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**Research Article**

# Virtual Coverboarding: Using Local Biodiverity to Engage Science Majors

Shem D. Unger [1*], William R. Merian [1], Mark A. Rollins [1]

[1] Wingate University, Wingate, NC, USA
***Corresponding Author:** s.unger@wingate.edu

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**ABSTRACT**

There is a current need to develop engaging, informative online activities for science majors and potential future citizen scientists, particularly given the increase in the online teaching environment following COVID-19. Given this potential for online teaching to continue to increase, it becomes ever more essential to provide undergraduate students with methods that allow students to remotely access common methods used for sampling species while still engaging students in learning about local species diversity. This study assessed the potential for an interactive, online course-specific website to connect and inform first-year undergraduate biology majors (pre-health majors to environmental science) on local leaf litter species diversity. The website included species encountered as part of an ongoing on-campus biodiversity monitoring project using coverboards. Students navigated to the website, answered questions on the types of organisms, and completed a short survey. The survey questions reviewed whether the website was engaging and informed students on campus biodiversity of both reptiles and arthropods. Students overwhelmingly responded positively that the website was helpful to advise them on local species and their natural histories and engaged and piqued their interest. Therefore, we recommend incorporating course websites as teaching tools to catalog local species to teach undergraduate biology majors.

**Keywords:** science education, herpetology, online biology, technology

## INTRODUCTION

There is a need in science education to provide engaging opportunities to both local communities and university students about local biological diversity (Ellwood et al., 2020; Novacek, 2008). One approach includes incorporating citizen science activities which improve biodiversity literacy skills alongside identification skills in an online environment (Paradise & Bartkovich, 2021). As online teaching increases, furthering avenues for engagement can provide science majors with multiple resources for learning about global diversity and the local species diversity on the university campus. Biodiversity collections that utilize online technology may increase access for students and even amateur naturalists (Balke et al., 2013), providing unique paths of learning content in science. However, if these online learning methods incorporate sample methodology, they can concomitantly establish the importance of species, as well as demonstrate how these surveys are performed by field biologists. Coverboards, either composed of metal or wood, are an established survey technique to study primarily reptile and amphibian communities (Hampton, 2007), have been used for education to increase awareness (Tomasek et al., 2005), and can also be utilized to collect data on non-herpetofaunal species, largely arthropods. However, there remain challenges of how to most effectively translate this field-based research and data collection into online content.

Innovative forms of teaching content to undergraduate science students online have included the development of video games (Annetta et al., 2010) or the use of websites and other forms of online content. The use of websites has been applied to teaching science, with digital platforms providing animations, text, and images as online learning media for biological conservation (Leksono et al., 2021). Incorporating digital technologies in biology field trips can also provide an effective tool to engage students (Lee et al., 2011). Immersing students in field trips and outdoor experiences is recognized as an effective method for engaging future scientists (Bindis & Currie, 2021). However, not all universities can conduct teaching activities in outdoor settings, either due to financial challenges, logistics involved in coordinating outdoor field excursions, or with larger class sizes. Moreover, delivering learning materials online may provide a flexible learning style with greater flexibility for undergraduate biology students, which reflects our changing world of course delivery (Peat,

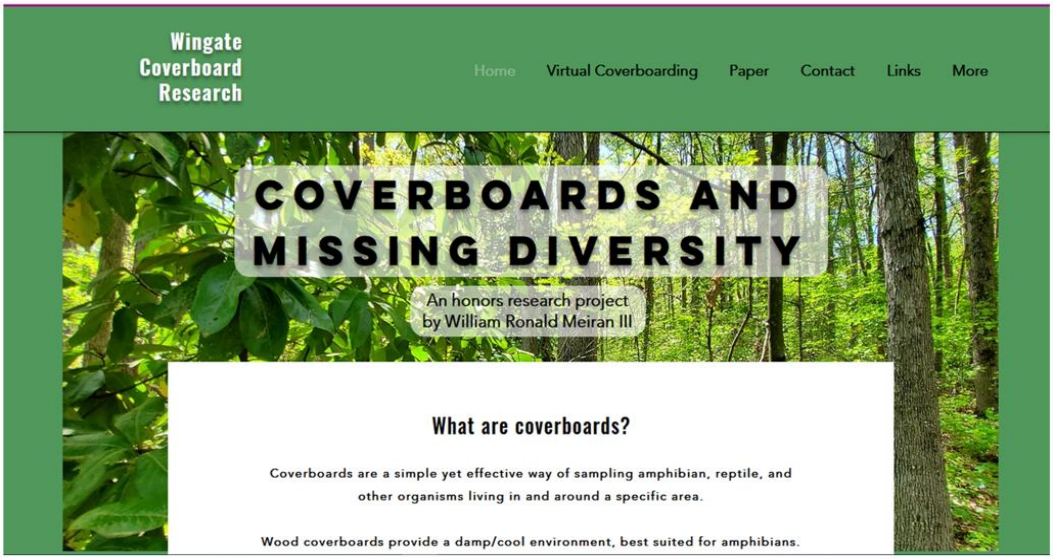


**Figure 1.** Home page of the course-specific website for this inquiry activity (https://bimeiran558.wixsite.com/wingate-coverboards). Tabs are shown in the upper right for "Virtual Coverboarding," along with other tabs

2000). Therefore, connecting students with the outdoors and field research can be accomplished via alternative methods, such as developing a website that still allows students to learn and practice standard survey techniques remotely. The use of alternative teaching methodologies has become even more prevalent following increases in online course offerings and recent safety concerns related to COVID-19 (Sepulveda-Escobar & Morrison, 2020). Online social media has even been implemented as a method of online teaching in undergraduate science (Whittaker et al., 2014). Lastly, Yli-Panula et al. (2018) found that innovative teaching methods such as games, field visits, etc., were the least used to teach biodiversity compared to more traditional methods such as teacher presentations. However, there have been mixed results and some debate on the effectiveness and consensus on the use of hands-on, virtual, and remote laboratory activities (Brinson, 2017; Ma & Nickerson, 2006).

In some cases, face-to-face biology laboratories are often perceived as more effective than virtual laboratories by students (Stuckey-Mickell & Stuckey-Danner, 2007). Yet websites and web-based learning environments have been utilized as an alternative tool to simulate important biological concepts (Gilman, 2006). These web-based environments have also been integrated into other science programs to increase student awareness and interest (Frailich et al., 2007; Vo & Sharp, 2019). Additionally, free developed websites can provide an interactive platform for learning about science online (da Costa et al., 2016), and a method to reinforce important course specific environmental concepts and overall learning. Therefore, much work remains to be done on developing innovative and engaging online content to teach biodiversity to undergraduate biology students, many of which have little sampling experience and will become future citizen scientists or medical professionals.

The main research questions guiding our project were:

1. *What is the effectiveness of a novel, course specific website to engage and inform students on local species diversity and the method of "virtual coverboarding"?*
2. *How did students evaluate the website, and was it perceived as informative and engaging?*

To assess these research questions, we developed a course-specific website to present images from ongoing research using deployed coverboards to monitor reptile and arthropod communities on campus and as a source for images.

## METHOD

### Participants, Deployment, and Identifications

This study included 124 participants, students from a small undergraduate university in a first-year introductory organismal biology course. Participants were all undergraduate biology students which include a combination of students whose emphasis or future careers include the fields of either molecular biology, organismal biology, environmental biology, or medical health sciences (i.e., pharmacy, nursing, pre-medical, pre-dental, etc.). Data was collected from students following the guidelines of the Wingate Biology Research Review Board.

Coverboards were deployed in December of 2020 as part of an ongoing monitoring project and honors research by authors, and allowed to remain in the field for several months prior to monitoring. In total, 30 wood and 30 metal coverboards were deployed at two locations on campus, Wingate Woods and Wingate Campus Lake. In brief, boards were monitored over a period of six months and visited periodically to obtain representative images from each site and coverboard type. Images of organisms found under boards were uploaded to iNaturalist for identification and verified by authors using standard keys. Images were taken using a Samsung Galaxy S10+ phone at ~0.2 m away from the board.

### Website Development

We created a website (**Figure 1**) using the free online content website provider Wix. The website can be found here, https://bimeiran558.wixsite.com/wingate-coverboards.


**Figure 2.** "Virtual Coverboarding" tab on the course-specific website, showing options for students to select for either Wingate Woods or Wingate Campus Lake, which take them to either wood or metal coverboards

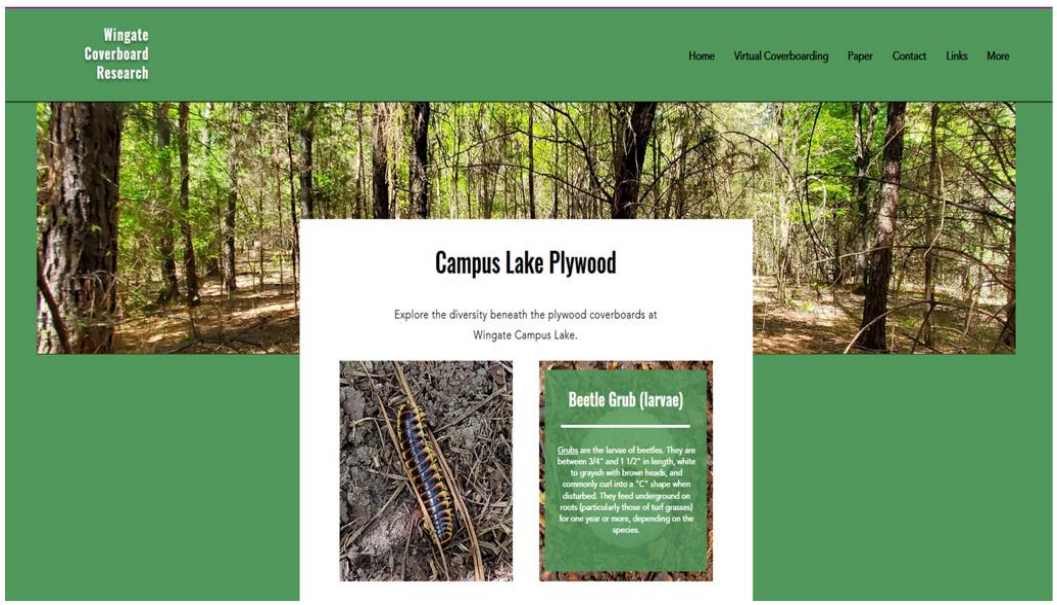


**Figure 3.** Example of images & natural history shown on the Campus Lake Plywood tab page on course-specific website students see when "Virtual Coverboarding." Note in the image, the cursor highlights the beetle grub image and it shows information on the species, with the Black and yellow flat-backed millipede unselected (clearly visible next to grub image selected)

The development of the website involved uploading images taken in the field from research related to coverboards. For each species image uploaded, we included species identification and brief natural history information obtained from iNaturalist, Animal Diversity Web, Tree of Life Web Project, or Herps of NC websites. The information included species-specific details such as lifespan, behavior, description on how to identify, overall body size, habitats, taxonomic information, and other interesting biological facts.

The website included several tabs: a home tab describing what coverboards are and how they are used in monitoring; a graph tab including visual representations of preliminary data on diversity; a contact information tab; a links tab including a link to iNaturalist and the university's website; and finally a more tab including references of websites useful to learn additional natural history information of taxonomic groups. Students visiting the website would navigate to the "Virtual Coverboarding" tab and see a question "Where would you like to explore?" then select either the image for Wingate Woods or Wingate Campus Lake (**Figure 2**).

Students would then select wood or metal coverboard to "explore beneath" within either of the chosen habitats. We included 8-9 representative species images for wood and 5-6 images for metal coverboards, along with natural history information for each species (image). This reflected commonly encountered species, of which the wood coverboards typically housed more on average than metal boards (**Figure 3**).

### Data Collection

Students participating in the online activity were asked a series of Likert scale questions on the utility and engagement level of this virtual coverboarding activity, including

1. Q1: "*I enjoyed virtual coverboarding on this website to learn about local forest species*,"
2. Q2: "*This activity helped me learn about local biodiversity and how biologist sample leaf litter forest communities*," and
3. Q3: "*I learned something new about the natural history of some local species while virtual coverboarding on the website*."

Likert responses were on a scale of 1 to 5, with the following possible responses: 1=strongly disagree, 2=disagree, 3=undecided, 4=agree, and 5=strongly agree. We also asked additional questions, Q4: "*Did you enjoy identifying species found around Wingate campus?"*, with either Y for Yes or N for No as a response, as well as a final reflection open-response question, *"In at least 2-3 sentences, elaborate on whether you enjoyed this activity/website."* We ranked reflection responses on the following scale: -1=negative or response of not liking activity, 0=neutral or responses which did not clearly state whether they enjoyed or did not enjoy the activity, and finally, +1=positive for responses which clearly stated they enjoyed the activity followed typically by specific reasons.

Survey results from participants were analyzed using either a chi-square analysis or a Fischer's exact test due to low sample size and presence of zeros in Likert responses for some categories (disagree category in two out of three Likert questions). We organized Likert scale responses into either disagree or agree categories and removed undecided responses for statistical purposes, resulting in a contingency table to test whether responses were different from random. We also report remaining results using primarily descriptive statistics. Lastly, we monitored the use and visits to the website by examining the "traffic reports" in the "analytics and reports" page of our created website. This feature allowed us to quantify date of use, page views (page use by users per date), unique visitors, and average session duration (time spent viewing the website).

## RESULTS

Student responses to the Likert question "*I enjoyed virtual coverboarding on this website to learn about local forest species"* (Q1) had a median of 4 or "agree:" (with combined percentages of 2.4% disagree, 8.1% undecided, and 89.5% agree). Responses to the question "*This activity helped me learn about local biodiversity and how biologists sample leaf litter communities*" (Q2) had a median of 4 or "agree" (with combined percentages of 0% disagree, 6.4% undecided, and 93.6% agree), while responses to the question "*I learned something new about the natural history of some local species while virtual coverboarding on the website*" (Q3) had a median of 5 or "strongly agree" (with combined percentages of 0% disagree, 7.3% undecided, and 92.7% agree). Fisher's exact test found significance for each of Q1, Q2, and Q3 with $p<0.001$ for each comparison. A Chi-square test was significant for Q4: "*Did you enjoy identifying species found around Wingate campus?", $X^2(1, N=124)=63.54$, $p<0.001$*, with 95.2% (118/124) answering yes and only 4.8% (6/124) answering no. The mean word count from student reflections on being asked to "elaborate on the website" was 35.5 words.

Overall, students overwhelming perceived the activity as enjoyable, enabling them to learn something new regarding local biodiversity via "virtual coverboarding." Overall, ranking student reflection responses resulted in four negative reflection responses (3.2%), four neutral reflection responses (3.2%), and 116 positive reflection responses (93.6%). Exemplar responses included (**Table 1**),

> "I thoroughly enjoyed this activity and interactive website, because I could see the identification of different animals, while also understanding what other species were found, and the environment in which they were found."

as well as

> "I really enjoyed this activity because I was able to explore without actually being out in the heat, I would prefer more activities like this in the future to learn new and interesting things about my local area."

However, the data in **Table 1** illustrates that not all participants found this activity as enjoyable. Negative rank category responses indicated several students did not like being outside in general or learning about animals or found the activity repetative. Neutral responses highlighted a preference for being outdoors or that seeing a snake was undesirable, indicating further refinement of the website could incorporate changes which potentially list taxonomic categories and not species if students have anxiety when seeing images of snakes. However, according to positive student response in **Table 1**, students were able to complete this activity on their own time frame and presumably from the safety and comfort of their dorm rooms (i.e., without being in the heat or to physically go near insects, which along with snakes, students may not appreciate), indicating this activity provided some flexibility to students while learning about local biodiversity. Additional **Table 1** responses such as

> "It was interesting to learn about metal and wood coverboards used for surveys",

> "I enjoyed the website because it has full information about biodiversity that is here on campus",

and

> "I enjoyed virtual coverboarding because I didn't know so many species were on campus!"

highlight students were successfully informed on coverboarding as a method in learning about biology and biodiversity and as a field-based experience in an online environment, as another response indicated

> "I liked this activity A LOT, its quick and easy and allows you to explore nature on Wingate campus from your laptop."

**Table 1.** Representative responses to "Elaborate on whether you enjoyed this activity/website," N=124, ranked by positive, neutral, or negative written reflection responses

| Rank category | Student responses |
|---|---|
| Positive (116/124: 93.6%) | *"I thoroughly enjoyed this activity and interactive website, because I could see the identification of different animals, while also understanding what other species were found, and the environment in which they were found."*<br>*"I enjoyed this activity because I got to look at the animals and insects without having to go near them or touch them."*<br>*"I enjoyed this activity because it allowed me to complete it on my own time, the website was very well designed and I enjoyed reading all the information provided for each species."*<br>*"I really enjoyed this activity because I was able to explore without about actually being out in the heat, I would prefer more activities like this in the future to learn new and interesting things about my local area."*<br>*"I enjoyed this activity because of the virtual aspect."*<br>*"I enjoyed this activity. The website was very easy to navigate and gave great information. The website had just enough detail and was easy to read, use, and comprehend."*<br>*"I enjoyed virtual coverboarding because I didn't know so many species were on campus!"*<br>*"I enjoyed the website because it has full information about the biodiversity that is here on campus."*<br>*"I liked this activity A LOT, its quick and easy and allows you to explore nature on Wingate campus from your laptop."*<br>*"It was visually pleasing to the eye."*<br>*"I really feel like this is a well put together activity, this could go well for alternative options for times students who might not enjoy or can't be around specific organisms."*<br>*"I'd rather do this activity virtually than in person because I don't like insects."*<br>*"It was interesting to learn about metal and wood coverboards used for surveys."* |
| Neutral (4/124: 3.2%) | *"It is alright. I would have enjoyed it much more if we did it in person, but it is also nice having the information on each species with the picture."*<br>*"This activity was definitely different compared to what I've done in previous classes. It was definitely enjoyable learning new information until I saw a snake. Definitely killed my mood."*<br>*"I wouldn't say this is my favorite activity, but better than trying to do it out in the sun."* |
| Negative (4/124: 3.2%) | *"I did not really enjoy the activity because for me personally, I hate being outside and don't really enjoy the outdoors."*<br>*"No, just because I am not a huge animal fan, it was somewhat interesting to know some facts but I can't say I was so crazy about knowing all of this."*<br>*"I did not enjoy this activity because I don't like things that I have to keep clicking on just to click back on."* |

Website analytics resulted in a range of one to 103 unique visitors per day, with a total of 243 unique visits to the website during the time of the activity/course. The mean number of pages (website included several pages) visited was 10.6 (median of 7), with time spent on the website ranging from 0.2 minutes to 116.5 minutes, with an average of 14.6 minutes spent by visitors (students) viewing the website. Therefore, collectively, these metrics indicate that many students successfully visited the website while also spent time learning about biodiversity as they worked through the different cover objects and sample site or habitat locations. Moreover, these analytics suggest that students took adequate time to read species descriptions while navigating the website or that students were able to be informed regarding local biodiversity via a novel method of coverboarding virtually.

## DISCUSSION AND IMPLICATIONS

The present activity revealed that online inquiry activities which focus on teaching undergraduate biology students about local biodiversity could be easily and successfully disseminated using an engaging, free website. This website promoted the discovery of species presence and related natural history information and was found to be overwhelmingly a positive experience for students. While not a replacement for conducting in-person field activities, such as students checking coverboards themselves, this website appealed to students for a variety of reasons based on comments indicating it was organized, easy to navigate, and teaching about the use of coverboards to sample biological communities. Moreover, many students revealed they preferred "virtual coverboarding" due to the ease and access to species-specific information and, in some cases, they did not prefer to be outside. This website can likely function as a pre-laboratory experience or a stand-alone website. It can be updated as new species are found or modified into other sampling methods, e.g., bug collection by netting, bird diversity by sound recordings, or even nocturnal mammals by uploading trail camera images. Designing websites while engaging students on biological diversity can take several forms and can easily be incorporated into teaching in science classrooms for both science and non-science majors.

Providing effective field-based experiences and laboratories to undergraduate biology students in an online environment presents challenges which balance the need for continued education of utilizing either a "field experience without the field" or a "bringing the field online" approach. Higher education faces challenges not only in the potential for courses to move online in the short term following COVID-19 safety requirements, but also as fully online Bachelor's degree programs in biology are increasingly being adopted by colleges and universities (Varty, 2016). Subsequently, online biology teaching may alternatively provide a unique approach using active and inclusive learning which allows students to feel connected to learning, their peers and their campus (Harris et al., 2020).

Innovative online laboratories, which have aided biology students master lab skill sets include the use of games within a PowerPoint-based platform to teach microbiology labs (Dustman et al., 2021), virtual lab demonstrations (Maldarelli et al., 2009), and increasingly virtual simulations (Alvarez, 2021). Moreover, Jones and Laughin (2009) utilized free online simulations which allowed students to virtually sample and calculate biodiversity indices. It is important to note that many

virtual laboratory simulation software require fees to access content. Therefore, free websites as we created to teach about local biodiversity in this study, may offer an alternative cost effective teaching tool which can be catered to educator learning outcomes and goals to a specific undergraduate biology course.

There may be several factors why educators do not utilize more websites as a teaching tool in the classroom, as free and open source technologies such as website use by educators, has received surprisingly little research as a teaching method (Blake & Morse, 2016). This is surprising as there are presently several free and readily available website building softwares which requiring minimal experience to develop. Some recent research has highlighted the Wix website builder that we used in our study, as an appropriate platform for communicating science (Ibit et al., 2021) or as a collaborative tool to involve students in watershed education (McConnell et al., 2020). Furthermore, the website we created was fully accessible via mobile devices, which has been found to be a practical tool when teaching about biodiversity (White et al., 2015). However, it is possible science educators are potentially unaware of this easy to use free resource, prefer in-person methods exclusively, or face technological or time constraint challenges to using websites to teach science. Based on feedback from students and overwhelming positive perceptions of this activity, we recommend educators consider using websites in addition to standard teaching practices (i.e., lectures, outdoor labs, etc.) to stress the importance of local biodiversity.

This activity and incorporation of a website can be modified to include plant surveys, aquatic surveys, and even natural history collections such as herbaria, as specimen/collection digitization has been successfully utilized as a teaching tool to engage the public (Monfils et al., 2017). We further recommend incorporation of follow-up writing assignments, potentially using species identified on the website or using online biodiversity websites, e.g., http://animaldiversity.org (Myers et al., 2013), which have been found to engage undergraduate students (Yahnke et al., 2013). One of the more valuable aspects of this website creation activity that can be further explored by researchers includes the ability to monitor website visitations, average time spent on the website, and other metrics. This provides educators, outreach education specialists, state agencies, or even citizen scientists a mechanism to monitor how frequently their website is visited and how many people can potentially be impacted. While we did not note a high number of unique visitors to the website (i.e., our students taking the course), it did allow us to look at important metrics, such as how long students spent on the website on average.

An alternative method for collecting images includes collecting photographs from students on campus taken using cell phones (Salas & Barquero, 2021), which may be a way to engage not only students but also citizen scientists at large. Websites can further be developed to accept images taken by local citizen scientists and students for inclusion in a website based local biodiversity project. Lastly, we recommend further development of websites similar to ours to reach a wider audience, as our website was specifically designed for a small number of students taking the course. A more targeted outreach science program could incorporate websites as both a teaching or training tool and as a mechanism for citizen scientists to be engaged if involved in specific survey and monitoring projects.

Engaging students in a manner that incorporates the joy of discovery is often overlooked and can be less emphasized over meeting goals for standards in education (Dean & Gilbert, 2021; Feynman, 1999). Knowledge of local biodiversity may go hand in hand with an interest in nature which is a factor in determining whether knowledge translates into promoting an understanding of biodiversity related issues (Palmberg et al., 2015). However, we recommend educators across academic levels pursue avenues that concurrently engage and educate while instilling a sense of discovery and interest when teaching about local campus biodiversity.

The website we developed allowed students to virtually navigate while learning about a range of species, from either their laptops or phones. The website can also serve as an additional activity for pre-laboratories, or one could even have students develop separate websites in groups for outreach and citizen science.

We recommend educators upload clear closeup high-quality images, and websites may be further designed to reflect specific goals. Moreover, educators should investigate different website formats that provide the best delivery of material and concepts to students. While not a replacement for in-person field sampling, the development and implementation of websites for biodiversity education can provide an engaging tool for educators to include in course design and delivery in the biological sciences.

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