Kids in the Gross Anatomy Lab: How an Outreach Program in Anatomy Educates High School and Undergraduate Students about Health Care

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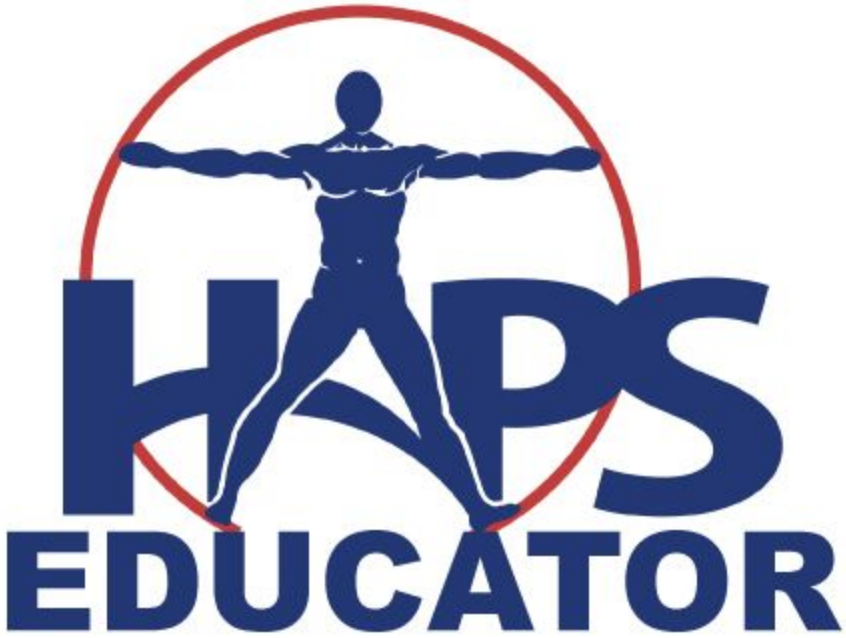

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Kids in the Gross Anatomy Lab: How an Outreach Program in Anatomy Educates High School and Undergraduate Students about Health Care

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Abstract
The growing movement in STEM education is popularizing active learning, which has benefits for high school and undergraduate students, especially those in rural areas with limited resources. In Mississippi, daunting health disparities in incidence of stroke, cardiovascular disease, type II diabetes, and obesity warrant the implementation of outreach programs that expose high school and graduate students to the health sciences, such as anatomy, and to health literacy. The outreach program at the University of Mississippi Medical Center (UMMC) incorporates informal learning sessions whereby high school and undergraduate students rotate in the gross anatomy lab through various stations featuring organ systems. These sessions benefit the students by engaging their critical thinking skills, motivating them to lead healthier lifestyles, and incentivizing them to pursue careers in the health sciences. https://doi.org/10.21692/haps.2018.031

Key words: anatomy education, anatomy outreach, STEM education, active learning, health disparities

Introduction
In April 2013, a nationwide push began for the adoption of the Next Generation Science Standards (NGSS) developed by Achieve, Inc., a non-profit organization with a mission dedicated to educational reform (Pruitt 2015). Due to the growing movement in STEM education in secondary schools in response to NGSS, there is a need to incorporate STEM concepts into classroom learning experiences.

Since many schools in rural areas may have limited resources or limited access to advanced science materials or technology, academic medical centers or other institutions of higher learning, specifically in the sciences, have an opportunity to respond. In this respect, these institutions can lend their own resources in designing and implementing lessons that serve as community outreach efforts for local and regional undergraduate and secondary education students. These lessons can revolve around health-related topics and integrate basic science knowledge with pathological conditions in order to foster critical thinking skills and problem solving practices between undergraduate and high school students.

The Science Teaching Excites Medical Interest (STEMI) project at the University of Mississippi Medical Center (UMMC) advocates STEM education in high schools. It also brings basic scientists, clinical anatomy students, and high school teachers together with the goal of training teachers in the development and implementation of flipped classroom modules that incorporate active learning strategies and healthcare disparity content (Notebaert *et al.* 2018). A similar outreach program at the University of Arkansas for Medical Sciences (UAMS) also provides high school science teachers with training and resources for teaching content in the health sciences (Burns 2002). Such outreach programs hold the potential for improving STEM education and could greatly benefit STEM education in Mississippi.

Why Outreach?
According to the Centers for Disease Control and Prevention, Mississippi has among the highest levels in the nation of obesity (CDC 2017b), type II diabetes (CDC 2017a), cardiovascular disease (CDC 2018), and stroke (CDC 2018) in which major disparities of incidence, severity, and mortality exist. The high number of healthcare disparities in Mississippi creates a compelling need to better educate students and the general public in areas such as risk factors for disease, social determinants of health, and preventative measures for addressing such discrepancies.

This need is especially apparent in Mississippi where students have average scores below the national mean in every Advanced Placement (AP) science and mathematics course, except AP Physics C: Electricity & Magnetism (College Board 2017). This need is also apparent due to the fact that Mississippi high school graduates had the second-lowest mathematics, science, and composite ACT score averages

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in the nation in 2017 (ACT 2017). The application of clinical relevance to biological concepts allows Mississippi students to see the influence that knowledge can have in encouraging lifestyle changes that improve their own health and the health of other Mississippians.

Program Description

The University of Mississippi Medical Center (UMMC) hosts an informal outreach program that receives undergraduate students from one of the local colleges and students from several high schools in the state. Faculty and students in the Clinical Anatomy program introduce students to the medical center's gross anatomy laboratory and guide them through activities.

The Institution

UMMC is the only academic medical center in the state of Mississippi. Located in Jackson, the state's capital and most populated city, the institution has the responsibility to serve as a hub for learning in the health sciences at all levels of education. Given the fact that Mississippi has some of the highest health disparities in the country, the medical center has the responsibility to serve as a beacon for health literacy, especially for individuals who have limited access to advanced scientific resources. Through the Clinical Anatomy program in the Department of Neurobiology and Anatomical Sciences, UMMC offers a free program for educating students about these health disparities, human anatomy, and the various health professions whose training includes anatomy.

Formal Anatomy Instruction

Of the seven different health professional schools on UMMC's campus, four of them incorporate formal anatomy instruction into their curricula. The first-year students in the School of Medicine, the School of Dentistry, and the Clinical Anatomy Ph.D. program in the School of Graduate Studies in the Health Sciences are required to learn content in macroscopic anatomy (gross anatomy), microscopic anatomy (histology), developmental anatomy (embryology), and neuroanatomy. In addition, the first-year students in the Occupational Therapy and Physical Therapy programs within the School of Health-Related Professions and students in the Master's in Biomedical Sciences (BMS) program within the School of Graduate Studies in the Health Sciences are required to learn content in gross anatomy and neuroanatomy. During their first year, the Ph.D. students in Clinical Anatomy also take two pedagogy courses to understand the nature of learning in general and to learn about various learning theories and teaching methods. In their second year, the anatomy graduate students take a pedagogy course in which they learn how to design curricula specific to anatomy. Moreover, in their second, third, and fourth years of the program, the anatomy graduate students gain training in teaching by serving as teaching assistants in at least one of the content areas in medical or dental anatomy each semester. Furthermore, anatomy graduate students have opportunities to teach undergraduate and high school students anatomical content during multiple visits scheduled throughout the year.

The gross anatomy lab is one of the traditional learning environments used by the on-campus health professional students and visiting undergraduate and high school students. While formal instructional lessons are conducted in the lab for the health professional students who take gross anatomy, the undergraduate and high school students participate in informal learning experiences with cadaveric material. Since anatomy courses are ongoing throughout the year, cadaveric material is available for informal teaching opportunities with the undergraduate and high school students. First-year medical students use the lab during the fall semester, first-year dental and BMS students use the lab during the spring semester, and first-year occupational and physical therapy students use the lab during the summer semester. The health professional students dissect donors during their lab sessions, affording undergraduate and high school students the chance to learn human anatomy from cadaveric specimens to which they would have otherwise not had exposure at their own institutions.

Informal Anatomy Instruction

During the experiential learning sessions, the undergraduate and high school students and their instructors become oriented to the gross anatomy lab. The students receive an introduction to the components of the laboratory space, the courses taught in the space, the Clinical Anatomy program, and the Body Donation Program through which the donors are acquired. The visitors are informed of the utmost respect given to the bodies of the donors, and they are prohibited from taking any photos of the donors or any other cadaveric material. The visitors are then provided with the appropriate protective attire, including white lab coats, latex gloves, and safety glasses. Afterwards, the visitors are given an overview of the lab stations through which they will rotate.

Each lab station is assigned an anatomy faculty member or an anatomy graduate student as a facilitator, and the time for each lab station is apportioned equally within the allotted timeframe for the lab visit. Since most undergraduate and high school students who visit the gross anatomy lab are enrolled in a human anatomy and physiology course, the topics of the lab stations revolve around individual organ systems. While human anatomy and physiology courses are taught using a systemic approach, gross anatomy is traditionally taught using a regional approach. In the informal learning sessions, the anatomy facilitators blend the regional approach of gross anatomy with the continuity of the systemic approach of human anatomy and physiology. This combination of approaches allows the students to understand entire organ systems in the context of specific body regions and these organ systems' relationships to the body as a whole.

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The instructional process typically begins with a brief introduction initiated by the facilitator and an invitation for the students to share their intended career goals. Most students have aspirations of pursuing careers in healthcare fields such as medicine, nursing, dentistry, and occupational and physical therapy. However, some students have plans to earn degrees in other disciplines such as psychology, music, and art. Other students have not made a decision about their future career. Regardless of their decided or undecided career plans, the students convey a genuine interest in the ensuing learning sessions.

All of the lab stations usually incorporate four primary elements, including 1) the engagement of the students' prior knowledge, 2) the practices of probing, or deep and guided questioning, 3) inquiry and experiential learning, and 4) emphasis on the clinical relevance of the content discussed. First, the students are asked to explain what they already know about the organ system featured in the station, including its functions. The students' responses inform the progression of the discussion that follows. This discussion usually connects the functions that the students mention to the compositional structure conveyed by the various organs comprising the organ system under investigation. The interaction gradually evolves into an exploratory journey through each component of the organ system. This anatomical adventure is punctuated with a series of guided questions that lead the students through the system. The students are encouraged to name each consecutive organ within the system and to explain its respective function. An interrogation with deep questions compels the students to delve further into the rationale underlying the structure-function relationships. The students are encouraged to think more critically with "why" and "how" questions. The students are immersed in a condition of inquiry whereby they are allowed and encouraged to ask additional questions. They are invited to experience the preserved, prosected specimens pertaining to the respective organ system by holding them in their hands and feeling their textures.

Several specimens in the lab exhibit abnormalities due to diseases or health conditions of the donors to whom they belong. For example, when discussing the cardiovascular system, the students are shown hearts that exhibit stitches denoting by-pass surgery on one or more of the coronary arteries. Many of these hearts are retrieved from donors whose sterna have been sutured closed with wire—evidence suggestive of open-heart surgery. Such clinical correlations allow the students to extend their thinking to see the relevance of anatomy to heath care. By comparing both normal and abnormal anatomy, students can understand just how crucial the practices of heath care professionals are in preserving the lives of patients by restoring their anatomy to normal or as close to normal as possible. Overall, the lab experience begins as a discussion and evolves into something much more. The exchange of comments and replies unfolds as a conversation that engages the students in active intellectual participation with the facilitator and each other rather than subjecting them to a one-way didactic lecture in which they serve merely as passive learners.

An Example of Lab Stations on the Cardiovascular System
1) The facilitator (ERM) began with an overview of the cardiovascular system and its components (heart and blood vessels, e.g. arteries, veins, and capillaries), and its basic functions. The names of the components were posed to the students as questions to gauge what the students already knew prior to the session.

<<The students moved to station with heart and lungs prosection.>>

2) The facilitator and the students discussed the circulation of blood beginning with the heart, allowing the students to describe the flow of blood from one structure to the next in both pulmonary and systemic circulation. (This was a situation where the facilitator asked them where the blood goes next, etc.)

After this discussion, the facilitator allowed the students time to ask questions that they might have concerning the circulation. Upon answering their questions, the facilitator moved to the next station.

<<The students moved to station with dissected heart.>>

3) The facilitator then showed the students the exterior and inferior surfaces of the heart, emphasizing the main features that contribute to the function of the heart (e.g. valves, muscular walls).

The facilitator also briefly discussed the histological significance of cardiac muscle and its function as a syncytium via the sinoatrial (SA) node, the pacemaker of the heart. The facilitator asked if they knew anyone who has ever had a pacemaker and if they could explain the function of pacemaker.

<<At this point, the facilitator showed the students an example of a donor who had a pacemaker.>>

The facilitator also asked students: "If the heart does all the pumping for blood, does it too need a blood supply?" The facilitator then listened to how the conversation ensued and proceeded with a discussion of the coronary arteries, asking if the students knew anyone who had had bypass surgery.

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<<The students moved to station with prosected cadaver.>>

At this station, the facilitator showed the students an example of a bypass surgery.

Once again, the facilitator allowed time for any questions the students might have.

4) At the same cadaver, the facilitator then led the students in a discussion of the major vessels in the body, pointing out some in the cadaver, but allowing them to first try to describe them (e.g. arteries: aorta and its branches, pulmonary artery and its branches, bifurcation of the aorta, etc., and veins: superior and inferior vena cava and some of their major tributaries). The portal system was left for another clinical anatomy graduate student facilitator (SW).

As the facilitator (ERM) talked about the bifurcation of the aorta, he showed the students an example of an abdominal aortic aneurysm. This demonstration catapulted the conversation into an inquiry about the causes of aneurysms, their dangers, and their treatments.

After, discussing the major vessels, the facilitator briefly discussed the histological differences between arteries and veins, allowing students to tell him some of the differences and similarities that they might have already known. While the students knew that arteries carried blood away from the heart (*a* for *away*) and that veins carried blood back toward the heart, they did not consider their different textures and histological compositions. Thus, the students were encouraged to touch various smaller arteries and veins so that they could compare the more elastic, thick-walled, opaque arteries to the flatter, thin-walled, transparent veins.

And finally, the facilitator initiated a transition to discussing the general idea of collateral circulation by pointing out the multiple arteries in places like the forearm and elbow. Students contemplated the rationale of extra sources of blood flow. The students eventually arrived at the importance of such additional blood circulation in the event that one source might be occluded, severed, or surgically removed.

A final two-part question the facilitator posed at the very end of the series of lab stations on the cardiovascular system was, "What part of the body receives the greatest amount of blood supply. And why?" The fact that the students spent a prolonged period of time contemplating the questions and pondering their responses further emphasized the answer since the brain is in fact the part of the body that requires most of the body's blood flow due to its high demand for glucose as a readily available energy source.

<<When they finished viewing the cardiovascular system stations, the students moved to stations with prosected cadavers pertaining to the digestive system with facilitator (SW).>>

Discussion

Despite the informality of these learning sessions in the gross anatomy lab, there is a rationale behind the techniques used in the guided questioning process. In addition, there are inherent benefits and challenges to implementing such a program that are worth noting.

Rationale

The guided questions which were provided in the aforementioned station descriptions were addressed to the students by the clinical anatomy student and faculty facilitators as a means to provide a just-in-time teaching experience (Marrs and Novak 2004) whereby the information the students needed to arrive at the answers was only given at the appropriate time. In this way, there was never a time that the facilitators simply gave the students the answers without first compelling them to think critically to arrive at their responses. These questions served as a formative assessment to appeal to the students' "logical thinking," a concept within the common set of values of scientific inquiry that is the nature of science. This concept is outlined under the disciplinary core idea of "Science and Engineering Practices" within the "Structure and Function" competency of the NGSS framework (NGSS Lead States 2013). In their reasoning, the students relied on their powers of observation to discover characteristic features within displayed images of photomicrographs of both normal and pathological tissues and organs. They also learned to relate structure to function.

One study showed that active learning promotes high school students' intrinsic motivation, their intent to enroll in advanced placement (AP) courses, and their interest in professions in scientific fields (Bryan *et al.* 2011). Therefore, programs that include learning sessions similar to the one used in the gross anatomy lab can encourage the incorporation of active learning modules regarding healthcare disparities into high school classrooms to encourage students to pursue careers in fields such as the health sciences.

Benefits

There are a number of benefits for students who participate in the lab visits. The students from the local college do not have access to cadavers due to the cost of maintaining a sustainable body donation program; therefore, field trips to the gross anatomy lab at the medical center nearby allows the students to gain experience with cadavers, even though the exposure may only be once per semester. Since their experience is free, access to human donors, though temporary, provides them with a cost-effective learning opportunity that

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is simultaneously realistic and enriching. Similarly, the high school students also receive the same learning benefits. The students also receive authentic learning experiences during which they understand the importance of health literacy for themselves, their families, and the citizens within their state. Such motivational learning has the potential to encourage students to consider health care fields more intently if they were already on the health care track or to consider them as an option if they were undecided.

These lab sessions also benefit the facilitators as they provide them with training opportunities to gain more experience in teaching anatomy. However, these opportunities provide the facilitators not only with another traditional instruction experience to add to their curricula vitae but also with low-stakes training to enhance their skills in facilitating small-group discussions and active learning sessions. These teaching methods are becoming more common in primary and secondary education. Evidence-based research suggests that active learning improves students' average scores on examinations by about 6% (Freeman *et al.* 2014). In addition, these types of instructional techniques are becoming more common in undergraduate and graduate education. Graduate students in Clinical Anatomy also learned ways in which they could assist in classroom lessons regarding anatomical content and its relevance to adverse health conditions. Just as university science students mentored elementary students and engaged them in scientific activities in one study (Bruce *et al.* 1997), so too can graduate university students challenge high school students.

There is also a mutual benefit for both the students and the facilitators as the dynamics of their interactions during the lab sessions are fully dependent on the engagement and activity of each individual member of the group during the interchange of ideas. The queries and explanations posed by each participant have the power to transform the discussion and prolong the life of the rich conversation to which each participant becomes a vital member; thus, no one is more important than the other. Such experiences teach young students that their thoughts are highly valued and have the potential to instill within them the confidence to voice their thoughts with resolution.

Challenges

Along with the benefits, there are a number of challenges to organizing these learning sessions. The first challenge is the obvious challenge of time. Most faculty and students within the Clinical Anatomy program are extremely busy with course work and other obligations; thus, they have limited time to devote to outreach. Professors at undergraduate institutions as well as teachers in secondary education are also busy with their own teaching schedules, so the planning of visits to the gross anatomy lab often requires considerable efforts. Moreover, while the program and department do not charge visitors for learning in the gross anatomy lab, there are associated costs with travel to the institution from high schools as far away as two and a half hours from the campus. Furthermore, even local high schools may not always receive district approval to use school transportation to visit UMMC, and some districts, even local ones, may not even have the funds to support such visits, even as educationally beneficial as they may be for the students. With the health disparities in Mississippi being so high, the efforts this program exerts in making a difference for the health care of the entire state may seem minimal. Nevertheless, the efforts of this program in concert with the efforts of the multiple outreach endeavors initiated by students and faculty at UMMC together have the capacity to engender small changes that, over time and with consistent implementation, can make a substantial impact on the wellbeing of Mississippi citizens.

Future Directions

Desired directions for the future of the program include expanding invitations for more high schools and undergraduate institutions to include more of those with large underserved and minority populations. In addition, the rural parts of the state with high schools that have limited resources and no means of providing their students with a mode for traveling to the medical center may require visits from representatives of the medical center. Instead of the students traveling to UMMC, faculty and students in the Clinical Anatomy program could make site visits to rural schools, especially those in dire need of exposure to health literacy content. Although UMMC faculty and students could not transport cadaveric material, they could bring anatomical expertise and skills in active learning to secondary students while engaging with existing embedded health sciences content. Further directions include exploring the existence of grants to fund such endeavors.

Conclusions

While the program described in this paper is a small, informal venture, it provides an enjoyable and informative experience for both students and facilitators. The learning sessions are also cost-effective ways for participating students to gain exposure to authentic human anatomy, real-world exposure to the health disparities evident in the pathologies of donors, and empowering discussions that foster higher order thinking and validation. These provisions serve as the ultimate incentive for students to become invested in the mission of improving the health care of Mississippians, either directly as health care providers, or indirectly as advocates for health care practices and the dissemination of health literacy.

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