Our planet is facing increasing environmental and social challenges, and education will need to play a key role in ensuring a sustainable future (Fischer et al. 2022). To help meet this need, we redesigned our elementary science methods course to focus on connecting science education to the United Nations Global Sustainable Development Goals. Our goal was to support preservice teachers in developing their elementary school students’ capacity to design solutions for a sustainable future. In our first lesson of the course, we engaged preservice teachers in a series of activities that used biomimicry to introduce and connect engineering design with sustainable development and to set the tone of the course as one of solutions-focused sustainable development education.

In 2015, the United Nations adopted 17 Sustainable Development Goals (SDGs) as a call to action to protect the planet and its people (Cars and West 2015); this set of goals includes concrete benchmarks addressing multiple interacting environmental and societal issues (see Online Resources). UNESCO, the education arm of the United Nations, encourages everyone to “empower learners of all ages with the knowledge, skills, values, and attitudes to address the interconnected global challenges we are facing, including climate change, environmental degradation, loss of biodiversity, poverty, and inequality” (UNESCO n.d.). Many of the SDGs align directly with the Next Generation Science Standards (NGSS) disciplinary core ideas (DCIs). For example, DCI PS3.B (Conservation of Energy and Energy Transfer) connects to both SDG 7 (Clean and Affordable Energy) and SDG 12 (Responsible Consumption and Production). Likewise, DCI ESS3.A (Natural Resources) connects to several goals, including SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), and SDG 15 (Life on Land). In our class for preservice elementary teachers, we used the SDGs paired with the DCIs as a lens for helping connect local activities to global issues and to identify problems to solve.

While the SDGs guided preservice teachers’ identification of problems to solve, biomimicry was useful for helping them to develop solutions. The Biomimicry Institute describes biomimicry as “the practice of applying lessons from nature to the invention of healthier, more sustainable technologies for people.” Designers who use biomimicry carefully observe living things and use what they learn from plants and animals to design solutions for human problems. Many examples of how scientists and engineers have used biomimicry can be found on the AskNature website (see Online Resources).

**TEACHER EDUCATION CONTEXT**

Preservice elementary teachers attended a small, 12-month, postbaccalaureate credential program combined with a masters degree and completed their science methods course across winter and spring quarters. The first implementation of these activities was in January of 2021, at a time when the university was in fully remote instruction due to the COVID-19 pandemic. The activities were implemented again in January of 2022 to the next cohort of the program when classes were remote for a brief time (due to the Omicron variant). In each of these instances, the set of four activities took 2.5 hours plus some work done prior to attending class to complete. These activities were also implemented in an in-person, 50-minute workshop for future teacher educators.

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This set of biomimicry activities served to introduce future teachers to the United Nations SDGs and to engineering design. The four short activities include the following: (1) Observing nature through an investigation of place, (2) Identifying structures and functions of species, (3) Exploring the SDGs to

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**Solutions-Focused Sustainable Development Education Through Biomimicry**

By Danielle Harlow, Devon Azzam, Julie Bianchini, and Karin Lohwasser

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**INTRODUCTION TO THE BIOMIMICRY ACTIVITIES**

This set of biomimicry activities served to introduce future teachers to the United Nations SDGs and to engineering design. The four short activities include the following: (1) Observing nature through an investigation of place, (2) Identifying structures and functions of species, (3) Exploring the SDGs to
make connections between investigations of place and global issues, and (4) Using ideas from nature to develop a solution to a human problem.

Each of the four short activities could be implemented independently or combined with the other activities in elementary school classrooms; at the end of our presentation of each activity, we discuss how a teacher might do so. However, since we developed the set of activities for a teacher education program, we foreground goals for preservice teachers and reflection topics for each activity along with connections to the NGSS DCIs, crosscutting concepts, and science and engineering practices. Our overarching learning goals for this set of activities were that preservice teachers would begin to connect local issues to global issues, develop creative thinking skills, and communicate their ideas. This lesson was then referred to throughout the rest of the course to remind the preservice teachers of the connection between observing nature and creative problem-solving. Each subsequent lesson of the course included links to the SDGs to continue to connect the work going on in elementary school science lessons to global sustainable development.

ACTIVITY 1: OBSERVING NATURE THROUGH AN INVESTIGATION OF PLACE

Research indicates that education for sustainable development requires implementing activities that help students both develop a connection to their local environment and see themselves as part of the solutions that will result in a sustainable future (e.g., Monroe et al. 2019). In the first activity, preservice teachers explored natural spaces around their school and/or home. They were encouraged to take photos of interesting animals and plants that they observed and to keep track of their observations and questions. They also researched the geographic features, geologic history, and the native stewards of the lands in their local areas. This was done as a homework assignment prior to the beginning of the methods course (see Supplemental Resources for assigned homework activity). It was informed by the Wondering Walks that are part of the Learning in Places curriculum (see Online Resources). The goal of this activity was for preservice teachers to think deeply about and connect with the natural spaces in their communities.

After completing this individual assignment out of class, preservice teachers shared their observations in small groups (breakout rooms) during the first class session. This was followed by a whole-class discussion on the variety of natural places that the preservice teachers found. These ranged from descriptions of nearby museums and botanic gardens to open spaces and parks within walking distance of their schools, to school gardens, to very specific observations such as a trail of ants along the exterior of a classroom wall, or birds that visited feeders visible through their classroom window.

For the preservice teachers, we highlighted the broad range of natural spaces easily accessible to their students, identified the benefits of outdoor experiences for children, and talked about classroom management considerations of taking children outside. For elementary students, this activity could be easily adapted to connect to performance expectation 2-LS4-1 (Make observations of plants and animals to compare the diversity of life in different habitats). Or teachers could ask students to make multiple observations or focus their attention on aspects of their observations, such as variations within members of the same species, to connect to performance expectation 3-LS4-2 (Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing). This activity lays the foundation for engaging in biomimicry by focusing attention on observing nature.

ACTIVITY 2: IDENTIFYING STRUCTURES AND FUNCTIONS OF SPECIES

In Activity 2, preservice teachers began by making observations about plant and animal species together as a group. We implemented this in multiple ways. When our program was remote due to the COVID-19 pandemic, we shared a screen of a webcam that showed living species, either in the wild or in captivity. For example, the Monterey Bay Aquarium maintained multiple webcams such as the Jelly Cam (see Online Resources). For the in-person teacher educator session, we provided specimens such as shells, sea stars, and seaweed for preservice teachers to investigate in small groups at their tables. When classes for preservice teachers are in person, we will plan a walk to natural spaces on campus.

We then modeled strategies to elicit participants’ observations and questions about these organisms. When this activity was done in a remote environment, we first used Google’s shared online whiteboard Jamboard to record observations and questions (we used the term wonderings to distinguish these informal questions from testable questions) as a class; when implemented in person, the future teacher educators worked in small groups to collectively record observations and discuss the observations as a whole class. They then returned to their
small groups, taking turns sharing the photos they collected on their walks for Activity 1 and practicing eliciting their classmates’ observations and questions. Next, they selected one example from their group and made a list of what they noticed about the plant or animal and the purposes they thought each structure served to better understand the NGSS crosscutting concept of structure and function.

The preservice teachers concluded this activity by discussing how they might implement this activity with their own students as well as other ways they might design activities for elementary school students to “construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction” (4-LS1-1). Overall, the purpose of this activity was to encourage the preservice teachers to think about how natural structures in plants and animals support survival as the basis for using these structures to inspire design, the core of biomimicry.

**ACTIVITY 3: EXPLORING THE SDGS TO MAKE CONNECTIONS BETWEEN INVESTIGATIONS OF PLACE AND GLOBAL ISSUES**

In the third activity, the preservice teachers explored the United Nations SDGs in a systematic way. This activity led to preservice teachers working in small groups to identify a problem that they could then use biomimicry to propose solutions.

To identify a problem, the preservice teachers reviewed all 17 SDGs (see Online Resources) and chose one or two that they were interested in exploring further. For those, they looked at additional information provided on the website and read the target indicators. For example, target 14.1 under the SDG 14 (Life Under Water) is the following: “By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.” They also investigated progress toward their selected goals on the SDG website (see Online Resources).

After exploring the SDGs, each group identified one SDG and defined a specific problem related to that goal that they would focus on in Activity 4. Along with identifying problems, the purpose of this activity was for preservice teachers to reflect on the role of science education in addressing the SDGs and the future they desired for their students to grow up in; they discussed these concluding ideas in small groups. If implemented with elementary students, this activity could be related to 3-5-ETS1-1 (Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost).

**ACTIVITY 4: USING IDEAS FROM NATURE TO DEVELOP A SOLUTION TO A HUMAN PROBLEM**

In this final activity, the preservice teachers worked in their same groups to brainstorm solutions to the problem or challenge they identified in Activity 3. These possible solutions ranged from transforming large social systems to designing specific tools for individuals. The only requirement was that their solutions were inspired by structures in nature. We implemented this activity in multiple ways, depending on the format of the class (in person vs. remote) and the time allotted (3 hours vs. 50 minutes). For longer remote implementations, preservice teachers drew ideas and developed a prototype with crafting materials that they had at home. For shorter implementations with future teacher educators, participants drew ideas on whiteboards or newsprint but did not develop a prototype.

One group of future teacher educators participating in an in-
person short workshop (no prototyping) examined shells set out on a table during Activity 2 and identified SDG 11 (Sustainable Cities and Communities) as their target in Activity 3. This goal aims to “make cities and human settlements inclusive, safe, resilient and sustainable” and foregrounds housing. The group recognized that hermit crabs come together in groups and organize themselves from largest to smallest to trade shells (homes) as they outgrow their own. The future teacher educators used this as a model for housing people. They recognized that there were many empty buildings in their local community and envisioned a future where, rather than having buildings sit empty, community organizations found ways to make them available for housing needs (see Figure 1).

As a second example, a group of preservice teachers participating in a longer activity (which provided time for prototyping) was remote. These preservice teachers focused on SDG 6 (Clean Water and Sanitation). They noticed how a plant stored water in its leaves and developed a hat and backpack system for collecting and storing water (see Figure 2).

This final activity concluded with a discussion of SDGs, NGSS three-dimensional learning, and engaging instruction. It emphasized how to guide elementary students to keep local and global issues in mind when searching for solutions that aid a sustainable future. If implemented with elementary students, this final activity could relate directly to performance expectation 1-LS1-1 (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).

DISCUSSION

Over the past two years, we have conducted this set of activities in multiple formats, including in-person and remote classes, and for different audiences, including preservice elementary school teachers and future teacher educators. We found that using biomimicry helped open up the preservice teachers’ and teacher educators’ minds to imaginative solutions. Through small-group discussion, the adult learners encouraged each other to engage in creative thinking and feel comfortable applying their imaginations to come up with futuristic ideas. Encouraging this type of thinking among preservice teachers will help them support their young learners in doing the same.

In our course for preservice teachers, we built on the SDGs, biomimicry, and engineering design in subsequent class sessions throughout the quarter. Indeed, each subsequent activity had learning goals linked to the SDGs, the NGSS, and engaging instruction. We then asked preservice teachers to synthesize and apply all they had learned in their final project, which was to develop and implement an activity in their student teaching placement that challenged children to identify local problems related to sustainable development and develop solutions.

CONCLUSION

To meet the SDGs identified by the United Nations, people around the world will need to work together to identify solutions. Science instruction informed by these SDGs and aligned with the NGSS can help elementary school students develop the capacity to identify and address local issues that connect to global goals. The activities described here provide an example of how teachers can use biomimicry, using nature to inspire design solutions, to help children begin to think about sustainable development and develop their engineering skills to solve prob-
blems. These same activities provide opportunities for teachers to learn about education for sustainable development and to develop their own creative problem-solving skills.

**Supplemental Resources**
Download the full homework assignment at [https://tinyurl.com/mrxftdew](https://tinyurl.com/mrxftdew).

**REFERENCES**


**ONLINE RESOURCES**
- The 17 Goals [https://sdgs.un.org/goals#goals](https://sdgs.un.org/goals#goals)
- AskNature [https://asknature.org](https://asknature.org)
- Biomimicry Institute [https://biomimicry.org](https://biomimicry.org)
- Measuring Progress Towards the Sustainable Development Goals [https://sdg-tracker.org](https://sdg-tracker.org)
- Monterey Bay Aquarium Jelly Cam [www.montereybayaquarium.org/animals/live-cams/jelly-cam](http://www.montereybayaquarium.org/animals/live-cams/jelly-cam)
- Welcome To the World’s Largest Lesson! [https://worldslargestlesson.globalgoals.org](https://worldslargestlesson.globalgoals.org)

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