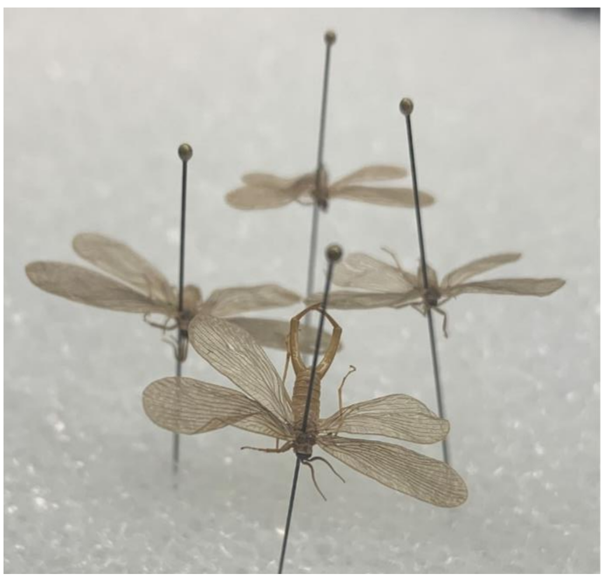
From Proposal to Publication:

Implementing a Graduate Level Research Experience

in an Undergraduate Course (Bio 301: Invertebrate Zoology)






Newell Innovative Teaching Award Application 2021

Jeremy D. Blaschke, MS, PhD

Assistant Professor of Biology

Description of the project

In popular culture, a "scientist" is often caricaturized as little more than a big brain brimming with obscure facts. In reality, successful scientists are well-rounded people who deeply understand the complexities of their field, the motivations for their personal research, and who are able to effectively articulate the importance of their work. In many institutions, undergraduate biology majors are educated in ways that reinforce the notion that knowledge is of singular importance—the actual practice of science is left to be discovered and muddled through during graduate school. My vision for Invertebrate Zoology (Bio 301) was to design a course that brings the experience of authentic scientific practice into the undergraduate classroom by embedding two novel, high quality research projects into the course curriculum beginning with grant proposals and ending with scientific presentations and peer-reviewed publications.

In doing so, I hoped my students would demonstrate in practice **who a scientist is** (1) a *curious* person who marvels, investigates, and is excited about discovery, (2) an *educated* person who has exceptional knowledge about their field, (3) a *thoughtful* person who understands the motivation behind their research and how their work connects to the broader world, and **what a scientist does** (1) *designs experiments*, understands how to ask interesting questions and the importance of controls, replicate samples, and statistical analyses, (2) *applies for funding*, convinces others of the importance of their research, (3) *performs research*, diligently, honestly, and meticulously, and (4) *communicates results*, in written and verbal form to laypeople and scientific peers.

To accomplish these objectives, I designed Bio 301 to mimic a graduate school research lab rather than a typical classroom. Our "lab" was an insect biodiversity and behavior lab, I played the role of their advisor, and each student was considered a graduate student. The class included no traditional lectures or assessments—no quizzes, exams, or lab practicals. Instead, each student was assigned a research task and a short writing assignment every week. The entire class worked collaboratively to accomplish two ambitious research projects and each student working individually on specific sub-projects of their own. Our two projects for the semester were both carried out at Cypress Grove Nature Park (Jackson, TN) from August–October, 2020. The first project was a survey of insect biodiversity and seasonal abundance using a Malaise trap (a tent-like structure that funnels flying insects into collecting jars), and the second was a comparison of different colored pan traps to attract various pollinators in both meadow and forest habitats.

How the project is innovative

As traditionally implemented, an invertebrate biology course is an introductory survey of all invertebrate life designed to prepare students for future specialization. Invertebrates are vastly diverse (>1.5 million species) and this class usually skims the surface of the anatomy, physiology, ecology, and systematics of everything from sponges and jellyfish to squid and butterflies. Because of the sheer volume of content, invertebrate biology is largely about accumulating information and generally lacks an emphasis on practical skills. In contrast, I reduced the content of Bio 301 considerably in exchange for a more intentionally holistic training of future scientists by emphasizing the importance of conducting original research, writing papers, and presenting results. The most significant innovations this past semester were the underlying framework of publication-quality research papers, the consequent scale of the research projects, and the intentional mirroring of a graduate school research lab.

This was my third time teaching Bio 301 and in previous semesters students worked in groups to complete three or four small research projects each semester. Two difficulties arose from this model. First, the research projects were often interesting and novel, but the students never had enough time to really produce something robust enough for scientific publication—a vital component of doing science. I was consistently disappointed that many fantastic projects were left 75% complete and were abandoned at the end of the semester never to be looked at again (heartbreaking, really!). Second, students don't like collaborative projects. Inevitably, not everyone will contribute equally and since grades are affected by all group members, conflict arises. I tried several ways to solve this difficulty but was never completely satisfied with the results.

This time however, I reduced the number of projects and greatly expanded the collaboration to include the entire class (12 including me). A dozen people working toward the same goal can produce a remarkable amount of data and thus have a greater chance of completing publication-quality research. An additional benefit was that grades were not affected by other collaborators. Everyone had their own data to work through and their success or failure rested on them alone. Similarly, all writing projects were done individually which prevented the less capable students of “hiding” behind the better writing abilities of their coauthors. Everyone was forced to work on improving their own writing and communication skills.

Writing and presenting

The value of publishing as an undergraduate is twofold. First, practically speaking, publishing is a rare achievement for an undergraduate, making it an impressive accomplishment that increases the chance of acceptance into graduate school. A publication on a CV indicates that a student has *experience,* not just knowledge, of scientific methods. Second, philosophically speaking, pursuing publication emphasizes the important fact that science requires communication of results. Science does not end with observation and experimentation—results *must be* relayed to your scientific peers and to the general public. Consequently, I designed this course to achieve that specific innovative goal: to produce multiple peer-reviewed scientific presentations and publications with undergraduate students as primary authors.

Attempting to publish original research is an intimidating task, but beginning the semester with this goal in mind allowed students to methodically work each week on specific tasks that never seemed too difficult in the moment. Although the final quality varied by student, by the end of the semester everyone had prepared a complete manuscript crafted for publication. The following components of scientific writing were introduced and practiced one week at a time: grant proposal, introduction, methods, results, discussion, abstract, and references. Every other Monday we would explore the question “What should be included in writing a scientific ________?” by reading together five examples from the primary literature of that week’s writing assignment. We worked together to highlight consistent features, topics, and trends found throughout our examples and the students were therefore able to answer our primary question on their own rather than simply taking my word for it via a lecture. After submitting an assignment, I would provide constructive feedback and they were encouraged to resubmit it later for additional half-credit.

In addition to publishing their results in writing, scientists should also be able to communicate the significance of the work through oral presentations. Many professional research lab groups have weekly seminars where grad students and professors share their current projects and receive helpful feedback, support, and solve problems as a community. I tried to mimic these valuable seminars in Invertebrate Zoology by requiring each student to present two five-minute research updates to the class throughout the semester. I emphasized the necessity of a streamlined verbal presentation that was detailed yet concise, including high-quality visual aids, and encouraged students to practice wearing appropriate attire, maintaining consistent eye-contact with audience, and speaking in a friendly but confident tone.

Successes, challenges, and future directions

By redesigning the structure of the class, I wanted students to engage with the actual practice of being a scientist, with all that entails, and in the end to produce professional-quality presentations and manuscripts. In summary, the class was an enormous success. Out of the eleven students, only one entered the class with a significant interest in invertebrate biology. Upon leaving the class however, eight out of the eleven expressed their desire to continue the insect biodiversity research they began in Bio 301. Three students will be using their research as a springboard into their three-semester senior research sequence, while several more have continued their work into the spring semester without any obligation for grades or class credit. They are simply scientists doing science!

Halfway through the semester after seeing all that we were able to accomplish as a group, I realized the class was working towards something significant and I wanted to share our results with the entire biology department. I had planned on students presenting their research to the class but realized it would be more constructive to formally present to their scientific peers. I scheduled Bio 301 to present the results of their two projects during a departmental research seminar at the end of the semester, and they performed wonderfully. Even more significantly, two of our seniors presented the projects at a professional scientific conference in March.[1],[2]

---

[1] Mullin, D., A. Armstrong, P. Buck, S. Childress, H. Juliussen, R. Kuhl, D. Mullin, S. Ross, E. Straley, C. Walker, G. Woodring, S. Zemke, and J. Blaschke. *Exploring insect biodiversity and seasonal abundance in a lowland cypress swamp.* Annual Conference of the Association of Southeastern Biologists. March 2021.

[2] Childress, S., A. Armstrong, P. Buck, H. Juliussen, R. Kuhl, D. Mullin, S. Ross, E. Straley, C. Walker, G. Woodring, S. Zemke, and J. Blaschke. *The hidden world of pollinators at Cypress Grove Nature Park (Jackson, TN).* Annual Conference of the Association of Southeastern Biologists. March 2021.

One downside to the extra effort in presenting to the department was a shift in priorities from preparing for publication to presenting at the end of the semester. The biodiversity project and pollinator project both produced more than enough interesting data for at least one publication each, but we ran out of time at the end of the semester to completely finish a polished version of either. However, this semester I have been working with several students to complete our drafts and plan on submitting both papers for peer-review this summer. The papers will include these students as first authors—a remarkable feat for an undergraduate—and all eleven students as coauthors. In future years, I will prioritize writing the paper during the class and presenting at conferences later. The students would have loved to actually submit these projects for peer-preview during the semester that we worked on them.

One major change I will make in the future involves the sorting of fungus gnats from the Malaise trap samples. Fungus gnats are very tiny flies that we collected in the thousands. For the first two weeks, I required students to sort through the entire trap contents and they tediously did so, sorting and counting almost 25,000 insects (~20,000 of which were just fungus gnats!). After a small nonviolent revolt, I decided it would be best to filter out all specimens <4mm before sorting and counting the rest. This change made the work much more realistic to accomplish and did not detract from the overall narrative we were constructing. In future classes we will have the "only count insects >4mm rule" in place from the beginning.

The writing assessments can be improved as well. Students enter the class with a diverse range of writing abilities which makes providing constructive feedback difficult and time-consuming for the class as a whole. Encouragingly, our seniors usually do very well and it is typically our sophomores and transfer students who struggle. I need to create a detailed rubric and/or writing guide for each assignment that will help the less well-trained students understand what scientific writing is and the quality of work I am expecting.

Due to the nature of the projects, students were forced to study aspects of the world we inhabit that usually go unnoticed. In each jar of specimens filled with tiny creatures there exists great beauty, intricate designs, fascinating anatomical features, and surprising discoveries. Their curiosity was ignited each week with new discoveries (like the incredibly rare forceps flies on the cover page), students became confident experts within their own taxonomic focus groups, and through the practice of researching and writing become well-versed in the *whys* of studying biodiversity. Working together, we achieved in a semester what usually takes many years and I am looking forward to seeing what else the students of Bio 301 will accomplish in future semesters.