A laboratory stations activity provides a rigorous, hands-on introduction to concepts and techniques in forensic anthropology in an introductory forensic science course.

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Abstract: This article presents the use of a laboratory stations activity in an introductory forensic science course in order to introduce students to concepts in forensic anthropology and techniques for estimating the biological profile of skeletal remains. After completing preliminary activities, students examined osteological replicas in order to estimate age at death, stature, and sex; and analyzed evidence of skeletal trauma. Students were provided with reference materials to aid in their analysis. The advantages of using this format included high student engagement and inquiry, real-world problem-solving, realistic case scenarios, and challenging content. Some of the challenges encountered included difficulty comparing the osteological replicas to sketches and photos in order to assign scores and identify bony landmarks. These issues could be resolved by incorporating more preliminary instruction and providing additional reference materials.

Keywords: forensic anthropology, biological profile, stations activity, inquiry

Introduction

The purpose of this article is to describe the use of a laboratory stations activity in a forensic anthropology learning module. This learning module was part of a college level introduction to forensic science course taught to juniors and seniors at a specialized high school in New York City. Students enrolled in the class have the option to apply for three college credit hours from the College of St. Rose. This is a full-year survey course that includes learning modules on (in order) history of and introduction to forensic science, eyewitness testimony, physical matching, crime scene processing and evidence examination, impression evidence, death investigation, serology, blood spatter, forensic DNA testing, and trace evidence.

The forensic anthropology learning module is part of the unit on death investigation, and is taught after the modules on forensic pathology and forensic entomology. At this point in the term, students should already be familiar with cause and manner of death, and the changes that take place in the body after death. The forensic anthropology module focuses primarily on examination of skeletal remains and estimation of a biological profile. Learning standards for this module are listed in **TABLE 1**.

TABLE 1 *Learning standards for the forensic anthropology learning module.*

Standards (SWBAT)	**Evidence of Meeting Standards**
Analyze the inventory of skeletal remains from a burial site in order to determine NISP and MNI.	Hand in a hard copy of **What Do We Tell the Sheriff? Part 4** (on the next page) as evidence of meeting this standard.
Distinguish between human and non-human bones.	Hand in a hard copy of **Laboratory Activity 4: Forensic Anthropology (Stations) Data Sheet** as evidence of meeting these standards.
Analyze characteristics of skeletal remains in order to estimate age at death.	
Analyze characteristics of skeletal remains in order to estimate sex.	
Analyze characteristics of skeletal remains in order to estimate stature.	

Identify and analyze evidence of traumatic injuries in skeletal remains.	

Before beginning the lab, students completed several preliminary activities including watching screencasts about forensic anthropology, taking notes on the content of screencasts and readings on an outline worksheet. This method is similar to the Cornell Note Taking system (1). The outline worksheet included required readings (2,3) and optional resources (4,5). The outline was completed independently and followed by a student-directed class discussion to address topics that require clarification. Students then worked in their small learning teams to label a simple diagram of the human skeleton obtained online (6) in order to become familiar with human skeletal anatomy and terminology. Since this worksheet was more appropriate for middle school students, the author modified it, adding several bones for students to label such as the subtypes of vertebrae (cervical, thoracic, lumbar), the sacrum, coccyx, individual bones and cartilage in the pelvis (ilium, ischium, pubic bone, pubic symphysis), and individual bones in the skull (maxilla, zygomatic bone, mandible). Students were given the option to color individual bones in different colors (rather than simply labeling the diagram) to aid in their understanding.

Once the students were more familiar with skeletal anatomy, they worked in their small learning teams to complete a case study from the National Center for Case Study Teaching in Science (NCCSTS) titled “What do we tell the sheriff?” (7). The students completed each of the four parts of the case study consecutively. In part 1, they were given a realistic scenario in which they are the forensic anthropologists called in to examine a scatter of bones discovered in a state park. Students determined the number of identified specimens and the minimum number of individuals based on which bones were identified in subsequent parts of the case. An ethical dilemma was also discussed in the context of the case study.

The final activity in the forensic anthropology learning module was the laboratory stations activity. A stations activity allows students to have several experiences related to the same topic, is self-paced, and requires students to move around the classroom and work with other students outside of their usual small learning team (8). The author has already used this format for laboratory activities related to tool marks and firearms as well as trace evidence.

It is difficult to create a hands-on laboratory activity for forensic anthropology in a high school setting, since realistic casts of bones are expensive. In previous years, the author used activities from the course textbook in which students analyze data collected from skeletal remains in order to estimate a biological profile (2). While such activities challenged students to apply their knowledge, the direct observation and measurement of realistic replicas of skeletal remains was lacking. A laboratory stations activity in which students analyze features of skeletal remains was discussed in an article by Dr. Shelley Montgomery published in *The Forensic Teacher* (9). The article presents using stations as a way to include a number of topics without setting up an entire mock crime scene or several labs. However, Dr. Montgomery’s activity was more appropriate for a class taught at the middle or high school level and, though some measurements were included, relied more on morphology to draw conclusions about characteristics of the remains. The use of the word “determine” instead of “estimate” when referring to the biological profile (sex, age, stature, and race) was also problematic since anthropological analysis can only result in an estimation of these features. It was this author’s intention to create a modified stations activity appropriate for a college-level course, and to raise students’ awareness of the shift to more robust, research-based methods that have been used in the field of forensic anthropology since the *Daubert* ruling (10).

The estimation of ancestry was excluded from the stations activity described here, due to the difficulties and association of this type of analysis with past racist practices and racial stereotypes. Biological features of skeletal remains are not always an accurate indicator of the ancestral origin a person identified with in life, and the forensic anthropology databases available for some ancestral groups are inadequate compared to others. The Fordisc program gives a highly accurate estimate of ancestry for certain groups, such as Americans of African or Caucasian descent for example, if enough data points for the skeletal remains are available to be entered into Fordisc (10). However, teaching students how to use the Fordisc program and providing students with numerous bone samples and/or measurements to analyze was beyond the scope of an introductory course in forensic science. Rather than relying on less precise methods of comparing morphological features to estimate ancestry, ancestry estimation was omitted.

Methods

Realistic casts of bones were purchased from Bone Clones, Inc., Osteological Reproductions (https://boneclones.com/) using grant funding from Donors Choose (https://www.donorschoose.org/) and Flex Funds from a Math for America Master Teacher Fellowship (https://www.mathforamerica.org/). All osteologic reproductions from Bone Clones include an osteological evaluation report. An osteometric board, disarticulated plastic skeleton, and sliding calipers were purchased by Staten Island Technical High School from Ward's Science (https://www.wardsci.com/store/).

Students were provided with a lab handout to answer questions and record observations and measurements, including instructions and hyperlinks to reference materials for each station (11-24). Questions on the handout required students to explain their reasoning for any conclusions. A classroom skeleton consisting of real bones (donated to the school by an alumnus) was used as a reference throughout the stations activity, and the skull of the classroom skeleton was analyzed at one of the stations as described below. The students rotated through the stations in any order and worked at their own pace. All of the bone samples at each station were labeled with a unique identification number, in case any samples were misplaced during class.

Station 1: This station tested students' knowledge of skeletal anatomy with a "name that bone" challenge. Students compared the replicas of ten different bones (from the disarticulated plastic skeleton) with the reference materials on skeletal anatomy (11, 14), and determined and recorded the identity of each. Bone samples included the humerus, cervical vertebra, rib, and scapula.

Station 2: Students examined Bone Clones Osteological reproduction #404, a coyote tibia and fibula, in order to assess whether the bones were human or non-human (12, 13). The instructions at station 2 stated that the bone was found in a state park in Nebraska. Students were asked to identify the bone and, based on the size and features of the bone (11, 14) and location where it was found, which animal it may have come from.

Station 3: Students examined two tibiae and two patellae (from the disarticulated plastic skeleton) in order to determine which is the left and which is the right, based on the location of bony landmarks such as the medial malleolus of the tibia and the articular surface of the patella. Reference materials included diagrams of each of these bones with the bony landmarks labeled (14). Students were also encouraged to use the classroom skeleton as a reference. Students had little difficulty defining left and right in anatomical terms, but found it hard to distinguish the bony landmarks present on each of the bones. One possible solution might be to allow students to examine the bony landmarks of other bones or to watch a screencast demonstrating identification of bony landmarks prior to the lab stations activity. In addition, the reference materials with labeled bony landmarks (14) could be printed on a larger scale so they are easier to read.

Station 4: Students examined Bone Clones Osteological Sample #540, a broken femur and fractured innominate from a female pedestrian struck by a large truck. Students were asked to examine and score the subpubic concavity, medial aspect of the subpubic ramus, ventral arc, and the sciatic notch in order to estimate the sex of the individual. They were provided with sketches and photos of these features and corresponding scores (16, 17), and with 3D replicas of a complete male and female pelvis for comparison purposes. Students also measured the diameter of the femoral head and compared it to known data sets and sectioning points for two ancestral populations (18). Students were asked to opine whether the injuries apparent in the bones were peri-mortem and to justify their conclusions. The students had difficulty comparing the three-dimensional osteological reproductions with two-dimensional sketches and photos of the features they were asked to compare and score. In the future, it may be helpful to have students observe these features in osteological reproductions prior to the lab stations activity, or to include photographs of actual bones in addition to comparison sketches of the features. Measurement of the femoral head diameter and comparison to sectioning points, as well as the trauma analysis, was more straight-forward.

Station 5: Students examined Bone Clones Osteological Sample #217, a male skull with two healed hammer blows, in order to estimate the sex of the individual, observe evidence of blunt force trauma, and determine whether the trauma was peri-mortem. Students also examined the skull of the classroom skeleton for the purpose of sex estimation. Students examined and scored the nuchal crest, mastoid process, supraorbital margin, supraorbital ridge, and mental eminence (missing from sample 217). Comparison of the three-dimensional osteological reproductions with two dimensional photos and sketches of the features of the skull (19) proved difficult once again. Students found it helpful to reference the Color Atlas of Human Anatomy (14) to clarify the locations and shapes of the features of the skull, particularly the supraorbital ridge. In the future, a printed copy of the labeled photographs of the skull from this reference will be included in the reference materials at this station.

Station 6: Students examined Bone Clones Osteological Sample #190, a skull, femur, and humerus from a five-year old human child. Students were also given dental X-rays for a five-and-a-half year-old child, obtained from a local dentist's office. The students compared the shape of the teeth and roots in the X-ray with the Atlas of Human Tooth Development (20) in order to estimate the age of a sub-adult. They measured the length of the humerus and femur with an osteometric board and compared their data to the averages for children of different ages (21). Based on the length of the long bones examined, most students underestimated the age of the individual. The dental X-ray comparison generally resulted in a more accurate age estimate, which was expected. One problem that should be addressed is the quality of the printed copy of the dental X-ray. Some students had trouble observing developmental stages of the teeth due to the clarity of the image, which the author plans to reprint at a higher quality.

Station 7: Students examined images of the sternal end of the fourth rib (22) and compared them to descriptions of sternal rib end phases (23) in order to estimate age in an adult. Students had difficulty with this comparison, since images were not included in the descriptions of each phase. Including pictures that are consistent with the phase numbers in the reference materials would improve this issue. Use of an osteological replica might also be helpful, especially when observing the depth of the depression in the sternal end of the rib, which is difficult to ascertain from a photo.

Station 8: Bone Clones Osteological Sample #178, a tibia and humerus from an African American female, were examined in order to estimate stature. The students measured the long bones using an osteometric board and used regression analysis (2) to calculate a range of heights for this individual. Students were required to convert from centimeters to feet/inches. An optional activity was for students to measure their own height and compare it to their self-reported height on their drivers' licenses.

Station 9: Students examined Bone Clones Osteological Sample #152, a human male skull with a .32 caliber gunshot wound in order to determine the entry and exit wound. Students were given a reference on skeletal trauma (23) to inform their conclusions. Although nearly all the students correctly identified the entry and exit wound, most of them based their conclusions on the size and shape of the wound rather than examining the beveling of the bone. In order to encourage students to conduct a more detailed analysis, the author plans to include additional reference materials with close-up photographs of beveling of the bone in gunshot wounds.

Station 10: Students examined Bone Clones Osteological Sample #804, which included six skull fragments from different individuals in order to determine the type of trauma (blunt force, sharp force, high speed projectile) that resulted in the wound. Students were required to examine any two of the six skull fragments for this activity. Because these were fragmented remains, students had difficulty identifying some types of skeletal trauma. In particular, the shearing fracture was frequently misinterpreted as sharp force trauma. Additional reference materials with photos or including fewer fragments could be helpful in addressing this. Students were able to identify injuries from blunt force trauma and projectiles most of the time.

Hazards and Safety Precautions

There are minimal safety precautions needed for this laboratory experiment. The osteological reproductions, osteometric board, and calipers should be carefully handled and stored. If digital calipers are used, the batteries should be changed as needed.

Results

Below are photos of students working on the stations activity during the forensic science class (**FIGURES 1-6**).

FIGURE 1 Students use an osteometric board to measure the length of the humerus at station 8.

FIGURE 2 At station 9, students examine a gunshot wound in order to determine entry and exit. Additional skull fragments from station 10 are seen on the table.

FIGURE 3 Students examine the skull of the classroom skeleton in order to estimate sex at station 5.

FIGURE 4 At station 4, students examine a fractured innominate bone in order to estimate sex. The femur from station 4 and the skull from station 5 are visible on the table.

FIGURE 5 Students examine a tibia and fibula in order to determine whether they are human or non-human at station 1.

FIGURE 6 At station 6, students examine the skull and femur in order to estimate age in a sub-adult.

Discussion and Conclusion

The forensic anthropology laboratory stations activity was an effective way for introductory forensics students to gain experience in analyzing skeletal remains. The students were highly engaged during the lab, and were able to complete most of the required tasks, giving accurate estimations of sex, stature, and age at death for the human remains they examined. Students were also able to correctly identify human and non-human bones. In addition, the set-up of the stations was relatively easy once all of the required equipment, reference materials, and osteological replicas were obtained and organized by station.

Class periods are 41 minutes long, which is always a challenge when carrying out complex, multi-step laboratory experiments. The author originally planned to allow a maximum of ten class periods total for students to complete data collection and analysis at all ten stations. This was assuming students would complete, on average, one to two stations per day. However, this activity was scheduled coincidentally during a COVID-19 outbreak. Due to the high rate of absenteeism and large numbers of students required to quarantine, the lab had to be extended an additional week, for a total of 15 class days. This is, in the author's opinion, too many class days to devote to this activity in an introductory forensic science course; however, with the evolving COVID protocols and guidelines it should not be a major issue next year and the students should be able to reasonably complete the lab within ten class days.

Most of the difficulties encountered with the lab stations activity were due to inadequate reference materials, the need for additional direct instruction, or the challenge of comparing three dimensional replicas with two dimensional sketches or photographs. At station 2, for example, the students had trouble identifying bony landmarks in order to distinguish between the left and right bones. This could easily be addressed by having students practice bony landmark identification, or providing students with a screencast in which this process is carried out prior to the lab stations activity. The practice or screencast should include bony landmark identification for a different bone than those included at the station so that the stations activity is a true assessment of the students' skills in this area. In the case of station 5, in which students found it challenging to locate the supraorbital ridge and supraorbital margin, providing students with a higher quality photo that clearly showed the location of these landmarks was sufficient in addressing the problem. The same was true for station 9, in which detailed photos of the beveling of the bone in gunshot wounds allowed students to more accurately determine entry and exit wounds. This could also be said for station 6, in which the quality of the printed X-ray could be improved to facilitate comparisons with the Atlas of Human Tooth Development (20). Including photos or sketches of the different phases and age ranges for the sternal end of the fourth rib at station 7 would also aid students in making a more accurate estimation of age at death. In addition, students struggled to toggle between the lab handout, reference materials, and specimens. It would be helpful to have printed, and preferably laminated, color copies of the necessary reference materials at each station, rather than having hyperlinks within the lab handout and hard copies of the books at a common station. This recommendation would save time as well.

The students were able to meet most of the standards for this learning module despite the need for improvement in the areas noted above. Students were also enthusiastic about having an authentic experience in the field of forensic anthropology. Several students expressed their surprise at how detailed and methodical the examinations and analysis were, in contrast with how forensic anthropology is portrayed in popular media. Though the lab stations activity was challenging, the students were highly engaged and motivated.

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