Journal of Mammalogy, XX(X):1–11, 2023
https://doi.org/10.1093/jmammal/gyad011

Integrating evidence-based teaching practices into the Mammalogy classroom

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The teaching practices used in college science classrooms have a profound influence on which students pass their courses (and continue to major in science) and which are 'weeded out.' Students from traditionally marginalized backgrounds have lower grades and learning gains compared to their nonmarginalized peers in courses that rely heavily on lecture and high-stakes exams. This achievement gap narrows or disappears when instructors use student-centered, evidence-based teaching practices. These teaching practices can include actions that shape our classroom environment, communicate course material, and assess student learning. In this paper, we provide a summary of the evidence supporting the use of student-centered teaching practices, followed by examples of several effective evidence-based teaching practices that can be integrated into organismal courses. Examples include faculty mindset for inclusion, teaching practices to increase student confidence and to reduce stereotype threat, increasing course structure by spreading points among several different types of activities, several active learning methods, jigsaws, Scientist Spotlights, course-based undergraduate research experiences, and inquiry-based labs. Each example is linked to supporting resources to help instructors easily implement these practices in their classrooms. The American Society of Mammalogists endeavors to be equitable and inclusive through numerous initiatives, and modifying our teaching practices can increase equity and inclusion of future mammalogists into our own classrooms.

Key words: evidence-based teaching, inclusive teaching, organismal courses, student-centered practices, teaching

Ensuring continued growth of the field of mammalogy, and the American Society of Mammalogists (ASM), necessitates recruitment and retention of students from diverse backgrounds. Typically, the first exposure of a student to mammalogy is through an upper-level vertebrate biology or Mammalogy course. But by this time, many students from diverse backgrounds have already left science, technology, engineering, and math (STEM; National Academies of Sciences 2016; Rozek et al. 2019), often due to poor performance (Chen 2013). To reduce the achievement gap, and thus to increase retention, a national movement has developed to reform introductory-level biology courses by integrating more evidence-based teaching practices (e.g., American Association for the Advancement of Science 2011; Freeman et al. 2011; Brownell et al. 2012; Feinstein et al. 2013; Auerbach and Schussler 2017). In contrast, such reforms have not been suggested for upper-level courses, even though the benefits from evidence-based teaching practices, such as active learning, are similar to those gained in introductory courses (Theobald et al. 2020). Two reasons for this may be lack of time for instructors to learn and to implement new teaching practices (Auerbach and Schussler 2017) and difficulty envisioning how evidence-based teaching practices can be incorporated into content-heavy courses such as Mammalogy.

We define evidence-based teaching practices as practices that have at least one peer-reviewed publication documenting efficacy in the context in which the practice is tested (i.e., combination of institution, student demographics, instructor demographics, and course). Here, we summarize research on the benefits of evidence-based teaching practices and provide examples of eight specific practices linked to supporting resources to facilitate their implementation. These examples are not an exhaustive list of evidence-based teaching practices; rather, we chose this subset based on the teaching practices we have integrated into our own classrooms. Our hope is that these examples will serve as a starting point, or refresher, for incorporating evidence-based teaching practices that encourage active student engagement with organismal material in mammalogy or other taxon-specific courses.

Why Use Evidence-Based Teaching Practices?

The most important reason to use evidence-based teaching practices is, as the name implies, that research has shown them to be effective for student learning and retention in STEM. Although most STEM instructors use scientific evidence to move their research agenda forward and to make informed decisions in their everyday lives, the same approach is not often applied to teaching (Handelsman et al. 2007). Nonetheless, considerable research relates to education generally, and an ever-increasing amount focuses on teaching college-level biology courses effectively.

Evidence-based teaching practices influence *which* students pass STEM courses and are retained in STEM majors. Such teaching practices benefit all students but disproportionately benefit students from groups that have traditionally been marginalized and who are first-generation college students (Eddy and Hogan 2014; Freeman et al. 2014; Rodenbusch et al. 2016; Ballen et al. 2017). Evidence-based teaching practices create supportive and inclusive classroom environments, which foster feelings of belonging and, in turn, promote self-efficacy (the belief of an individual they have the ability to perform tasks or behaviors at a satisfactory level), which leads to student engagement and achievement (Zumbrunn et al. 2014). Indeed, evidence indicates that poor retention of underrepresented students in STEM majors is linked more strongly to a weak sense of belonging than to a lack of preparedness (Wilson et al. 2015; Banchefsky et al. 2019).

Examples of Evidence-Based Teaching Practices in Mammalogy

Faculty mindset for inclusion

Evidence.—Teaching for inclusivity requires that instructors spend time reflecting on their positions in their classrooms, universities, and larger society (Killpack and Melón 2016; Dewsbury and Brame 2019). For example, instructors should consider how their own identities, experiences, and privileges may differ from those of their students. We cannot assume that creating classes like those in which we achieved success will also help our students to be successful. Instead, we must examine our assumptions and biases and consider how they influence our teaching and shape our classrooms. To create a classroom in which all students can achieve success, we must spend time learning about the students in our classrooms and how they define success. Engaging students in dialogue not only provides information that can guide how we teach and structure our courses (Dewsbury 2017), it also demonstrates to students that they matter and increases their senses of belonging in our classrooms (Dewsbury and Brame 2019).

Implementation.—We recommend highlighting the multifaceted identities of mammalogists. Many of us are in positions where highlighting facets of our own identities can challenge stereotypes about 'who is a scientist' and humanize instructors; both can increase a sense of belonging by students. On the first day of class each semester, after introducing the class, author JMD spends time introducing herself before segueing into activities that allow students to introduce themselves in small groups. JMD describes how her own experience as a first-generation college student from an economically disadvantaged background has shaped her beliefs and approach to inclusive teaching. Typically, multiple students stay after class to express gratitude for the introduction and some follow-up with an inquiry about research opportunities in her lab. Representative student quotes from the chat of a remotely taught section are shared below:

> Thank you for your openness and vulnerability.
>
> Thanks professor, it has been really great to hear you talk about how much you care about all kinds of students, I've never heard it from a science prof. before- it means so much!

Even instructors who do not identify with an underrepresented group can still humanize themselves and create supportive environments by sharing with students their backgrounds and paths to science. For example, instructors can share experiences from times when they felt as if they did not belong or when they were uncomfortable in a class, in a discipline, at a meeting, or with peers. The key is to be authentic and to demonstrate approachability, empathy, and respect for students. Instructors can also emphasize diversity in the sciences by highlighting the contributions of mammalogists from underrepresented groups (see 'Scientist Spotlights' below). While instructors may already be familiar with the contributions of some mammalogists from underrepresented groups, they can also learn more through the many databases and directories of diverse scientists found online (see 'Resources' below).

Instructors can discuss communication in the sciences. More often than not, students are unfamiliar with communication norms in the sciences. Explain the use of titles such as 'doctor' and 'professor' and the expected level of formality in verbal and written communication. Some instructors ask students to send emails to them as a means of practicing written communication. Instructors should discuss the use of scientific terminology and binomial nomenclature as a universal scientific language. To facilitate student comfort with the scientific language, JMD leads an activity early in the semester in which students work in groups to brainstorm ways of remembering binomial names for a selection of local mammals. Coming up with mnemonic devices or catchy jingles helps students to feel that remembering terms or names does not have to be overly challenging; speaking the scientific language and becoming part of the scientific community is within their reach.

Instructors can increase access to course materials and resources. Students may not have adequate financial resources to fund their studies and some may depend on income earned from jobs worked outside of classes. Additionally, students may have other obligations outside of the classroom, such as care of family members, which could preclude their abilities to work additional jobs for income and represent large demands on their time. Instructors can reduce or eliminate the costs of textbooks by relying on primary literature or online texts, creating their own handouts, placing some textbooks on limited-time reserve at the library, or using old editions of textbooks that can be bought used or borrowed from a library. Instructors should also consider barriers faced by students outside of the classroom when selecting office hours and deadlines so as to avoid times of heavy commuter traffic, opening and closing times of child-care facilities, etc.

Resources.—Dewsbury and Brame (2019) provided an excellent guide to inclusive teaching with sections focused on developing self-awareness and empathy with students (https://lse.ascb.org/evidence-based-teaching-guides/inclusive-teaching/). The Inclusive STEM Teaching project offers a 6-week course designed to help instructors cultivate inclusive STEM learning environments (https://www.inclusivestemteaching.org/); the course can be completed for free via an audit track. A number of databases compiling information on diverse scientists are online. The Database of Diverse Databases provides links to a large number of these databases on one user-friendly webpage (https://editorsofcolor.com/diverse-databases/)

Teaching practices to increase student confidence and to reduce stereotype threat

Evidence.—Both instructors and students are aware of positive and negative stereotypes related to underrepresented groups and academic achievement. While instructors are encouraged to identify and to address their own implicit biases to treat and to evaluate all students equitably, they should also consider how the biases of a student can affect student learning and performance. An illustration of this is the pressure a student who identifies with a group may feel when asked to perform a task for which that group is stereotypically thought to perform poorly (Steele and Aronson 1995). For example, women have conventionally been perceived as weak in math and physically incapable of performing fieldwork, potentially leaving female-identifying students feeling additional mental and emotional burdens to perform these tasks successfully. Such pressure can increase cognitive load and physiological stress, which can negatively affect grades and test scores (Walton and Spencer 2009; Spencer et al. 2016). This phenomenon is referred to as a 'stereotype threat' (Steele and Aronson 1995). Stereotype threat can be activated by cues in the environment that increase student awareness of membership in a negatively stereotyped group or emphasize a task as a measure of intelligence or ability (Sawyer et al. 2005). Fortunately, instructors can identify, reduce, and even replace such cues (Killpack and Melón 2016).

Implementation.—Instructors can reduce cues for negative stereotypes and replace them with opportunities for self-affirmation. Instructors should avoid collecting demographic information from students before a task such as an exam or survey and if collection of these data is necessary, leave it for after the task. Instructors could consider whether students might benefit from a reminder of a shared positive social identity, such as 'college student' or 'mammalogist.' A short statement before a challenging task in which students are reminded of their acceptance into college and their capabilities to succeed are affirmed can counter negative stereotype threats (Rydell et al. 2009).

Instructors can encourage a growth mindset. Rather than refer to the abilities of a person or intelligence as impermeable, instructors should describe them as attributes that grow through a lifetime. Students who are encouraged to use a growth mindset demonstrate increased interest and enjoyment of learning, as well as greater academic achievement (Aronson et al. 2002; Canning et al. 2022). Instructors can further encourage a growth mindset by describing experiences and struggles that helped them or other scientists grow. JMD regularly describes how her fear of speaking in an ecology class as an undergraduate left her with an instructor who was unable to write her a letter of recommendation. She follows this story with encouragement to ask questions in class or to attend office hours, along with strategies students can use to overcome fear of speaking in class.

Resources.—Rydell et al. (2009) described research testing strategies for decreasing negative stereotype threat, and Killpack and Melón (2016) further explore these and other strategies for inclusive teaching in STEM courses.

Increasing structure in course design and grading

Evidence.—Increasing course structure can refer to both how information is systematically presented in a course to decrease perception of 'surprises' and how points earned in a course are distributed across several categories so that performance on any one assignment is not a high-risk event. We will use this broad definition for this discussion. Course material that is organized clearly and consistently can reduce student concerns related to course expectations, enabling students to focus on learning (McGlynn 2020). Transparency in what students are expected to know and to be able to do (learning objectives and outcomes; Simon and Taylor 2009; Osueke et al. 2018) and how students will be assessed (rubrics; Allen and Tanner 2006) can increase student learning and comfort in a course. During assessment of student learning, additional categories can supplement or replace traditional exams and often include frequent quizzes, discussion assignments, in-class activities, projects, etc. These types of activities offer students opportunities to reinforce concepts and to practice high-order thinking skills in low-stakes environments (worth a small proportion of the course grade) before taking exams, while also allowing them to demonstrate their knowledge of and competence with subject material via a variety of assessment modalities. Eddy and Hogan (2014) showed that such an approach benefits all students, particularly first-generation college students and Black students. These researchers compared the exam performances of students in a traditional lecture course to students in a course with increased structure that included weekly quizzes, in-class activities, and review assignments. While exam scores increased for white and continuing-generation students in the increased structure course compared to the traditional course, they increased significantly more for Black and first-generation college students (Eddy and Hogan 2014). This study (and many additional studies) makes it clear that relatively simple and easy changes to course structure can decrease the performance gap measurably between white, continuing-generation college students, and first-generation college students from traditionally marginalized groups.

Implementation.—Changing course structure can take a variety of forms and can integrate a variety of approaches to teaching practices. Here, we present several examples of changes that can be made to structure courses to increase student comfort and learning and create opportunities for low-stakes assessment of learning.

Instructors can focus on concepts rather than marching through Orders. Many taxon-based courses tend to progress through the Orders or Families of sequential focal groups, resulting in a course that relies heavily on the abilities of students to memorize a list of facts and names. A more integrative approach is to focus instead on concepts, like mammalian evolution, sensory systems, or community ecology, using specific mammalian examples to illustrate each concept.

Instructors can share learning objectives for each slide deck. At the beginning of each slide deck, state what the students will be learning. This is not just an agenda or an outline. State what the students should know and be able to do at the end of the class period (or slide deck). We also suggest indicating on each slide which learning objective(s) are associated with that slide. Well-written objectives are then easy to convert into exam questions to assess whether students achieved the stated learning objectives.

Instructors can use multiple assessment modalities. Assessing students in multiple ways allows them multiple opportunities to demonstrate their knowledge and competencies in a variety of modalities. Possible modalities include peer-group discussions, writing assignments, and term projects. Author LD gives students the opportunity to decide the weight of the various assessments. After sharing the percent value that she has assigned each activity, students may contact her within the first 2 weeks of the semester to change the values. The instructor can give parameters (e.g., all assignments must be worth at least 5% and no single assignment may weigh more than 20%) or determine the values together during a discussion with the student. For some students, this opportunity greatly alleviates anxiety associated with certain assignments and empowers them to highlight their strengths while demonstrating their knowledge and competencies.

Instructors can include graded weekly quizzes. Quizzes help students stay consistently engaged with subject material in a timely fashion. These are graded for correctness but can be made relatively straightforward to automate or to ease grading for the instructor.

Instructors can conduct weekly discussion assignments. These can be paper discussions, discussion questions, or activities related to the topic(s) of the day or week. These assignments can facilitate interactions among students related to subject material, thereby giving students incentives to come to class prepared. Ideally, the discussion or activity prompts will have multiple right and wrong answers, increasing discussion among the students and giving them practice in explaining their answers. Students can turn in their written responses, which can be graded based on completion, not correctness. Such assignments can serve as an important formative assessment and an early warning of widespread misconceptions among students, and grading on completion eases instructor grading burden as well. Author LEP often includes such discussion questions on her take-home Mammalogy and Zoology exams.

Instructors can share grading rubrics. Rubrics make your expectations clear to the students and are less subjective than grading based only on a gut feeling of what constitutes a particular letter grade. Using grading rubrics has also been shown to create a more equitable learning environment by helping to reduce unconscious biases while grading.

Resources.—*The Chicago Guide to College Science Teaching* (McGlynn 2020) offers an excellent overview of how one might structure a course to maximize diversity and inclusion. Several mammalogy-specific examples of assessment modalities and discussion activities are included in the sections below.

Active learning methods

Evidence.—Active learning is a subset of evidence-based teaching practices that leads students to engage actively with course material, the instructor, and each other, in contrast to a traditional lecture format. Teaching such that students experience active learning encompasses a wide range of activities, including think-pair-shares, polling methods, games and simulations, jigsaws, concept maps, and problem-based learning, to list but a few examples (Handelsman et al. 2007). Implementing these techniques improves the learning of students and their assessment scores while decreasing failure rates (Freeman et al. 2014). For example, after peer discussion without input from the instructor, more students can answer questions correctly than is the case without peer discussion (Smith et al. 2009). Active learning also benefits disproportionately those biology students from groups that have been traditionally marginalized in science (Ballen et al. 2017).

Implementation.—Many descriptions of activities have been published that are geared toward introductory or lower-level, concept-based biology courses. Far fewer descriptions of active learning activities have been published for taxon-based, upper-division courses. Consequently, instructors with little training may have difficulty imagining, developing, and implementing these teaching techniques in courses like Mammalogy. Below, we give some examples of how we have implemented several activities in our courses.

Instructors can try polling and think-pair-share. Wherever possible, stop lecturing for a few moments to gauge student understanding using one or more multiple-choice polling

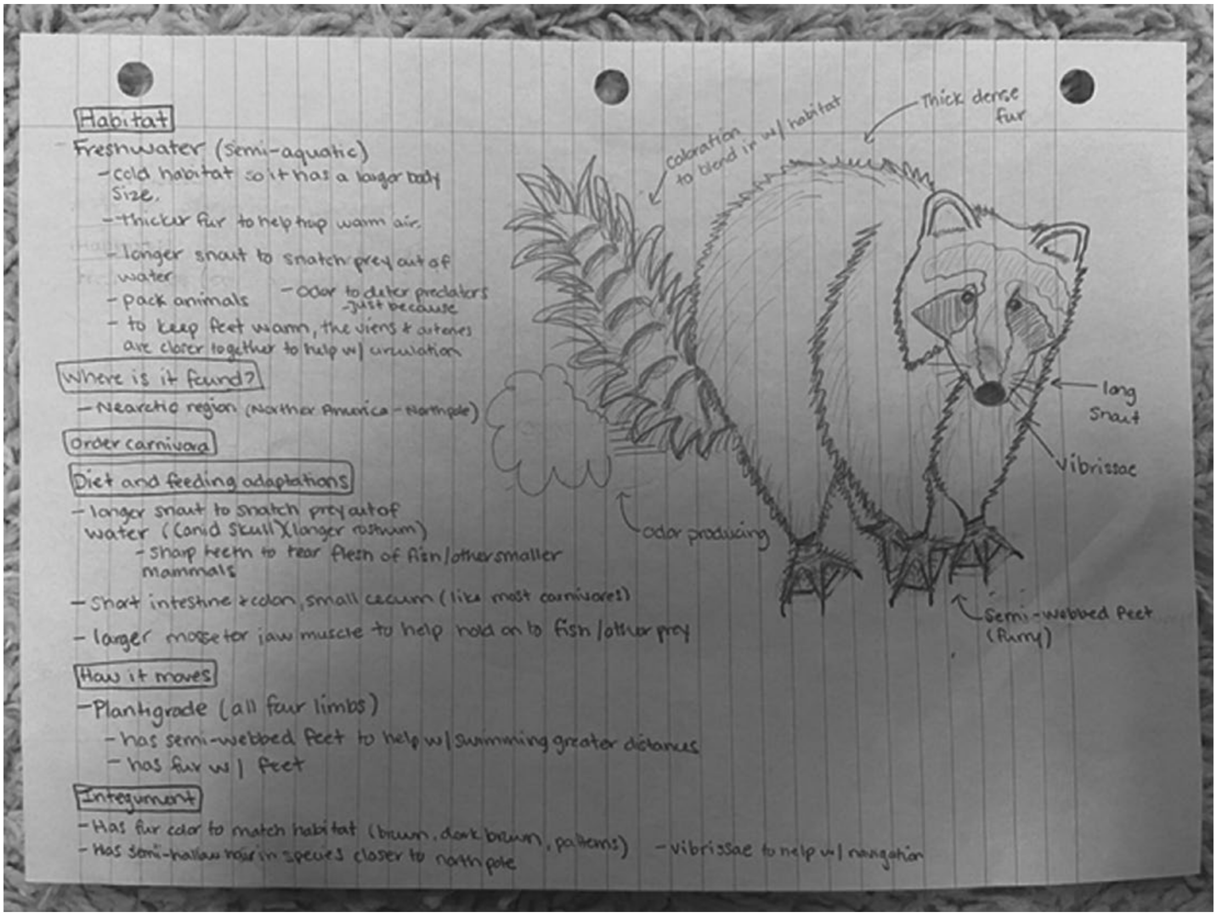

Fig. 1.—Student example of the “Design your own mammal” assignment. Shared with permission of the student, Michaela Sielaff.

questions (for example, clickers, show of hands, throat vote in which students vote semi-anonymously by showing the number of fingers corresponding to the option they are voting for close to their throat or chest, free online tools). If students disagree on the correct answer, have them discuss among themselves and re-vote. When asking open-ended assessment questions during lecture, give students time (at least 1 min) to think to themselves. After formulating their own ideas, have each discuss their idea with someone else in the class before sharing with the rest of the class. LD asks the students in her classes to write down their individual thoughts, which helps her students formulate them and articulate them to themselves before sharing with others. Each student uses a single document to record thoughts throughout the semester and LD collects those documents periodically to assess engagement. She grades these documents based on completion rather than content, to give students the space to think freely and creatively. Both polling and think-pair-share help an instructor to assess student understanding while ensuring that all voices in class are heard.

Instructors can have students ‘design your own mammal.’ In LEP’s Mammalogy lecture course, the first several weeks of the semester are spent on mammal evolution, morphology, and physiology. Prior to the first exam, LEP assigns students to ‘design your own mammal’ that does not already exist. This exercise helps students to synthesize and to apply course content to new situations. A student must describe the habitat of the new mammal and its adaptations to survive where it lives, including anatomy, diet and foraging adaptations, movement, and describe its closest relatives. The full assignment is provided in Supplementary Data SD1. In class, students describe their mammals to each other in small groups, defending why they chose particular adaptations and modifying their mammals if needed. They then do the same for the whole class. This assignment actively engages students with subject material and each other and allows them to get creative (Fig. 1).

Discuss diversity in mammalogy and privilege. To make mammalogy and the other ‘ologies’ more inclusive and equitable, mammalogists, as a community, need to discuss honestly the history of the field, its current state, and some of the reasons that inequities still exist among mammalogists. LEP devotes an entire lecture period to this discussion. Prior to class, the students read a paper by Nielsen et al. (2017) on the advantages of gender diversity in science, go through slides giving a brief history of mammalogy in the United States, and partially complete a discussion worksheet (Supplementary Data SD2). During the lecture period, students discuss their worksheet answers in small groups and then as a whole class. Next, LEP presents diversity data that include when women and people from traditionally marginalized groups were allowed to attend universities and the proportion of female first authors at annual meetings of the ASM (Dizney et al. 2019; Supplementary Data SD3). The main activity, adapted from those presented by Brown et al. (2016), is for students to grapple in groups with what privilege might mean for a field biologist by choosing only a subset of fieldwork privileges from a list, then share their reasons, after which they complete their worksheets. Some examples of these privileges include: it is unlikely that I would be asked about my immigration status while hiking through deserts of the Southwest United States; when doing fieldwork, if I encounter a man I don't know, I don't feel afraid; while in National Parks, I am not reminded of the forcible removal of my ancestors. We strongly recommend using the full list of privileges supplied by Brown et al. (2016). This activity helps students to gain perspective on diversity, equity, and inclusion in field sciences. Combined, the topics in this lecture period make space for discussion of how students can foster diversity, equity, and inclusion now and in their future careers.

Instructors can ask students to 'create a curriculum vita (CV).' Toward the end of JMD's Mammalogy course, students learn about the structure and purpose of CVs and resumes, and then create their own CVs. The activity includes students working in small groups to brainstorm skills and experiences they can include on their CVs, which helps students reflect on their learning in Mammalogy, as well as other courses, while hearing about the experiences of their peers. As a result of this assignment, each student completes the course with a finished CV that has received faculty feedback. A representative from the career center of an institution could be invited to help with this activity as well.

Resources.—Handelsman et al. (2007) provided an overview of teaching techniques that facilitate active learning and Tanner (2013) provided easy and equitable assessment techniques. Journals listed in the 'Getting Started' section below publish activities and lesson plans, although few are specific to mammalogy. Our mammalogy-specific materials can be found in Supplementary Data SD1-SD3. Some of our favorite online polling tools are Poll Everywhere (https://www.pollev-erywhere.com/) and Kahoot (https://kahoot.com/).

Jigsaw

Evidence.—Jigsaw is a specific student activity that facilitates active learning and that lends itself well to taxon-based courses like Mammalogy. In this activity, students are split as evenly as possible into a number of groups, called home or focus groups, and given a specific task. In a lecture setting, this task might be for each focus group to read and to summarize a different paper. In a lab setting, each focus group might be given a different set of skulls on which to examine the relative locations, shapes, and sizes of the bones in each skull. Once each focus group has completed its task and is comfortable explaining the result of its task, the students in the groups are considered 'experts.' This phase may take 10–45 min, depending on the tasks. The students then 'jigsaw' from their focus groups to form new 'task' groups, consisting of one 'expert' from each of the original focus groups. 'Experts' then teach their new groups about their papers, skulls, or other tasks (Brame and Biel 2015). When this activity was implemented in a chemistry course, students who learned specific topics during the jigsaw scored significantly higher on exam questions covering the jigsaw content compared to students who did not learn using a jigsaw (Doymus 2008; Baken et al. 2022).

Implementation.—In a Mammalogy lab, LEP has found that the jigsaw is particularly useful during the beginning of the semester to help students learn not only the bones of the skull for different taxa but also for getting to know each other. Jigsaws also work well in dissection labs and help reduce the number of specimens and cost because only one specimen is needed per group. JMD finds jigsaws can provide students with a head start when reviewing literature, for example, before conducting research projects. Groups of 3–5 students are each assigned a different paper to read and, after discussion within groups to strengthen and build confidence in understanding, students are mixed into new groups where they discuss similarities and differences in the papers they read. LD uses jigsaws early in the semester to introduce students to different perspectives regarding the relationship between humans and nature. Student groups investigate a religious, spiritual, or philosophical (conservationists versus preservationist) viewpoint and after sharing this with their task group, discuss big-picture issues such as climate change and loss of biodiversity from their assigned perspective.

Resources.—Brame and Biel (2015), Doymus (2008), Baken et al. (2022), and Handelsman et al. (2007) provided excellent instructions for implementing this technique.

Scientist Spotlights

Evidence.—Scientist Spotlight assignments profile scientists who represent the diversity of people working in science and whose research or work is relevant to the course material for that week. Students read a profile, watch videos, or read news stories about the scientist and then write a reflection using several guiding questions. These assignments are meant to be low-stakes and are graded based on completion. Importantly, they expose students to a wide variety of scientists who may serve as role models or who represent dimensions of diversity to which students can relate. This assignment has been shown to increase student course grades and relatability to scientists compared to students in a control group who received an alternative homework assignment (Schinske et al. 2016).

Implementation.—LEP has implemented Scientist Spotlight assignments in her Zoology, Ecology, and Mammalogy courses and has been assessing what students at a small, rural, state university gain from the assignments. Throughout the semester in Mammalogy, she highlighted five scientists who work with mammals, while students chose a sixth mammalogist to profile; these assignments were worth 10% of the course grade. Full results for all three courses will be reported in a forthcoming publication. Some representative student quotes regarding this assignment are shared below:

> I've always seen scientists as in the lab, but this changed it because I can see now that a lot of work is done outside in the field.
>
> It helps to show what types of jobs are available in the scientific community that I otherwise wouldn't have known about.
>
> It helps us understand and see how many different aspects go into being a mammologist. They help us realize what kinds of people do mammalogy. And shows that there is a study for everyone in this field…

JMD regularly implements Scientist Spotlights in her Mammalogy and Vertebrate Natural History courses. Each semester, she invites 3–5 scientists—usually friends or collaborators—to join the class via Zoom or Skype for a ~20-min interview focused on their career. Speakers are asked to describe their jobs, their favorite and least favorite aspects of their jobs, as well as the path they followed to their career. The activity is beneficial not only in exposing students to diverse scientists, but also in highlighting the range of careers available to students interested in mammalogy.

Resources.—LEP has made her Mammalogist Spotlight assignments available in Supplementary Data SD4. Other profiles of interest for taxon-based classes have been supplied by Brandt et al. (2020) and Yonas et al. (2020). An extensive database of Scientist Spotlights is available on the Scientist Spotlights Initiative website (https://scientistspotlights.org/).

Course-based undergraduate research experiences

Evidence.—Course-based undergraduate research experiences (CUREs) integrate authentic research into courses, allowing more students to gain experience in research without having to participate in traditional mentored research as an extracurricular activity. CUREs increase student content knowledge, data analysis skills, science identity, and science self-efficacy, as well as increase the number of students who go on to graduate or professional school (Brownell et al. 2015; Linn et al. 2015; Shapiro et al. 2015; Olimpo et al. 2016). In addition, CUREs significantly increase not only the number of students graduating from STEM majors but also the number of students graduating in general, including students from diverse backgrounds (Rodenbusch et al. 2016).

Implementation.—While definitions of CUREs are many, most include the goal of providing a research experience in which students practice the scientific process by investigating authentic questions that generate new information. CUREs can range from a single class or lab section to an entire semester, depending on the learning goals. Probably the easiest way to implement a CURE is to use one that has already been developed. LD and JMD are co-creators and frequent users of the Squirrel-Net CUREs (https://www.squirrel-net.org/), which include: (1) a squirrel behavior observation activity; (2) an assessment of foraging trade-offs using giving-up densities; (3) a comparison of three techniques for population estimation; and (4) an advanced activity using radiotelemetry. Each activity is associated with a shared national data set to which students submit their data. Because data are collected from a variety of years, habitats, geographical regions, and species, students are able to generate broader and more complex questions and hypotheses than they could with data from the habitats and species that are accessible from their own institution. These CUREs have been implemented in courses ranging from introductory to upper division and spanning anywhere from 2 to 16 weeks.

Resources.—The Squirrel-Net CUREs can be accessed through the Squirrel-Net website (https://www.squirrel-net.org/) or several publications in CourseSource (Connors et al. 2020; Duggan et al. 2020; Varner et al. 2020; Yahnke et al. 2020; Dizney et al. 2021). All necessary supplemental materials are available, including slide presentations, student handouts, instructor preparation resources, example IACUC documents, and assessments. Additionally, an accompanying essay describes how each CURE can be adapted to various levels of inquiry, from instructor-led, introductory courses to student-led advanced courses (Dizney et al. 2020).

Other CURE sources not specifically about mammals are available at CourseSource (https://qubeshub.org/community/groups/coursesource/courses), the museum specimen-based BCEENET (https://qubeshub.org/community/groups/bceenet), and CUREnet (https://serc.carleton.edu/curenet/index.html). To integrate your own or other research into your courses, Bakshi et al. (2016) offered a flexible framework and assignment templates to help facilitate CURE creation and implementation.

Inquiry-based labs

Evidence.—Inquiry-based labs allow students to formulate questions, to collect data, and to analyze and interpret data in a constrained manner that represents the unpredictability of the scientific process more accurately than do more traditional 'cookbook' labs. The results are unknown to the students, but unlike in CUREs, are likely known to the instructor or the broader scientific community. Nonetheless, students still learn important lessons about the scientific process, particularly the meaning of accepting or rejecting a hypothesis. Inquiry-based labs tend to be more difficult to implement compared to traditional cookbook labs but are typically less difficult than implementing CUREs since they are more constrained and the instructor can better anticipate likely results. Inquiry-based labs increase student enjoyment of biology and student understanding of science as a process (Tessier 2010).

Implementation.—LEP has implemented inquiry-based labs in a variety of contexts. During three weeks in her Fall 2020 Mammalogy lab, she implemented inquiry-based data analysis from the Grinnell Resurvey Project (as described in Lacey et al. 2017). Student feedback was mixed, but mostly positive: "I loved doing this. It was a lot of work and it was difficult but worth it because I learned so much." and "The resurvey project was valuable but low risk experience with interpreting data that I do not think students get in other ways."

Resources.—The Association for Biology Laboratory Education (https://www.ableweb.org/) has a variety of general biology, inquiry-based labs. In addition to the

Mammalogy-based inquiry lab described above (Lacey et al. 2017), Walsh et al. (2019) offer a mammal- and collection-based inquiry lab activity.

How to Start Integrating Evidence-Based Teaching Practices in Your Courses

To smooth the transition to evidence-based teaching, instructors should start using these techniques early in a semester and explain the rationale for implementation (Handelsman et al. 2007; Tanner 2013) to both students and any teaching assistants. In this way, students expect activities to be a normal part of the course, understand their benefits, and are likely to participate fully (Handelsman et al. 2007; Smith and Cardaciotto 2012; Tanner 2013; Cavanagh et al. 2016). Often instructors report student resistance to more active engagement in a course when activities are introduced in the middle of a term; the precedent for passive listening has already been set and students may be reluctant to change their expectations part way through a course.

Instructors should not try to overhaul their entire course at once. Often instructors are inspired to transform their courses by adding as many evidence-based teaching techniques as possible and as fast as possible. While the intent is admirable, a major overhaul can leave instructors overwhelmed and may, ultimately, discourage them from changing much or any part of a course. Instead of jumping into the deep end of evidence-based teaching practices, we suggest dipping a toe, gradually adding more course revisions as instructors become comfortable with each new practice. Add one new activity each week or two of the term, for example. Next time, add an additional activity each week or two and revise any activities that did not work as anticipated during the previous semester. After a few iterations, a variety of teaching practices that increase equity and student success will be integrated into the course without burnout.

Activities do not have to fill the entire class time or to replace lectures entirely. Lectures are still an effective way to introduce new concepts and facts, and these new concepts and facts can form the foundation for active learning. Although the preponderance of evidence shows that evidence-based teaching practices such as active learning benefit students, exactly how much class time should be devoted to such activities is unknown, particularly for upper-level taxon-based courses like Mammalogy. Students and instructors across STEM disciplines and universities report wanting 30–50% of class time devoted to active learning (Patrick et al. 2016, 2021; Patrick 2020; Gonsar et al. 2021) but these preferences do not demonstrate that this range of time is ideal. These preferences do suggest, however, that devoting this amount of time to active learning will likely be well-received by students.

A number of publications and repositories provide activities and lesson plans on a variety of biological topics, although relatively few are specific to Mammalogy. Before starting to develop an activity from scratch, see if others have made similar activities available. Such activities can always be modified to fit your course and can serve as an important jumping-off point. Below is a nonexhaustive list of sources we have used to find activities for our own courses:

- CourseSource: https://qubeshub.org/community/groups/coursesource/
- Bulletin of the Ecological Society of America—ECO 101
- American Biology Teacher: https://online.ucpress.edu/abt
- BioQUEST/QUBES educational database: https://qubeshub.org/publications/browse
- Project Biodiversify: https://projectbiodiversify.org/
- HHMI Biointeractive: https://www.biointeractive.org/
- National Center for Case Study Teaching in Science: https://sciencecases.lib.buffalo.edu/

Even the most well-planned activity can fail to create the anticipated learning opportunity. If that happens, instructors should reflect on what went wrong, take notes, modify the plan, or modify the activity next time. The types of activities that work well for one instructor may not work well for another because of the personality of an instructor, teaching styles, institutional context, course level, student demographics, or comfort levels with content and activity type. Trial and error may help to find what works best in a given context. Students tend to be forgiving when an activity does not work if an instructor is honest with them and acknowledges that the activity needs modifications.

Asking students what worked for them and what did not is beneficial. This is an easy but often overlooked way to assess the effectiveness of evidence-based teaching practices. Students often conflate the way they prefer to learn with the best way they learn, so their feedback should be interpreted with caution. Instructors will still gain valuable insight, however, into what students feel is working for them and what is not. We suggest at a minimum asking students to complete a survey about teaching practices of their instructor after the first exam and again at the end of the semester. The survey should ask students how valuable particular course components or activities are to them, why they chose their response, what the instructor should continue doing, and what the instructor should consider changing. This type of feedback could be invaluable to improving the course. For example, in her first semester teaching Mammalogy, LEP had students write *Mammalian Species* accounts in teams over the course of the semester. She found from the end of semester survey that this project was universally hated by all students in the course. This prompted her to reach out to colleagues at the Kansas Department of Wildlife and Parks, an agency many of her students aspired to work for, to find out what kinds of documents graduates would be expected to write. She used this information to revamp the writing assignments in her Mammalogy course and was transparent with the students about the reason she chose these specific assignments. In subsequent semesters, students reported that these writing assignments were among the most valuable aspects of the course.

Once instructors have gained some practice incorporating predesigned activities into their courses, they might consider designing and implementing their own. When ready, we suggest using the principles of backward design (Wiggins et al. 2005; Handelsman et al. 2007):

Identify learning goals.—First, ask "What will students know, understand, and be able to do after completing the activity or assignment?" Instructors should not design activities or assignments as busy work or to simply fill class time. Each activity should replace lecture material or reinforce concepts that students are required to understand.

Determine how to assess the activity.—How will the instructor and students gauge progress toward the learning goals? Before deciding on activities, instructors should determine what evidence for learning to use and when. These can take the form of formative assessments during or immediately after the activity itself, using student responses to questions or discussions, or summative assessments based on student exam responses.

Plan the activities.—Plan learning experiences and instruction by asking "What activities will engage a diversity of students in learning?" A variety of activity types, each suited to different time frames, particular types of information or concepts, and teaching styles, are available. It takes some practice to identify a good match between concepts and activity types, but students usually learn something, even if the activity doesn't go exactly as planned.

Align goals, assessments, and activities.—Finally, circle back to the beginning. Do activities and assessments help students achieve the desired learning goals? If not, instructors should determine which is the weak link and modify it so that the activity and assessment meet those goals.

As scientists, we understand the importance of using evidence to drive our research. Evidence-based teaching practices offer an opportunity to apply the same rigor to our instruction. By starting with just one or a few evidence-based teaching practices and being transparent with students about why we are using specific practices, we have found that gradually incorporating new teaching practices has been easy and enjoyable. We have found most of the practices to be readily adapted to online learning (but see Beckman et al. this issue for additional online learning strategies) and we have found that even small changes have helped our students feel welcome in our courses and valued during the learning process. We hope that sharing the strategies that have worked well in our classrooms will encourage others to begin or renew transforming their teaching to be more inclusive, equitable, and effective for all. As a result, the increased diversity of students who succeed in our classrooms will help ensure the growth of the field of mammalogy and the future of our Society.

Acknowledgments

The authors would like to thank the reviewers and editors for their suggestions to improve the manuscript.

Funding

Funding for part of this research was provided by the National Science Foundation under a collaborative grant which includes 2013281 to J.M. Duggan.

Supplementary Data

Supplementary data are available at *Journal of Mammalogy* online.

Supplementary Data SD1.—An example of a 'design your own mammal assignment.'

Supplementary Data SD2.—An example of a 'history of mammalogy discussion.'

Supplementary Data SD3.—Slides used in a 'history and diversity in Mammalogy discussion.'

Supplementary Data SD4.—Examples of 'Mammalogist Spotlights.'

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Submitted 17 March 2022. Accepted 14 December 2022.

Associate Editor was Roger Powell.