Biologists and Graph Interpretation Network

Unveiling Lizard Evolution: Graphical Insights into Behavioral Ecology in the Era of Climate Change

A BioGraphI Module Lesson Guide for Instructors

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Course Information
Department/Program: Biological Sciences
Level: Introductory level
Course type: Lecture
Delivery mode: in-person
Students: majors
Number of students:>200
Estimated duration of activity: 1-2 classes of 50min

Expected date or dates of implementation
Fall 2023

Purpose/Background
The proficiency of entry-level undergraduate students in comprehending and interpreting scientific graphs often requires improvement. In light of this, the objective of this instructional module is to enhance their aptitude in understanding, analyzing, and applying authentic biological research, specifically through data visualization and graphical representations.

To achieve this goal, a BioGraphI lesson has been developed, which involves in-class group-based discussions centered around a lizard graph. This exercise aims to cultivate critical thinking skills and foster an understanding of scientific research through collaborative learning. Furthermore, students will be tasked with writing an individual reflective essay to examine their reasoning and application of the scientific method in formulating scientific questions.

To augment the learning outcomes, a social media assignment has been incorporated to promote the students' perceptions of counterstereotypic scientists and their contributions to the field. This assignment will be given as individual homework submissions.

These assignments and activities will be implemented during the mid-semester, to ensure the students have a solid understanding of the foundational concepts before diving into practical applications.

List of materials needed for the lesson

- Activity 1: Appetizer Discussion:
  4_Activity 1 – "Appetizer" Discussion_Lizard Evolution.pdf
- Activity 2: Lizard Evolution lecture and in-class Group-based graph discussion
  - Link to interview on YouTube
  - Link to presentation slides
  - Link to optional in class worksheet-student version
  - Link to optional in-class worksheet-teacher version
- Activity 3: individual reflective essay
- Activity 4: Diversity in Biology - Social Video Assignment

About BioGraphI modules

This lesson is a BioGraphI module. BioGraphI modules address data literacy while fostering diversity in undergraduate biology classrooms. They are lessons about graph and data interpretation, featuring the scientific contributions of biologists who are members of historically excluded groups (HEGs). They include video interviews with these biologists, allowing students to hear directly from HEGs about their discoveries. For more information about how the BioGraphI project is advancing inclusion in biology and improving data literacy, visit our webpage.

Student Learning Objectives

The BioGraphI Student Learning Outcomes (LOs) describe what students can expect to gain by the end of the BioGraphI lesson. They are written in a format that can be shared directly with students.

Content learning objective(s)

1. Apply the scientific method to formulate a scientific question and testable hypothesis.
2. Explain the significance of evolutionary concepts in behavior ecology.
3. Discuss and predict how global climate change influences the adaptation and evolution of the lizard population.

Quantitative learning objective(s)

1. Interpret graphs and/or data figures related to the concepts from this lesson.
2. Reflect on your perceptions about using graphs or figures in biology.

Diversity/equity/inclusion learning objective(s)

3. Reflect on your perceptions of people who do biology.
4. Compare your own interests and/or identities to those of people who do biology.

Assessments

To help the BioGraphI Project to measure the effectiveness of our modules in improving data literacy and fostering diversity in biology classrooms, we invite your students to participate in a voluntary, anonymous pre-/post-lesson survey (Geneseo IRB #202021048). This survey is designed as an opportunity for reflecting on the Quantitative and D/E/I learning objectives above and administered via LimeSurvey. Click Instructions for access to BioGraphI PrePost-Lesson Student Survey to request a survey to be set up for your students, at least 7 to 10 days in advance of your class meeting date.

Objective(s)	**Formative Assessment**	**Summative Assessments**
Interpret graphs and/or data figures related to the concepts from this lesson.	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey) Activity 1: Appetizer Discussion Activity 2: Lizard Evolution lecture and in-class Group-based graph discussion	BioGraphI Student Post-Lesson Survey (link for instructions to access survey) Activity 3: Individual reflective essay after the lesson is completed
Reflect on your perceptions about using graphs or figures in biology.	Activity 2: Lizard Evolution lecture and in-class Group-based graph discussion	Activity 3: Individual reflective essay after the lesson is completed
Reflect on your perceptions of people who do biology. Compare your own interests and/or identities to those of people who do biology.	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey) N/A	BioGraphI Student Post-Lesson Survey (link for instructions to access survey) Activity 4: Diversity in Biology - Social Video assignment

Apply the scientific method to formulate a scientific question and testable hypothesis. Discuss and predict how global climate change influences the adaptation and evolution of the lizard population	Activity 1: Appetizer Discussion. Activity 2: Lizard Evolution lecture and in-class Group-based graph discussion	Activity 3: Individual reflective essay after the lesson is completed

Lesson context

Learning goals of unit

The content learning outcome established for this lesson is to reinforce the comprehension and reasoning skills related to the scientific method. This outcome is aligned with the overarching objectives of the course, which are to:

1. critically review scientific research and literature in the life sciences, and
2. Apply the scientific method to formulate testable hypotheses, gather data that address the hypotheses, and analyze the data (statistically, graphically) to assess the degree to which their scientific work tests their hypotheses and draw appropriate conclusions from the data.

Through this lesson, students will have an opportunity to develop and hone their critical thinking and analytical skills, which are essential for learning and evaluating scientific research. In addition, students will learn how to apply the scientific method to design the research, collect, analyze and interpret data, as well as draw conclusions. These outcomes will equip students with a deeper understanding of the scientific process and ramp up their learning competencies in authentic scientific research.

Prerequisite skills or knowledge

Students are expected to have

1. basic knowledge of biology, particularly related to animal behaviors, ecology, and genetics.
2. basic graph reading skills with appropriate axes and axes labels
3. understanding of statistical methods.
4. good communication and teamwork skills.

Preparation for lesson

- Assign BioGraphI Student Pre-Lesson Survey as homework for students to complete before the in-class activity.

Lesson sequence

Each row of this table is a step of the activity. Column headings reveal what the instructor, interviewee, and students do at each step.

Information from instructor (live in-class)	**Information from scientist (within pre-recorded video interview)**	**Student follow-up or transition activity**
Prior to class, assign the Activity 1-Appetizer Discussion graph.	N/A	Students complete pre-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) ● *Purpose*: prepare for class; LO 2 & 3 – Pre-lesson reflection on data literacy and perceptions of scientists ● Appetizer discussion on a lizard graph.
Introduction slides- project, lizard, microhabitats and first kick-off graph discussion (slides 1-6)	N/A	**Fundamental activity:** ● Introduce lizard and microhabitats by a think-pair-share activity. ● Discuss figure 1.
Plays first video segment - introduce the interviewee, and wrap up the first kick-off graph discussion (slides 7-9)	***Required interview Q.*** Why did you use lizard as the model organism in your research? Orient us to the figure 1.	**Fundamental activity:** Students interpret/re-interpret graph with the correct axis labels and variables. Infer the hypothesis that was studied.
Lecture the 2nd graph and lead the discussion. Plays next video	***Required interview Q.*** Tell me about the research that these data came from in figure 2. Dr. Warner explained figure 2.	

segment (slides 10-13)		
Lecture the 3rd-4th graphs and lead the discussions. Plays next video segment (slides 14-18)	***Required interview Q.*** Tell me about the research that these data came from figure 3 and 4. Dr. Warner explained figures 3 and 4, and describe the follow-up experiment.	Based on these results, what should the scientist investigate next? Share out. ● *Purpose*: Transition to next steps; could be used to align Content LOs or LO 1A or B ●
Lecture the wrap-up slides for the research (slides 19-22)	***Required interview Q.*** Can you explain the significance of this research, in your view? Why does this research/results matter? Dr. Warner discussed the research significance.	What's significant about these findings? Share out. ● *Purpose*: LO 1A or B, and could be used to align Content LOs
Adds a little info about the scientist (slide 23)	N/A	With your neighbors, brainstorm ideas: What questions do you have about Dr. Warner's path to this work, or where he is today? - discuss and share out. ● *Purpose*: LO 4 - Identifying potential connections between students and scientist
Plays next video segment (slides: 24-31)	***Required interview Qs*** What kinds of scientific questions interest you the most? When and how did you know you wanted to be a scientist? Tell us about the paths that led you to your current job. Would you like to share your identity or background with us? And what is it like being a scientist with this background? What keeps you motivated to do research?	*Purpose:* Answers the questions identified by students

	Tell me about a moment when you felt like you really belonged in the field of science. ***Strongly suggested Qs*** What is a typical day like for you? Could you give any academic advice or career advice to my students?	
Instructor shares contact info (twitter, email, etc) of scientist so that students can ask leftover questions! #BioGraphI… (Slide #33-reflection)	What was your biggest takeaway from this lizard research? How do you plan to apply your learning in your future academic and professional pursuits?	Students ask their questions during class. • *Purpose*: LO 4 - Identifying potential connections between students and scientist. Closes the in-class portion of the lesson.
Instructor could provide other resources on scientist (e.g., website, papers, etc.), release the homework. (slide #32 and 34)	Submit one more question for Dr. Warner that wasn't answered in this interview. Complete the post-lesson survey	Students complete homework/post-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) • *Purpose*: LO 2 & 3 – Post-lesson reflection on data literacy and perceptions of scientists

Alignment to Universal Design for Learning Guidelines

UDL Guideline	**Lesson Alignment**
Multiple means of Engagement	Recruiting interest: Students have the opportunity to generate their own questions for the scientist Self-regulation: Students reflect on their dispositions and knowledge of scientists and

	graph interpretation before and after the lesson
Multiple means of Representation	Perception: Captions are provided on the interview video. Google Slides offers automatic captioning for presenter. Alt text for images provided in Google Slides. Comprehension: The activity highlights big ideas and the relationship between lizard research to the topic of ecological/environmental conservation. A few questions are designed to let students think of a big picture to transfer or generalize their knowledge.
Multiple means of Action and Expression	Expression & communication: Multiple types of media are used in the lesson (visual, audio, text). Physical action: In the activity, I will be using various means to promote students' actions, including group discussion, self-writing and video-watching. Executive functions: A worksheet is provided to guide note-taking/activities

Implementation notes

Imple entation Plan

The teaching module will be implemented in two Introductory Biology classes with approximately 200 students each in the fall of 2023. Both classes will be conducted in-person. The module was developed by expanding upon the existing "Appitizer lizard activity" (Activity 1) and the lizard reflective essay (Activity 3). This was achieved by including additional activities focused on graph interpretation and a biology social video assignment. During the fall semester of 2023, a 50-minute class session will be dedicated to implementing all in-class activities (Activities 1 and 2). Activities 3 and 4 will be assigned as extension and wrap-up assignments.

The in-class teaching module will begin with Activity 1, the Appetizer Discussion, where students will read a graph and generate potential research questions. Following this, I will deliver an introductory lecture using PowerPoint slides, providing information about the Learning

Objectives of the module, invasive lizard species *Anolis sagrei*, its original native distribution range, introduced range, and its habitats.

Then, a mystery figure (Figure 1) will be presented to stimulate student discussions on the research questions investigated by researchers, followed by a video explanation from an interviewed scientist. Moving forward, students will analyze Figure 2, read the graph, and create a title, summarize the conclusion, and explain the supporting data. They will also be prompted to discuss how this data relates to broader topics such as climate change.

To further explore the study, students will examine Figure 3, which includes new dependent variables, and engage in discussions of its implications. Based on their understanding of this figure, students will propose potential follow-up research questions. The in-class activities will conclude with a summary of the data displayed in Figure 4.

Students will then revisit the concept of microhabitats, discussing the independent variables utilized in this research. This discussion will encourage higher-order thinking skills relating to the importance of microhabitats in lizard evolution and their correlation with climate change. Additionally, students will have the opportunity to leave messages to Dr. Warner, the researcher, regarding his specialty in this field. This transition will seamlessly lead the teaching module to the subsequent section, which will involve addressing seven science identity questions.

Then, students will be directed to go back to review the microhabitat concepts and discuss what types are used as independent variables in this research. The discussion will be further leveled up to the higher-order thinking skills about why are microhabitats matters to lizard evolution, as wells as its coorelation to the climate change.

In addition, I will also provide students' opportunity to leave message to Dr. Warner about his path to the current research, which will smoothly direct the teaching module to the next section, 7 science identity questions.

Potential Problems

One potential challenge in large classrooms may be facilitating student discussions within the limited class time (either 50 or 75 minutes). To address this, it is recommended to utilize peer instructors or Learning Assistants to facilitate these discussions.

Other possible strategies to enhance student engagement in after-class assignments include incorporating peer reviews of their reflective essays (Activities 3 and 4) and providing opportunities for students to discuss their reflections during class.

Suggestions for Adaptation

This teaching module can be adapted for use in both introductory-level biology courses (for both majors and non-majors) as well as upper-level biology courses.

References/resources

1. Paper for case study activity: Maternally Chosen Nest Sites Positively Affect Multiple Components of Offspring Fitness in a Lizard.
2. Guest interviewee Daniel Warner's website and lab website
3. Interviewer Dr. Min Zhong's website

Funding for BioGraphI

This project is funded by the Directorate for Biological Sciences, Division of Biological Infrastructure as part of efforts to address the challenges posed in Vision and Change in Undergraduate Biology Education: A Call to Action (http://visionandchange/finalreport/). Award number 2120679.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

Transcript of interview

Lizard Evolution Interview Script

0:00 - 0:58 Introduction
MZ (Min Zhong): Hello everyone. I am Dr. Min Zhong, a senior lecturer at Auburn University.For the BioGraphI project interview, I invited Dr. Daniel Warner,who is an associate professor at Auburn University.
Dr. Warner's research area is evolutionary ecology of reptile populations. Hello, Dr. Warner!

DW (Daniel Warner): Hello Dr. Zhong! Happy to be here to talk with you about my research.

0:59 - 1:50 Project Intro
MZ: Thanks! In this teaching module, we adopted one of your research article titled "Maternally chosen nest sites positively affect multiple components of offspring fitness in lizard" published in Behavioral Ecology in 2012.. Today, we would like chat with you about your research hypothesis from this paper and some graphs you made. Does it sound good to you?

DW: Awesome, I'm excited to talk with you about this project.

MZ: Can we start the interview with an interesting question about lizards? Would you please let us know why you used lizard as the model organism in your research?

DW: There are three main reasons. First, lizards display a wide range of interesting behaviors that are relatively easy to observe and study, and the fact that they lay eggs makes it convenient to conduct experiments on the developing offspring. Second, they are fascinating animals that play an important role in their ecosystem. Third, more personally, I have had an interest in lizards ever since I was a kid.

1:50 - 3:28 Figure 1
MZ: Thanks! Lizard is one of my favorite animals too. Now, let's discuss some graphs you made in this research. Please tell us about the research in Figure 1 that you have subtitled "nest-site choice in relation to substrate moisture content and the presence of a plant".

DW: Females of this lizard species will dig a hole in the ground, lay an egg in it, cover it up and leave it. There is no parental care, so the location that females choose is really important, and female have lots of choices of microhabitat to lay their eggs. If the egg is in a sunny/hot location the embryo will overheat, it is in a dry location the egg will desiccate. But yet, we see baby lizards all the time, so the embryos are clearly surviving and developing. We hypothesized that embryos survive well because mothers choose nest locations with conditions that are good for developing embryos/eggs. This figure clearly shows that females almost always select sites with high levels of moisture and avoid dry areas when nesting.

3:29- 4:01 Figure 2
MZ: This is very interesting! So, moving forward to Figure 2 subtitled "Effect of incubation moisture", what does the Figure 2a show?

DW: The previous figures shows that mothers are choosy, and this figure shows that they are making good choices! The wet nest environments that moms choose result in high hatching success of the eggs.

4:02 - 4:59 Big Picture
MZ: So, connecting to the current concerns about the global climate change, Are there any indications from this result to the bigger picture?

DW: Overall, both figures show that dry conditions kill eggs and does so very quickly. We are predicting changes in precipitation patterns due to climate changes. Things are going to get drier in some locations and droughts are going to have serious consequences because this won't provide moms with good options for laying eggs. This could lead to local declines in some areas or possibly extinctions depending on severity of droughts.

5:00- 5:53 Figure 3
MZ: So, in Figure 3 subtitled "Effect of egg incubation moisture on hatchling", you measured new variables. Can you explain what they are and what the results look like?

DW: We also measured the size of the offspring – this is important because body size is usually a predictor of survival of the babies. We show that not only do eggs hatch better under wet conditions, those conditions also produce better quality offspring than drier conditions.

5:54 - 6:47 Figure 4
MZ: Thanks. moving forward to figure four, could you please describe what figure 4 shows us?

DW: Here we take things a bit further and raise the offspring over several weeks to monitor their survival. You can see clearly that offspring are growing but the incubation moisture had little effect on that. However, offspring from the wettest incubation environment (75%) continued to have high survival over the 12 week period compared to those in the drier conditions.

6:48 - 8:04 Follow-up research
MZ: So, what is the follow-up experiment did you do?

DW: Sure. So here we used stable environments, but in nature moisture fluctuates a lot over time. This means that a good site that moms choose may later become unsuitable. So we wanted to see if moms are able recognize areas with moisture fluctuations and choose nest site appropriate. We actually show that moisture fluctuations make it much more difficult for mothers to choose nest locations that are good for their offspring.

8:05 - 9:14 Significance of the research
MZ: Can you explain the significance of this research, in your view? Why does this research/results matter?

DW: In a broader sense, this work tells us how animals may shift their behaviors in ways that help them deal with environmental variation. The brown anole lizard that we studied is not a species of conservation concern (it is invasive), but many reptile have similar nesting behaviors and our results here can be applied to many other species that may be threatened or endangered. This can give us insight in how we might protect habitat in ways that provide suitable nesting areas for them.

<u>Graph interpretation questions end! (~6-8min in total)</u>

9:15 - 10:05
MZ: Thanks for sharing your research! Now I would like to ask you a few questions about being a scientist and how you became a scientist. how does that sound?

DW: Sounds good

MZ: So, what kinds of scientific questions interest you the most?

DW: I'm very much interested in questions about animal ecology. Understanding what animals do behaviorally or physiologically is important, but I'm really interested in the evolutionary questions that get why animals do what they do (behaviorally or physiologically).

10:05 - 10: 53
MZ: When and how did you know you wanted to be a scientist?

DW: It wasn't until my later years of college that it really become apparent that we know very little about life on our planet. There is an endless number of unanswered questions about the natural world, and most haven't even been explored. Science is like exploring the unknown, and it is very stimulating to discover something for the first time, even if it is just a small part of a bigger puzzle.

10:54 - 11:47
MZ: I can definitely feel your curiosity and passion for science! So, after you figured out that you wanted to be a scientist, what did you do next? Tell us about the paths that led you to your current job.

DW: Graduate school was the next step. This gave me the opportunity to dive in deeper into the specific field I'm interested in and conduct research in that area – and that just opens up a whole new can of worms!

11:48 - 14:19
MZ: Would you like to share your identity or background with us? And what is it like being a scientist with this background?

DW: One thing that I see about myself that is counter-stereotypical of a scientist is that I really struggled academically during high school and college. I took remedial classes in high school, mostly corrective reading classes, and was behind most of the time. In college, I nearly failed my science classes. There are many students that struggle in these ways, but typically not those that go into a science career. My low grades almost caused me to drop out of college early on, but I didn't know what else I would do so I stuck with it. I had little confidence in myself.

The things that turned my attitude around was volunteer work at an aquarium and a zoo, and then I got a small paid position in a research lab at my undergrad institution. I got exposed to science by doing field work and lab work on reptiles, and I interacted a lot with graduate students. I was hooked and I feel that much of my education was from my practical experiences. Then my course work seemed more meaningful because I could see how it can be applied. I even authored several research papers as an undergraduate based on projects that I helped with. My grades did not get me into graduate school, but rather I feel that my experiences, recommendation letters, and motivation is what got me over that cliff!

14:20 - 15:14

MZ: Thanks for sharing your unconventional personal growth. I can see the resilience, determination, and growth mindset that you have demonstrated show lots of values and inspiration to our student's personal development and their career choices. So, what keeps you motivated to do research?

DW: It is thrilling to learn new things and create new knowledge about the organisms that live around us.

15:15 - 16:24
MZ: Students are usually curious about what a typical day is like for you, can you share that with us?

DW: Like any job, there are repetitive aspects of my work, but my work varies seasonally. I teach during the school year and juggle that with data analysis and writing research papers, running a lab and mentoring graduate students. During the summer we do more field work and experiments. There is always some type of new challenge. The most important thing is having a healthy balance with work and personal life.

16:25 - 17:01
MZ: Thanks! Can you share with us a moment when you felt like you really belonged in the field of science?

DW: I would say after I published my first scientific paper from my MS research – this was work I really felt ownership of and it was a great sense of accomplishment when that was published and being recognized by experts around the world.

17:02 - 18:43
MZ: That was very exciting! I had the similar feeling. I do have the last question. I am teaching many talented students who are interested in science or have claimed science-related majors. Could you give any academic advice or career advice to my students?

DW: Follow what interests you, and figure out how to gain experience in the field of your interest. Take volunteer opportunities because this can lead to new opportunities. You classwork is important and good grades make things flow smoother, but that's not everything. I recommend students to use the summer times to find an internship rather than rush through classes. Practical experience is the best education (at least for me), and sometimes I feel that students let their class work get in the way of their education.

MZ: Thanks for the advice. I agree with the value of practical or hands-on experience in scientific areas. I believe your advice can be very inspiring for my students to re-consider their learning and career choices! Thank you so much for sharing your information of the research and your daily life with us today!

DW: Alright, thank you!