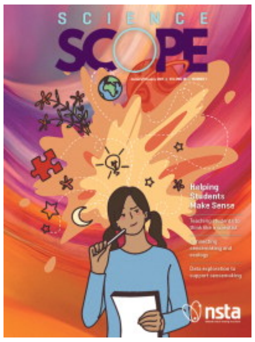

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Scientific Sensemaking:

Designing Solutions for Puffin Restoration

BY JAN MOKROS, CAITLIN HARRIGAN, JACOB SAGRANS, AND PENDRED NOYCE

ABSTRACT

Scientific sensemaking is described in the context of studying a three-week, sixth-grade unit on the ecology and restoration of puffins living off the coast of Maine. Students engaged with a scientific adventure story, observed local bird species, used AI and webcam-facilitated tools, designed puffin burrows, and explored data sets about puffins. Students' ideas were elicited through discussion of the challenges faced by scientists who restored the puffins; sharing observations of chick-rearing behaviors from a webcam; critiquing and revising classmates' burrow designs; writing about bird behavior in response to prompts; poring over data to detect patterns in the long-term success of bird restoration; and training/testing AI for identification of puffins. This multiplicity of strategies effectively engaged students from a range of backgrounds, including those who were multilingual learners. This educational approach to scientific sensemaking through bird restoration is relevant and generalizable to students throughout the country, given the dwindling population sizes of many bird species nationwide.

KEYWORDS: Sensemaking; Ecology; Data; Artificial Intelligence; Ornithology

What do birds need to survive and thrive, and how can scientists and students support this quest? It begins with understanding behaviors of a particular bird species and the ecosystem in which it lives. Many birds are losing ground, with populations declining due to predators, loss of habitat, and climate change. One of every four breeding bird species in the United States and Canada has been lost over the past 50 years, and 70 birds are "tipping point species" that have collectively lost two-thirds of their populations in the same time period (State of the Birds 2022).

To address the challenges birds face, scientists must make sense of a great number of interconnected phenomena. Students need to engage in sensemaking (see link to sensemaking in Online Resources) as they strive to study and monitor bird populations and, ultimately, to help bird species survive. Close study of the management of a bird species allows students to not only learn about ecology, but also consider and apply a range of science and engineering practices. In this report, three curriculum developers and a sixth-grade teacher of multilingual classrooms describe how students spent three weeks engaged in scientific sensemaking as they studied Atlantic puffins, a charismatic seabird found off the Maine coast (see Figure 1). Atlantic puffins can be found across the North Atlantic, including the waters near Maine, the Canadian maritime provinces, Iceland, and Europe. During most of the year, Atlantic puffins travel great distances across the ocean (as much as 10,000 miles in one year) following the migration of preferred food sources such as herring. In the summer breeding season, they stay closer to land, including on several islands off the coast of Maine, using nesting burrows (nests made in the ground) to lay eggs and raise puffin chicks ("pufflings"). As adults, Atlantic puffins return each breeding season to the islands they were born on.

Students learned to "think like a scientist" and, equally important, to "think like a puffin." In the Puffins Curriculum Project (see Puffins Teacher Guide 2024–2025 in Online Resources), sensemaking is anchored in a scientific narrative about bird restoration, providing coherence and bringing together key scientific content areas and practices. Students consider how technology enables advances in scientific discovery as they learn to make use of tools such as webcams and artificial intelligence (AI). Making sense of long-term survival prospects of a bird species involves learning about its ecosystem, making careful observations, exploring data sets about bird populations, and using technology to monitor behavior. The strategies we employed are applicable to a wide range of bird species

FIGURE 1: Puffin prints made by students.

nationwide. All teachers have opportunities to identify a local species of interest to students—unfortunately, it is easy to identify one of the many bird species in decline across the United States (Stevens 2024).

Sensemaking processes

We address three sensemaking processes: (1) identifying a phenomenon and wondering about it together, (2) utilizing scientific and engineering practices, and (3) eliciting students' ideas. Typically, class began with the teacher or students in pairs reading an excerpt from one of the two books to introduce the day's focus. A whole-group discussion followed, with introduction of an activity such as training AI, designing a puffin burrow, or graphing puffin populations. Most activities were carried out in pairs or small groups assigned by the teacher, and a second whole-group discussion summarized the day. Altogether, about 70 percent of the time was spent working in pairs or small groups.

Identifying a phenomenon and wondering about it together

The phenomenon students were grappling with is easy to grasp: by the early 20th century, puffins had almost disappeared from the Maine coast due to hunting and poaching. They later made a dramatic comeback, thanks to the work of scientists in re-establishing them in their native habitat. Their existence is threatened again today, largely because of climate change and the resulting changes in habitat and food supply. Puffins, which thrive on herring, are facing food shortages as sea temperatures rise and herring move to colder waters. Studying puffins and how they and their habitat change over time offers students an opportunity to make sense of all aspects of *NGSS* MS-LS2 and address and answer the question: "How does a system of living and nonliving things operate to meet the needs of the organisms in an ecosystem?" (see link in Online Resources). Note that this work envelopes all of "Practice 1: Asking Questions and Defining Problems" (see link to Appendix F in Online Resources).

We used the compelling narrative of ornithologist Stephen Kress to drive students' interest in the phenomenon of bird ecology and restoration. Kress and his colleagues have worked for the past 50 years to bring puffins back to the coast of Maine. Kress described this scientific adventure in two books for children, a picture book (Kress and Salmansohn 1997) and a longer chapter book (Kress and Jackson 2020).

Both books give all students, regardless of English language proficiency, high-level texts that support language learning. Students read the picture book and had an opportunity to read the longer text. Excerpts from these books were used to engage students in two fundamental questions: "What happened to puffins to cause them to disappear?" and "What did scientists do to restore puffins?" Using a combination of the teacher reading aloud, students reading with partners, and students reading independently played a key role in getting students invested in the phenomena. The narrative was the "anchor" for the unit and brought together different scientific themes and practices, ranging from understanding puffin behavior to understanding human impact on the environment.

Utilizing science and engineering practices

Practices that are critical to bird restoration include observing carefully, designing and rebuilding habitats like nesting structures, and monitoring population data over long periods of time. Like scientists, students can engage in these practices. This process is greatly facilitated by technologies such as AI, webcams, and the use of large data sets collected by ornithologists.

AI and Webcams

Although students could not observe puffin behavior directly, they simulated this process by observing birds in their schoolyards. A growing number of AI-enabled birdfeeders, such as Bird Buddy, BirdReel, and Netvue's Birdfy, offer an identification of each bird seen and currently cost between $200 and $300 per feeder. Using an AI-enabled birdfeeder allows students and teachers to view daily photographs and videos, with accompanying AI identifications, by way of a smartphone app that teachers can project from their phone for the full class to see. In the process, they learn that there are advantages and disadvantages to using AI. The placement of the device is important and determines which birds will be attracted, as does the type of birdseed used, the weather conditions, and the presence of humans. AI birdfeeders can easily be taken down and brought inside at night or over the weekend to limit the potential for vandalism/theft, and also to plug in the feeder to charge its battery (a fully charged battery lasts at least several days, and also some more expensive models have solar panels that can charge the battery). An advantage of an AI birdfeeder is that it detects activity 24/7, and the observations it makes can be condensed into a concise, time-stamped history. This technology can be employed anywhere with Wi-Fi connectivity and with any birds that use feeders.

In our program, students grappled with the pros and cons of using AI. Most often, the AI feeder was accurate in identifying one or two possibilities for a particular bird it photographed. But sometimes, it was wrong. As one student explained: "I learned that AI is harder [to use] … than I thought because the AI kept getting the wrong answers/bird species…. Half the time the AI would get a bird from a whole other country, which is hilarious." We explained to students that the birdfeeders, along with other AI devices, are dependent on the training they have received. While AI birdfeeders are making rapid progress with respect to accuracy, there is still work to be done. Students easily connected the AI birdfeeder and how AI could be used to study puffins. When asked about the general usefulness of AI to scientists, the same student responded: "[AI] could be used to detect predators or threats…. It could also be used to track puffins without humans needing to be there." We found that over the course of the unit, students developed a more nuanced understanding of how AI could be trained and tested to help scientists with their observations.

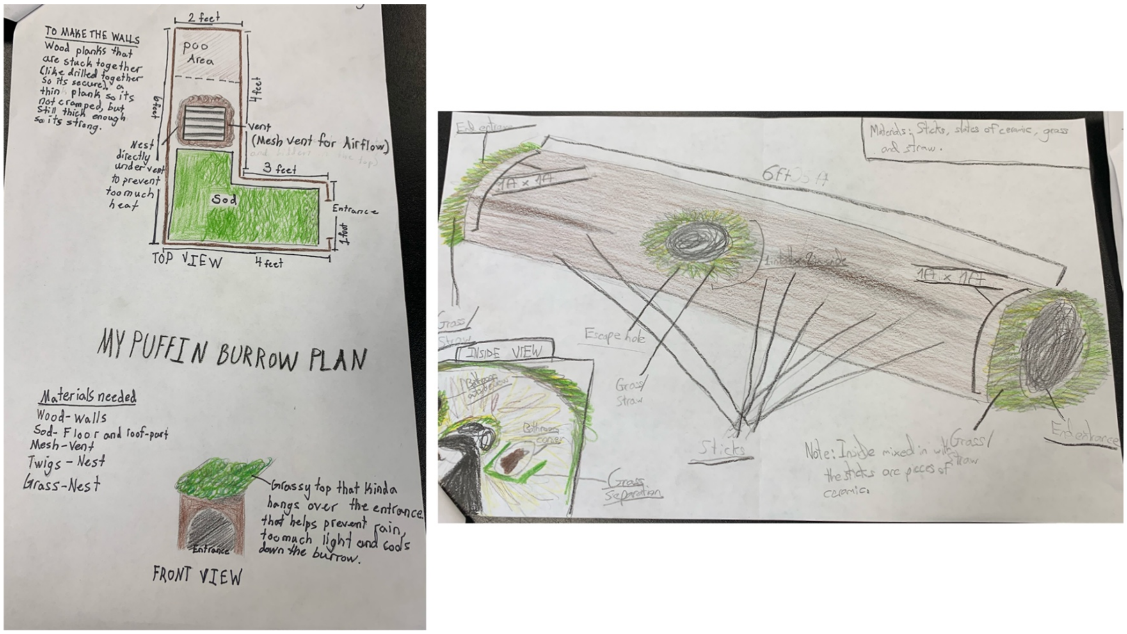
Students in the program also relied on a solar-powered camera placed in a puffin burrow on Seal Island, Maine (see link in Online Resources) to monitor activity via a publicly accessible livestream provided by the National Audubon Society. Scientists frequently use such webcams to track a wide range of birds and other species (see link to Explore: Livecams in Online Resources). Students are familiar with this technology, which gives them a chance to closely observe and monitor birds in their own regions as well as from areas around the world. Students looked at highlights from puffin webcam footage (see link to Explore: Birds Bats Bees in Online Resources). They were asked to describe what they saw at four critical points in time. The behaviors included a parent delivering fish to a puffling and the puffling's attempt to eat fish of different sizes. We found students took this assignment seriously, observing and replaying the video until they were confident about the behaviors.

Engineering Burrows

Particularly interesting for students was how scientists established nesting burrows for pufflings that were relocated to Maine. Because Atlantic puffins had almost disappeared from Maine due to hunting and poaching, at first there were no established burrows on islands off the coast of Maine. Starting in the 1970s, Kress and his colleagues began building man-made burrows for pufflings brought to Maine from Canada, but they encountered many challenges. How would they keep the burrows cool and well ventilated so the pufflings would not overheat, while also making sure the burrows did not flood in rainstorms? How would they ensure the pufflings were safe from predators? And how would the pufflings avoid contaminating themselves with their feces, which could stain their wings, making it hard to fly? Addressing these questions requires students to engage with Practice 6: Constructing Explanations and Designing Solutions (see link and to Appendix F in Online Resources).

Students had imaginative ideas for designing puffin burrows of their own, as seen in Figure 2. Students shared their burrow plans with each other, providing structured verbal feedback for revising the designs. Each student reviewer offered three suggestions for the designer. For multilingual learners, this process involved the use of home language vocabulary routines that they used in ESOL classes. New vocabulary also was supported via the use of Google Translate. A rubric (see Supplemental Materials) was used to assess students' engagement with the engineering design process.

FIGURE 2: Two students' burrow designs.



One important takeaway was that scientists also need to be engineers, designing and tweaking material and placing the nesting structures appropriately. Another takeaway was about patience and persistence: Kress tried various solutions to designing burrows for the transplanted pufflings because there was no solution known in advance. Bird restoration frequently means providing human help with habitat, especially when existing habitat has been compromised. This is true whether it is building and placing a nesting box or determining how to protect nesting materials (like marsh grass) from human destruction.

Using Big Data

Some urgent questions recurred for Kress and his colleagues: Were the efforts to return puffins to their home islands working? What factors made it more likely that puffins would return and breed on a Maine island? These questions are impossible for scientists to address without collecting data carefully. Although students themselves cannot collect these data directly, they can and should describe and interpret authentic existing data. The National Audubon Society has collected data over decades on bird restoration projects. There are 50 years of data on the number of puffins returning to Maine islands, along with data on factors that may be related to the rate of return. These include the health of the pufflings (weight at fledge), the type of fish they eat, and the temperature of the sea surface surrounding them.

Studying data is an essential scientific practice and a key practice in the *NGSS*. Scientists could not evaluate the success of restoration efforts without data, yet students seldom pore over data to make sense of it like scientists do. To do this, students need accessible tools and datasets. We used the Common Online Data Analysis Platform (CODAP) to introduce the puffin data (Concord Consortium n.d.). Students used CODAP in conjunction with the Audubon data to easily drag and drop variables onto a graph showing the number of puffins that returned to an island over a 40-year period. They could see the trend with respect to rising puffin population. Making and examining these graphs was not affected by language proficiency, as trends on the graphs could be described via gestures as well as words.

It is more challenging to look at data that includes two or more variables, yet our assessments of students' work showed they were able to see relationships between puffin health and other variables. Figure 3 shows a graph that a student made of the relationship between puffin weight and sea surface temperature.

Each dot represents a puffin, with the trend line in green. The student explained in response to a writing prompt: "The higher the sea surface temperature the less weight the puffins get. That is because the higher the sea surface temperature the more butterfish appear and it is hard for baby puffins to eat them."

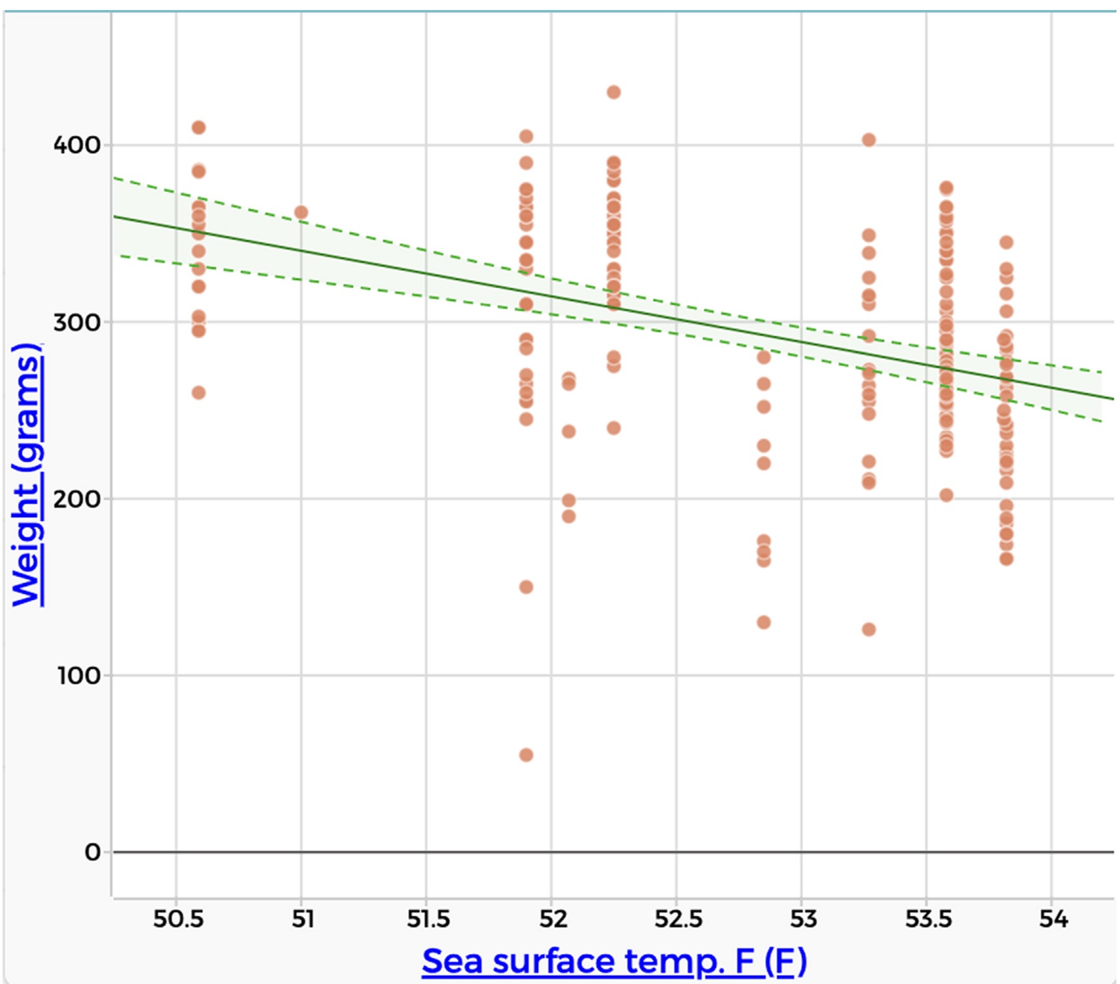
The process of integrating data about puffins, sea surface temperature, and fish populations was a powerful sensemaking experience. The process clearly addresses the *NGSS* MS-LS2 performance expectation aligned with Practice 4 to "Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem" (see links to MS-LS2 Ecosystems and to Appendix F in Online Resources).

Eliciting students' ideas

The classrooms where we worked included a large number of multilingual learners from many countries. Students' ideas were elicited in multiple ways, including:

- Previewing tools, such as graphs and maps, to build background knowledge;
- Listening to a story, frequently pausing and sharing ideas about content;
- Using concrete objects, or realia, such as puffin burrow materials and a puffin decoy to convey information in ways not dependent on language;
- Using home languages in conjunctions with Google Translate to share ideas;

FIGURE 3: A student's CODAP graph showing sea surface temperature vs. puffin weight.



- Making, sharing, and discussing sketches to promote oral language skills;
- Using sentence frames to support the development of writing skills;
- Making graphs with a simple tool to explore relationships;
- Observing, as well as writing and discussing puffin video footage;
- Vocalizing or "growling" like a puffin;
- Using AI and accompanying bird descriptions and maps to identify birds.

Conclusions

Scientific sensemaking, in the context of bird restoration efforts, is an integrated and multifaceted process that involves field work, adventure, observation, engineering, and examination of data. In our experience, students who focused on a compelling narrative about the challenges and successes of restoration efforts were deeply engaged in scientific and engineering practices and were eager to understand the factors leading to successful restoration. Students from diverse backgrounds, including multilingual learners, were engaged in sharing ideas via discussion, writing, making and sharing representations, observing via webcams, and using AI birdfeeders.

SUPPLEMENTAL MATERIALS

Puffin burrow assignment rubric—*https://doi.org/10.1080/08872376.2024.2433772*

ONLINE RESOURCES

All About Birds—*https://www.allaboutbirds.org/*

Appendix F: Science and Engineering Practices in the NGSS—*https://tinyurl.com/2udewhmk*

Explore: Puffin Burrow, Seal Island, Maine—*https://explore.org/livecams/puffins/puffin-burrow-cam*

Explore: Livecams—*https://explore.org/livecams*

Explore: Birds Bats Bees, Puffin Burrow—*https://youtu.be/r52Ooi9zf8o*

Puffins Teacher Guide (2024–2025)—*https://bit.ly/PuffinsGuide2425*

Sensemaking—*https://www.nsta.org/sensemaking*

Appendix F: Science and Engineering Practices in the NGSS—*https://tinyurl.com/2udewhmk*

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics—*https://tinyurl.com/yv5rjm96*

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