Inquiry-Based Learning on Biomimicry
Linking science and literacy using children’s picture books in the early childhood classroom

By Amanda Deliman and Kimberly Lott

Biomimicry is the field of engineering that uses nature to design solutions to human problems and challenges. For young students to understand this complex phenomenon, they need opportunities to explore, ask questions, and discuss ideas about the nature-inspired solutions. While direct hands-on science experiences with biomimicry would be ideal, this may not always be practical, but elementary teachers can bring this phenomenon into the classroom with picture books. Picture books create the context in which students ask questions, define problems, and develop potential solutions using the key competencies found across the Next Generation Science Standards (NGSS). Children’s picture books are engaging and have the potential to spark curiosity and creativity that spill over pages of the book.

For this article, we’ve conducted a content analysis on multiple picture books that focused on the topic of biomimicry. After conducting our thorough review, we chose three recently published picture books that would serve as the anchors for creating inquiry-based activities for first-grade students. The multifaceted learning engagements showcased in this article can help students explore dimensions of science learning while advancing their literacy skills.

In the following sections, we describe opportunities to advance understanding through the use of high-quality picture book read-alouds. First, we share summaries of three picture books that could be read aloud in the early childhood classroom. Then we provide examples of how to connect the NGSS with literacy standards while implementing inquiry-based learning engagements. Table 1 provides a summary of these descriptions, including materials needed for each learning engagement.

To understand biomimicry, students need to have a basic understanding of inventions. If students are not familiar with inventions, the teacher should introduce biomimicry by having students recognize the inventions all around them. A teacher might ask a student to come up to the whiteboard and write their name, but do not give them a dry erase marker. The student will realize that they can not write on the board without a dry erase marker. The teacher can then ask the students to look around the classroom for other inventions (e.g., computers, pencil sharpeners, etc.). Teachers should emphasize that inventions do not have to be electronic but can be as simple as a tissue or bandage.
Integrated Play-Based Learning Engagements

In *Mimic Makers: Biomimicry Inventors Inspired by Nature* (2021), Kristen Nordstrom writes about 10 inventors she calls *mimic makers*, who create innovations after becoming inspired by the living world. In one example, Nakatsu Eiji, a former director of technical development at West Japan Railway Company, noticed how a kingfisher plunged its beak into the water like an arrow. Nakatsu’s observation of the kingfisher’s beak inspired the design of the bullet train, a faster and more energy efficient style of train.

This engaging book will appeal to plant and animal lovers and those who are inspired by science. For students to critically think about how the natural world has inspired technological innovations, hands-on activities can foster curiosity and promote opportunities to hypothesize what knowledge was needed to build the innovation.

In this inquiry-based learning engagement, we integrate NGSS 1-LS1-1 From Molecules to Organisms: Structures and Processes and CCSS ELA-Literacy.W.1.10 Text Types and Purposes. In this context, *play-based learning* refers to opportunity to explore and develop curiosity using materials that are interesting to students. The engagement with materials is child-initiated and supported by the teacher.

Engage

Introduce *Mimic Makers: Biomimicry Inventors Inspired by Nature* by pausing on the first two pages, which include several questions related to nature observations (e.g., Why are whale’s flippers bumpy? Why do maple seeds twirl when they fall?). Next, explain that some inventions come from observations from nature. Students will then listen to the picture book read-aloud (or selected excerpts) with openings provided by the teacher for asking questions and fostering curiosity on the topic of biomimicry. Last, show students a picture of a dog with burrs on its fur and ask the guiding question, “What invention do you think was inspired by this observation in nature?”

Explore

The students will then determine which materials can be linked to the innovation of Velcro, invented by George de Mastrel, a Swiss electrical engineer who invented the hook and loop fastener that he named Velcro. He was inspired by the way burrs from burdock plants stuck to his dog during a hunting trip. Working in partnerships or groups of three, the students will each get a small piece of Velcro, scotch tape, a Band-Aid, a piece of fake fur, and a hairy cloth (see Table 1). Instruct the students to examine the materials with their peers. The students will work together to determine which invention was inspired by burrs getting stuck in the fur of a dog. The teacher can walk around to the small groups and ask scaffolded questions to promote curiosity and expand meaning-making with the young learners (e.g., Which material sticks to the fur? Does it fall off when the fur is shaken?).

Explain and Evaluate

After playing with the materials, students gather together as a whole class to discuss their ideas regarding which material was the best mimic of the natural burr in the dog fur. Students discuss their reasonings while the teacher records them in an anchor chart on the board. Using the anchor chart as a guide, the students will then write about which invention (scotch tape, Band-Aids, or Velcro) was created by mimicking the natural world, including evidence and reasoning to back up their claim. The culminating activity could include students sharing their writing and/or displaying them near the anchor chart in the classroom. Student writing is assessed using a CER rubric (see Supplemental Resources).

Using Informational Texts for Comparing and Contrasting Solutions

In *Nature Did It First: Engineering Through Biomimicry* (2020), Karen Ansberry appeals to young readers by incorporating factual information using nonfiction features, poetry, and important scientific discoveries, along with playful illustrations by Jennifer DiRubbio. One example of how an innovation was inspired by an animal is shown in an image of a woman pulling burrs out of her large, fluffy St. Bernard. In addition to fostering curiosity around nature inspired innovations, a foundational reading skill includes describing connections between scientific ideas or concepts in informational text. This picture book could be read all at once or excerpts could be used to direct attention to engineering through biomimicry, one innovation at a time.

In this inquiry-based learning engagement, we combine NGSS 1-LS1-1 From Molecules to Organisms: Structures and Processes and CCSS ELA-Literacy.RI.1.3 Key Ideas and Details. This activity expands on the ideas introduced in the previous activity by having students consider other examples of biomimicry and comparing/contrasting solutions developed through biomimicry.

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Engage

To begin the activity, the students will listen to the picture book read-aloud. For each biomimicry example, the authors ask, “What other problems could be solved by mimicking...?” so teachers can pause throughout the read-aloud to allow time for students to expand meaning-making through the sharing of ideas. This not only strengthens comprehension skills in the young readers but also helps build community and collaboration skills while broadening perspectives. To further engage the students, ask if they have ever seen a pill bug (referred to as Roly-Polies in the text) while playing outside. It is likely one or more student may be familiar with the tiny crustacean. To foster curiosity, the teacher can ask questions about defense mechanisms and why a pill bug might roll up into a tiny ball.

Explore

After reading the book, the students are placed in small groups of two or three where they will compare and contrast solutions to problems described in the book using a box and T chart to help the students organize their thinking. Each small group will receive a box and T chart worksheet (see Supplemental Resources) and groups of notecards that include images and written examples of biomimicry shared in the picture book, plus several burrs to serve as a real example (see Table 1). First, the small groups will review the materials and identify the key innovations. Next, they will choose two solutions to compare and contrast. Last, they collaborate as a small group to determine another problem that might be solved by one of the biomimicry structures. An example in the book explains how the kingfisher’s “super-streamlined beak and remarkable diving skills” inspired inventors to make modifications to a bullet train that originally had a rounded nose. The issue with the rounded nose caused noise pollution when the train sped out of the tunnel. When changed to a new shape, similar to the kingfisher’s beak, the inventors solved the noise problem.

Explain and Evaluate

As a culminating activity, the small groups will share another solution that they thought of based on one of the biomimicry structures and explain their rationale. Each small group will present their solutions orally to their classmates. Peers can be encouraged to ask questions as a way to promote higher level thinking. The key element for this science integration activity is to ensure the students fully describe both solutions before explaining which solution was most effective.

Designing Nature-Based Solutions Through Inquiry

In Biomimicry: When Nature inspires Amazing Inventions (2020), Stephanie Menu and Emmanuelle Walker describe multiple ways nature has inspired us to create inventions in science, medicine, clothing design, and architecture. One example describes how adhesive, such as glue, was inspired by observing nature. Not only does the picture book inform the reader of these nature inspired inventions, an important part of reading informational text includes asking and answering questions to clarify meaning in a text. This colorfully written picture book provides openings for young readers to explore how inventions imitate life with appropriately placed scaffolded questions asked by the teacher. For example, after describing how Isaac Newton made an observation that led to developing the theory of gravity, there is a poignant statement worth unpacking with first graders. It says, “Observation leads to comprehension, which leads to action” (Menu and Walker 2020, p.30). A teacher might ask students to explain what that statement means and how it relates to inventions imitating nature.

In this inquiry-based learning engagement, we combine the following standards, NGSS 1-LS1-1 From Molecules to Organisms: Structures and Processes and CCSS ELA-Literacy.RI.1.4 Craft and Structure, where students use materials to design solutions to problems using biomimicry. This activity incorporates what students have learned about biomimicry from the previous books and challenges them to create their own biomimicry solutions to problems.

Engage

To begin the activity, the students will listen to the read-aloud. To address complex vocabulary, the teacher will use think-aloud strategies (Sonmez and Sulak 2018) to help students define and understand meanings of unknown words. The teacher will present different animal names and ask the students what parts of the animal support the animal’s ability to survive and why. Next, the teacher will ask, “How could an animals’ features become inventions to solve problems?”

Explore

After reading the book together and discussing characteristics of animals, the students will work in groups of two or three to create their own representations of a solution to a problem that was inspired by plants or animals, such as
<table>
<thead>
<tr>
<th>Book Title/Author</th>
<th>Next Generation Science Standards (NGSS)</th>
<th>English Language Arts Standards (ELA)</th>
<th>Materials Needed</th>
<th>Inquiry-Based Classroom Connections</th>
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</thead>
<tbody>
<tr>
<td><em>Mimic Makers: Biomimicry Inventors Inspired by Nature</em> (Nordstrom 2021)</td>
<td>(1-LS1-1) From Molecules to Organisms: Structures and Processes Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs</td>
<td>CCSS.ELA-Literacy.W.1.1 Text Types and Purposes Write opinion pieces in which they introduce the topic or name the book they are writing about, state an opinion, supply a reason for the opinion, and provide some sense of closure</td>
<td>Picturebook Pencil Paper Velcro Band-Aids Scotch Tape Image of burrs on dog A piece of fake fur A hairy cloth Anchor chart paper Chart markers</td>
<td>Students will participate in a play-based learning engagement to determine how an invention was created mimicking the natural world. They will explain their understanding through writing.</td>
</tr>
<tr>
<td><em>Nature Did It First: Engineering Through Biomimicry</em> (Ansberry 2020)</td>
<td>(1-LS1-1) From Molecules to Organisms: Structures and Processes Use materials to design a solution to a human problem by mimicking how plants and/or animals use animal parts to help them survive, grow, and meet their needs</td>
<td>CCSS.ELA-Literacy.RI.1.3 Key Idea and Details Describe the connection between two individuals, events, ideas, or pieces of information in a text.</td>
<td>Picturebook Copies of a Box &amp; T Chart for each small group Groups of cards (each including written words and real images of examples shown in the book) burrs, echolocation, stick and unstuck, super slippery surfaces, bumpy surfaces, rolling into a ball, and streamlined shapes</td>
<td>Students will identify key innovations, compare and contrast two solutions, and determine which solution was most effective for solving a problem.</td>
</tr>
<tr>
<td><em>Biomimicry: When Nature Inspires Amazing Inventions</em> (Menu and Walker 2020)</td>
<td>(1-LS1-1) From Molecules to Organisms: Structures and Processes Use materials to design a solution to a human problem by mimicking how plants and/or animals use their parts to help them survive, grow, and meet their needs</td>
<td>CCSS.ELA-Literacy.RI.1.4 Craft and Structure Ask and answer questions to help determine or clarify the meaning of words and phrases in a text</td>
<td>Picturebook Cardboard pieces in various sizes and shapes Recyclables Paper plates Pipe cleaners Straws Scissors Tape Glue Cups Cotton balls Sponges Staples and Staplers Plastic Wrap Aluminum Foil Writing paper Pencils</td>
<td>Students will ask and answer questions while reading the text to determine meaning and they will use different materials to come up with an invention inspired by characteristics and/or features of animals.</td>
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lotuses or turtles. The key to this inquiry-based exploration is to encourage children to discover their own ideas and promote creativity with the materials provided (see Table 1). For example, students might consider how the hard outer surface of a turtle protects the body by serving as a protective shell. The students then brainstorm ideas where a hard outer surface might serve as a protective factor in a human situation (e.g., bicycle helmets, protective equipment for sports, etc.). The students will then use the provided materials to create one of their ideas.

**Explain and Evaluate**

As a closing activity, the students will gather together as a class and share their design with their peers. Each student group will describe their problem and explain how nature had inspired the solution. Student designs could be assessed using a rubric (see Supplemental Resources).

**Conclusion**

If you are looking for ways to pique your students’ curiosity about important science concepts, picture book read-alouds have the potential to do just that. Discussions before, during, and after read-alouds that include critical and evaluative questions can help students build and deepen their understanding of core ideas related to science and literacy. Furthermore, using student-centered, inquiry-based learning engagements that focus on key Next Generation Science Standards provides an opening to help children develop key life skills, including strengthening communication, bolstering collaboration, and increasing the ability to solve problems and find solutions. Exploring exciting science phenomena such as biomimicry can heighten curiosity in our young learners, which can inspire them to want to learn more about our natural world.

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**Supplemental Resources**

Download a blank Claims-Evidence-Reasoning chart, box and T-chart, and rubrics at [https://tinyurl.com/ma486hwm](https://tinyurl.com/ma486hwm).

**REFERENCES**


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Amanda Deliman (amanda.deliman@usu.edu) is an assistant professor at Utah State University– Salt Lake. Kimberly Lott is a professor at Utah State University in Logan, Utah.