Thinking with KIBO

Introducing Artificial Intelligence in Early Grades

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Introduction

Thinking with KIBO is a curriculum introducing early elementary age children to core concepts of Artificial Intelligence (AI), using KIBO as an "object to think with" (borrowing Seymour Papert's phrase from his 1980 book *Mindstorms*[1]). KIBO is a hands-on, screen free robot kit designed to introduce coding, engineering, and computer science in early childhood education. Although KIBO is not an advanced AI system, working with KIBO provides children with a concrete way to approach the concepts.

Why AI in Early Elementary?

Early STEM education, where children learn at a young age about technology, computers, coding, and AI, is the key to giving children understanding and mastery of AI tools. We want students to understand these tools, understand how they work, and think critically about how they can be used to improve people's lives and communities.

Broadly, "Artificial Intelligence" describes computer systems that can do the sorts of things we associate with human intelligence. AI covers a wide range of abilities, like having conversations, writing text, recognizing objects in pictures, driving a car, and finding patterns in lots of information. AI depends on new inventions by human engineers and computer scientists, like better sensors, faster computers, and techniques like "machine learning" where systems can improve their own performance over time. Artificial intelligence will be part of the tools engineers will create in the future and that people will use every day.

Artificial intelligence is not magic; it is simply a kind of computer program. It works the way it does because human engineers – just like our students! – designed it, tested it, fixed it, and improved it. These engineers used the same basic practices of sequencing, modularity, and the engineering design process that we find in K–5 computer science standards. In short, AI is a great framing to teach children about computer science and a vital new application of STEM concepts.

Why KIBO?

Educational theorists have long recognized that children think and learn best when moving, playing, interacting with each other, and engaging with concrete objects. Just as engaging with a physical robot like KIBO is a research-proven[2] way to teach young children about computer science, robotics also provides the perfect vehicle for teaching young children about artificial intelligence. Not only do we gain the educational benefits of concrete objects and manipulatives, we can also build on the many parallels between robotics concepts and AI concepts, such as the "sense – think – act" cycle that we'll explore in more detail.

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[1] Papert, S. (1980). Mindstorms: Children, computers and powerful ideas. New York: Basic books.
[2] See kinderlabrobotics.com/research for more on the research supporting KIBO.

KIBO's simplicity also helps highlight some of the ways that simple robots are *not* examples of artificial intelligence. Although KIBO's "ear" sensor can hear sounds, KIBO can't respond to spoken commands like a voice assistant. Although KIBO can sense obstacles with its distance sensor, it can't predict a path through a crowded room or even remember the obstacles it sensed previously, as a self-driving car can. Exploring the differences between KIBO and more complex systems also help children think about AI.

Purpose

Although there are important questions about how AI tools will and should be used in the classroom, the focus of this curriculum is on how AI systems *work*. The curriculum aims to engage students with the following core learning objectives:

AI is a tool made by people. Artificial intelligence can sometimes seem like "magic." But it is just a tool invented and created by human engineers. This understanding can help demystify AI and, for some students, make it seem less scary.

AI systems (and robots!) act based on input and rules. Both robots and AI rely on what engineers call the "sense – think – act" cycle. The systems take input, determine what to do based on rules, and then take action. Humans design the sensors, the rules, and the actions. An AI system's rules can be very complicated, and the rules can even change over time (through machine learning), but they are still rules.

AI doesn't think like people do, and it's not alive. Although we use the words "artificial intelligence", the intelligence of these systems is different from human intelligence. In fact, AI systems using the "sense – think – act" cycle don't really "think" the way we do at all. They can't choose what to do outside of their rules or come up with new ideas, and they aren't aware of themselves the way people are.

AI can help people solve difficult problems. Even though AI doesn't really "think," AI is still an amazing tool for helping *people* think by processing far more information than people are able to. Exploring the uses of these systems will help students understand how AI can be used responsibly, and it might even inspire them to work on developing AI themselves!

Format, Pacing, and Classroom Practice

Thinking with KIBO is designed as a supplemental curriculum of 5 one-hour lessons. Lesson 5, which involves a more complex and open-ended KIBO project, can optionally be extended across multiple class meetings if more time is available.

As in our core curriculum *Growing with KIBO*, each lesson is divided into four segments:

- **Inspire (5-10 minutes)**: This is a guided circle-time meeting in which the theme, new ideas, and content of the lesson are introduced and discussed. Optional scripting is provided (in purple text) to help the teacher introduce new concepts.
- **Connect (5-10 minutes)**: This is an opportunity to contextualize the activity. In some lessons, the Connect segment will be a book to read or video to show. In others, it will be a physical game or exercise to get kids moving and thinking.

- **Engage (30 minutes)**: The engage segment is the core activity of the lesson. This will usually take the form of small-group, hands-on work with KIBO. An ideal group size for KIBO work is 2 to 4 students per KIBO kit.
- **Reflect (10 minutes)**: Each lesson closes with a "technology circle" where students share their work, recognize collaborative contributions made by their peers, and discuss aspects that were particularly rewarding or challenging.
- **Remaining time is allowed for cleanup**. Engage the students in cleanup in order to reinforce their good digital citizenship and positive choices of conduct.

Prerequisites and Target Age

The curriculum is designed primarily for students aged 6–9, or first through third grade. Before beginning this curriculum, students should be familiar with KIBO's advanced capabilities, including sensor programming, the use of IF/END-IF and REPEAT UNTIL, and nested loops and conditionals. *Thinking with KIBO* would naturally follow completion of the Advanced section of *Growing with KIBO*.

Logistics and Required Supplies

For whole-class engagement, work with groups of 2–4 students. Each group should have access to one KIBO kit.

For full engagement with all activities, students should have access to the KIBO 18 kit or higher. The lessons take advantage of KIBO's most advanced programming capabilities, including nested conditional programs using the sensors found in the KIBO 18 kit and higher.

Most lessons involve decorating KIBO. You can use familiar classroom art materials such as construction paper, cardboard, pipe cleaners, tape, markers, and scissors. If you have the Building Brick Extension Kit, students can also use LEGO™-compatible bricks to decorate their KIBOs.

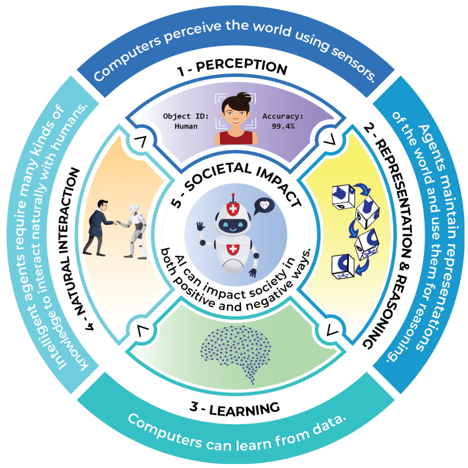
Alignment to Content Guidelines

Thinking with KIBO was developed in alignment with the Artificial Intelligence for K–12 initiative's (AI4K12) curriculum guidelines. These guidelines are a collaboration between AAAI and CSTA[3]. The lessons in *Thinking with KIBO* engage with AI4K12's "Five Big Ideas in Artificial Intelligence" in the following ways:

- **Perception** (explored in lessons 2 and 3). AI can "see" and "hear" using sensors. Just like humans and animals using their senses, sensors help the robot or AI understand the world around it.

[3] The complete AI4K12 guidelines, sample activities, readings, and other resources are at ai4k12.org.

- **Representation and Reasoning** (explored in lessons 2 and 3): AI can process the information it takes in from its sensors and other inputs. It uses the information to make decisions.
- **Learning** (explored in lesson 2): AI can store and even learn from the information it gathers, so it can get better at tasks. Simple robots like KIBO may not be able to learn from their experience, which is a big difference between KIBO and other AI systems.
- **Natural Interaction** (explored in lesson 4): AI can communicate with humans in a natural way, such as through conversation or lifelike behaviors and appearances. These attributes can make it easier for humans to relate to AI and robots.



AI4K12's "Five Big Ideas in AI"

- **Societal Impact** (explored in lesson 5): Human engineers decide how AI and robots will be used. We need to make sure these systems are used in positive and helpful ways. Our students will be those engineers of the future!

Please visit <u>**kinderlabrobotics.com/curriculum**</u> for more information about KIBO curriculum and standards alignment.

Ready to get started?

Curriculum at a Glance

Thinking with KIBO is divided into five lessons. Each of the first four lessons require about 1 hour to complete. The fifth lesson is an integrated project which may extend across several meetings for a total time of 2–3 hours.

Lesson	Lesson Summary and Powerful Ideas
Lesson 1: AI and Automation	Students will explore the big ideas of artificial intelligence and see how they relate to their own experiences. They'll review some fundamentals of KIBO programming that relate to AI.
Lesson 2: Sensing and Organizing	A robot or AI system experiences the world through sensors and input. Most AI systems can only sense certain kinds of things. Limited input can make the world simpler for AI to understand (abstraction), but it can lead AI systems to make mistakes. **AI4K12 Big Idea(s)**: Sensing, Representation and Reasoning, Machine Learning
Lesson 3: A KIBO Rover	Students will create a rover robot that uses its sensors and programming to explore a new environment. KIBO will illustrate the "sense – think – act" cycle that is fundamental to both robotics and AI. **AI4K12 Big Idea(s)**: Sensing, Representation and Reasoning
Lesson 4: What is KIBO's Personality?	AI systems can be designed to interact with us the way we interact with each other: through natural language, speech, and even recognizing facial expressions and gestures. In this lesson students will explore this aspect of AI design. Students will learn that AI systems can seem alive without being alive. **AI4K12 Big Idea(s):** Natural Interaction
Lesson 5: KIBO Can Help Us!	Using KIBO's existing capabilities, both robotic and AI-related, students will design a Helper KIBO to make a positive impact. They'll consider the differences between the simple KIBO robot and more advanced AI, and they'll imagine what else their helper robot could do if it had more AI capabilities. **AI4K12 Big Idea(s)**: AI and Society

Lesson 1: AI and Automation

(1 hour)

Overview: Students will explore the big ideas of artificial intelligence and see how they relate to their own experiences. They'll review some fundamentals of KIBO programming that relate to AI. They'll gain practice with creating programs using repeat loops that allow KIBO to operate independently.

Learning Goals: Students will:

- Become familiar with the definition of artificial intelligence.
- Understand parallels between AI and robots.
- Practice creating loops with KIBO's REPEAT: FOREVER statement.

Lesson Plan

Inspire: An Introduction to AI

"Today we will start to explore the idea of 'artificial intelligence' or 'AI'." Introduce the term "Artificial Intelligence" or "AI". Ask students if they have heard this term – perhaps from their parents, or in stories and movies - and encourage them to share their ideas and impressions.

"One definition of 'Artificial intelligence' is when engineers make a computer or robot sense what is happening and react to it. Human engineers decide what the computer or robot should do. They give the robot rules like 'if it's dark, you should turn on a light.'" Ask the students to think about programming they've done with KIBO before, and share times they've decided on rules like this.

"'Artificial intelligence' involves rules like this too. But an AI system combines lots of these rules at once. Sometimes AI systems can be so complicated and have so many rules, they can do amazing things like drive a car by themselves or answer spoken questions. We will explore how some of these systems work using KIBO!"

Connect: Real World AI

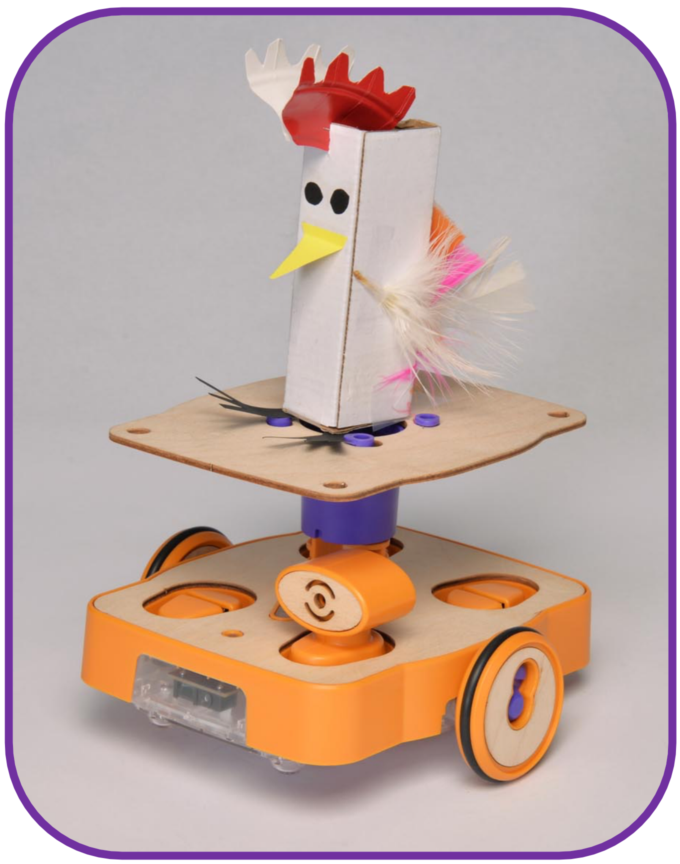
Optionally, play a video about real-world examples of artificial intelligence[4]. Ask students if they know of any systems that use AI that they might encounter during their day. Some examples to contribute if they aren't sure:

- Self-driving cars
- Voice assistants like Amazon's Alexa or Apple's Siri
- Home automation systems that turn lights on automatically at night
- Finding routes in Google maps
- Space probes and rovers that operate on their own
- KIBO!

Review the list afterwards. For each example, ask students to talk about what the computer is doing that is either like or not like the way a person thinks. You might also share if *you* have used AI to help you teach, such as for assessment, tutoring, or lesson planning.

Engage: Repeating a Task

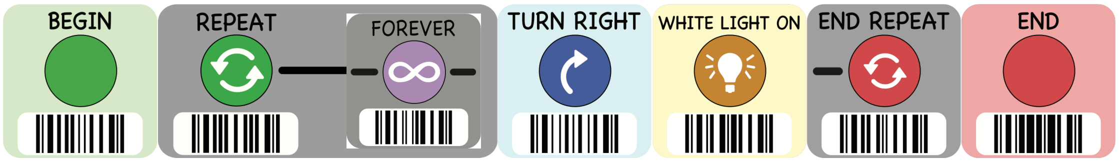
One of the powerful ideas of robotics that relates to AI is the concept of **automation**. For the main activity, students will practice and refresh their KIBO loop coding skills by creating a robot that *operates independently*. "**Automation** refers to the ability of a computer system, or robot, or AI to carry out a task over and over by itself. Robots and AI don't get tired of repeating the same task over and over again! That's one of the ways they can be helpful to people."



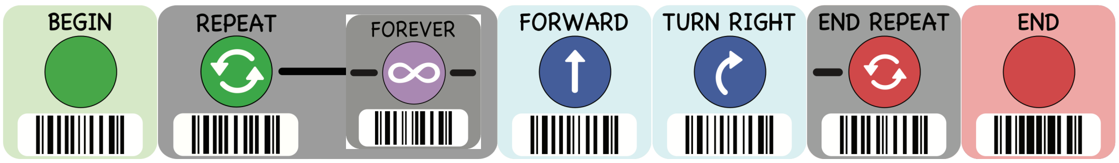
With KIBO, we can explore the concept of automation through the REPEAT and END REPEAT blocks. For today's group activity, ask the students to imagine something they'd like a helpful robot to do that requires the robot to do the same thing over and over again. Each group should decide on a helpful behavior, then represent this helpful behavior in a KIBO program inside a REPEAT: FOREVER loop.

[4] Some suitable videos are linked from KinderLab's curriculum page at kinderlabrobotics.com/curriculum.

Some examples/prompts for REPEAT: FOREVER programs:

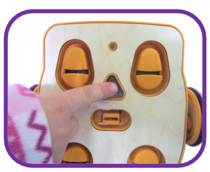


A KIBO light house that rotates and shines a light in each direction



A KIBO guard that patrols the castle walls in a square

A KIBO bird that sings and hops from branch to branch



Tip: To stop a REPEAT: FOREVER loop, just press KIBO's triangle button again while it is still running. (Also, a KIBO running a loop will shut itself off after about 15 minutes to save battery power.)

Reflect: How is KIBO helping?

Ask students to describe and share the program they created. What helpful activity is their automated robot doing? If they could imagine any sort of helpful robot, what kinds of things would it do? Would it need to be able to see, or hear, or speak with people, to help better? (We will explore these additional capabilities in future lessons!)

Background for the Teacher

A helpful definition of AI comes from the Association for the Advancement of Artificial Intelligence (aaai.org): "AI is a collection of techniques that allow computers to do things that, when people do them, is considered evidence of intelligence." This definition highlights the fact that AI systems don't need to *be* intelligent – they simply are able to do things that we associate with intelligence, like understanding speech, producing written text, organizing information, and operating independently. The techniques referred to include computer science breakthroughs in machine learning, signal processing, and automation. We will engage with these capabilities and techniques, in simple terms, through these lessons.

Lesson 2: Sensing and Organizing
(1 hour)

Overview: A robot or AI system experiences the world through sensors and input. Most AI systems can only sense certain kinds of things. Limited input can make the world simpler for AI to understand (abstraction), but it can lead AI systems to make mistakes.

Learning Goals: After this lesson, students will:

- Understand that robots and AI take in information using sensor input.
- Understand that AI can use abstraction to organize information based on simple criteria.
- Understand that AI can learn from information it receives, but simple robots cannot.
- Be able to create a program to organize information taken in by KIBO's sensors.

AI4K12 Guidelines Addressed:

- 1-A: Sensing
- 2-A: Representation
- 3-A: Nature of Learning
- 3-C: Datasets

Lesson Plan

Inspire: Sensors to Experience the World

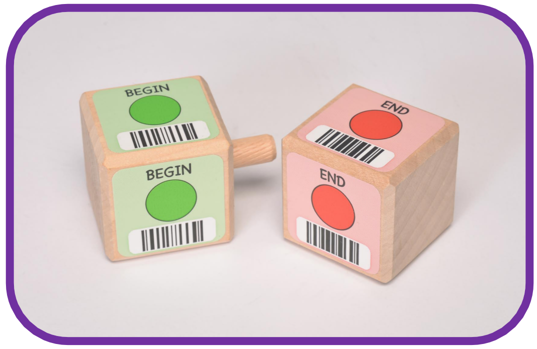
"Today we will explore some of the ways robots and AI systems experience the world. Just like we have parts of our body that let us hear and smell and see, robots have **sensors** to let them take in information. KIBO has sensors. Can you name them?" Guide the students in a refresher about KIBO's "ear" sound sensor, "eye" light sensor, and "telescope" distance sensor.

"When we use our senses, the information goes to our brains, so we can think about what we have experienced. AI doesn't think in the same way we do, but it does **process** the **information** that comes from its sensors." Review the WAIT FOR CLAP, REPEAT, and IF blocks, along with the sensor parameters (LIGHT, DARK, NEAR, and FAR, along with the UNTIL… versions).

"Because AI can't think the way we do, it's important to simplify the information coming from the sensors. With KIBO, the light sensor can only sense "light" or "dark"; it can't sense color. The sound sensor can only hear a loud clap; it can't understand words. Even in a more complex AI system, information is simplified in a way that makes it easier for the computer to work with. This process is sometimes called **abstraction**. Today we'll play a game that introduces this idea."

Connect: Sorting Game

This group game will engage with **abstraction**, which is one of the tools AI systems use to analyze the world. Complex objects can be viewed as a collection of simple properties, like color, size, and shape. For example, a KIBO END block might be viewed as "red," "small," and "square." But which properties we (or AI) choose to focus on can have a big impact on how we understand the things we look at.



For this game, use some of KIBO's parts (body, sensors, light bulb, wheels and motors) and some of KIBO's programming blocks. You can include other objects too, such as items from nature or familiar classroom items. Put all the objects in the center of the circle. Ask children to suggest ways that we might group these objects together based on what we can observe about them. They might suggest attributes like shape, color, material (wood or plastic), purpose (building KIBO or programming KIBO), or anything else they observe or wonder about.

As the children suggest ways to group the objects, record their ideas on a flipchart and test them out by physically moving the objects into new groupings. When something is unclear, engage in a discussion to decide together which group an object belongs in. Emphasize that sometimes something doesn't clearly belong in one group or another, but an AI system using abstraction must choose.

Encourage students to notice how some objects end up in the same or different groups based on which criteria we use. For example, when grouping by material, all the wooden programming blocks will be in one group and all the plastic KIBO parts in another. But when grouping by color, KIBO's orange BEEP and SING blocks may end up in the same group as the orange plastic sensor parts.

Discuss with the students how KIBO would handle this game. "How we group things depends on what we can perceive about them. If a robot or AI were trying to group the objects by color, it would need a color sensor to do it! Could KIBO group objects by color? What groups could KIBO make using the sensors it does have?"

Engage: Light Detector Robot

"In this activity, we will use one of the sensors available to KIBO – the light sensor – to explore and learn about KIBO's environment, the classroom! We will use KIBO's sensor to **sort** the classroom into light and dark areas, just like we sorted objects in our sorting activity."

Demonstrate the following simple program using IF and END IF blocks:

Ask the children to predict what KIBO will do. Now run the program in a brightly lit area. The KIBO will beep, but that's all. Now move KIBO to a dark area and run the program again. The IF statement means KIBO behaves differently based on the sensor input: light or dark.

"KIBO's program allows it to detect darkness. We just 'sorted' those two spots in the classroom: one light, and one dark. Because KIBO's light sensor can only detect light or dark, that's all KIBO can tell us about the room."

Draw a simple map of the classroom on a flipchart sheet or whiteboard. Assign each group to a general area of the classroom. Ask each group to design a program using KIBO's light sensor. In their program, KIBO should react to the sensor condition in some way. They can use a program exactly like the one you demonstrated or design their own.

They will need to use either:

- IF/END-IF blocks with LIGHT and DARK parameters; *or*
- REPEAT/END-REPEAT blocks with UNTIL LIGHT and UNTIL DARK parameters.

Beyond that, students can experiment with their own different program designs.

Groups will then use their programmed KIBO "light and dark detectors" to explore the locations within their area of the classroom. By running their KIBO program in different spots, they can record what they learn about the light and dark locations within their area. You can merge what they discover back into the classroom map on the flipchart. In this way, the class will use KIBO's sensors to "sort" the whole classroom into light and dark areas.

Reflect: What Can KIBO See?

Gather the students to review the map they created together. Allow students to share the detector programs they created. Discuss the results of the process with them. Were they surprised at all about what KIBO detected? Were there areas of the room that KIBO reported as "dark" that the children thought were light? KIBO's sensors don't work exactly like human eyes, and this is one of the ways that AI and robots can sometimes surprise us.

Reflecting on the map that the class created together, ask them whether KIBO itself learned anything about the classroom. Could KIBO use the map to avoid certain areas and navigate a path through only lighted parts of the room?

In fact, KIBO has no way to remember what its sensors experienced and use that information in a new program. This limitation is one of the biggest differences between a simple robot like KIBO and a more complex AI system. An AI system can "sort" using abstraction like KIBO, but it can also remember what it learned about the objects and use that information to help it operate in the future.

"In our next activity, we will teach KIBO to navigate on its own, based on KIBO's sensor input and the program we create. But even with a more complex program, KIBO cannot remember what its sensors detect or learn from it."

Lesson 3: A KIBO Rover
(1 hour)

Overview: Students will create a rover robot that uses its sensors and programming to explore a new environment and operate independently. KIBO will illustrate the "sense – think – act" cycle that is fundamental to both robotics and AI.

Learning Goals: After this lesson, students will:

- Understand that AI and robot behavior can be understood as "sense – think – act."
- Be able to create a program for KIBO that uses sensor data to act independently.
- Understand that robots and AI's ability to operate independently is limited by their sensors and programming.

AI4K12 Guidelines Addressed:

- 1-A: Sensing
- 1-B: Processing
- 2-C: Reasoning

Lesson Plan

Inspire: Sense – Think – Act

"Today we will create KIBO Rovers to explore a new environment. We'll use what we know about KIBO's **sensors** and **programming** to make KIBO operate on its own."

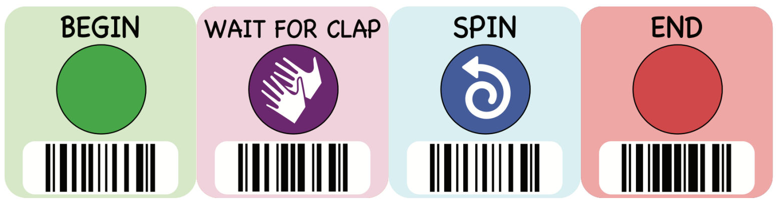
"Rovers and explorers are real-world robots that sometimes have to operate far away from people, so they need to be able to act on their own." Ask students to share ideas for places that would be interesting to explore but difficult for humans to go to. This could include other planets like Mars or Venus, difficult to reach places like dark caves, or environments like the deep sea where humans can't survive. What about these places make robots more suited for exploration?

"Sometimes scientists can remote-control these explorer machines, like they were driving a car. But other times they use artificial intelligence to let these explorer robots make decisions themselves about what to do next. Robots can use their sensors and their programs to decide what to do. We call this the '**sense – think – act**' cycle."

Talk to the students about each of these steps:

- **Sense**: robots use their sensors to gather information. Ask the students to recall examples of KIBO's sensors and what they can detect.
- **Think**: robots use their programs to make decisions based on what their sensors tell them. Ask the students to recall examples of KIBO's conditional programming blocks (WAIT FOR CLAP, IF/END-IF) and how they represent decision-making.
- **Act**: robots act (such as by moving) based on their decision. The actions they can take are also determined by their program.

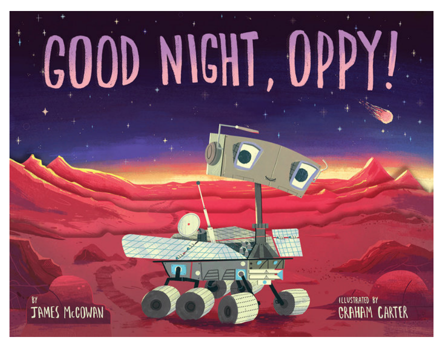
With a KIBO equipped with the **sound sensor** (ear), demonstrate this program:



Discuss with the students how KIBO's sensors and program illustrate each element of **sense – think – act**. Ask students to share ideas for more complicated programs that use this cycle. We will explore their ideas in the group activity.

Connect: Read *Good Night, Oppy!*

Read *Good Night, Oppy!* by James McGowan and Graham Carter[5]. This book follows the NASA Opportunity rover on its mission to Mars. Several AI and robotics related themes are included, such as what sensors Opportunity used to explore its environment and how the Earth team communicated with the rover across long distances. For older students, the book includes optional side passages with additional material about space exploration.



Afterward, reflect with the students on the way the author represented the communication between Opportunity and the NASA team on Earth. What decisions was Opportunity making using the sense – think – act cycle?

[5] If you don't have access to the book, a teacher-created read-aloud video is linked from KinderLab's curriculum website at kinderlabrobotics.com/curriculum.

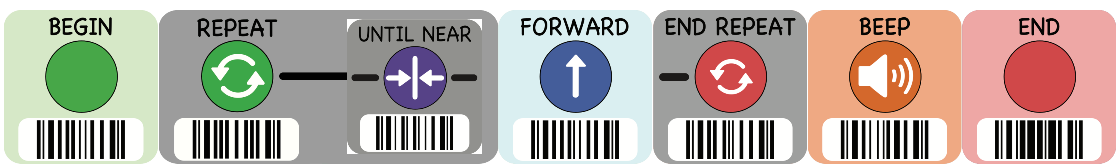
Engage: Exploring a Distant World

"Now it's time to create our own robotic rovers!" Each group will design a KIBO program to explore an environment using the sense – think – act structure. Allow students to design their own programs including the following elements:

- Wheels and motors to allow KIBO to explore the environment;
- At least one sensor;
- Conditional program elements such as REPEAT: UNTIL…, IF/END-IF or WAIT FOR CLAP driven by the sensor;
- An action to take based on the sensor input.

Here are examples of programs the students might create, drawing on prior work they've done with sensor programming. Share these examples if students need guidance:

KIBO will travel forward once, then check if the environment is dark. If so, it will turn on its light to make the environment safer for human explorers later.



KIBO will keep rolling forward, checking to see if an obstacle is near. When it reaches an obstacle, it will beep to let the scientists know it found something!

Tip: Optionally, students can use the IF NOT block from the Advanced Coding Extension Set to create more sophisticated "think" behavior.

Students can use art and craft materials to decorate their rovers. What features might be useful in navigating the environment they're exploring: fins and tanks for an undersea robot, or big wheels and solar panels for a Mars explorer? Let the students be inspired by their imaginations when decorating their KIBO rovers!

Reflect: Advantages and Disadvantages of AI Explorers

Allow each group to demonstrate their rover robot. They should explain how their robot engages in the sense – think – act cycle. They should also describe the environment their robot is exploring, and how the independent action of the AI program allows the robot to perform its task.

Discuss with the students: Compared to humans exploring dangerous or challenging environments, what are the advantages of AI-driven robotic explorers? What are the problems or limitations? What if a robot encountered something completely unexpected?

Lesson 4: What is KIBO's Personality?
(1 hour)

Overview: AI systems can be designed to interact with us the way we interact with each other: through natural language, speech, and even recognizing facial expressions and gestures. In this lesson students will explore this aspect of AI design. Students will learn that AI systems can seem alive without being alive.

Learning Goals: After this lesson, students will:

- Understand that robots and AI can be made to seem alive, but that they are not alive.
- Understand that natural interaction, like speech or facial expressions, can make robots and AI easier for people to use.

AI4K12 Guidelines Addressed:

- 4-A: Natural Language
- 4-C: Understanding Emotion

Lesson Plan

Inspire: Talking With AI

"We interact with computers and robots in many different ways throughout our days." Ask the children to share some of the ways they or their family members interact with computers, like on a screen, phone, or tablet.

"To make computers easier to use, programmers and engineers design AI to allow people to interact with AI as if it were a person. We can speak to AI assistants like Alexa or Siri and they can respond by speaking back to us."

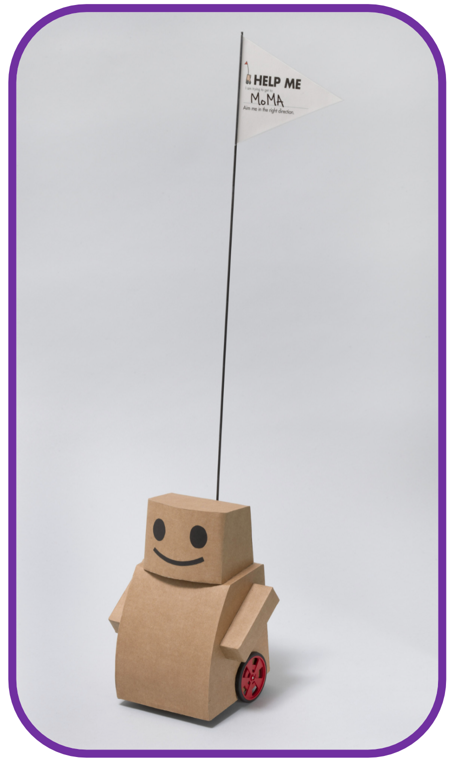
Ask students if they have experienced any computers – like Amazon's Alexa or Apple's Siri – that speak with them.

Ask students to share the feelings they have had when interacting with AI assistants like this. Was it similar or different from talking to a real person?

"When we interact with AI systems like this, the systems seem like they are 'alive' or have feelings. This feeling can make these systems more useful; for example, it's easier to use a computer program that you can just talk to. But it's also important to remember that AI and robots are not alive, and when they seem like they are alive or having feelings, it's just part of the programming that the human engineers designed."

Connect: Helping a Lost Robot

"Artist Kacie Kinzer created a simple cardboard robot named Sam the Tweenbot with a cute face, and a flag asking for help getting to a particular place in her city of New York. The robot couldn't steer or navigate at all; it didn't even have sensors like KIBO. It just rolled forward, getting stuck on curbs, falling over, getting turned around. But every time it got stuck or trapped, people passing by would stop to help it along. Sam's story was even shown as an exhibit at the New York Museum of Modern Art!"



Tweenbot image: www.moma.org/collection/works/145467

Show the children the picture of Sam the Tweenbot at the New York MoMA website here: https://www.moma.org/collection/works/145467

You can also play the 3 minute video found here: http://www.tweenbots.com/.[6]

Ask the children why they think people were so helpful to Sam and the other Tweenbots. Did elements like the cute face encourage people to respond positively? What about the flag asking for help?

Engage: Robots that Seem Alive

In this open-ended activity, each group will program and decorate a KIBO robot that "seems alive." They should begin by imagining a character or personality for their KIBO. Then think about how to express that personality through both programming (behavior) and decoration (appearance). Encourage groups to consider how the behavior they program can be made responsive to the environment or people around it. Their goal is to create a robot that seems alive and intelligent to the people who interact with it.

Tip: Ask the groups to spend some time planning and designing before they begin building. This would be a great time to review the Engineering Design Process, with its familiar steps: Ask, Imagine, Plan, Create, Test & Improve, and Share.

Students can use KinderLab's *Engineering Design Journals* to document their process.

[6] Tweenbot resources are linked from KinderLab's curriculum website at kinderlabrobotics.com/curriculum.

Some examples of responsive, "alive" robots the students might create:

- A clumsy robot that moves independently around the classroom, like Sam the Tweenbot, but reacts by saying "Oh, excuse me!" (using the KIBO Sound Record / Playback Module) when bumping into an obstacle (using the "telescope" distance sensor).
- A skittish robot that drives forward and says hello, but gets startled and runs away when it hears a loud clap (using the "ear" sound sensor)
- A musical bot that gives a performance when the spotlights shine on it (using the "eye" light sensor) but which hums quietly to itself when the spotlights are off.

Tip: KIBO's **Sound Record / Playback Module** allows students to record their voices, music, or other sounds and play back the sounds in their programs. This module is very helpful in creating expressive behavior. It is included in KIBO 21 kits or higher, and it is available for purchase separately at shop.kinderlabrobotics.com.

Encourage the children to try a variety of decorations to give their KIBO a personality matching the behavior. Ideas include:

- Drawing a face on KIBO's whiteboard Expression Module. (A second face, with a different expression, could be waiting on the reverse side!)
- Putting a favorite classroom stuffed animal on KIBO's art stage.
- Building a cute bot inspired by Sam the Tweenbot.

Reflect: How Did You Feel?

Allow plenty of time for groups to demonstrate their "alive seeming" robots. If you have time, rotate the groups and allow students to interact with other groups' robots independently.

At closing circle, ask students to share what feeling or personality they were expressing. Ask students how it felt to interact with other groups' robots. Did they feel that the robots had strong personalities of their own? What elements of the designed behavior and appearance gave them those feelings?

Discuss with the students: If a robot or AI is designed to seem alive or intelligent, is that a good thing? Can seeming alive make a robot or AI more helpful to people? Can the students imagine any problems that might arise from people believing that robots or AI systems are alive or intelligent?

Lesson 5: KIBO Can Help Us!
(1 – 3 hours)

Overview: Using KIBO's existing capabilities, both robotic and AI-related, students will design a Helper KIBO to make a positive impact. They'll consider the differences between the simple KIBO robot and more advanced AI, and they'll imagine what else their helper robot could do if it had more AI capabilities.

Learning Goals: After this lesson, students will:

- Understand that the goals of AI systems are defined by people.
- Understand that robots and AI can be helpful when designed to help.
- Be able to create a "helper robot" prototype and describe the additional helpful abilities AI might give this helper.

AI4K12 Guidelines Addressed:

- 5-A: Ethical AI
- 5-D: AI for Social Good

Lesson Plan

NOTE: You may wish to conduct this lesson as a multi-meeting integration project, to give students more time to create, test, improve, and share. You can organize the individual meetings in whatever way makes sense for you and your class. A typical extended KIBO project might flow like this, spread out over multiple meetings:

- Circle time, readings, games, and movement activities to introduce the project;
- Small group time to imagine and plan;
- Circle discussion to share plans;
- Small group hands-on time to create;
- Circle discussion to share challenges and successes;
- Small group time to test and improve the creation;
- Final showcase to reflect on the process and share the projects.

Inspire: AI Designed to Help

"We've learned a lot about artificial intelligence and robots. We've also talked about some things — like learning from its experiences or having conversations — that KIBO can't do but more advanced AI systems can. What are some other ways that KIBO is like or different from other AI systems we talked about?" Let the children share their observations and ideas based on the experiences of the previous lessons.

"One of the most important things about the design of any robot or AI system is how it can help people. Some robots or AIs do helpful things like assisting people in doing their jobs, or guiding people who are lost, or answering questions. Human engineers decide what these systems should do. If a robot or AI is helpful, it's because a human engineer designed it to help." You can share examples, such as AI helping climate scientists predict weather patterns over long periods of time by analyzing huge amounts of data about temperature, wind, sunlight, and more; or AI helping doctors diagnose diseases by comparing information about many patients and many symptoms all at once.

Ask the students to share their ideas for the kinds of abilities that a super-advanced AI KIBO might have that could help people. Reminding students of the sense – think – act cycle from Lesson 3, ask the students what the KIBO they imagined would need to sense, or evaluate, or remember, or be able to do, in order to help in the ways they imagine. You can record these advanced capabilities on a flipchart to refer to later in the lesson.

Connect: What Problems Can We Solve?

Divide the children into groups or pairs. Ask each group to brainstorm and share some challenges or difficulties they know about in the world or their own lives. These could be very immediate challenges, like how it can be hard to get to school on time; or larger challenges faced by the world like pollution or forest fires. After the groups spend a few minutes discussing challenges, gather them together and ask students to share. Record these challenges on a flipchart as well.

Engage: Imagine a Helper KIBO

"We've thought of some helpful AI abilities that a super-advanced KIBO might have. We've also thought of a lot of challenges people in the world face every day. Let's design some advanced AI-powered KIBOs to help!"

Review the advanced capabilities the students brainstormed before, and the problems or challenges they shared.

Ask each group to choose a challenge they feel inspired to address. Using KIBO's existing capabilities and the imagined advanced abilities from the brainstorming session, each group will design a Helper KIBO to make a positive impact. They can use *Engineering Design Journals*, or just sketch paper, to draw their design.

Some starting point ideas:

- A rescue robot that can locate the darkest parts of a forest to search for lost hikers, and then remember the shortest path back home.
- A companion robot that can ask questions and have conversations with elders living alone and can smile and laugh with them.
- A pollution-cleanup robot that can sense areas of the ocean with lots of plastic or chemicals, then safely gather the harmful materials without hurting fish or coral reefs.

Ask each group to create a "proof of concept" with KIBO using KIBO's existing parts. Even though KIBO doesn't have the advanced abilities they imagined, groups can create a program that represents the actions their helper robot would take. They can build decorations or attachments that represent the additional parts their robots might have.

Reflect: AI Robots for the Future

Conduct a "showcase" to give each group time to share and demonstrate their helper robot. During sharing, ask each group what additional abilities their imagined advanced AI robot has. What additional sensors does it have? How does it analyze or remember information, and how does it make decisions? What actions can it take?

Bring the unit to a close by asking the students to share what they know about artificial intelligence. What would they want *other* people to know about robots and AI?

Background for the Teacher

At mid-point technology circles in a longer integration project, invite children to share their in-progress work, and let them know that this is a time for questions and feedback. You may want to model for children what helpful feedback is, and lay some ground rules to avoid hurt feelings. Sample rules might include:

- If you say something you don't like about someone's project, also say something you do like.
- If someone is dealing with a problem that you also had, share how you solved it, or let them know you also have the problem and you can work together to solve it.
- Remember how you would feel if someone told you they don't like your creation that you worked hard on. Try to use words that wouldn't hurt a friend's feelings when you give your feedback.
- Use sentences that start with "I" (example: "I like...", "I notice...", etc.).

KIBO is a robot kit specifically designed for young children. With KIBO, children build, program, decorate, and bring their own robot to life. KIBO is entirely screen free, as children program their robots with "tangible code" made of wooden blocks. KIBO is the result of more than 20 years of research, led by KinderLab co-founder Professor Marina Bers, PhD., Director of the DevTech Research Group at Boston College.

To learn more, or to purchase KIBO for your classroom, visit our website at www.kinderlabrobotics.com. There you'll find more information about KIBO and its standards-aligned computer science curriculum, along with a wide range of add-on modules to support many hours of classroom STEAM activities from Pre-K to elementary grades.

Contact us at:

www.kinderlabrobotics.com

info@kinderlabrobotics.com

Social media @KinderLabRobot

7 Sun St, Waltham MA 02453, USA

KinderLab robotics