2021

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Abstract

The shift from face-to-face instruction to remote teaching and learning has proven to be a challenging endeavor for many reasons, including lack of time, resources, and inspiration. Lab courses, the "hands-on" portion of many curricula, may be especially difficult to adapt to online learning given the common use of specialized equipment, materials, and techniques that require close supervision. Without the time and resources to creatively modify existing activities or create new ones, remote lab courses run the risk of becoming less effective, equitable, and/or engaging. Squirrel-Net has created four field-based activities for biology labs that are easy to implement, highly flexible for different course aims, and readily adaptable to a remote learning environment. In this essay, we briefly summarize the modules and propose several ways that each can be adjusted to accommodate online teaching and learning. By providing authentic learning opportunities through distance delivery we hope to promote widespread student engagement and creative solutions for instructors.

Citation: Dizney L, Varner J, Duggan JM, Lanier HC, Connors PK, Erb LP, Flaherty EA, Yahnke CJ, Hanson JD. 2021. Squirreling from afar: Adapting Squirrel-Net modules for remote teaching and learning. *CourseSource*. https://doi.org/10.24918/cs.2021.2

Editor: Luanna Prevost, University of South Florida

Received: 9/23/2020; **Accepted:** 12/21/2020; **Published:** 1/27/2021

Conflict of Interest and Funding Statement: This material is based upon work supported by the National Science Foundation under a collaborative grant (Nos. 2013483, 2013281, 2013308, and 2013320). PKC, JMD, and JV were supported by the 2019 CourseSource Writing Studio. Support for EAF was provided by the USDA National Institute of Food and Agriculture, Hatch Project 1019737. None of the authors has a financial, personal, or professional conflict of interest related to this work.

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INTRODUCTION

As the COVID-19 pandemic is shifting teaching and learning from in-person classes to remote instruction, many instructors are struggling to find ways to effectively educate students online. Laboratory courses are particularly challenging to adapt to remote teaching in that they are usually the "hands-on" portion of each discipline, often working with specialized techniques, equipment, or materials that are unavailable or otherwise not feasible to use away from a campus setting. Adapting labs to remote learning so that they remain relevant and meaningful takes energy to think creatively, time to restructure existing activities, and resources to produce completely new ones. Without the means to make this investment, many lab courses may suffer from loss of important content or substitution with activities that are less meaningful. Tellingly, instructors of field courses believe the shift to remote activities will negatively affect teaching and learning in terms of both effectiveness and equity, including a shift from student-led to more instructor-led activities and a replacement of typical field course activities with less-effective remote activities (1).

In spite of these concerns, we believe moving to remote learning does not necessitate a decline in quality of field-based activities. Indeed, each of our four Squirrel-Net modules (2-5) can be easily adapted to provide high levels of student engagement, maintain their focus on student-centered learning, and provide equitable and effective field experiences for all students. Moreover, their flexibility allows them to be modified for various levels of inquiry (a teaching and learning continuum that moves from largely instructor-led to increasingly student-led) and/or scaffolded into a course or curriculum (2-6). Because squirrels are found throughout North America in both rural and urban areas, including on most college campuses (7,8), nearly all students will have access to a field site and study subjects without the need to travel. Since most squirrel species are diurnal, observations can occur during daylight hours. Furthermore, squirrels are readily identifiable, highly visible, and quite charismatic, making observations easy to carry out and interesting for students. Squirrel-Net (https://www.squirrel-net.org/) has a list of resources to help identify squirrels and their habitat.

From an instructor perspective, many aspects of each Squirrel-Net module are already online-ready, which helps facilitate implementation in a remote environment. All instructional materials are available to instructors and can be shared with students electronically. Students enter the data they collect into a national database, easily accessed from personal computers. The instructor can share the database with students via a learning management system (LMS; e.g., Canvas, Blackboard, Moodle, D2L), and students can analyze the dataset even if students are unable to submit data themselves. Classroom or group discussions can be carried out via video conferencing, a LMS discussion forum, or chat platforms. Consequently, the only part of each module that may need modification to accommodate online teaching is the data collection. Below, we briefly summarize each module and then offer adaptations to data collection for remote learning and/or physical distancing.

SUGGESTED ADAPTATIONS OF TEACHING MODULES

Squirreling Around for Science: Observing Sciurid Rodents to Investigate Animal Behavior (2)

In this behavioral ecology module (2), students work in pairs to observe squirrel behavior for 5 minutes to determine the amount of time they spend in each of four behavior states (vigilance, foraging, social, or other). One student is initially the observer while the other is both the recorder and timer, recording the behaviors observed by their partner at 20s intervals. Additional environmental data (e.g., weather, habitat type, proximity to human structures) are gathered so that students can test a variety of hypotheses about how behavior changes based on extrinsic factors. There is a short video available on our YouTube channel (accessible via our website: http://www.squirrel-net.org) introducing the goals of the module that instructors could share with students.

The simplest adaptation for students to collect data remotely is for students who have access to squirrels in their neighborhoods or nearby parks to work in-person with a partner, such as students still living on or near their campus. In this scenario, the only modification to the protocol would be to maintain physical distancing while carrying out data collection. If such face-to-face interactions are not feasible, then students can pair up remotely via video calls (Facetime, Skype, Zoom, etc.) on smartphones or computers. A benefit to working in pairs remotely is that even if one student does not have access to squirrels, this student can still perform the observer role by having their partner follow a squirrel while on a video call.

If students cannot work in pairs, an individual can still perform observations by being both the observer and the recorder/timer. To make this task easier, Tabata timer apps are readily available and keep track of 20s intervals so that the student will only need to observe and record squirrel behavior when the timer beeps. Alternatively, this activity can also involve friends, family, or other household members in an educational and enjoyable way. An individual of almost any age can time or record, and sharing the behaviors exhibited by squirrels can be a fun activity to engage others in the students' household. Beyond the required data collection, other possible extensions include asking younger siblings to observe different kinds of animals (birds, cats, dogs) to see how behavior differs from one species to another or between pets and wildlife. Such a family-oriented activity could give students practice in the protocol before they collect the data that will be entered into the database for analysis.

Besides collecting squirrel behavioral data, students are also required to measure distances to several entities, such as nearest human structure and nearest tree or burrow. Instructors might consider demonstrating how to create a measuring tape by marking paper or a string held next to an online ruler. In this way, students can make life-size measuring tapes or ruler/meter sticks for use in the field if measuring tools are not available at home. Since all of our modules call for some sort of measurement, this could be a useful adaptation for any of the modules.

Even if students do not have access to squirrels for data collection, this Squirrel-Net module could also be adapted by having the instructor provide videos of squirrels and their environs. Ideally, the instructor would not only record squirrels for 5 minutes, but also keep in mind the other necessary measurements (proximity of human structures, habitat, etc.) so that students could also record those data. One way to accomplish this would be for the instructor to lay a tape measure from where the squirrel was observed to the variable being measured (nearest human structure, nearest tree or burrow, etc.) allowing students to read and record the distances themselves. Video observation could be performed synchronously or asynchronously and/or individually or in pairs as described above. An added benefit of sharing videos is that students can examine how the collected behavior data varies within the class even when observing the same squirrel. These suggested adaptations are compiled in Table 1.

Sorry to Eat and Run: A Lesson Plan for Testing Trade-offs in Squirrel Behavior Using Giving Up Densities (3)

In this Squirrel-Net module, students place a known quantity of seeds or nuts in sand-filled trays to test how foraging behavior differs based on locale (e.g., near or far from safety or humans), type of bait, or species of squirrel (3). After a day or night (depending on the target species), students gather the trays, sift the sand to recover the remaining bait, and weigh the remaining bait to determine the giving up density (GUD), or the amount of food left when an animal abandons a foraging patch. Based on optimal foraging theory, GUD measurements allow students to analyze the decisions involved in foraging, such as safety of the patch and/or quality of the food. An introductory video available on our YouTube channel (accessible via our website: https://www.squirrel-net.org/) explains how to set up the trays and experiment.

Modifying this module to a remote modality requires only a few, readily available supplies for students to obtain usable data. In fact, researchers were able to obtain publishable data examining squirrel foraging behavior along an urban-rural gradient by providing GUD supplies and protocols to non-scientist volunteers (9). If an instructor is able to send supplies to students, then GUD packets should include: a plastic tray, sand, a small weighing scale, a sifter, and bait (sunflower seeds or peanuts). Small kitchen food scales can be purchased for around $12 but could be eliminated if needed. For example, the instructor could weigh the bait before sending out the packets and then have the students return the leftover bait to be re-weighed. Perhaps an easier alternative is for the instructor to determine the average weight per seed/nut, then have students determine the total weight by counting the number of seeds/nuts before and after the tray is left out. Sifters can be purchased or made by poking small holes into pie tins. Table 2 summarizes alternate supplies that could be used in this module.

If students do not have access to squirrels near their homes, students can also conduct GUD experiments with the nocturnal small mammal community (e.g., mice), which should be available in nearly every habitat! Our national database is currently set up to accept non-squirrel observations for students working under such conditions. Because this protocol does not require direct observation of the animals, it is easily adapted for nocturnal animals, and analyzing differences in behavior between diurnal and nocturnal rodent communities could be a fruitful option for developing and testing student hypotheses.

How Many Squirrels Are in the Shrubs: A Lesson for Comparing Methods for Population Estimation (4)

This module asks students to compare three commonly used techniques for estimating population sizes of wildlife (strip censuses, scat counts, and camera traps) to evaluate the outcomes and underlying assumptions of each (4). Strip censuses require students to record the distance to any detected squirrel while walking transects. For scat counts, plots are cleared of scat, and then students return sometime later to count any new scat from the focal species. Camera traps capture images of wildlife in the area, and students estimate population size based on the number of images of their focal species. The protocol also includes how to calculate the estimated population size based on the technique. To introduce students to this module, including data collection protocols, assumptions, and calculations for each method, a short video is available on our YouTube channel (accessible via our website: https://www.squirrel-net.org/). Students can then use the national dataset to test hypotheses associated with the performance of each estimator, given variation in species' natural history (e.g., burrowing vs. tree squirrels), habitat structure/biome, or proximity to human structures.

The easiest remote adaptation of this module is if students are living near a squirrel species that they can study, presumably near campus. Because of the nature of the national dataset, not all students need to work with the same squirrel species, but rather, data can be aggregated across different species and habitats for analysis. In these circumstances, students can be assigned times during which they will visit the plots to avoid encountering other students. Students could also be paired up such that someone living near a study site works with someone unable to access the study site. Using video calling, one student can be on-site performing the activity while the other is recording the data.

If most or all students are unable to visit suitable areas of habitat, then the instructor could provide video of walking transects and scat counting while the students record the data, or images of the scat plots from which students count scat pellets. Camera trap images could also easily be sent to the class for each student to analyze. Students who live in areas where the techniques could be implemented could also provide recordings of themselves performing the transects and scat counts. If cameras are available to mail to these students, they could also set them up and send the resulting imagery to the class. Squirrel-Net is currently establishing an equipment loan system for such uses, and updates about the equipment can be found on our website. As mentioned for Squirreling Around for Science above, an advantage to using shared video is the opportunity to discuss error and/or variation that occurs in the collected data, even when all students used a standardized protocol and the same video. Table 3 provides a summary of the above suggestions.

Squirrels in Space: Using Radio Telemetry to Explore the Space Use and Movement of Sciurid Rodents (5)

In this module aimed at upper division students in wildlife and ecology courses, radio-collared squirrels are tracked with RFID antennae and receivers (5). Additional data are collected such as habitat type and proximity to human structures, allowing students to examine how squirrels use their environment. An introductory video will soon be available on our YouTube channel (accessible via our website: https://www.squirrel-net.org/).

This module is easily adapted to remote learning when students have access to campus and/or locations with previously radio-collared squirrels. In this instance, students could schedule a time to pick up and use equipment to track animals on their own or with a physically-distanced partner. A safety protocol including cleaning of equipment with disinfectant before and after use should be made available. In situations where radio-collared squirrels are present on campus but students are not living on/near campus, students could be paired with someone who can access the telemetry equipment. The remote students could be part of the team by watching the student(s) with telemetry equipment and recording the generated data. Alternatively, students could generate and test hypotheses based on data they collect from an instructor-generated video demonstrating animal tracking with telemetry. Though students are not performing radio telemetry themselves in these remote adaptations, several excellent YouTube videos (curated playlist available on our website: https://www.squirrel-net.org/) can give them a good feel for using the equipment. Table 4 recaps the suggested adaptations for this module.

Additional Ways to Use Squirrel-Net for Remote Teaching and Learning

Even with the above suggestions for module adaptation to remote teaching and learning, there may be instances where it is not possible for students to collect their own data for these lessons. However, even under such circumstances, Squirrel-Net modules can be implemented remotely because each module has a database with contributions from institutions across the country. Instructors could utilize these existing datasets to focus on hypothesis testing, data analysis, and interpretation of results. These teaching materials and data have also been used to teach students about repeatability in science (e.g., asking multiple students to re-score the same video to learn about inter-observer variability), or as examples to build from for students to design their own protocols.

Squirrel-Net also has several projects in development to aid students and instructors while using our modules remotely. For example, we are in the process of developing a video repository, where instructors can upload their videos to share with other instructors, which will be available on our website: https://www.squirrel-net.org/. In this way, students will be able to observe use of the modules in different habitats and environments and/or have access to multiple videos from which to practice collecting data. Additionally, we are establishing an inter-institution buddy system for students called "The NEST" (Network to Engage Students Trans-institutionally), which will be available on our website. The NEST will pair any interested student with a student from a different institution working on the same module. The student pairs can then work together to develop and test hypotheses across different species or habitats, analyze data, interpret their results, and present the findings, if interested, at an end-of-semester online symposium. By increasing direct connections between students at different institutions, we hope to increase students' sense of belonging both to our national network and to the larger scientific community. Another Squirrel-Net project currently in development is a no-cost loan system for telemetry equipment and camera traps, enabling instructors to overcome equipment limitations and use additional modules, even in remote-learning circumstances. Please check out our website for updates. Lastly, the Squirrel-Net team presents workshops at regional and national meetings to teach interested people how to use our modules, including remote-learning adaptations (schedule available at https://www.squirrel-net.org/). As many meetings move to a virtual format, we hope that attending our workshops will become more feasible, in turn broadening the range of instructors using our modules.

CONCLUSIONS

Field-based courses offer a unique challenge when moving from in-person to remote learning. To keep field activities engaging and student-centered takes time and creativity, both of which may be in short supply during the COVID-19 pandemic. Learning field methods and collecting data can be especially difficult to adapt to online classes, yet these skills are considered the most important learning outcomes among instructors of field-based courses (1). Squirrel-Net seeks to provide innovative and engaging field activities that maintain student-centered, hands-on learning of field-based skills. We hope these simple adaptations will equip instructors with effective and equitable teaching modules in order to provide all students positive field experiences while learning in a remote environment.

ACKNOWLEDGMENTS

We would like to acknowledge all of the students and instructors who have provided helpful feedback on these modules as we developed and piloted them. We are extremely grateful to the editorial staff at CourseSource for their encouragement and generous support throughout the publishing process.

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Table 1. Summary of remote learning adaptations for Squirreling Around for Science (2).

Access to squirrels	Students pair up remotely	Students do not pair up remotely
Yes	Student pairs communicate via smartphones.	Students work in pairs while maintaining physical distancing. Students work individually using a Tabata timer. Students work with family or friends.
One student in a pair has access	The student with access to squirrels observes a squirrel while on a video call with the other student who times and records. When switching roles, the student with access can follow or record a squirrel for their partner to observe.	
No	Students use instructor provided videos to measure behaviors in pairs, communicating via smartphones.	Students work individually to observe instructor-provided squirrel video. Students analyze data from the national dataset.

Table 2. Alternatives to supplies needed for Sorry to Eat and Run (3).

Supply	Alternative
Plastic tray	Pie pan (tin or aluminum)
Sand	Dirt, sawdust, or kitty litter
Scale	Instructor pre- and re-weighs seed samples or gives students average seed weight and students count seeds to determine total weight
Sifter/sieve	Window screen mesh, fine colander, pie pan with small holes made with nail or awl
Sunflower seeds or peanuts	Other seeds or nuts

Table 3. Summary of remote learning adaptations for How Many Squirrels are in the Shrubs (4).

Technique	Living near plots	Not living near plots
Transects	Students assigned times to visit plots to keep physical distancing in place.	Students pair with a student who has access to the plots.
Scat counts	Students assigned times to visit plots to keep physical distancing in place.	Students pair with a student who has access to the plots. Students use video from the instructor or other students to count scat.
Camera traps	Students assigned times to visit plots to keep physical distancing in place.	Students pair with a student who has access to the plots and can collect camera trap data to share online. Instructor shares camera trap data online.

Table 4. Summary of remote adaptations for Squirrels in Space (5).

Access to equipment	Remote adaptation
Yes	Students assigned time to use equipment to keep physical distancing in place and instructions for cleaning equipment are included in the protocol.
No	Students pair up with a student who has access to equipment. Students watch instructor-generated telemetry videos. Students watch Youtube videos to visualize how to use the equipment.