HAMSTERS, PICTURE BOOKS, AND ENGINEERING DESIGN

A STEM unit teaches primary students about engineering design.

By Kristina Tank, Christy Pettis, Tamara Moore, and Abby Fehr

Peeking in the door of a kindergarten class, you see a child holding a picture of a hamster glued to a popsicle stick and moving it along a trail, shouting, "It's escaping!" Another child yells, "Catch it!" while a third insists, "We need to close the hole in the trail!" This is engineering—kindergarten style! We led kindergarteners through an engineering design challenge, and this was one group's first attempt at testing their newly designed habitat. Throughout this unit, students learned about animals and habitats before using that knowledge to design a habitat for an imaginary classroom pet.

With the integration of engineering into science instruction, teachers have been seeking ways to add engineering in their classrooms. This article presents a primary (K–2) STEM unit that took place in a half-day kindergarten classroom as a way to address the scientific and engineering practices (dimension 1, p.41) and the disciplinary core idea ETS1: Engineering design found in *A Framework for K–12 Science Education* (NRC 2012, p. 204). More specifically, this unit addresses the science and engineering practices #1, asking questions defining problems (p. 54) and #6, designing solutions (p. 67).

This unit, Designing Animal Habitats, is the product of the PictureSTEM project, an ongoing initiative to design curriculum that uses picture books to help facilitate meaningful STEM learning in elementary classrooms, with an emphasis on engineering design. PictureSTEM units use national standards to determine mathematics and science content students are already learning and build an engineering design challenge based on this learning. This allows students to have firsthand experience both with engineering and with using their science, technology, and mathematics knowledge to solve problems. The unit consists of five pairs of literacy and STEM-content lessons (see Table 1), and for this article we will focus on the science and engineering activities.

Building Background

The first two lessons helped to build some of the science background that would be helpful as students move into the engineering design challenge. More specifically, these two lessons addressed the life science grade band dealing with ecosystems (LS2), from *A Framework for K–12 Science Education*, which suggests that by the end of second grade, students should understand that "animals depend on their surroundings to get what they need, including food, water and shelter" (NRC 2012, p. 157). Students participated in a sorting activity where they identified the physical characteristics of various animals. In pairs, the students placed their animal cards in one of the boxes labeled *fur*, *wings*, *fins/flippers*, or *scaly skin*. As we floated around the room, we were able to get a quick visual about how well the students were doing with their sorting. Mrs. Fehr noted that, "We hadn't done much with animals before this unit, so it was nice to be able to see what they knew, and this activity helped me to do a quick check on background knowledge and if they had an idea about the different parts and characteristics of animals." Students quickly started noticing that similar animals were ending up in the same box on their sorting mat, which was a great starting point for a class discussion on animal groups.

Table 1.

Unit overview.

Sample First-Grade Module: Designing Hamster Habitats					
	Day 1 – Animals	**Day 2 – Animal Habitats**	**Day 3 – Shapes and Animals**	**Day 4 – Designing Your Habitat**	**Day 5 – Testing Your Habitat**
Literacy Focus: Suggested guided reading: animals, habitats	Book: *Is my Hamster Wild?* Strategy: Main idea from informational text	Book: *Magic School Bus Hops Home* Strategy: Making connections – human and animal homes	Book: *Three Pigs, One Wolf and 7 Magic Shapes* Strategy: Comprehension monitoring: questioning	Book: *Leo Cockroach... Toy Tester* Strategy: Fiction and vocabulary – using "juicy words"	Book: *The Perfect Pet* Strategy: Identifying important details
STEM integration activities	Identify animals' basic needs. Sort animals by characteristics and basic needs.	Looking at how habitats provide for animals' basic needs. Using pattern blocks to identify places where needs are met	Students create the animals in the story above with tangrams, then create some on their own.	Introduce engineering and the engineering design cycle. Plan the hamster habitat and how many pieces are needed.	Build and test a hamster exercise habitat using 3-D geometric shapes that will meet the hamster's basic needs.

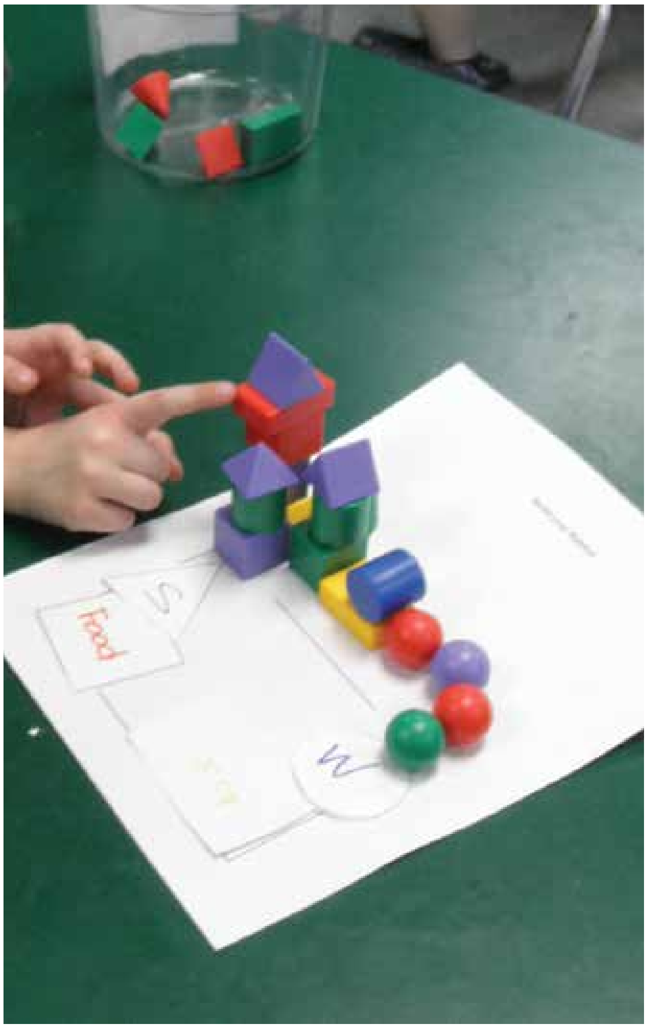
In the first lesson, we read *Is My Hamster Wild? The Secret Lives of Hamsters, Gerbils, and Guinea Pigs* (Newcomb and McLarney 2008), which builds background knowledge about the behaviors and living conditions of hamsters in the wild and as pets. This information helps build context for the engineering design challenge. After reading, together with the students we identified the different physical characteristics of hamsters and labeled them on the poster-sized hamster on a SMART board.

Students worked in pairs to make a plan for a habitat trail.

The next day's lesson started with *Magic School Bus Hops Home* (Relf 1995), which introduces the idea of animal habitats and how those habitats provide for the basic needs of the animals living there. We built upon the concept of animal habitats by having students work in pairs to place the appropriate animal cards into one of four possible habitats: arctic, ocean, rainforest, or desert. After some time working with their partners, we had the students work together on the SMART board to drag the correct animals into the correct habitat.

The Importance of Testing

After building the necessary background knowledge, the last two lessons of the unit introduced the students to the core idea ETS1: Engineering design, as they learned about identifying problems, asking questions, and gathering information about these problems, and the fact that problems often have multiple solutions (NRC 2012, ETS1.A, p.205). The first of the engineering lessons starts with the picture book *Leo Cockroach…Toy Tester* (O'Malley 1999), which introduces students to the importance of testing materials through a story about an underappreciated cockroach who tests toys at a toy company. This book models part of an engineering design process for students. We then introduced students to their final challenge, to design a habitat trail for their imaginary hamster with three-dimensional shapes, but just like Leo Cockroach, they would first need to test their materials to learn a little more about them. We explained to the students that because they will be using these shapes to create their design, they needed to test which of the shapes might roll away and which shapes can be easily stacked on top of each other. They would do this by placing the shapes into their "testing tub" (a copy paper box) and performing two tests, the "stackability" test where they try stacking the different shapes



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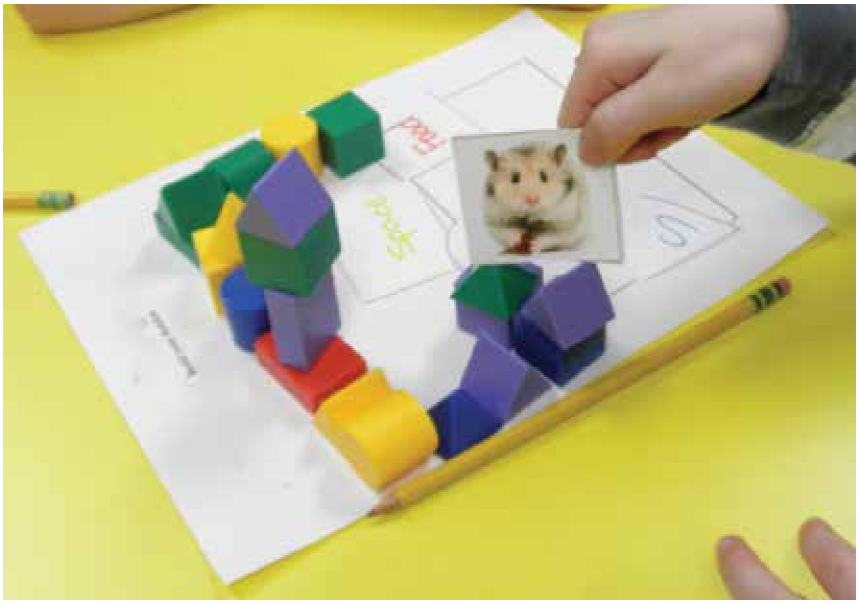
Students used two-dimensional shapes to represent the basic needs of water, food, and shelter.

on one another and the "flickability" test where they (gently!) tap each shape to see whether it slides, rolls, or falls over when pushed (see NSTA Connection for handouts). Students should not "flick" shapes in the direction of other students. All around the classroom, the children huddled around tables, putting different colorful three-dimensional shapes on placemats and then tapping them with their fingers to see what would happen. After sharing the results for some of the shapes as a class, they wrapped up for the day with the testing knowledge necessary for their engineering challenge.



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Students tested their designs by counting their shapes and moving a picture of a hamster along the trail.

Engineering Design

The final engineering lesson began with *The Perfect Pet* (Palatini and Whatley 2003), an amusing story about a girl trying very hard to persuade her parents to let her have a pet. Each of the pets that she suggests have different needs that her parents use as a reason not to get it, such as a horse needing a lot of space and a dog needing a lot of exercise. This sets up a discussion with the children about a pet hamster's needs, allowing them to use what they learned earlier in the unit about how a hamster's habitat needs to provide the hamster with food, water, shelter, and space. We also talk about how we want our habitats to be similar to a hamster's natural habitat, and since hamsters are excellent diggers who like to make burrows with connected tunnels, we will make a habitat trail to allow the hamster to move through tunnels. While we are reviewing, we are at the same time setting up the engineering design challenge of creating a habitat trail that would meet the hamster's needs. To complete the engineering design challenge, students worked in pairs to make a plan for a habitat trail on an 11"×17" preprinted template with spaces marked for the beginning and end of their trail. We reminded students that for a successful habitat trail, they needed to use 20 shapes, and their habitat trail needed to meet the hamster's basic needs of food, water, and shelter, with "shelter" being thought of as ensuring a safe place for their hamster to rest. We also explained that the shapes could be placed next to each other or stacked, but in order for the hamster to travel through the habitat trail, the shapes must always be touching because any gaps between shapes would be the equivalent of a hole in the trail through which the hamster could escape. After a quick review of the different shapes that they tested in the previous lessons, the students started deciding together how many of each shape they would use to get to the total of 20 shapes.

As they had done in an earlier lesson in the unit, students used two-dimensional shapes to represent these basic needs (i.e., a blue circle as water, an orange square as food, and a green triangle as shelter), placing the shapes alongside the trail to indicate points where the hamsters can eat, drink, and sleep. Once pairs had created their habitat trails, they tested their designs by counting their shapes and moving a picture of a hamster along the trail, pretending that it is a real hamster running through the trail. The students were able to pretend to let the hamster escape if they came to any gaps in their design, and pretend to have their hamsters eat, drink, and rest when they reached the designated shapes representing these basic needs along their trail. We assessed student learning through a checklist by having each pair orally report where and how their habitat met the basic needs requirement, how many shapes they used, and what improvements they have made/would like to make to their habitat.

SCI LINKS THE WORLD'S A CLICK AWAY
Keywords: What Is a Habitat?
www.scilinks.org
Enter code: SC071302

After designing their habitat trails, children shared with their classmates, giving them a chance to demonstrate how their habitat fulfills the three requirements of the challenge and to see examples of other ways the challenge could be met. Introducing students to the idea that it is acceptable and encouraged to share with and learn from others and that there are multiple pathways to success are important ideas in engineering and the optimization of designs (ETS1.C, NRC 2012, p. 209). Finally, the pairs were given the opportunity to redesign their trails, fixing any areas in which the original challenge requirements were not met. They tested their designs using the same method as before. As students were quite comfortable both with the requirements and with the trail design at this point, the redesign and retesting phase took only a short amount of time. However, this provided a critical learning opportunity to children as they got to experience firsthand the idea that the engineering design process is iterative and that learning from failures and building on past successes are both desirable in engineering.

Conclusions

Providing kindergarteners with the opportunity to use science knowledge in an engineering design challenge was a great experience. We found that while on a field trip to a nature preserve, the students surprised the naturalists by correctly using the word "habitat" when talking about animals and their homes. Later in the year, when working with their FOSS science kit and adding to their aquariums, one student remarked, "We're adding their habitat," showing that they had gained a deep and broad view of what a habitat is and how it functions in an ecosystem.

One concern that teachers have as they consider how to incorporate engineering into their early elementary classrooms is time and resources. This unit provides teachers with a literacy and STEM unit that uses materials which are relatively inexpensive and/or often already available in many schools. For example, one classroom copy of each book is needed, along with photocopies and class sets of tangrams, and three-dimensional solid shapes. Furthermore, introducing young children to engineering and engineering design through this literature-enhanced STEM integration unit can be a meaningful and engaging way to facilitate connections between science, mathematics, and engineering. ■

Connecting to the Standards

This article relates to the following National Science Education Standards (NRC 1996):

Content Standards

Grades K–4

Standard C: Life Science

- The characteristics of organisms
- Organisms and environments

Standard E: Science and Technology

- Abilities of technological design
- Abilities to distinguish between natural objects and objects made by humans

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

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NSTA Connection

Download the handouts used in this lesson at *www.nsta.org/SC1307.*