Cookie Jar Alarms

Early Childhood Engineering With Robotics

By Kimberly Lott, Sara Urbanek-Carney, and April Mitchell

Robotics is emerging as an effective strategy for bridging the gap between technology and engineering design in early childhood classrooms (Bers, Seddighin, and Sullivan 2013). Robots are a tangible manifestation of computer coding. Robots allow young students to not only engage in developmentally appropriate play activities but also actively participate in solving problems through engineering design.

Using a STEM grant received from our school, we purchased a KIBO-18 set from KinderLab Robotics (*kinderlabrobotics.com*) and incorporated it into our morning choice time where students work in small groups coding KIBO. KIBO is a robot that can light up, make sounds, and move (see Figure 1). It also has sensors that allow it to respond to sound, light, and distance. Students program KIBO by using wooden blocks to arrange a sequence or program and then scan the blocks using the KIBO body. *Safety note*: The scanner used by KIBO is a Class 1 LED (like those used in the grocery store) and considered to be safe for the eyes under all operating conditions; however, we still reminded the students not too look directly at the light or to point it directly at other students' eyes. Once the KIBO is programmed, a button flashes green, and when it is pressed, the KIBO acts out the program. See Table 1 for pictures and descriptions of KIBO programing blocks.

FIGURE 1

KIBO robot.

PHOTOS COURTESY OF THE AUTHORS

Coding KIBO was explained using a sandwich analogy. The "Begin" and "End" blocks were like pieces of bread and everything you wanted KIBO to do had to be in between. Using that same analogy, the "Repeat/End Repeat" were the pieces of bread and everything you want to repeat goes in between. It was also explained that you can have a sandwich within a sandwich (i.e., "Repeat/End Repeat" sandwich inside of the "Begin/End" sandwich).

This article outlines a two-week engineering challenge for first-grade students using KIBO to create a cookie jar alarm, as an introduction to our unit on light and sound. This challenge is aligned to the first-grade *NGSS* standard 1-PS4-4, *Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance* (NGSS Lead States 2013). Using the engineering design process as a framework, students actively participated in "engineering talks" throughout the unit to discuss the benefits of clearly defined problems, criteria for solutions, and optimized designs. Prior to this challenge, students had been playing with KIBO for several weeks in the morning and completed simple programming tasks. Table 2, p. 68, outlines the tasks the students had mastered before beginning this challenge.

INTRODUCTION TO ENGINEERING

Before beginning our engineering challenge, each student was asked to draw an engineer at work. We also added a written component under their picture to give us more information about what they thought an engineer did. When first given this task, about half of the class did not know what an engineer was or did. One student asked, "Is it a person or a thing?" These drawings and writings revealed that most students' ideas were either unrelated to engineers or included trains (see Figure 2, p. 68, for sample drawings).

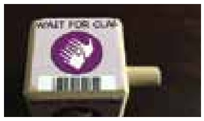
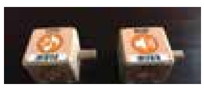
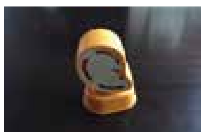
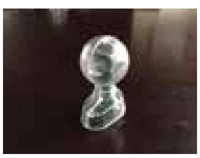
After students completed their drawings, they gathered on the rug. The teacher then introduced the word *engineer* to the class. Using signals to indicate agreement, the teacher asked, "How many of you think an engineer drives a train?" Several students signaled that they agreed. The teacher went on to explain that engineers do indeed drive trains, but there is another type of engineer who create things to solve problems. She explained that engineers solve lots of different types of problems, including bridges, machines, and computers. And lastly, she explained that all types of people can be an engineer.

INTRODUCE THE PROBLEM AND IMAGINE SOLUTIONS

The next day, the teacher read *Who Took the Cookie From the Cookie Jar?* by B. Lass and P. Sturges (2000) during the literacy block. During the first reading, students were focused on CCSS.ELA-Literacy.RL.1.1 (Ask and answer questions about key details in a text) and CCSS.ELA-Literacy.RL.1.2 (Retell stories, including key details, and demonstrate understanding of their central message or lesson). The teacher then read the book again, and students were focused on CCSS.ELA-Literacy.RL.1.3 (De-

TABLE 1

Description of KIBO coding blocks.

PROGRAMING BLOCKS	DESCRIPTION
	**Begin/End** Students put these at the beginning and end of their codes. KIBO will act out all of the blocks in between these blocks.
	**Wait for Clap** When this block is placed in the code, the KIBO will only complete the steps after this block when the students clap near the sound sensor.
	**Repeat/End Repeat** Anything placed between these two blocks will repeat 2, 3, 4 times or ∞ (forever). KIBO will also repeat until a certain condition (near, far, light or dark) exists.
	**IF/End IF** If any blocks are placed between these two blocks, KIBO will only perform those actions if a certain condition exists (near, far, light, dark).
	**Light on** These blocks are used when students want the KIBO's light to blink.
	**Sound blocks** KIBO will beep and also sing (several beeps in a short musical arrangement).
SENSORS	**DESCRIPTION**
	**Sound Sensor** This sensor is used for KIBO to "hear" sounds. This is used with the "Wait for the Clap" programming block.
	**Distance Sensor** This sensor is used for KIBO to detect motion that is near or far from it. This is used with the IF/End IF blocks with either the Near or Far conditions.
	**Lightbulb** KIBO's lightbulb will light red, white, or blue.

scribe characters, settings, and major events in a story, using key details). The teacher reminded students to think of themselves as engineers and to look for a problem in this story that they might be able to solve, which is a key detail in reference to the standard being addressed. After reading, the teacher asked, “What was the problem?” Students all agreed that someone stealing cookies was a problem. The teacher explained that this was the first step in the engineering process and wrote “Ask: What is the problem?” on the board.

The teacher then asks, “What could we do to solve this problem?” Students’ initial responses varied, from “Just hide your cookies” to “Create a trap to catch the person stealing the cookies.” The text shared with the class lends itself to students wanting to trap the thief, so we had to scaffold their thinking to focus more on how you know someone is stealing the cookies. So the teacher then asked, “What if we knew who was stealing cookies, but just wanted something to let you know they were stealing them? For example, how do we know that there is a fire drill at school?” The students immediately looked at the fire alarm on the wall. “What does the fire alarm do?” Students responded that it has a loud sound and it also flashes a light.

The teacher then drew an arrow on the board from “Ask: What is the problem?” to the word “Imagine.” The teacher then explained that before engineers imagine a solution, they have to carefully define the problem, which helped students focus on using sound and light to protect their cookies. “Engineers also have to consider what materials they have available when imagining their solutions,” the teacher explained. The teacher reminded them that the problem was to create an alarm that could be seen or heard at a distance and that they would be using KIBO to create this alarm. Students were asked to imagine again how that alarm might look (considering the components of KIBO) and what they would want KIBO to do to create an alarm (how to best communicate over a distance). Students returned to their desks and drew a picture of what their KIBO cookie alarm might look like and wrote an explanation of what it might do (see Figure 3).

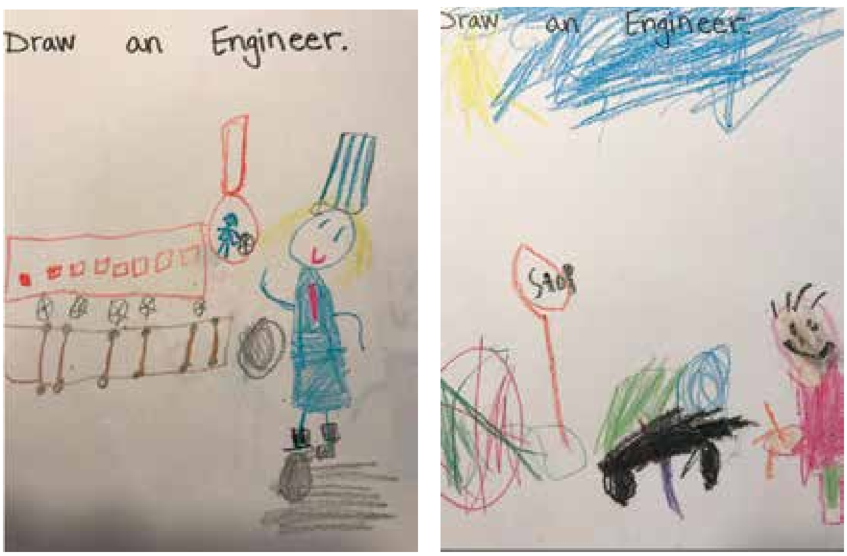
TABLE 2

KIBO coding tasks completed.

LEVEL 1	LEVEL 2
1) Make your KIBO sing.	1) Make your KIBO beep two times.
2) Make your KIBO sing, then turn on the blue light.	2) Make your KIBO sing, then blink the red light two times.
3) Make your KIBO blink red, white, and blue.	3) Make your KIBO blink white and beep three times, then sing.
4) Make your KIBO blink red, white, and blue after you clap.	4) Make your KIBO blink red, white, and blue forever.
5) Make your KIBO beep, and then blink red, white, and blue after you clap.	5) Make your KIBO blink red, white, and blue forever after you clap.

FIGURE 2

Sample of engineering drawings from the beginning of the unit.



PLAN, TEST, AND IMPROVE

The next day, students gathered on the rug and the teacher added the word “Plan” to the flowchart on the board.

She explained that after imagining and drawing a possible solution, the next step is to create a plan for building the solution. The teacher reminded students that engineers carefully consider their problem and how they would know if it was successful before making their plans.

To scaffold this for students, we broke up the alarm building into two steps: (1) create an alarm and (2) make the alarm go off when someone is near. Students worked on their plans to build the alarm. In pairs, students used paper KIBO coding cards (see NSTA Connection) placed in sentence strip pockets to plan out the code they wanted KIBO to follow in order to alert them that their cookies were being stolen. Paper coding cards were used at this stage to slow down their thinking so that they had a solid plan before building their code with KIBO blocks.

Since there was only one KIBO for the entire class, the testing of alarms was integrated during a literacy block with students working in small groups of four (or two pairs). Students were grouped for maximum participation, not on achievement levels. Students of similar personalities were grouped together to ensure that one student did not "take over" the design process. Student groups testing their codes worked with the KIBO robot set and the teacher, which was helpful to keep students on task and ensure that each pair of students had equal time with the robot. (Note: If using multiple KIBO kits, we recommend that an adult be available to assist with each kit.) Students not testing their KIBO code were focused on literacy activities, such as independent reading, writing, word work skills, or an online literacy program. These independent work routines were established at the beginning of the year, and student stamina to stay on task was established well before the teacher attempted to pull small groups for literacy-related instruction or included this STEM activity into the literacy block.

Before moving into their literacy block the first day, the teacher explained that testing was the next step in the engineering process and added "Test" to the flowchart on the board. The teacher reminded students of the criteria for the alarm working. "You can hear (or see) it from a distance." She then asked, "What do you think we need to do if it does not work?" "Try to fix it," a student responded. The teacher then added "Improve" to the flowchart on the board and indicated the circular part of the process. "Engineers do not just guess how to fix it; they have to go back to imagine and then plan for the improvement."

During their small-group testing time, pairs of students decided on one plan and used the KIBO cards on pocket sentence strips to make their codes (see Figure 4). It was explained that if they wanted to test more than one design, they could do that during their morning choice time. Student pairs would then take turns actually building their code out of KIBO

FIGURE 4

Students planning codes with KIBO cards.

FIGURE 3

Sample of imagine drawing with plans.

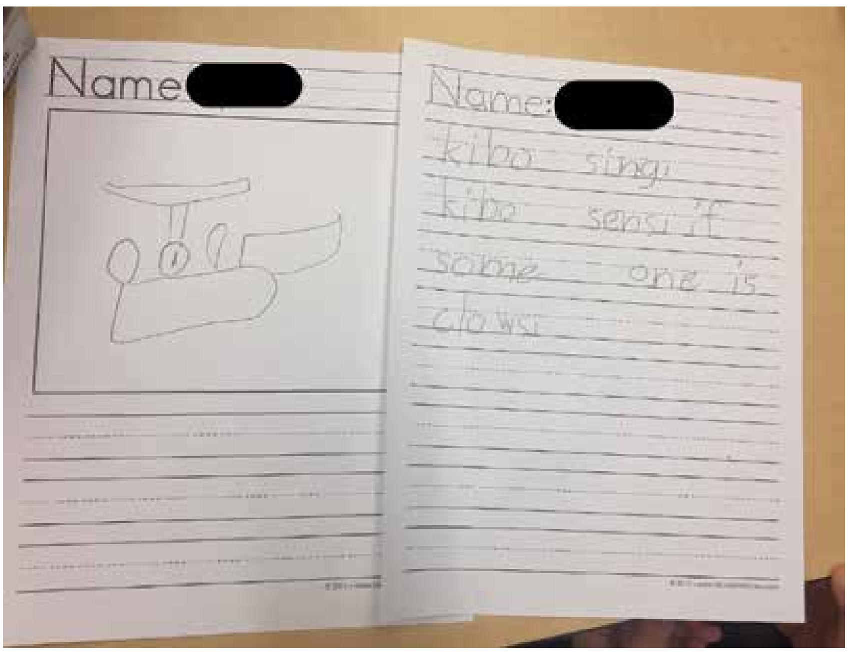


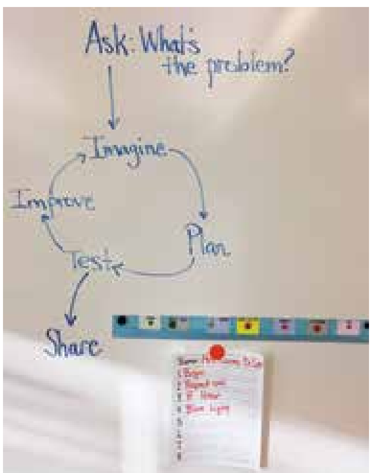
FIGURE 5

Students testing codes with KIBO.

wooden blocks with the teacher on the rug (see Figure 5). If their code did not work, then they would return to the table, make a new plan with their KIBO cards and try again. Students returned to the table to improve their code to help them focus, think through the steps, and not simply guess. (Note: If a student is unable to work with KIBO on the rug due to special needs, then all activities could be completed at the table.)

FIGURE 6

White board anchor for engineering talks.



It took three days before each pair of students had a chance to test their codes and create a successful alarm. Each day before testing, the teachers would have an "engineering talk" where they would share their successes and challenges. Students told about codes that both worked and did not work. The teacher modeled with the coding cards to help create a visual representation as students talked. This helped clarify their thinking for all students in the classroom. For the codes that did not work, the teacher asked if any students had suggestions to help fix the codes. Figure 6 shows the whiteboard that anchored these talks, including the flowchart, KIBO cards for modeling and samples of writing if needed.

Once all student pairs had successfully created their alarms, the teacher introduced the conditional "IF/End IF" KIBO blocks. This component was needed to complete the second step in the alarm-building process. The teacher explained that KIBO has a distance sensor, but it will only use the sensor if we tell him to do something if someone is near. Using the sandwich analogy, the teacher demonstrated that "IF/End IF" were pieces of bread and everything in between would be what KIBO does when that condition was present (i.e., someone was near the cookie jar). The teacher then asked, "If you want your alarm to repeat only if someone is near, then where should the 'IF sandwich' need to be placed?" A student immediately responded, "Inside of the repeat sandwich."

Students then added the "IF/End IF" to their codes and retested their alarms during literacy block. This testing went faster because students were only adding two additional blocks and their skill level with KIBO was improving. Once students had successfully created an alarm that would sound (or light and sound) when someone was near, then the students wrote out their coding sequence on paper (see Figure 7). This sequence writing is aligned to CCSS.ELA-Literacy.W.1.7 (Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

FIGURE 7

Students writing final codes.

SHARE

Before literacy block the next day, the teacher added "Share" to the engineering design flowchart and explained that when solutions work, then it is time to tell others about it. Using their final plans, each student pair demonstrated their alarms in their small group to the teacher. A paper bowl was placed on KIBO's stage to represent the cookie jar. Students were encouraged to role play actually taking a cookie from the bowl and not just placing their hands in front of the distance sensor. They were reminded that if they wanted to catch a cookie thief, they had to act like a thief to see if it would work.

On the final day of the unit when all the students had demonstrated their alarms, the students gathered on the rug for their final engineering talk. We talked about their challenges and successes. "The biggest challenge is when your code does not work, you have to go back through the cycle," one student shared. Success comments included, "Our alarm worked when we found the right code" and "I enjoyed helping other groups with their alarms."

The teacher explained that there are many ways to successfully engineer a cookie jar alarm. "Engineers often compare successful designs to look for strengths and weaknesses to make their designs even better," the teacher added. We talked about the strengths and weaknesses of different designs. The students agreed with one student who said, "Sound is better than light because you can hear it even if your back is turned."

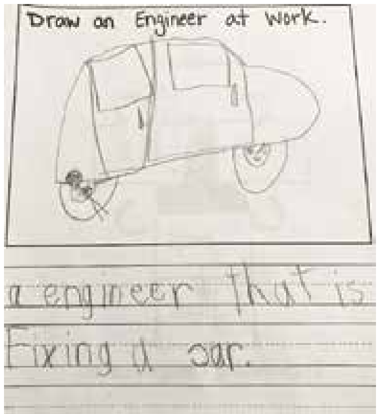
While the students were talking on the rug, one of the student alarm programs was programmed into KIBO, a container of real cookies was placed on it, and then placed on a table near the rug to see if it would really catch a cookie thief. The teacher had asked the principal to come by at that time to see what the first-grade engineers had created. When he arrived, he sat at the table with the armed KIBO cookie alarm. As he tried to steal a cookie, the alarm went off. The students were so excited that their alarm had worked! This created a real-life connection to the problem of the cookie jar alarm.

ASSESSMENT

Following the unit, the students again drew an engineer at work (see Figure 8). Out of 23 students, 20 correctly described an engineer as someone who solves problems or designs solutions to problems. The students also were given the Engineering Design (see NSTA Connection), and 17 out of 23 students correctly sequenced the steps. When we compared the six that could not remember the process to their drawings, four out of the six had accurate perceptions of what engineers actually do.

FIGURE 8

Sample of engineering drawings at end of unit.



Throughout this unit, students were actively engaged in the engineering design process to solve a real-world problem of protecting the cookies in their cookie jar. We continually reminded students that they were acting like "real engineers" and several were starting to see themselves as engineers. In their final engineering drawings and writings, many students included themselves in their writing about what an engineer does (e.g., "I am building a machine."). Students were also beginning to recognize that everyone could be an engineer with several engineers in the final drawings being female. This was also seen in their final writings, "An engineer fixes things and if it doesn't work she will try it again."

Through this challenge, we found that even children can learn the basics of coding using KIBO robotics. This lesson integrated science, technology, engineering, and literacy to provide a transformative experience for these children. Lastly, engineering challenges are often perceived as only appropriate at the end of a science unit, but this challenge was used as an introduction to our sound and light unit. For example, one of the weaknesses of the alarm noted by students was that the KIBO's beep was not very loud. This lead to the question, "Why are some sounds loud and some sounds soft?" The students were now very engaged in learning more about light and sound. ●

REFERENCES

Bers, M.U., S. Seddighin, and A. Sullivan. 2013. Ready for robotics: Bringing together the T and E of STEM in early childhood teacher education. *Journal of Technology and Teacher Education* 21 (3): 355–377.

Lass, B., P. Sturges, and A. Wolff. 2000. *Who took the cookies from the cookie jar?* Boston: Little, Brown Books for Young Readers.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press.

NSTA Connection

Download the KIBO block cards and engineering design assessment at *www.nsta.org/sc1019*.

Kimberly Lott (***kimberly.lott@usu.edu***) is an associate professor of science education, **Sara Urbanek-Carney** is a first-grade teacher at Edith Bowen Laboratory School, and **April Mitchell** is a doctoral student, all at Utah State University in Logan, Utah.

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

Standard

1-PS4 Waves and Their Applications in Technologies for Information Transfer

www.nextgenscience.org/pe/1-ps4-4-waves-and-their-applications-technologies-information-transfer

- 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 this article are just one step toward reaching the performance expectation listed below.

Performance Expectation

1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practices	
Asking Questions and Defining Problems	Students define the problem of someone taking cookies from a cookie jar.
Constructing Explanations and Designing Solutions	Students imagine a solution by creating an alarm that will alert them from a distance if someone is taking a cookie.
Developing and Using Models	Students make a drawing of their alarms and use that to plan a program for KIBO.
Obtaining, Evaluating, and Communicating Information	Students discuss the results of alarm testing with peers, and then share and evaluate successful solutions for strengths and weaknesses.
Disciplinary Core Idea	
PS4.C: Information Technologies and Instrumentation People also use a variety of devices to communicate (send and receive information) over long distances.	Students create an alarm and demonstrate that it can be seen and/or heard from a distance.
Crosscutting Concept	
Cause and Effect	Students experience the effects of their code during the testing of their alarms. When alarms do not work, they have to decide the cause within the code and then try to fix it.