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Engaging High School Students in a University-Led Summer Anatomy Camp to Promote STEM Majors and Careers

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ABSTRACT: University-led K-12 outreach programs are designed to expose students to a variety of fields and career choices, but the benefits and outcomes of these have not been well documented. Existing programs often range from short presentations to more extensive residential summer programs. Nationally, there are only a few university-led high school human anatomy camps, with no current publications focusing on a formal evaluation of their goals. Described herein is a week-long human anatomy summer camp at Colorado State University (CSU) designed to inspire high school students to attend college and attract them to STEM majors and careers. The camp schedule includes lectures presented by CSU's faculty, hands-on activities including learn from human cadavers and animal organs, as well as mentorship opportunities. Success of the program is measured by qualitative feedback and a follow-up survey to measure if the goals of the camp were well received. The data shows that all 28 of the senior high school students who attended camp have applied to college and are considering a STEM career after college. Camp counselors have reported continued mentor/mentee relationships with the students after camp.

INTRODUCTION

Many public and charter schools lack formal hands-on science laboratories which could be largely be attributed to the decrease in funding for Science, Technology, Engineering, and Mathematic (STEM) programs (Gonzales, 2012; Executive Office of the President, 2010). Additionally, there is an increased curricular focus on standardized testing, which ultimately decreases students' opportunities to explore all aspects of STEM, including exposure to college majors and career choices (Strauss, 2012; Hammack et al., 2015). In a recent study, high school and college students expressed that the most important factor influencing their career choice is the information provided by teachers, school counselors, and their parents (Hall et al., 2011). Information regarding STEM college majors and career choices is limited to the knowledge of faculty and staff, and by the funding and resources available to each school. In order to increase college enrollments in STEM majors, extracurricular outreach activities are needed to give students access to more information regarding their choices in college and beyond. Universities are in a unique position to facilitate this endeavor by widening students' interest in STEM through valuable experiences on a college campus where resources and expertise are abundant. Following is a description of reported summer camps focusing on engaging and recruiting high school students into STEM.

At the University of Rhode Island Kingston campus, Levine and colleagues created a weeklong chemistry camp for middle school students filled with hands-on experiments, field trips, and interaction with female scientists (2015). One key goal of camp was to encourage the girls' interest in STEM disciplines and STEM careers. Survey results showed success in changing attitudes towards applicability of science and interest in pursuing a STEM-related career. Similarly, Adventures in Chemistry Camp is a week-long

program during which students lived in college residence halls at the University of Nebraska Kearney and participated in daily hands-on chemistry experiments (Exstrom et al., 2000). The intent was to facilitate their first college experience. The small faculty-to-student ratio and the open-ended laboratory projects conducted in a research setting were important components of this camp compared to other chemistry camps currently offered. Results indicated that overall, the camp was well perceived by the students. In their exit survey, students indicated that they enjoyed staying in the dorms and conducting research with their advisor.

To increase interest and knowledge about STEM, Hammack and colleagues (2015) measured the effects of a weeklong engineering summer camp on middle school students. School teachers and one engineering professor from a local university facilitated the camp at their school and measured how participating in a weeklong engineering summer camp affected middle school students' attitudes towards engineering. Findings indicated that the students improved their understanding of technology and attitudes towards engineering. Likewise, Yilmaz and colleagues (2010) created a camp called YESTexas (Young Engineers of South Texas) with the goal to expose high school students to STEM concepts through a set of hands-on engineering projects. Results demonstrated that 24 out of 30 (80%) of the high school students had an increased interest in engineering disciplines after attending camp. Overall, the camp provided an opportunity to promote critical thinking, teamwork, writing, and leadership skills.

"Girls on the Go: The Mobile Computing College Experience" is a summer camp designed for high school girls (Burge et al., 2013). This camp was created to encourage the students to attend college and to interest them in computer science as a possible career option. This camp was free of charge, held at Miami University in Florida, and focused on technical, informational, and social activities to give the students an idea of a balanced college experience. A comparison of pre- and post-surveys on 28 students suggested that the girls' confidence in computer science and their understanding of careers in computer science increased. Furthermore, ten out of 25 students volunteered to continue working on the design for a computer application started during camp.

In addition to laying a foundation of STEM knowledge and experience, residential camps create mentorship opportunities. University mentors provide more information about college majors, share their college experiences, and offer encouragement (Castleman, 2014). Mentors have an opportunity to shift student perception of social norms regarding choices regarding college majors and activities.

It is not uncommon for first-year college students to struggle with a sense of belonging, which could be addressed by having mentors present on campus before or during their Freshman year (Walton and Cohen, 2011; Stephens et al., 2014). In 2014, Castleman created a peer-mentor intervention through which college students and advisors conducted outreach to support high school graduates in their college transition. Text and/or peer mentor interactions composed of in-person meetings and follow-up phone conversations took place in urban school districts in Boston, Lawrence, and Springfield (MA), Dallas (TX), and Philadelphia (PA). College enrollment varied across study sites ranging from 14 to 53% (Castleman, 2014). Castleman proposed that this method provided a "low-cost behavioral nudge" helping students reduce the complexity associated with navigating college and financial aid information. It also increased parents' awareness of required pre-matriculation tasks. However, these interventions were only designed to help with applying to college and did not include continuous mentorship.

To date, only a few university-led summer high school camps focusing on human anatomy have been documented, such as the Clinical Anatomy Summer Program at Stanford (Stanford Medicine, n.d.), the One-Week Summer Medicine Program at Boston Leadership Institute (Boston Leadership Institute, n.d.), and the Anatomy & Physiology Camp at the Appalachian State University Beaver College of Health Sciences (Appalachian State University, 2020). All of the aforementioned programs focus on using hands-on anatomy exercises to expose students to a variety of career options. However, there is a lack of a detailed evaluation of the goals and outcomes of these camps. The field would benefit from more research on how to successfully implement and assess the impact of these outreach endeavors. To simultaneously address the issues of exposing students to a variety of career options within STEM, especially the medical field, facilitate their first college experience, and create a long-term mentorship program, we developed a week-long human anatomy camp for high school students at Colorado State University.

METHODS

The main goals of the camp were to (1) expose high school students to various activities involving anatomy and introduce them to a variety of STEM major and career options, especially within the medical field, (2) facilitate their first college experience and (3) enable mentorships. Reported herein is the development, implementation, and evaluation of this summer anatomy camp, as well as implications for future outreach efforts (Figure 1).

Camp Application and Student Cohort. Colorado State University's annual Anatomy Camp was launched in summer of 2016 and takes place at the Fort Collins campus. High school students are accepted to camp based on several factors including year in school, interest in science, leadership potential, and written essay responses. Students need to have completed two years of high school to be eligible

Figure 1. Photographs of Camp Activities. Clockwise from top left: Whitewater rafting; suture clinic; clay modeling; laboratory work; case study work; VR exposure; laboratory work; visit at the local museum.

to apply. Applications are accepted until camp is full; once camp is full, applications are accepted for the waitlist. Tuition for anatomy camp is $1,850 per student and includes six nights of lodging in a residence hall, meals, a laboratory manual written by CSU's Biomedical Sciences faculty, supplies, extracurricular camp activities, and a set of scrubs. Three scholarships are available to campers seeking financial support: The diversity scholarship aims to recognize and support students with diverse cultural, socioeconomic and ethnic backgrounds. The overcoming adversity scholarship provides support for students that have demonstrated strength in the face of adversity. Finally, the leadership award recognizes incoming campers that display leadership qualities and is funded by donations from previous camp counselors, faculty and parents of former campers.

As the camp is residential, applications are collected from all over the country with the greatest number of applicants from Colorado, followed by California. In addition to traditional camp registration forms, parents of attendees are required to send complete consent forms, either agreeing or declining their child's ability and desire to take part in this research study. Campers are also asked to describe, in essay form, their expectations and hesitations about camp. Each year, 32-34 students are accepted, split into six total groups with two assigned counselors who help guide them throughout the week.

Counselors are a mix of both graduate and undergraduate students who have successfully completed the human anatomy courses at CSU (Human Gross Anatomy, Honors Gross Anatomy, Human Anatomy Dissection, and Advanced Human Anatomy). Counselors undergo a rigorous application process which includes submitting resumes, essays describing mentoring experiences, and references. Applicants are then brought in for a group interview where they need to demonstrate teamwork, leadership ability, compassion for others, and problem solving.

In the weeks preceding camp, selected counselors participate in an online course designed to introduce them to concepts of teaching and learning. Topics include educational philosophy, experiential learning and multiple intelligences, ice breakers, Bloom's taxonomy, lesson planning, and critical thinking. Two in-person training days are also scheduled to further work on these topics and receive feedback from faculty and staff on their lessons. After camp, the counselors are required to reflect and submit an essay on their experiences. Their impressions are collected not only to improve camp, but also to provide an opportunity for personal reflection.

All high school campers stay in a residence hall to facilitate a real campus experience. The counselors have individual rooms distributed along the hall of the dorm to facilitate interactions between counselors and students. This arrangement enhances our goal of enabling mentorship opportunities. Comparing the accepted high school students over the years of 2017-2019 (n = 100), it can be observed that 83% of high school camp attendees identified as female and 17% as male. The female to male ratio for counselors is generally about the same every year (Table 1).

Table 1. *Overview of Accepted High School Students. Total number of students, number of females and males, and number of camp counselors during camp in 2017, 2018, and 2019.*

	2017	2018	2019
Total number of students	34	34	32
Number of females	29	28	26
Number of males	5	6	6
Number of camp counselors	10	10	10

Camp Curriculum. The camp schedule builds off two main goals to expose high school students to a college-level anatomy experience and to a variety of STEM major and career options. Table 2 in Supplementary Material illustrates this schedule with human anatomy lectures, computer-based cross-sectional anatomy, and solving clinical case studies. Faculty and staff from the Department of Biomedical Sciences facilitate the daily lectures and laboratories, which are designed to mimic the undergraduate anatomy course. The lecture and laboratory content allow each camper to experience a college level course. This experience is a valuable experiential learning tool as well as an effective college recruitment tool.

In order to make college-level content accessible to high school students, each counselor facilitates a hands-on, interactive lesson at the beginning of each day. Counselors have reported that this teaching experience is incredibly valuable for their personal and professional growth. Additionally, it exposes the campers to the material in a fun, low-pressure environment. This gives campers confidence with the new material before they step foot into a more fast-paced faculty-led lecture.

Each camp day incorporates significant time learning from prosected human cadavers and dissecting animal organs in the laboratory. These laboratory sessions provide students with hands-on experiences from human cadavers in a small group setting. The regions covered throughout camp are organized chronologically as follows: Lower Limb; Thorax, Abdomen and Pelvis; Head and Neck; and Upper Limb. Laboratory sessions are accompanied by a written guide authored by CSU's faculty and staff to provide students a more self-directed learning experience. When the students are in the laboratory, they are divided into their respective groups and assigned to one cadaver at a time. For 15-20 minutes, the students focus only on one system (blood supply, nerves, bones, musculoskeletal, radiographs) within a specific region of anatomy. During that time, they use the provided laboratory guide as a written narrative that leads them on a self-guided discovery of each system. After 20 minutes, the groups rotate to another cadaver to learn about a different system. Counselors and faculty are present at each station to guide them and answer any questions. At the end of the week, counselors and faculty facilitate a fun anatomy challenge in which students compete to test their acquired anatomy knowledge. Similar to a laboratory examination in the human anatomy course at CSU, campers are exposed to a tagged cadaver. In their respective groups and with a provided word bank, campers try to associate the tagged structure with the correct anatomical term. The group with the highest number of correct answers wins a prize.

At CSU, we are fortunate to have both Animal Anatomy and Human Anatomy laboratories. This provides us with the unique opportunity to offer an interactive comparative laboratory lesson to increase the application of knowledge. During this hour, students are exposed to a variety of animal specimens to compare specific anatomical features across species. Many high school students are still narrowing down their interests and we believe that providing them with more options within biomedical sciences is valuable.

To be successful in the discipline of anatomy, it is important to be able to understand spatial and structural relationships (Langlois et al., 2017). Many students, even at the professional level, struggle with analyzing two-dimensional images. To introduce this concept, we incorporated digital cross-sectional anatomy exercises in each anatomical region throughout the week. Software programs including the Visible Human Dissector (ToLTech, 2020) and CSU's own virtual reality program (BananaVision) expose students to two-dimensional cross-sections and link these to complete three-dimensional anatomy. We believe this early introduction to cross-sectional study gives students a glimpse of the anatomy seen in medical imaging.

Anatomy Camp's curriculum is based around six clinical case studies chosen to highlight different regions of the body. In order to solve the case studies, campers learn a four-step systematic approach to help them solve the novel problem. This method has been previously described by Meyer and colleagues (2018). After the students have read the clinical case, they are encouraged to ask for definitions on unfamiliar terms, determine the correct timeline of symptoms (chronic or acute), explain what systems could be involved (musculoskeletal, nervous, integumentary etc.), and state what other unique features are in the case study. Once these fundamental questions are answered, students identify the major concern of the patient and apply their anatomical knowledge until a diagnosis is reached. During the week of camp, each group of students is required to work through the systematic approach with their assigned clinical case study. Counselors provide guidance but encourage small groups to research the case on their own. Each group is assigned a different case that focuses on an important anatomical concept. All lectures and laboratories are designed to help campers solve their case. Each team then creates a presentation covering the anatomy of their case study. This activity enhances their critical thinking and presentation skills. It also provides each student the opportunity to work collaboratively within their group. During the final day of camp, each small group presents their case study findings in front of faculty, peers, and families. Practicing this approach provides students with

a framework that can be applied to any novel problem. This technique can be a valuable tool throughout their academic career.

To supplement the academic aspects of camp, campers are given free time in the residence hall, campus tours, and time to explore CSU's recreational center. Campers and counselors are also given the opportunities to experience the surrounding area with outings at the Fort Collins Museum of Discovery, a whitewater rafting trip in the Poudre Canyon, and a group hike at Horsetooth Mountain Park. While campers and counselors naturally develop a mentor/mentee relationship, these fun activities away from the classroom provide additional opportunities for the counselors to share their college experiences. Mentors often share their favorite courses exposing high school students to the variety of STEM material offered at CSU. In addition, the college's Assistant Director of Student Success meets with the campers over lunch and shares information about the college and undergraduate degrees. To increase their exposure to the STEM field in the greater Fort Collins community, we invite a medical professional from the surrounding community to talk about pathways into medicine. This interaction exposes the students to careers they may not have even known existed in the medical field.

EVALUATION

In order to evaluate the impact of CSU's Anatomy Camp on high school seniors attending camp in 2017, 2018 and 2019, a full board review was approved by CSU's Institutional Review Board (19-9636H). The Anatomy Camp team collected observations and feedback during and at the end of camp. Additionally, a formal follow-up survey facilitated through SurveyMonkey was sent out to all senior students approximately one year after their attendance:

1. Why did you sign up for camp?
2. What major are you considering in college?
3. Did CSU's Anatomy Camp change your perception about STEM majors in college? Explain why.
4. What do you want to do as a career after college?

The response rate of the follow-up survey in 2017 was 83.3%, 66.7% in 2018, and 85.7% in 2019 (Table 3), with all three years averaging 78.6%. Among the respondents, 25 of the 28 high school students (89.3%) indicated that they attended camp because they wanted to go, two (7.1%) stated that their parents encouraged them to attend, and one student (3.6%) reported that they signed up for camp to attend with their friends (Figure 2).

Table 3. *Follow-up Survey Responses. Number of contacted students for the follow-up survey in 2017, 2018, and 2019 with their responses, no responses, and response rate.*

	2017	2018	2019
Number of contacted students	12	9	14
Responses	10	6	12
No responses	2	3	2
Response Rate	83.3%	66.7%	85.7%

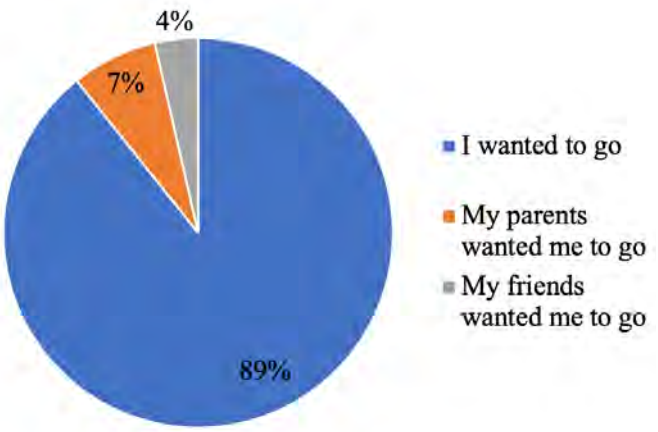

Figure 2. Reasons for Signing Up for Camp. Students had to indicate their reason why they signed up for Anatomy Camp (n = 28).

Overall, the camp was well received by the high school students, parents, and the undergraduate and graduate students who served as camp counselors. High school students reported that they mostly enjoyed the cadaver laboratories and suture clinics as they mimicked working in a health profession. Furthermore, they appreciated working with counselors of different majors, meeting a medical guest speaker, and talking to the college's Assistant Director of Student Success about admissions.

The first goal of camp was to expose high school students to various activities involving anatomy and showing them a variety of STEM majors and career options. Data show eleven students (39.3%) were considering Biomedical Sciences/Microbiology/Environmental Health/Neuroscience as a major in college, eight students (28.6%) were considering a Biology/Zoology/Botany major, three (10.7%) were looking into Chemistry/Biochemistry, and two (7.1%) were interested in Psychology/Human Development. Additionally, four (14.3%) selected "Other" as an answer choice and were considering Epidemiology, Speech disorders, Anthropology, or a mix of Psychology and Neuroscience. The answer choices "Engineering/Mathematics/Physics, Nursing", and "not attending college" weren't selected (Figure 3). Importantly, 14 students (50%) indicated that CSU's anatomy camp changed their perception and opinions about STEM majors in college. Qualitative data from the high school students specified that "Camp showed [them] that a STEM major is possible and even fun;" that "it made [STEM] less intimidating," that "females can do it," and "it showed [them] how

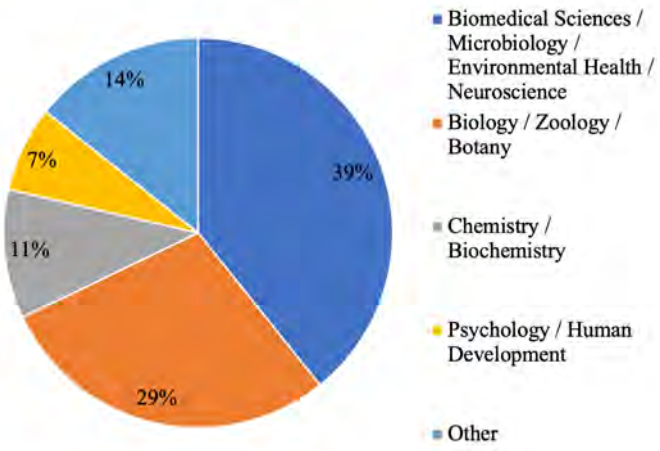

Figure 3. Consideration of Major in College. Students had to indicate what major they are considering in college (n = 28).

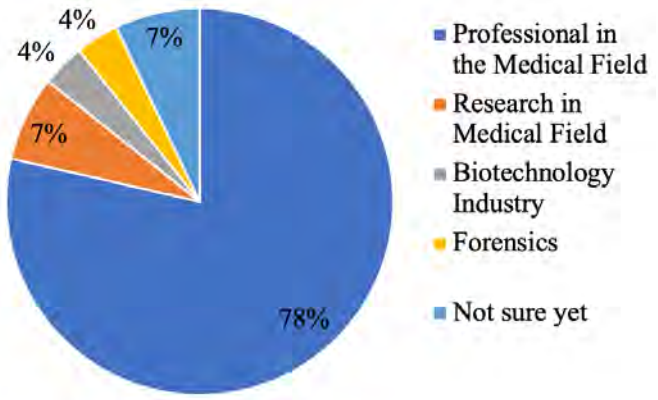

Figure 4. Career Aspirations. Students had to choose of a variety of career options they would like to pursue in the future (n = 28).

expansive the medical field really was, other than becoming a physician." Based on the survey responses, it was unclear why the 14 other students (50%) selected that there was no change in perception of STEM majors in college. It may be that these students likely were already interested in STEM before attending camp. Lastly, 22 students (78.6%) responded that they intended to pursue a career as a professional in the medical field including as a physician, a veterinarian, physician assistant, nurse, dentist, physical therapist, or veterinary technician. Two students (7.1%) indicated that they would like to pursue research in the medical field, one student (3.6%) was interested in the biotechnology industry, and one (3.6%) would like to pursue a career in forensics. Two students (7.1%) were unsure about their future (Figure 4).

The second goal of camp was to facilitate the students' first college experience. Staying in the dorms for the duration of the camp was an adjustment for some students. However, observations throughout the week indicated that the overnight stay enabled students to quickly form friendships and get acclimated to CSU's campus. Students reported that it showed them a glimpse of life as a college freshman, living and dining in a college dorm.

The third goal of camp was to enable mentorships. Email addresses between counselors and students were exchanged at the end of camp. Counselors have reported that students have reached out for advice with their college application which further underlines the impact of counselors throughout the camp experience.

CONCLUSION AND FUTURE DIRECTION

After four successful years of implementation of Anatomy Camp at CSU, the immersive college experience has provided unique opportunities for many high school students. This opportunity simulates a college experience, complete with campus living for the duration of the camp and the delivery of educational content from faculty. Campers participate in various activities involving human anatomy laboratories, including learning from prosected human cadavers and solving complex clinical case studies. Student campers are exposed to STEM majors and career options within the medical field through interactions with faculty, staff, and student counselors. The follow-up survey indicated that all 28 of the senior high school students who attended Anatomy Camp have applied to college and are currently considering a STEM career after college. Furthermore, camp counselors reported continued mentee/mentor relationships with the students after camp and have helped them with their college applications.

Limitations of this study include lack of a follow-up survey for non-senior students. In the future, a survey will be sent out to the students who attended camp as a junior and are considering college following their high school graduation. It would be interesting to explore in future studies whether the effects observed in the follow-up survey responses will persist over multiple years. Future efforts will focus on continuing to administer surveys to students who attended camp, to track their long-term interest in science, as well as their choice of future career after college. Additionally, there is a lack of a formal survey for the camp counselors in order to assess their experiences as well as their impact on the high school students. Data on their mentoring experiences will be collected and evaluated in order to enhance the study. Lastly, including international students would add a unique cultural diversity that would improve the camp experience for all campers and counselors. Enhanced recruitment for Anatomy Camp at CSU may be used to attract international students in the future.

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Author Contributions

NH and HH conceived, planned, and carried out the study. NH took the lead role in writing the manuscript. All authors contributed to the analysis and interpretation of the results and provided evaluation to help shape the research and manuscript.

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ABBREVIATIONS

CSU: Colorado State University; AP: Advanced Placement; STEM: Science, Technology, Engineering, and Mathematics; YESTexas: Young Engineers of South Texas

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