The Evolution of a Partnership

How a Scientist, a Teacher, and a Researcher Brought Real-World Science to Students

BY KATHRYN GREEN, BRIAN LANGERHANS, MELISSA DEMPSEY, CESAR DELGADO

The need to improve people's understanding of evolution offers an exciting opportunity for scientists and teachers to work together to teach K–12 students more about this concept. While teachers are directly responsible for most of students' science learning, visiting scientists in the classroom can offer insight on how scientific skills and knowledge are applied in the world outside the classroom (Taylor et al. 2008). In this article, we focus on how a scientist, Brian, a science education doctoral student, Kathryn, and a middle school science teacher, Melissa, collaborated to clarify evolutionary concepts in a seventh-grade science classroom using authentic data from ongoing scientific research. While this article

CONTENT AREA

Life science

GRADE LEVEL

7

BIG IDEA/UNIT

Evolution and genetics

ESSENTIAL PRE-EXISTING KNOWLEDGE

Scientific inquiry and process skills, ecosystems and energy flow, adaptations

TIME REQUIRED

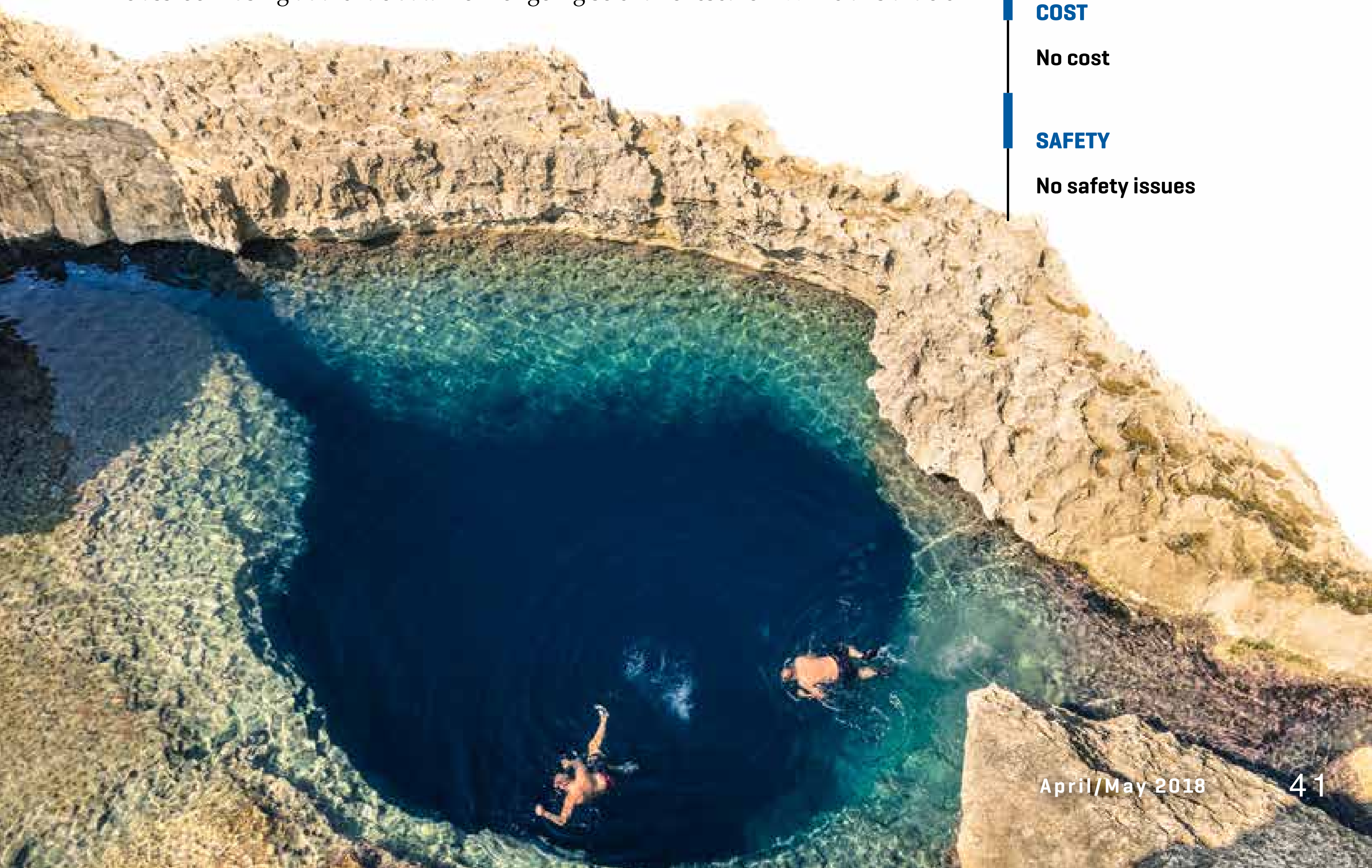
One or two one-hour class periods

COST

No cost

SAFETY

No safety issues



will contain information about the evolution lesson, its aim is to share an example of how teachers and scientists can partner to improve science education.

The goals of the lesson were to:

- review and reinforce basic concepts related to evolution, natural selection, and experimental design;
- use authentic data in the classroom to show students that scientists are studying evolution every day;
- allow students to apply their knowledge about evolution; and
- offer students the opportunity to meet a real, live scientist in person.

These goals aligned with the national and state standards and with Kathryn's research interests and Brian's desire to give students an idea of what a working scientist's day was like. Scientists are frequently funded by grants that require them to participate in outreach and education opportunities that make broader impacts, and this partnership allowed Brian to meet an outreach goal as well. Kathryn and Brian created the 5E model–based lesson together and Melissa approved the lesson**.** Melissa teaches in a year-round middle school that has a traditional bell schedule with 50-minute classes, and Kathryn and Brian visited for the entire day so they could work with all the classes. See Figure 1 for a summary of the lesson plan.

The lesson began with a game on an educational online platform (Kahoot; see Resources) to engage students and review the basic concepts of evolution, natural selection, and experimental design. Students worked in pairs to answer 13 questions about concepts such as adaptations, mutations, variables, and phenotypes.

Next, Brian gave a short presentation about his research on the evolution of the mosquitofish (*Gambusia hubbsi*) that he studies in inland blue holes, water-filled, vertical caves that formed about 15,000 years ago on Andros Island in the Bahamas (see the PowerPoint in Resources). He explained to students that not all science takes place in a lab, and that sometimes scientists can use naturally occurring "experiments" to study how evolution takes place. In this case, the mosquitofish live in two types of blue holes that differ only by the absence or presence of predators. Some blue holes contain both mosquitofish and bigmouth sleepers (*Gobiomorus dormitor*), the only known predator of the mosquitofish. Aside from the absence or presence of predators, all other variables such as temperature and salinity are similar among the blue holes. These conditions allowed Brian and his team to attempt to test the predictability of evolution of mosquitofish due to predators. You can

FIGURE 1: Lesson plan using the 5E model

Engage	Students made connections to former knowledge and presenters framed the experience using the Kahoot game to review vocabulary and introduce new terms.
Explore	Although we did not have time for this stage, students could examine photos of mosquitofish to observe the similarities and differences between individuals.
Explain	Brian explained his research on the evolution of mosquitofish in the Bahamas using PowerPoint slides.
Extend/Elaborate	Students worked in groups to create questions that could be answered with the data. After choosing a question, students were given the data to see if they could determine the answer to their question or refute their hypothesis.
Evaluate	The "Predicting Evolution" activity was used to evaluate students' understanding of the research.

learn about Brian's research on his website at *http://gambusia.zo.ncsu.edu*. During and after the presentation, students were full of questions about being a scientist, working in the Bahamas, and exploring blue holes. For instance, one student was interested in how the fish arrived in the inland blue holes, and how the scientists found their research site.

Melissa had previously divided students into heterogenous groups of three or four based on their mathematical abilities, including their skills in reading and analyzing data. Students were asked to make a list of questions they wanted to explore about the evolution of mosquitofish. Some students created questions that could be answered with Brian's data (for example, "Do mosquitofish who live in predation environments have more muscle than those who live without predators?"), while others asked questions that were unanswerable by the available data (for example, "Would mosquitofish survive if they were put in another environment with other predators?"). We guided each student group in creating questions that could be answered with the available data.

Next, students were given the data that were needed to answer their question (see Figure 2). Students worked in their groups to average and compare data to find out if their hypothesis could be rejected. For instance, one group's hypothesis was that mosquitofish living in blue holes containing predators would

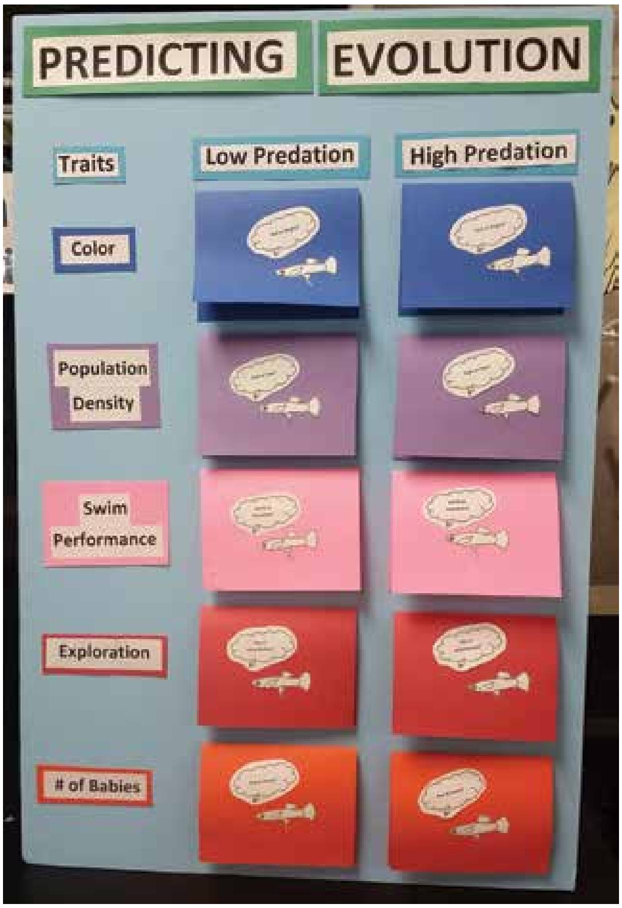
FIGURE 2: Example of data used in lesson

Predation	Blue hole	Male standard length (mm)	Female standard length (mm)	Caudal peduncle area (mm^2)	Mid-body depth (mm)
Predators absent	East Twin	23.43	30.35	38.04	5.20
Predators absent	Gollum's	23.28	29.91	36.73	5.14
Predators absent	Hubcap	20.96	24.64	35.40	5.38
Predators absent	Ken's	23.52	30.09	40.65	5.39
Predators absent	Pigskin	22.79	27.94	39.41	5.49
Predators absent	Rainbow	23.47	26.29	37.02	5.35
Predators absent	Voy's	20.86	28.40	38.04	5.53
Predators present	Cousteau's	25.82	35.29	44.21	5.93
Predators present	Hard Mile	21.53	28.06	40.90	5.52
Predators present	Rivean's	26.00	29.84	41.32	5.83
Predators present	Runway	23.19	25.04	41.23	5.55
Predators present	Shawn's	19.98	26.93	43.50	5.83
Predators present	Stalactite	23.31	30.36	41.35	5.83
Predators present	West Twin	24.02	27.95	42.23	5.84

Notes: The caudal peduncle area is the lateral part of the fish's surface area that is responsible for thrusting movements seen during escape behavior. The mid-body depth is the length of the line that connects from where the dorsal fin attaches to the fish's body to where the anal fin attaches to the fish's body. Both were measured using high resolution digital fish images and a computer program.

be larger to scare away predators. They initially thought they could compare the mass of the mosquitofish, but these data were not included in the handout. Kathryn asked the group to decide which of the data points in the handout could be used to test their hypothesis, and after discussion, the group members decided that average length would be the most accurate variable to use. To test their hypothesis, the group needed to find the average length of males and females in predation environments and compare these averages with those of males and females in non-predation environments. While students were testing their own hypotheses, we had a great opportunity to remind students that scientific theories are constantly being tested to determine their accuracy. Although some groups struggled with their data

FIGURE 3: "Predicting Evolution" activity used as a formative assessment at the end of the lesson



analysis, having three adults in the room allowed students to ask in-depth questions when needed. For example, the adults needed to help students with the mathematical processes and help them decide which parts of the data set would answer their questions. After finishing their analysis, student groups each chose a spokesperson to verbally report what they had learned from the mosquitofish data.

At the end of the class period, Kathryn used a formative assessment activity she had previously created for use at a museum event. The activity is a poster that asks students to predict evolution based on what they have learned about mosquitofish. There are flaps that have a question about mosquitofish on the front and flip up to show the answer underneath (see "Predicting Evolution" poster in Figure 3). For instance, some mosquitofish are more adventurous, exploring in their environments, while others behave in a shy manner and do not explore novel environments very much. Students were asked if they would expect the adventurous mosquitofish to live in the blue holes with predation or without predation. Using this activity at the end of the mosquitofish evolution lesson helped uncover misconceptions about population density. Students thought that mosquitofish would have higher population densities in blue holes with predation because the population needed to be larger so that some could afford to be eaten. Instead, the population density is much smaller because mosquitofish suffer higher mortality rates in the presence of bigmouth sleepers. This activity drove home the point that a basic understanding of how a species lives in the wild and interacts with its environment (its natural history) helps scientists make reasonable predictions about how natural selection might operate in an environment and how various traits might evolve.

As usual, the adults learned from this lesson as well as students. After the first class period, we realized that the Kahoot game took up too much time if we played for points. We turned off the points, which decreased the time for the game by about 50% after the first class period. We also learned about some of the misconceptions that students had about evolution and natural selection. For instance, stu-

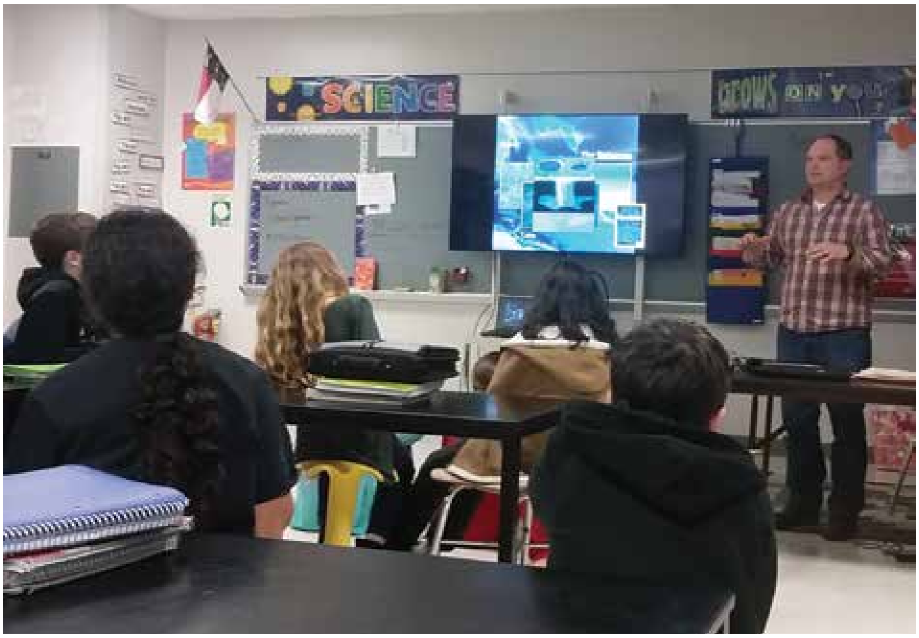


FIGURE 4: Students make predictions on mosquitofish evolution.

dents thought that adaptations occurred for a purpose, such as that the mosquitofish in a predation environment would have turned dull because they needed to adapt in order to survive. Finally, we learned that a longer amount of time for Brian to answer questions would have been useful. Melissa had used exit tickets to gauge what students had learned about being a scientist, thereby assessing our third goal. Many students had unanswered questions, mostly related to learning more about what the visiting scientist did every day. Overall, this partnership was a win-win situation for all involved and we are planning another one soon. When we repeat this activity, we will use two class periods instead of one. This will give us more time for questions and data analysis.

If you would like to have a partnership like this for your classroom, here are some tips:

1. Contact your local college or university. Many scientists are required to make broader impacts beyond their own research to satisfy grant requirements and may be interested in partnering with a classroom. Graduate students are also often looking for outreach opportunities in which they can participate. Contact a friend of a friend, or try reaching out to department heads, who often know which professors and graduate students gravitate toward outreach.

2. Contact local governmental agencies, such as Fish and Wildlife, Extension offices, or water treatment plants. Outreach coordinators may be available to help form partnerships with scientists.

3. Attend professional development opportunities, workshops, and conferences as frequently as possible. Go to events at your local museum or zoo, and ask questions of the scientists or researchers who are presenting at these events. Scientists often have an interest in education but do not always know how to get involved. A simple conversation at the annual science festival near you could lead to an amazing collaboration opportunity. ●

REFERENCES

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NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards.*

Taylor, A., M.G. Jones, B. Broadwell, and T. Oppewal. 2008. Creativity, inquiry, or accountability? Scientists' and teachers' perceptions of science education. *Science Education* 92 (6): 1058–75.

RESOURCE

Kahoot lesson—*https://play.kahoot.it/#/k/822c5d00-5532-424c-8dde-cf290b3b5c29*

ONLINE SUPPLEMENTAL MATERIALS

Mosquitofish PowerPoint—*www.nsta.org/scope1804*

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Standard

MS-LS4 Biological Evolution: Unity and Diversity
www.nextgenscience.org/dci-arrangement/ms-ls4-biological-evolution-unity-and-diversity

Performance Expectation

MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practice	
Analyzing and Interpreting Data	Students use phenotypic characteristics to compare mosquitofish populations that live in blue holes containing predators to those that live in blue holes containing no predators.
Disciplinary Core Idea	
LS4.C: Adaptation Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	Students examine how natural selection linked to predation causes differences between mosquitofish in the two sets of blue holes.
Crosscutting Concept	
Patterns	Students examine data for differences between two different populations of mosquitofish.

Connections to the *Common Core State Standards* (NGAC and CCSSO 2010)

Mathematics

6.SP.B.5. Summarize numerical data sets in relation to their context

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