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COMMENTARY

Science Unseen: Inclusive Practices in Introductory Biological Anthropology Laboratory Courses for Blind and Low Vision Students

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Abstract

Science education relies heavily on observable phenomena or imagery, making it by and large inaccessible to blind and low vision (BLV) students. Laboratory science courses are frequently necessary to complete general education requirements in higher education, and teaching practices that are not inclusive to BLV students inhibit their retention and scientific literacy. While many disciplines and some anthropological subdisciplines have resources for BLV students, few resources exist for biological anthropology. As introductory courses in biological anthropology fulfill laboratory science requirements at many institutions, it is fundamental that educators consider accessibility for BLV students. This essay describes laboratory activities, adapted for BLV students and their sighted peers, satisfying three conceptual modules (genetics, primatology, and skeletal anatomy) that are common in an introductory biological anthropology course with a lab component. Best practices and student and instructor reflections are also presented to emphasize peer-learning focused on auditory and kinesthetic strategies.

Keywords: *biological anthropology; lab courses; blind and low vision; assistive technology*

Introduction

During the inactive hum of a college campus in summer 2019, I first met an incoming student enrolled in my laboratory course for the fall semester. We exchanged more than a handshake, however, as I asked to take their arm to guide them to my office and teaching laboratory (counting steps and pointing out shifts in floor texture along the way). They were blind, a sophomore, and concerned about how to succeed in *Introduction to Biological Anthropology*. This is one of the courses at my institution that partially fulfills the general education laboratory science requirement, and the student had been unsuccessful in others.

This article presents resources and strategies for designing more inclusive laboratory exercises in biological anthropology for blind and low vision (BLV) undergraduates.

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Drawing on both educator and student experiences during a single semester, I present examples of adapted activities and best practices which can support inclusive learning, not only for blind and low vision students, but their sighted peers as well.

Vision impairment, usually referring to 20/70 vision or below, is the most common disability in the world and blind adults are the largest disabled group in the United States (13% of adults), but there is no "typical" BLV student (AFB 2020). Vision loss exists on a spectrum and depends on the specifics of the eye or brain condition; vision loss can fluctuate throughout life and throughout the day, and it is influenced by many factors (WHO 2019). Vision loss results in major challenges to education and employment opportunities leading to marginalization of the needs and abilities of those affected (Bell and Silverman 2018). In 2020, 23% of individuals over the age of 16 with vision impairment participated in the workforce fulltime, with unemployment rates twice as high as the general population (AFB 2020; Bell and Silverman 2018). The fact that only 15.72% of BLV Americans have a bachelor's degree or higher may be a contributing factor (AFB 2020; Fraser and Maghuve 2018). Therefore, inclusive practices that provide evidence-based results for improving learning for BLV students are needed (AFB 2020).

Scientific literacy is a core general objective of higher education. The ability to understand scientific concepts and processes enables students to understand the physical human experience through observation, data, and prediction. Scientific literacy is also key in the growing remote and technology industry, in which few BLV people are included (Malakpa 2007). Because science disciplines involve abstract concepts and visual phenomena, science education is one of the least accessible fields for BLV students (Erwin et al. 2001). Though 2.7% of science, technology, engineering, and mathematics (STEM) employees report a disability of any kind (Woods 1996), no data exist about the number of BLV people in the STEM workforce other than the fact that fewer than 300 PhDs are awarded to BLV people each year (Supalo et al. 2009). What is known is that, while vision impaired people have an interest in science topics in primary and secondary school, the lack of inclusive learning strategies or strong mentorship discourages life-long learning or occupational training in science and technology (Kumar et al. 2001).

A major factor in the underrepresentation of BLV people in the sciences is the challenge of providing effective laboratory experiences in high school and college (Jones et al. 2006; Sahin and Yorek 2009). Use of assistive technology (AT) or mobile assistive technology (MAT) allows more BLV people equal access to general education topics, improves literacy and communication options, and enhances their functional capabilities toward independence in their education (Supalo et al. 2009). There are a variety of high- and low-tech AT/MAT tools for BLV students, from optical devices, audio readers, Braille image descriptions and embossers, to haptic computer software and 3D printers (Caldwell and Teagarden 2007). When BLV AT/MAT devices are selected and used appropriately, they can enhance employment, quality of life, and health (Kaldenberg et al. 2011). In many studies, BLV students learning in classrooms with sighted peers outperform their counterparts in segregated learning environments (Kumar et al. 2001). Additionally, use of 3D tactile objects in a laboratory course has been shown to increase BLV student performance from 80% to 95% competency on exams (Kumar et al. 2001). For BLV students, use of AT/MAT combined with interaction with their sighted peers is correlated with direct (e.g., social skills, language development, sense of belonging, friendships) and indirect (e.g., happiness, self-esteem) social benefits; heightened inclusivity in the classroom is therefore also likely to lead to college retention (Katz and Mirenda 2002).

Most college faculty are unfamiliar with AT/MAT, but even a simple introduction to the range of options would allow educators to informatively apply and adapt AT/MAT to promote their course learning outcomes for BLV students (Ojha 2015). However, there are few, if any, published resources specific to introductory biological anthropology laboratory course accommodations for BLV students. When a call to share BLV-inclusive resources, assignments, and strategies for biological anthropology was made to Teaching College Anthropology, a social medial group devoted to teaching and learning practices for college anthropology courses, none of the 1,044 members could offer help other than anecdotes describing the overwhelming need for support. Indeed, while the American Anthropological Association has accessibility options like large print, screen readers, and audio/visual descriptions for BLV members attending and presenting at conferences, resources for biological anthropology educators with BLV students are not available.

Activity Descriptions

Like other science laboratory courses, *Introduction to Biological Anthropology* uses image-rich materials to cover topics such as DNA structure, protein synthesis, natural selection, primate taxonomy, and human evolution. Traditional teaching materials and strategies for these concepts may be ineffective or limited for BLV students. Below are descriptions of inclusive lab activities for biological anthropology. There are many related topical ideas that have been developed and shared. I direct the readers to a shared drive where they may access activities described here and other resources, as well as add to living documents to grow resources that are open to all educators; this drive is available at https://drive.google.com/drive/folders/1JP3zUXo4uvGwfAFL1vWxG20s-qLVwxp3. This resource is intended as a crowd-sourced hub (to which educators can add their own materials and ideas) that is completely open-access (available for use and adaptation by anyone). While the activities and experiences discussed in this essay are based on a single semester, these experiences led to successful application for an Innovative Teaching Grant at my home institution. The funding from that grant was used to 1) purchase assistive technology and supplies for laboratory assignments in *Introduction to Biological Anthropology* based on experiences and need during that semester, and 2) conduct research to compile BLV resources for open-access use.

Textualizing Genetics and Variation

There are many options for including more accessible activities in the genetics and variation modules of this course, some of which require only minor adjustments. A DNA Twist model (along with genetics simulations/models), available through the American Printing House for the Blind (APH; https://www.aph.org), demonstrates the structure of the DNA molecule through the use of contrasting textures to convey base-pairing rules. BLV students can also easily participate in demonstrations of DNA extraction from cheek cells by using talking measuring equipment and a talking liquid level indicator to measure the alcohol, soap, and salt required in the procedure; students can then touch the resulting DNA. Mendelian traits can be observed through touch and recorded using raised-line Punnett squares or Braille-labeled tiles. Instructors can also use karyotypes pre-made from pipe cleaners and textured beads. These models allow students to compare the karyotypes of evolutionarily related species based on relative spacing of the alleles (i.e., beads), while centromere position can help demonstrate crossing-over and recombination (Figure 1). Additionally, exercises involving simulations for natural selection, gene flow, genetic drift, and mutations are accessible with the addition of differently textured, shaped, or sized objects to sort, count, and manipulate. Specific examples and links to useful AT/MAT can be found in the resources folder linked above.

Figure 1. Pipe cleaners used to model chromosomes with textured pony beads representing alleles. This photograph was taken by the author.

Listening to Primate Behavior

While exercises about primate behavior tend to be exclusively focused on visual observation, I chose to deconstruct the densely academic research questions and methodologies of primatologists who focus on primate sounds. The assignment was designed to challenge all students in similar ways and still fulfill the objectives of the primate behavior course module and allow leveled peer interaction. In this assignment, students convey an understanding of theoretical concepts by analyzing published data, demonstrating their ability to follow and critique the scientific method, practicing discipline-specific methodology, and considering the relevance of their data and inferences to human evolution as a whole. Students complete the following procedures:

- Procedure 1: Students listen to YouTube videos that introduce the concept of vocalizations varying as a behavioral response to environmental stimuli.
- Procedure 2: Students examine and answer questions using a published catalogue or ethogram of chimpanzee vocalizations along with demographic frequencies of vocalization types. Next, they create their own ethogram from gibbon and gorilla vocal recordings on YouTube. They then use their ethogram for focal sampling of a primate in a group.
- Procedure 3: Students listen to YouTube recordings of primate alarm calls given in context (for example the vervet monkey call for seeing a leopard). They then match both the primate and potential stimuli to decontextualized calls.
- Procedure 4: Students use the free software Praat to measure the mean pitch and intensity of pre-recorded vocalizations of a chimpanzee in response to known food stimuli to formulate hypotheses and predictions regarding the connection of sounds to visual behaviors (see Boersma and Weenink 2022 or https://www.fon.hum.uva.nl/praat/).

After completion of the course, the student gave permission to be formally interviewed about their experiences and to share them in a published form. Responding to this laboratory exercise, the BLV student remarked, "I never had any interest in primates before. They just were not something I could relate to. But hearing them and matching that with behaviors and intentions was my first time 'seeing' them and it helped motivate me for that entire module in class." This complete exercise with the YouTube audio links is available in the resource folded linked above.

Manipulating Skeletal Anatomy

Most exercises requiring students to identify whole bones, features of bipedalism, and traits distinctive to each hominin species require little modification with the availability of skeletal casts. First, orient students to the relative placement of bones by showing them how to palpate the bones in their own bodies. I have had success using miniature models of a complete skeleton (easily bought during the Halloween season) to have students identify bones in relation to others through touch and description. Instructors can additionally give BLV students basic descriptions of long bones, flat bones, and irregular bones and the locations of these classes of bone, then let students feel compact and trabecular bone textures. BLV students can independently contribute to skeletal measurements using Braille calipers and by creating charts and graphs using graph paper with raised lines, punched-out dots, or by pinning strings along axes to create tactile graphics of their data. In my class, I created a labeled 3D map of the skeleton by pinning Braille labels with strings leading to each skeletal element on a small model (Figure 2). This map was used as a study aid as the student prepared for activities and exams. If available, kinesthetic/haptic technology, such as the Novint Falcon Game Controller, can also be used to help students realize the structures of 3D virtual fossil models on a computer; this can be especially useful for online courses, when fossil casts are unavailable, or for remote study.

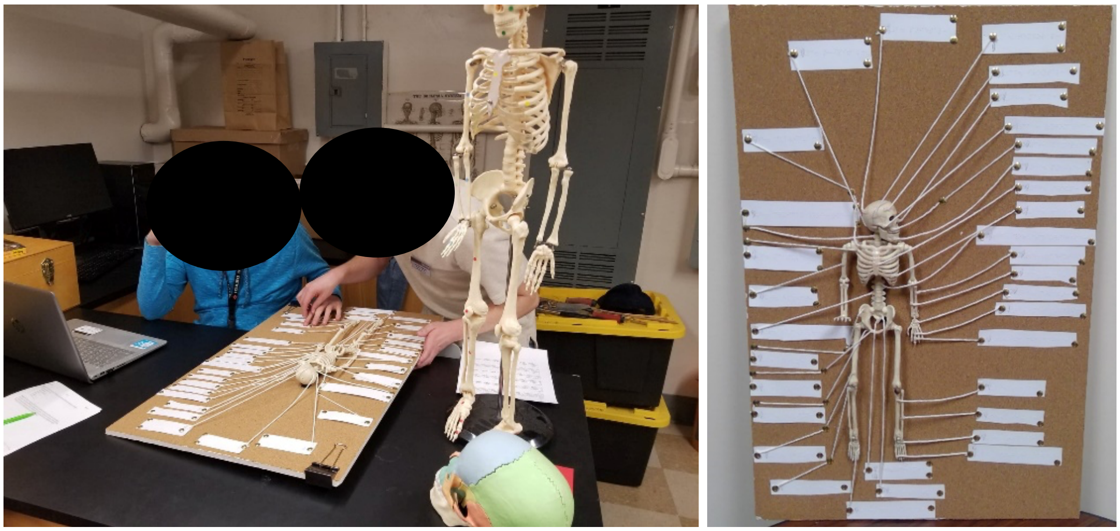

Figure 2. In the image on the left, a BLV student learns to use the label for the skeletal map with a paraeducator. In the right corner of this image sits a magnetic model of a human skull which comes apart much like a puzzle to allow for examination of each piece and of spatial relationships. The image on the right shows a closer view of the skeletal map with Braille labels and strings leading to skeletal elements. Faces were intentionally hidden and only models of skeletal material (no real human remains) are shown here. These photographs were taken by the author.

Student and Educator Impact

The BLV student in this course is now a recent college graduate, having succeeded in completing their laboratory course requirement. The student expressed, "I felt connected to the material and my classmates. I never thought I would be able to pass a science course, since I tried and failed before, let alone be able to understand genetics and anatomy." They continued, "I gained a lot of confidence in this class especially in osteology and comparing the fossils. I helped my lab partners with the bones. Being able to touch them and read them with my fingers was my favorite part."

While more formative, summative, and quantitative assessment is called for in the future (when a broader sample can be assessed), an initial comparison of post-lab quizzes/exams from sighted students and the BLV student shows no significant difference in the achievement of learning objectives when activities modified for BLV students were used by all students. The sighted students regularly chose the BLV student as their lab partner, with one recalling that they immersed themselves into the labs in innovative ways that they benefited from when partnering. While this type of statement requires further exploration and discussion in future studies, the importance of inclusive learning practices has been previously demonstrated, and it is used here to emphasize the impact of inclusive peer learning in this circumstance.

As an educator, the overall experience has encouraged me to incorporate additional inclusive, multi-model strategies, AT/MAT, and universal strategies in my other courses (see Table 1 for a list of best practices for educators and examples applicable to designing BLV-inclusive materials in any discipline or topic). These strategies have inevitably led to improved course discussions, deeper student-instructor rapport and trust, and a reinvigorated sense of creativity in my teaching and learning that have benefitted the class environment and learning and attitudinal gains. Additionally, the Disability Services Specialist at the institution repeatedly praised the course innovations to institution administrators and encouraged other BLV students to take the course, saying that a lab course in biological anthropology was ideal for BLV students' success in completing their science requirements as it was a naturally tactile discipline

Table 1. Best Practices and Examples for Educators

Best Practices for Educators	Examples
Work with the institution's disability resources experts early and often	These experts can help transcribe visual course materials, create Braille documents, arrange for support from a paraeducator, and provide AT and AT training. Speak to administrators and other educators about resources and safety accommodations around campus for BLV students.
Consider specific safety needs	Orient the student to lab safety and the lab layout, assign lab safety partners, label containers, and move items obscuring the bench or lab floor.
Use descriptive words for visual material	Take time to practice describing in detail images in lecture slides, materials in activities, etc. On-the-fly raised images can be created using impressions boards.
Get to know the specific needs of the student and their preferred AT	AT must be learned, so do not assume all students read Braille, can interpret

	embossed images, or intuitively know how to use readers.
Use large print (Ariel, 16-18 font), Braille, audio, and digital formats	Use accommodation suggestions/settings on learning platforms, word and lecture slide processers, and provide more than one way to read material.
Consider audio or tactile alternatives to activities for all students	Use AT, get creative with textures and sizes, add auditory observations and manipulative objects in activities for all students.
Explore/modify existing resources	Resources and exercises are available at websites including: perkinslearning.org, blindsci.org, sciencefortheblind.com, teachingvisuallyimparied.com, blindteachers.net, aph.org, and nfb.org. Explore resources form your state commission for the blind and institutional disability services office.
Ensure peer learning	BLV students should be in groups with sighted students and not isolated to interactions with instructors.

Conclusions

Overall, literature has shown that laboratory learning for BLV students is best accomplished using auditory and tactile senses, but also most successfully when done in an active-learning environment shared by sighted students (Kumar et al. 2001; Katz and Mirenda 2002). Generally, BLV accommodations are made using embossed or raised images and Braille descriptions of images or haphazardly crafted models by paraeducators (Caldwell and Teagarden 2007). Often, embossed images or models are over-simplified, or information is omitted or annotated by non-STEM employees rather than STEM educators/experts. This form of teaching does not maximize learning effectiveness. It forces BLV students to rely upon others' interpretations of visible patterns, traits, or phenomena, which for sighted students is a significant part of the learning process. While on-the-fly ways for data from laboratory exercises to be collected and displayed for this BLV student have been devised with help from paraeducators, these rarely allow interaction with classmates, and the full experience of discovery from independent and small-group learning is compromised. Therefore, it is highly recommended that any accommodations be fully inclusive by engaging all students with varying abilities.

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