORK

Medical doctors and their staff have been saving and improving lives for centuries. The preparation and study has grown into an extensive program with complex testing, situational problem solving and an immense amount of background knowledge. How can a doctor prepare for the diversity of medical situations he or she will see in their career? The American College of Emergency Physicians defines emergency medicine as "the medical specialty dedicated to the diagnosis and treatment of unforeseen illness or injury" (2007). Dr. Harris, an emergency medical physician in Vermont, says that he has to be ready to handle any emergency conditions that may occur encompassing every body system and having the knowledge base to make sure a patient is safe, comfortable and as healthy as possible (Orin, 2014).

How are medical professionals around the world educated for such a wide range of emergency situations? The answer is usually provided that it is through thorough schooling and experiences, one of them being medical residencies. Defined by Meriam-Webster.com, Medical residencies are a period of advanced medical training and

education that normally follows graduation from medical school. Medical residencies play a large role in this learning and skill building process to become a successful board certified and licensed medical doctor. Medical residencies traditionally involve giving the students a structured supervised program of anywhere from three to seven years containing a mixture of education through cadaver labs, lectures and online learning (Brown, 2010). Depending on the medical school, some structure their gross anatomy courses to be an everyday class while other medical schools opt to hold the course three times per week, lasting anywhere from three months to one year or more (Divita, 2014). Some of these learning strategies can carry a higher value and effectiveness pertaining to the medical student's working knowledge base.

There is a variety in the teaching methods that medical students are exposed to in a typical surgery residency program. In the early 1980's some opinion-based data shared that medical students received an "overcrowded curriculum with excessive memorization, didactic lectures centered on the teacher, passive learning and lacking communication with patients" (Older, 2004, p.80). As time passed, a core curriculum with the essential fundamental learning was presented to students and teachers. In addition to the typical anatomy cadaver lab, some medical schools used a variety of enhanced learning tools such as ultrasound, MRI's and multiaxial computerized image reconstruction (Older, 2004). A major subject in pre-clinical medical education is anatomy and the course is typically taught via gross dissection (Korf, H., Wicht, H., Snipes, R.L., Timmermans, J., Paulsen, F., Rune, G., & Baumgart-Vogt, E., 2010). The authors' findings stated that the value of dissection laboratory has been under discussion at different universities due to

high costs and shortness in time to cover the required curriculum *with* the desired outcomes (Korf, H. et.al., 2010). Older agrees that hands-on learning for medical students is important by stating ,"the student-cadaver encounters in medical education is the 'nodal point'- the moment in time between stopping and starting; from absolute convergence to comparative divergence" (Older, 2004, p.80). The opportunity for the student to use his or her knowledge in a life-like simulation allows the student to assemble his or her understandings with actual outcomes and compare these findings to their prior expectations. This "nodal point" permits the ideal, reflective student experience.

Seen quite often either in early residencies or nursing programs is the use of standardized patients-individuals who are trained to consistently act as a patient both in physical presentation and health history. This has been a growing and well researched area in the medical field for teaching medical students that aspect of reality (Bornais, J., Raiger, J., Krahn, R., & El-Masri, M., 2012). John Hopkins School of Medicine also uses standardized patient simulation to allow students the practice of physical exam skills, communication skills, history taking skills and other skills (John Hopkins University Website, 2015).

There has been some research compiled using a blended classroom. A blended classroom typically results in a web-based portfolio, a valuable instrument for residents, administrators and future employers. The Accreditation Council for Graduate Medical Education (ACGME) set forth the web-based portfolio model for competency-based learning. This portfolio is comprised of six core competencies that must be acquired

during training and is largely based on the growth and reflection model that permits tracking of the learner's development over time. These six competencies include: patient care, medical knowledge, professionalism, interpersonal and communication skills, practice based learning and improvement and systems based practice (Lewis, C.E., Tillou, A., Yeh, M.W., Quach, C., Hiatt, J.R., & Hines, O.J. p.40-43). Cluster models in New South Wales, Australia place students in a set group with a set time to focus on a specific ward or unit. This allowed the students to familiarize themselves with the patients in conjunction with learning the content materials being taught by the supervisor at the station (Bourgeois, 2010).

A newer and more modern learning and teaching technique is that of simulation centers and simulated patients. SimMan 3G, among several others, is a wireless, high-fidelity manikin that can respond physiologically to the selected treatment the given controller choses. The Wyoming Simulation Center, located in Sheridan, Wyoming has provided this new type of exposure for the junior college nursing program students. These manikins are also being used in trauma and mass casualty training for the Air Force to help improve how quickly and efficiently the patient is addressed and assessed with proper interventions, especially under duress in a team environment (Johnson, 2014). John Hopkins University's medical facilities have been using manikins in clinical simulations to "allow future and current physicians to 'practice on plastic' first" (John Hopkins University Website, 2015). These manikins not only allow for virtual feedback via computers, but can simulate heart tones, pulses and chest raises- all providing real-time information to students. This allows for those students to practice their clinical skills

in a regulated environment preparing themselves for their futures as physicians with skillful evaluation and treatment techniques (John Hopkins University Website, 2015).

Lecture is by far the most common and oldest type of teaching style. According to Khan, each school day millions of students listen to 50- to 90- minute lectures with very little interaction (2012). The educational benefit of lecture based teaching has met some opposition in the last decade or two.

"In 1996, Indiana University professors Middendorf and Kalish published research on human attention and retention and how it speaks against the value of long lectures. They determined that college students needed a three- to five- minute period of settling down, which would be followed by 10 to 18 minutes of optimal focus. Then, no matter how good the teacher nor how compelling the subject matter, they would develop a lapse in retention" (Middendorf & Kalish, 1996, p. 2).

Middendorf and Kalish went on to add that most research tells us that the brain, while listening to a lecture, does not record information like a videocassette recorder. The brain, instead, reduces the information into categories or meaningful "chunks" (p. 1).

Tracie White, reporting for Stanford's School of Medicine, believes that large changes are needed to advance our medical education, one of them being a reduction in the number of traditional lectures (White, 2012). In addition, Stanford's Senior Associate Dean for Medical Education and Professor of Organizational Behavior, respectively, Drs. Charles Prober and Chip Heath stated that "when contemplating medical education reform, the efforts must be geared towards optimizing the retention of lessons". The core biochemistry class at Stanford medical school was redesigned in 2012 to follow Salman

Khan's flipped-classroom model with an integration of 10- to 15- minute videos. The class time was then used for rich and engaging interactive discussions. Results showed an increase in student attendance from 30 to 80 percent, even though class attendance was optional" (White, 2012).

A study at Warwick Medical School and Cambridge University Clinical School, both in the United Kingdom, compared the use of didactic lectures with that of interactive discussion sections for 77 undergraduate orthopedic and trauma medical students. The results showed that the students in the interactive discussion group rated the presentation higher (more popular and preferred) and ultimately performed better on their end-of-placement written test. In addition, the study also found evidence suggesting that knowledge retention is better following an interactive teaching style (Costa, Rensburg, & Rushton, 2007. p.214)

Throughout all these different medical teaching strategies, which proves to be the most effective *and* preferred by students? Medical resident at UCSF and co-founder of AdmissionsMentor.com, Dr. Sean Alemi says, "The most important task as a first year medical students is to learn how to *learn*." He adds that over the course of the first year of medical school and all the information you're presented with you will not only be asked to retain and regurgitate it, but also "bridge the gap between retention and application of knowledge" (Alemi, 2014).

Educators from a variety of professions and subjects strive to find the best teaching methods to engage and educate students, taking into consideration the optimal length of time of exposure to content (Bornais, 2012, p.295). Most typical medical

schools rely on a combination of lectures and problem-based learning modules (Divita, 2010). The question then becomes which module carries a higher success rate for the majority of medical resident students: taking information gathered from a hands-on learning style and applying it to the real world versus lecture learning style and applying it to the real world? According to Dr. Lisabetta Divita, there are two types of medical schools: Allopathic Medical Schools, schools that confer an M.D. degree, and Osteopathic Medical Schools, schools that confer a D.O. degree. Divita adds that "schools may have a traditional or systems-based curriculum. A systems-based curriculum means that all of your classes are divided up by body systems" and taught on a per system spacing format (Divita, 2010). Alemi's example supports the hands-on learning style by saying:

> "Let's say I ask you what cranial nerve is responsible for innervation of the muscles of the tongue. You correctly answer: cranial nerve XII, the hypoglossal nerve. I also ask you what functions those muscles are responsible for. You're able to correctly tell me all the functions of the intrinsic and extrinsic tongue muscles. That is reproduction of retained knowledge. Now let's say that instead I ask you to describe the findings in a patient with a lesion affecting the left 12th cranial nerve. If you're able to apply your knowledge of what that nerve controls and how those muscles function, then you'll be able to correctly describe the physical exam findings in a patient with a left-sided 12th nerve palsy."

A study done in September 2011 at the University of Sydney in Sydney, Australia, evaluated feedback from 137 medical students completing their third and

fourth year rotations in geriatric medicine following a blended learning model. This blended learning model, referred to as WebCT (Web based set of Course Tools), combines e-learning and person-to-person interaction in a way that focuses on self-reflection, access to technology, interactive learning with multidisciplinary teams, increase exposure to patients and regular feedback (Duque, 2013, p.103). Of 137 students, 88% of the students agreed that WebCT was a useful tool while 68% felt comfortable using a paper-based portfolio. (Duque, 2013, p. 104-105).

In conclusion, medical professionals around the world successfully prepare themselves for a wide range of emergency situations through many experiences. One of these experiences is through medical residencies, where the trainee is exposed to many different situations, practices, and procedures. Among other tasks, the medical resident is required to know, in substantial detail, the human body's anatomy and physiology. Human anatomy and physiology is taught to the residents via many different methods. Of these methods, students researched have noted that lecture is the least effective method for learning human anatomy and physiology. Blended learning models, simulation manikins and dissection courses were cited as the top methods for learning human anatomy and physiology.

METHODOLOGY

The purpose of this study was to search for a standout learning style or technique that worked best to best allow comprehension of concepts of human anatomy and physiology. I collected data from medical professionals and students that *use* human anatomy knowledge every day in an effort to discover what has helped them learn the anatomical concept(s) the most effectively. In addition to the medical professionals and

students, I collected data from the Sheridan High School human anatomy and physiology students to discover what helped them learn human anatomy for the first time the most effectively. My data collection techniques are summarized in Table 1.

Table 1
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
Primary Question: How can the perceptions of medical professionals (surgical residents, medical students, nurses, radiologists, fellows and surgeons) at UCSF related to their educational experiences suggest teaching methods to a high school anatomy and physiology course?	January 2015 Surgery Residents Interview's and Responses to Questions	Anatomy and Physiology course surveys and interviews at Sheridan High School January 14 & 21, 2015	June 2014 Pilot Data- Survey and Interview Data
Secondary Question 1: What educational experiences in anatomy and physiology do medical professionals perceive as most helpful in their medical career development and success?	January 2015 Surgery Residents Interview's and Responses to Questions	June 2014 Pilot Data- Survey and Interview Data	Interview medical professionals at USCF and in the Sheridan, Wyoming Community Health network

Secondary Question 2: What teaching and learning suggestions do medical professionals have for high school anatomy and physiology students and teachers?	Medical Professionals Interview's and Responses to Questions	June 2014 Pilot Data- Survey and Interview Data	Interview medical professionals at USCF and in the Sheridan, Wyoming Community Health network
Secondary Question 3: What interview information can high school students that are currently enrolled in a human anatomy and physiology course share about their learning styles and strategies respective to learning human anatomy.	Sheridan High School Human Anatomy Student Questionnaire (Pre- and Post-Course)	Sheridan High School Human Anatomy Students Interviews (Pre- and Post-Course)	Sheridan High School Anatomy and Physiology Teachers Interview

SHS Human Anatomy and Physiology Course

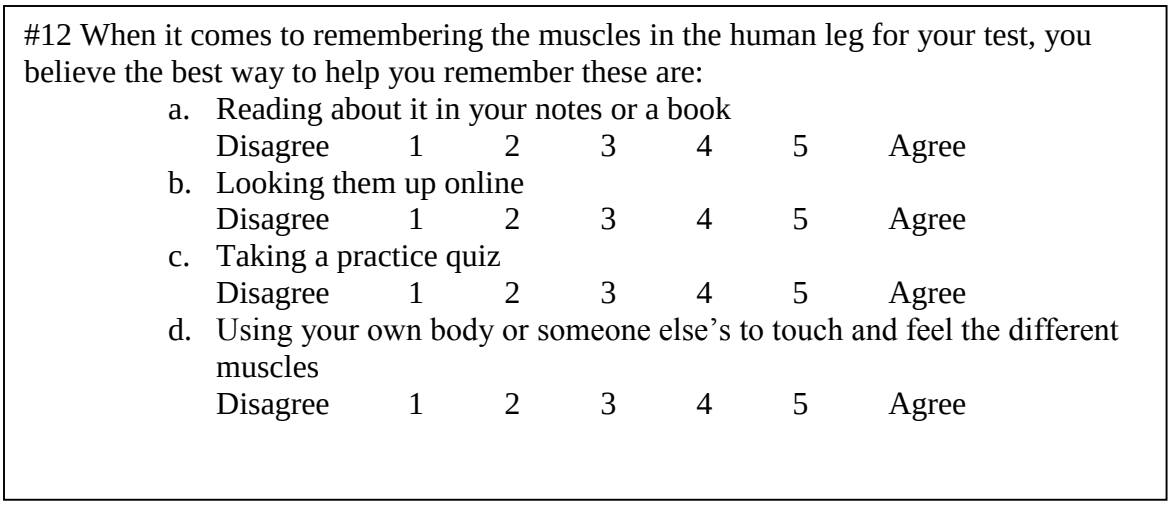
The Human Anatomy and Physiology course taught at Sheridan High School in Sheridan, WY is a semester long, 18 week course covering the topics of the skeletal, muscular, endocrine and digestive systems (Table 2). Instructors use animal dissections as their primary technique to teach these concepts. In addition, the course uses supplemental videos, simulations and worksheets as secondary techniques. Students are assessed via formative and summative assessments at the end of each system. Since there is such a large amount of content that is covered throughout this one semester course, it is simply a "skim" of the content covering human anatomy. However, the cat dissection

project, lasting between 4 and 7 weeks provides an opportunity for students to explore a topic in depth.

Table 2
Sheridan High School Human Anatomy and Physiology Semester Course Scope and Sequence

Unit	Title	Description of learning objectives
1	Human Body Orientation	Organ system overview, anatomical directions and planes
2	Cells and Tissue	Cells and tissues, bioethics and cancer
Mini-unit	The Endocrine System	Hormones and Glands presentation
3	Skin and Body Membranes	Skin layers identification, skin of the cat, hair density lab, disorders of the skin
4	The Skeletal System	Bone identification, joints of the upper appendage, bone breaks, skeletal forensics lab
5	The Muscular System	Muscle tissue construction, cat hind limb muscle identification, knee deconstruction
6	The Cardiovascular System	Blood pressure, blood types, heart dissection
7	The Respiratory System	Lung capacity lab, respiratory system dissection
8	The Digestive System	Tooth extraction and examination, organic/Inorganic compound lab, digestive system micro-dissection
Mini-unit	Special Senses (Eyes)	Visual senses lab, eye extraction and dissection
9	The Nervous System	Nervous system physiology lab, brain dissection

I started with a voluntary questionnaire given to all 53 SHS Human Anatomy students. From that questionnaire, I selected students to interview randomly from the class roster lists provided to me. I chose this method to eliminate bias and because I knew many of the surveyed students from previous years in my classroom. I interviewed twenty-one individuals from Sheridan High School Human A&P courses. Seven students from semester one, that were just finishing up their coursework and fourteen students, seven per class, from semester two that were just starting their coursework. The questions were focused towards learning preferences when dealing specifically with human anatomy type scenarios (Figure 1).



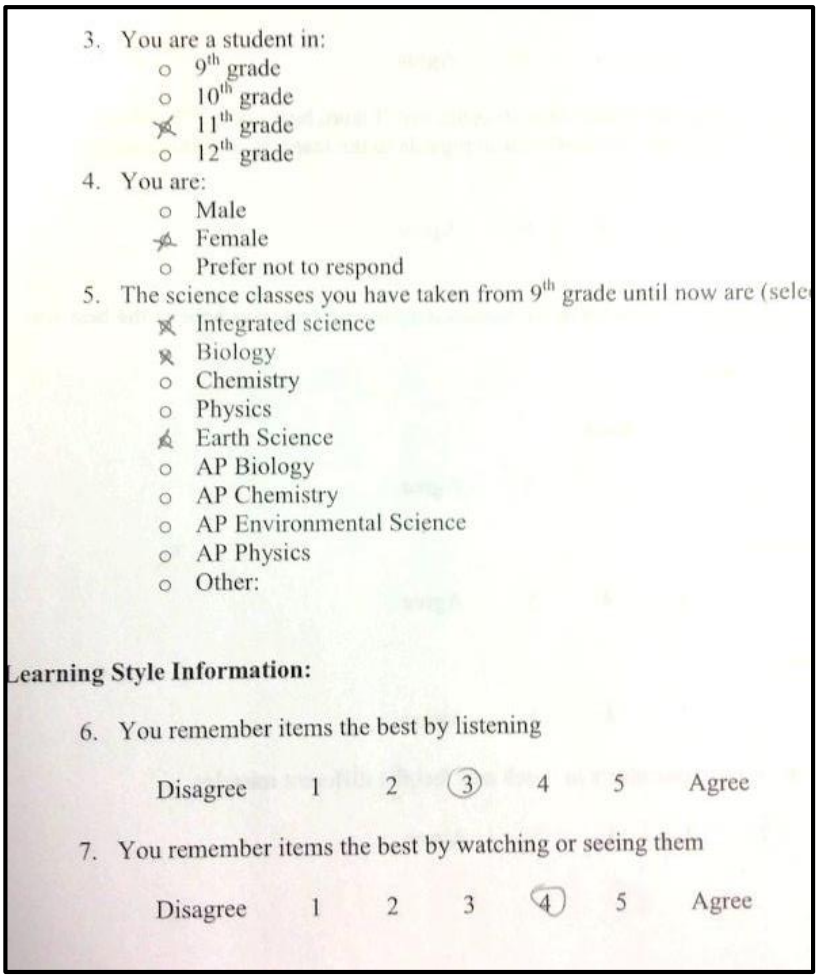
#12 When it comes to remembering the muscles in the human leg for your test, you believe the best way to help you remember these are:

a. Reading about it in your notes or a book
   Disagree 1 2 3 4 5 Agree
b. Looking them up online
   Disagree 1 2 3 4 5 Agree
c. Taking a practice quiz
   Disagree 1 2 3 4 5 Agree
d. Using your own body or someone else's to touch and feel the different muscles
   Disagree 1 2 3 4 5 Agree

Figure 1. Sheridan High School survey question example.

The average grade level among the three Human A&P courses at SHS this school year is junior level and the average number of science courses taken in high school before Human A&P is 3 (Table 3). I asked all students from each class to complete a voluntary survey that included demographic questions about their previous science courses and grade level, and scenario questions about preference for learning anatomy concepts. They

responded by checking boxes from lists or circling agree to disagree spectrums responses (Figure 1).



3. You are a student in:
   - o 9th grade
   - o 10th grade
   - x 11th grade
   - o 12th grade
4. You are:
   - o Male
   - x Female
   - o Prefer not to respond
5. The science classes you have taken from 9th grade until now are (sele
   - x Integrated science
   - x Biology
   - o Chemistry
   - o Physics
   - x Earth Science
   - o AP Biology
   - o AP Chemistry
   - o AP Environmental Science
   - o AP Physics
   - o Other:

Learning Style Information:

6. You remember items the best by listening

   Disagree 1 2 (3) 4 5 Agree

7. You remember items the best by watching or seeing them

   Disagree 1 2 3 (4) 5 Agree

Figure 2. Sheridan High School survey student response example.

I randomly selected seven students from 1st semester and seven from both 2nd semester Human A&P courses to interview in addition to previously gathering their survey information. The interviews were conducted in my classroom during passing periods and after school, in the hallway before and after school, and during lunch, study halls, free periods or teacher aid periods.

I followed the same protocols for each student during the interviews. First, I would ask the student for confirmation of their name which I associated with the last four digits of their school identification number. Second, I would ask the student for confirmation of whether they were just finishing up Human A&P or just starting Human A&P. Third, I would ask the student the interview questions and scribe their responses. Every fifth student I interviewed I would record the audio on an iPad to save for further referencing. I would ask each student before I recorded if I had their permission to record. No students refused the recording permission. (Appendix E)

Table 3
Demographics for Sheridan High School Human Anatomy and Physiology course

Parameter	Human A&P Fall 2014 Students completed course	Human A&P Spring 2015- A Students starting course	Human A&P Spring 2015- B Students starting course
Sample Size (*n=53*)	15	17	21
Proportion 9th grade (%)	0	0	1
Proportion 10th grade (%)	0	29	38
Proportion 11th grade (%)	40	18	29
Proportion 12th grade (%)	60	53	23
Mean Number of Science courses taken prior to Human A&P	3.1	3.1	2.76

Research Participants

This study evaluated two groups of medical professionals at University of California San Francisco (UCSF). Group 1 data collection began June 7th, 2014 and ended June 26th, 2014. Group 2 data collection began January 2015 and lasted through February 2015. From group 1, 67 medical professionals at USCF were interviewed and/or surveyed on their preferences and opinions regarding their most successful methods to learn anatomy and physiology. From group 2, I interviewed and/or surveyed 38 surgery residents on their learning styles, past and present learning tactics and opportunities that successfully taught them anatomy and physiology to the medical level. I also asked them to share any opinions they have or would suggest to high school students and teachers currently in anatomy and physiology courses.

Collecting data from Group 1 was completed using a Google Form document on an iPad mini that I carried around with me from clinic to rounds to meetings to pre or post-surgery settings. Under the direction of Dr. Rogers, I was navigated through UCSF's medical facility and was introduced to many different medical professionals. It was then that I was able to find a few minutes to ask that medical professional to fill out a survey on my iPad and visit with them regarding the final few questions of the survey (Appendix A).

The goal was to collect high school aged-data on student opinions towards how they learn human anatomical concepts the most effectively and compare it to the data of medical professionals who have previously taken a human anatomy and physiology course prior to medical school.

Table 4
Demographics for University of California San Francisco Medical Professionals Surveyed

Parameter	UCSF June 2014 Participants	UCSF January 2015 Participants
Sample Size (*n*)	67	38
Proportion surgeon (%)	15.6	0
Proportion resident (%)	46.9	100
Proportion student (%)	9.4	0
Proportion fellow (%)	4.7	0
Proportion other (%)	23.4	0

Data Collection

Data from medical professionals at UCSF and students at Sheridan High School enrolled in human anatomy and physiology was collected via questionnaires and interviews. My end goal was to answer the question: "Is hands-on learning the most effective way for teaching human anatomy?" My data collection approach is summarized in Table 1.

June 2014 was spent collecting pilot data through watching University of California San Francisco medical professionals in action- surgery. Pre or post operation I had the opportunity to visit with, survey and/or interview a variety of medical students, medical residents, fellows, surgeons, nurses, radiologists and one medical sales representative. During these conversations, I asked questions to find out background information such as what their undergraduate degree was in, what medical procedures

they are involved in on a regular basis and what learning tools helped them the most for human anatomy concepts.

January 2015 was spent collecting a second round of data from 38 surgical residents at University of California San Francisco Medical Center. I focused on surgical residents solely because I wanted avoid getting data from previous participants and have a more uniform group. I asked them questions similar to the pilot data: such as what their undergraduate degree was in, what year they are in residency, what medical procedures they are involved in on a regular basis and what learning tools are helping them the most for human anatomy concepts in medical procedures. From voluntary responses to be interviewed, I asked those surgery residents questions about their exposure to human anatomy they had prior to medical school; what strategies, tools and teaching techniques helped them learn human anatomy to level required of a successful surgical resident; what strategies, tools and teaching techniques were the least helpful; advice to high school teachers on how to best teach human anatomy (Appendix B).

January 13th, 2015 I passed out a questionnaire to the 15 currently enrolled semester one human anatomy students at Sheridan High School (Appendix D). From that information, I chose 7 students based on their responses to interview the following day. In addition, I also passed out the same questionnaire to all of Sheridan High School's semester 2 Human Anatomy and Physiology two courses January 21st, 2015. There were 22 students enrolled in Class A and 22 students enrolled in Class B on January 21, 2015. I chose 7 students from Class A and 7 from Class B based on their responses to interview the following days after (Appendix E).

DATA AND ANALYSIS

The survey and interview results from the University of California San Francisco (UCSF) medical professionals, including surgery residents, indicated that hands-on methods, such as dissection based courses, were the most influential to successfully learn human anatomy and physiology. No participants noted that lecture based learning was the preferred method. *Anatomy books/Reading Literature* survey option received the lowest scores on the effectivity scale. The survey and interview results of the Sheridan High School (SHS) human anatomy and physiology students indicated that there was very strong agreement with the statement: "I learn best via the hands-on method". Of the 53 total SHS students surveyed, 30 of the students selected a "5" on the "disagree/agree scale" (1=disagree strongly/5= agree strongly) for the statement: "I learn best via the hands-on method".

The educational experiences that influenced medical professionals and high school students the most is defined in this section. The results of the surgery residents' responses to survey and interview data indicated that dissections (cadaver and animal) were the most influential in developing human anatomy skills and knowledge. Specifically, the results from UCSF surgery residents interviewed and surveyed in January and February 2015 exposed an overwhelming response of the use of cadavers being the most mentioned (31 out of 38) and perceived most helpful tool in their medical careers development and success (N=38).

Many of these surgery residents also mentioned hands-on experiences and exposure played a vital role in their development to be successful in medical school and

into their career. When asked what educational experiences in human anatomy they remember having the greatest educational impact, early on in their education and currently, one surgery resident commented: “Dissecting a pregnant shark at age 12…In residency, we dissect cadavers and simulate operations twice a month.” Another resident commented, “Frog dissection in elementary school, cadaver dissection in medical school.” Several residents also added that seeing videos or using 3D software technology helped them remember some of the more detailed material and concepts. In opposition, many surgery residents responded that text book reading and lectures were the least helpful in development and learning of human anatomy.

The results from the medical professionals (surgical residents, medical students, fellows, surgeons, nurses, radiologists and others) surveyed and interviewed in June 2014 had congruent responses to the question posed about what educational experiences in anatomy and physiology were the most helpful for medical career development and success (N=67). Many responses included the statement that hands on learning is best (30 out of 67).

When given a choice set of the following: 1) anatomy books and reading literature, b) anatomy lab (animals), c) anatomy lab (cadaver), d) virtual/online-learning/simulations, e) hands-on during surgery, f) during surgery skills lab, g) radiology studies (including cross sectional imaging), or h) other, 43 of the 67 (64%) medical professionals chose the “hands-on during surgery” option as the most effective way for them to learn anatomy in preparation for the medical field. Interview responses aligned with those from the surgery residents’ interview responses in January and February 2015.

An attending surgeon stated, “Hands on learning is best. Multimodality learning is also very important- read first, and then learn further with hands-on.” A third year medical student said that “Hands-on experience was key for me.” One registered nurse responded by saying that, “the hands on approach so that the ideas become real to the students.”

Sheridan High School Human Anatomy and Physiology Course

Sheridan High School students enrolled in the Human Anatomy and Physiology course shared their preferences and thoughts about what strategies and learning styles are most important and relevant to learn human anatomy successfully (*N*=53). When given the following scenario, “When it comes to remembering the muscles in the human leg for you test, you believe the best way to help you remember these are…” students ranked Option C- taking a practice quiz- and Option D-using your own body or someone else’s to touch and feel the different muscles- the highest of the four choices. Reponses were recorded on an agree/disagree scale; 1= Disagree and 5= Agree (Figure 2 and Table 5).

Table 5
SHS Survey Responses Question #12: “When it comes to remembering the muscles in the human leg for your test, you believe the best way to help you remember these are?”

Parameter	Human A&P Fall 2014 Students completed course	Human A&P Spring 2015- A Students starting course	Human A&P Spring 2015- B Students starting course
Sample Size (*n=53*)	15	17	21
Proportion Choice A: Reading about it in your notes or a book (%)	3.27	3.6	3
Proportion Choice B: Looking them up online (%)	3.47	3.25	3

Proportion Choice C: Taking a practice quiz (%)	4.07	4.3	3.43
Proportion Choice D: Using your own body or someone else's to touch and feel the different muscles (%)	3.73	3.87	3.43

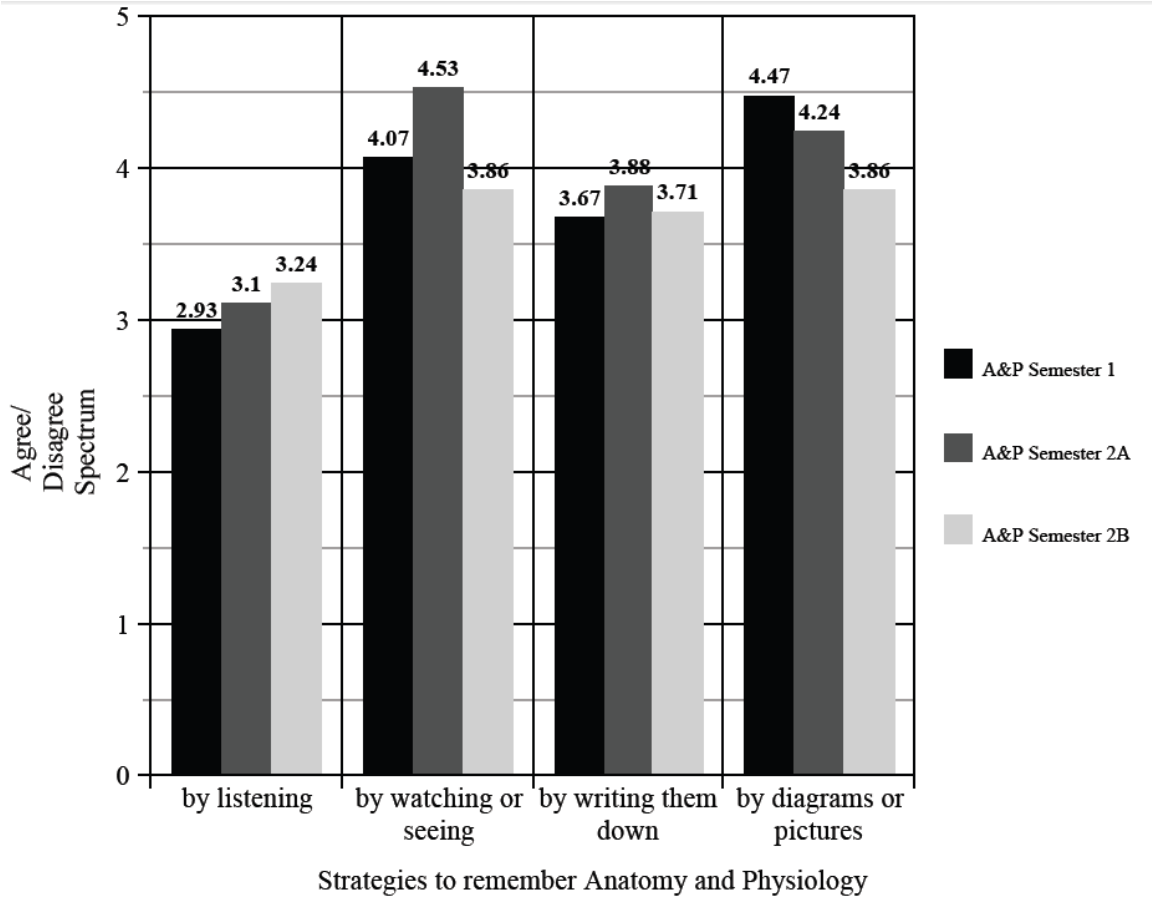


Figure 3. Sheridan High School Survey student response question #12.

In response to the survey question, "I learn best via the "hands-on" method. How strongly do you agree with this statement in regards to the learning of human anatomy

and physiology?" High school students responded very strongly to the agree spectrum side. Human A&P Fall 2014 students responded with five students choosing a 4 on the scale (33.3%) and the remaining ten students choosing a 5 on the scale (66.6%) (*N=15);* Human A&P Spring 2015-A students responded with one student choosing a 2 on the scale, one student choosing a 3 on the scale, five students choosing a 4 on the scale and nine students choosing a 5 on the scale (52.9%) (one student did not respond) (*N=17).* Human A&P Spring 2015- B students responded with two students choosing a 1 on the scale, eight students choosing a 4 on the scale (38%) and eleven students choosing a 5 on the scale (52%) (*N=21).*

Students responses on the survey recorded that remember items by listening and by writing them down were the two lowest categories. In the broken arm scenario, reading was the lowest category and showing on the skeleton was the highest category (Figure 4). The "broken arm scenario" was presented to students by asking the students if they had a broken arm, how they would prefer the attending doctor to explain their injury. The student then ranked the following options, using the "agree/disagree scale": a) the doctor tells you about your broken arm, b) the doctor gives you something to read about your broken arm, c) the doctors shows you on a skeleton about your broken arm.

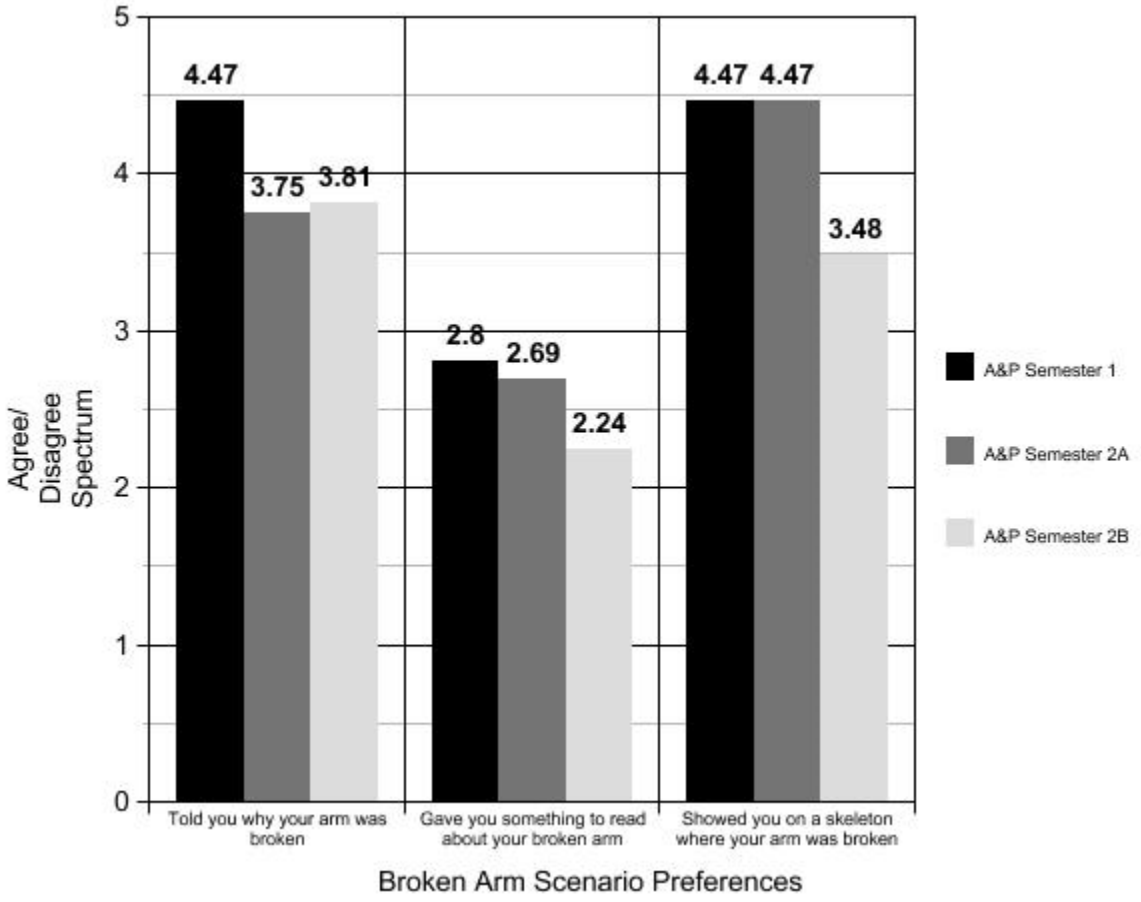


Figure 4. Sheridan High School Survey Student Response Question #10: You have a broken arm, you would prefer that the doctor… .

The response results from SHS A&P student interviews indicated that students found hands on activities and labs to be the most helpful when learning human anatomy. For example, one student responded by saying, "physically touching stuff helped me the most." Another student said, "…actual cat dissection because we got to see the joints." Some students mentioned using apps on phones or iPads and online games worked well as help for memorizing the material covered in class.

When interviewed on what learning tools or strategies were the least helpful in human anatomy and physiology class, the most common response mentioned bookwork and worksheets as being the least helpful. For example, one student said, “For me, the worksheets, those aren’t very helpful.” Another student said, “Probably just reading from the textbook because I don’t process the info.”

In summary, the survey and interview results from two different groups of medical professionals and three different groups of high school students regarding the learning experiences associated with successful human anatomy and physiology concepts indicated that “learning through doing” (i.e. “hands-on” learning such as dissection and surgery) was the most preferred method for learning.

INTERPRETATION AND CONCLUSION

I was impressed but not surprised by the results. According to the data, learners in both the medical field and high school anatomy class groups learn best and prefer learning human anatomy and physiology concepts in particular via hands on methods, specifically through dissection and surgery. This study verified that medical professionals (surgical residents, medical students, fellows and surgeons) preferred learning human anatomical concepts through cadaver labs and hands on in surgery as the most influential to be successful their medical careers. Data collected on high school anatomy and physiology students indicated that this group of learners also prefer learning anatomy and physiology material through the hands-on method (e.g. dissection, over other methods used by SHS teachers).

The educational experiences in human anatomy and physiology that medical professionals perceived as the most helpful in their medical careers development and success is most definitely not reading from textbooks or lecture. A 4th year medical student shared their thoughts by saying: “Start with the text book and virtual 3D images only to get a good frame of reference and idea of the nomenclature. Then use something like hands-on dissection or three-dimensional modeling.” A perioperative nurse in the field for more than 30 years shared that, “virtual / online is second best to cadaveric studies.” A fourth year plastic-surgery surgery resident shared that colleagues thought human anatomy was a subject that students of all ages must “constantly review over and over again…and relating what is taught to the student’s own bodies is probably beneficial. I remember a teacher saying that we are our own “cheat sheets” for anatomy.”

A SHS human anatomy and physiology teacher agreed with the statement saying that high school students appear to learn anatomy concepts best when using a hands-on approach in the classroom. This teacher added that: “In addition to the dissection, I believe that it is important to also incorporate the videos, physiology labs, text book reading and unit tests. I have also found that I need to give frequent formative assessments along the way to make sure that retention of knowledge is being maintained.” Another SHS human anatomy and physiology teacher shared that she has “found lecture is the least effective way to transmit information.” She added: “When we do a dissection and then answer questions about anatomy and function later, then the interest is piqued and they perform better and are more engaged.”

SHS human anatomy students had aligned responses and suggestions. Student 1D that was interviewed from the 2nd semester course when asked what tools will be the least helpful to learn human anatomy responded by saying: “Probably just reading from textbooks because I don’t process the information.” Another student, 2C from a different 2nd semester course, had a similar response: “probably just a paragraph describing something or reading about it.”

When the SHS human anatomy teachers were asked about what experiences they think have the greatest educational impact for students, they said: “Dissections seem to have the greatest educational impact, though they also like learning about systems disorders. It's more personal, so they hone in on it.” One SHS human anatomy teacher responded by saying:

> “I try to integrate throughout the different units, as much of their prior knowledge from the previous science classes as I can. Making them think back to their biology, chemistry and physics to hopefully see the overall connection. I also try to open the kids’ eyes on how the future job market will be demanding people that have an exceptional grasp of human anatomy physiology… Showing the students the connections to their own lives outside of the classroom is key to their buying into the class.”

Recommendations derived from this study to improve high school human anatomy and physiology learning will include a thorough introduction to the relevance of human anatomy and physiology teaching and learning methodology. Based on the findings from this study, lectures are likely the least preferred way to deliver educational

content, and videos, simulation, dissection and other hands-on teaching opportunities will therefore be recommended as the most preferred, and hence likely the most effective, method for teaching anatomy and physiology content to students. When teaching the specifics of a given anatomy system (for example, the muscle system), the most preferred method for delivering this content will be via a "hands-on approach" (e.g. touching and examining the actual muscles on an organism).

VALUE

The way human anatomy and physiology is taught currently at Sheridan High School has many opportunities and suggestions for improvement. From the 2014-15 students at SHS enrolled in the course to the instructors that teach the course to a wide range of medical professionals, including a close look at this year's surgery residents that are applying the courses knowledge on an everyday basis- this a great amount of data and suggestions that can be shared to "beef up" the SHS human anatomy course.

Currently, the SHS course is taught using a variety of different methods and strategies, one of them being the fetal cat dissection (among other smaller, less complex dissection). The cat dissection is one that many students brought up, in a positive light, during the student interviews that I conducted. As the medical professionals shared their opinions and suggestions on what experiences have had the greatest educational impacts, hands-on learning and dissections being the most, this then tells me to continue with the SHS fetal cat dissection.

This project impacted me in several ways, one of which was the exposure to so many different approaches to learning the same concept: the human body! Throughout

my time as a high school and junior college science educator, I believed that students of all intelligence levels and ages learn via different methods. At the start of this project, I assumed that learning human anatomy and physiology would not be any different. This project allowed me to discover that when learning something complex, such as human anatomy and physiology, the majority of learners prefer to learn the information the same way.

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APPENDICES

APPENDIX A

UCSF PILOT DATA SURVEY JUNE 2014

UCSF Survey of Anatomical Learning Strategies and Their Effectiveness

Thank you for taking the time to complete this voluntary survey

1. Please select from the following choices what you would classify yourself as....
    - Surgery resident
    - Other resident
    - Medical resident
    - Fellow
    - Attending surgeon
    - Other:
2. Based on your answer above, what YEAR of residency/fellowship/medical school are you in.
    if it applies to you please answer
    - 1st year
    - 2nd year
    - 3rd year
    - 4th year
    - 5th year
    - Other:

3. Your Speciality
   (If a specialty applies to your studies/schooling please list that here)

4. What was your undergraduate degree in?

5. Of the following, which type(s) of surgery do you perform?
   (check all that apply)
    - minimally invasive surgery
    - laparoscopic surgery
    - robotic surgery
    - open surgery
    - other:
6. What two learning tools are the most helpful in the learning of 3D anatomy for videoscopic procedures
   (Choose 2)
    - Anatomy Books/Reading Literature
    - Anatomy Lab (animals)
    - Anatomy Lab (humans)
    - Virtual/Online-Learning/Simulations
    - Hands-on during surgery
    - During Surgery-Skills Lab
    - Radiologic Studies (including cross sectional imaging)

- Other:

7. What do you believe was the most effective way for you to learn three-dimensional anatomy in preparation for the medical field of study?

- Anatomy Books and Reading Literature
  Not Effective 1 2 3 4 5 Very Effective

- Anatomy Lab (animals)
  Not Effective 1 2 3 4 5 Very Effective

- Anatomy Lab (humans)
  Not Effective 1 2 3 4 5 Very Effective

- Virtual/Online-Learning/Simulations
  Not Effective 1 2 3 4 5 Very Effective

- Hands-on during surgery
  Not Effective 1 2 3 4 5 Very Effective

- During Surgery-Skills Lab
  Not Effective 1 2 3 4 5 Very Effective

- Radiologic Studies (including cross sectional imaging)
  Not Effective 1 2 3 4 5 Very Effective

8. Of the choices above, which was the MOST effective for you? (choose one)

   - Anatomy Books/Reading Literature
   - Anatomy Lab (animals)
   - Anatomy Lab (humans)
   - Virtual/Online-Learning/Simulations
   - Hands-on during surgery
   - During Surgery-Skills Lab
   - Radiologic Studies (including cross sectional imaging)
   - Other:

9. What advice do you recommend to High School science teachers/students on how to best teach/learn anatomy?

APPENDIX B

UCSF RESIDENT SURVEY JANUARY 2015

Residents at UCSF - Survey of Anatomical Learning Strategies and Their Effectiveness

Thank you for taking the time to complete this voluntary survey

1. Would you be willing to spend a few minutes on a phone interview regarding your feedback and opinions?
    - No
    - Yes
        - Phone Number
        - Best time to call
          Evening, Afternoon, Morning

2. Did you take an anatomy course in high school?
    - No
    - Yes

3. Please select from the following choices what you would classify yourself as....
    - Surgery resident
    - Medical resident
    - Other:

4. Based on your answer above, what YEAR of residency are you in?
    - 1st year
    - 2nd year
    - 3rd year
    - 4th year
    - 5th year
    - Other:
5. What learning tools or strategies have you found to be the most helpful throughout your education in the learning of human anatomy?

6. What learning tools or strategies have you found to be the LEAST helpful throughout your education in the learning of human anatomy?

7. Typically in a science classroom, one would hear students say “I learn best via the “hands-on” method”. How strongly to agree with this statement in regards to the learning of human anatomy and physiology?

8. What advice do you have for high school science teachers on how to best teach human anatomy?

9. What educational experiences in human anatomy do you remember having the greatest educational impact? Early on in your education vs. most recent?

10. Additional thoughts on what you believe was most helpful in the development and success of your medical career?

APPENDIX C

UCSF RESIDENT INTERVIEW JANUARY 2015

Residents at UCSF – Phone Interview of Anatomical Learning Strategies and Their Effectiveness

Thank you for taking the time to complete this voluntary interview

1. Did you take an anatomy course in high school?
    - No
    - Yes

2. Please select from the following choices what you would classify yourself as....
    - Surgery resident
    - Medical resident
    - Other:

3. Based on your answer above, what YEAR of residency are you in?
    - 1st year
    - 2nd year
    - 3rd year
    - 4th year
    - 5th year
    - Other:
4. What learning tools or strategies have you found to be the most helpful throughout your education in the learning of human anatomy?

5. What learning tools or strategies have you found to be the LEAST helpful throughout your education in the learning of human anatomy?

6. Typically in a science classroom, one would hear students say "I learn best via the "hands-on" method". How strongly to agree with this statement in regards to the learning of human anatomy and physiology?

7. What advice do you have for high school science teachers on how to best teach human anatomy?

8. What educational experiences in human anatomy do you remember having the greatest educational impact? Early on in your education vs. most recent?

9. Additional thoughts on what you believe was most helpful in the development and success of your medical career?

APPENDIX D

SHERIDAN HIGH SCHOOL HUMAN ANATOMY STUDENT SURVEY JANUARY 2015

Last Four Digits of Student ID # _____

Sheridan High School Human Anatomy Students – Learning Style Survey

Thank you for taking the time to complete this voluntary survey, your participation or non-participation will not affect your grade or class standing in any way.

Student Background Information:

1. You are a student that is currently enrolled in Course: "HUMAN ANATOMY AND PHYSIOLOGY" at Sheridan High School:
    - Yes
    - No

2. You are a student that is _____ your semester of Course: "HUMAN ANATOMY AND PHYSIOLOGY" at Sheridan High School:
    - Just finishing up taking
    - Just beginning

3. You are a student in:
    - 9th grade
    - 10th grade
    - 11th grade
    - 12th grade
4. You are:
    - Male
    - Female
    - Prefer not to respond
5. The science classes you have taken from 9th grade until now are (select all that apply)
    - Integrated science
    - Biology
    - Chemistry
    - Physics
    - Earth Science
    - AP Biology
    - AP Chemistry
    - AP Environmental Science
    - AP Physics
    - Other:

Learning Style Information:

6. You remember items the best by listening

   Disagree 1 2 3 4 5 Agree

7. You remember items the best by watching or seeing them

   Disagree 1 2 3 4 5 Agree

8. You remember items the best by writing them down

   Disagree 1 2 3 4 5 Agree

9. You prefer a teacher or presenter that uses diagrams or pictures

   Disagree 1 2 3 4 5 Agree

10. You have a broken arm. You would prefer that the doctor

    a. Told you why your arm was broken

       Disagree 1 2 3 4 5 Agree

    b. Gave you something to read about your broken arm

       Disagree 1 2 3 4 5 Agree

    c. Showed you on a skeleton where your arm was broken

       Disagree 1 2 3 4 5 Agree

11. Typically in a science classroom, one would hear students say “I learn best via the “hands-on” method”. How strongly do you agree with this statement in regards to the learning of human anatomy and physiology?

    Disagree 1 2 3 4 5 Agree

12. When it comes to remembering the muscles in the human leg for your test, you believe the best way to help you remember these are:

    a. Reading about it in your notes or a book

       Disagree 1 2 3 4 5 Agree

    b. Looking them up online

       Disagree 1 2 3 4 5 Agree

    c. Taking a practice quiz

       Disagree 1 2 3 4 5 Agree

    d. Using your own body or someone else's to touch and feel the different muscles

       Disagree 1 2 3 4 5 Agree

APPENDIX E

SHERIDAN HIGH SCHOOL HUMAN ANATOMY STUDENT INTERVIEW QUESTIONS JANUARY 2015

Last Four Digits of Student ID # _____

Sheridan High School Human Anatomy Students – Learning Style Interview

Thank you for taking the time to complete this voluntary survey, your participation or non-participation will not affect your grade or class standing in any way.

(Post= refers to students ending the semester of A/P; Pre= refers to students starting the semester of A/P

1. (Post)What learning tools or strategies have you found to be the most helpful throughout your education in the learning of human anatomy?
   (Pre)What learning tools or strategies do you think will be the most helpful throughout your education in the learning of human anatomy?

2. (Post)What learning tools or strategies have you found to be the LEAST helpful throughout your education in the learning of human anatomy?
   (Pre) What learning tools or strategies do you think will be the LEAST helpful throughout your education in the learning of human anatomy?

3. (Post) What advice do you recommend to Sheridan High School students on how to best learn human anatomy?

4. (Post) What educational experiences in human anatomy do you remember having the greatest educational impact?

5. (Post) Additional thoughts on what you believe were most helpful in the development and success in human anatomy at SHS?

APPENDIX F

SHERIDAN HIGH SCHOOL HUMAN ANATOMY TEACHER INTERVIEW QUESTIONS MARCH 2015

Sheridan High School Human Anatomy Teachers Interview

- What learning tools or strategies have you found to be the most and least helpful to teach human anatomy to high school aged students?

-What educational experiences in human anatomy do you think has the greatest educational impact on high school students?

-Additional thoughts on what you believe are most helpful in the development and success for a high school student in human anatomy at SHS?