Robotics I and II

Extension Activities

Recommended Grade Levels: Grades 5 – 12

Major Concepts

- Energy
- Circuitry
- Programming

Key Words

Energy – In science, we say that energy is the ability to do work, but by 'work,' we can mean a lot of different things! Energy is 'at work' anytime something lights up, makes noise, or moves.

Circuit – A circuit is a continuous line or route that starts and finishes at the same place. Energy flows through circuits, but only when they're complete and continuous. 'Breaking' a circuit at any point causes energy to stop flowing through the whole thing. What other words can you think of that include the *circ-* prefix? What do you think *circ-* means? (It means "around" as in the way you sit at a circus, a circle, its circumference, how blood circulates, or how sailors circumnavigate the globe!)

Program – A program is a multi-step set of instructions coded for the automatic performance of a particular task.

Robot – In science, we classify robots as tools that can do work that's too dirty, too dangerous, or too distant for humans to do. Can you think of a robot that does work that's too dirty for a human? Too dangerous? Too distant? In order to be a robot, something has to be programmable. So think about it:

- Is a vacuum cleaner a robot? (No… it's not programmable. It can simply turn on and off. However, a Roomba style self-directing cleaner *is* a robot, as it skates around a room programmed to avoid obstacles using sensors.)
- Is a microwave a robot? (Yes! It's programmed so that a touch of the "popcorn" button cooks the popcorn, measuring the steam produced until just the right amount is sensed.)
- What about a toaster? (Not a robot… The knob you turn simply instructs a timer. There's no set of coded instructions for automatic performance!)
- A car wash? (Yes! Car washes are robots programmed to activate and deactivate different elements like brushes, soap, and water as cars pass through.)

COSI Connection

COSI's **GADGETS** exhibition explores how simple machines, force and motion, energy, and engineering power the world around us.

- Take a look at the pair of white robots at the entrance to the exhibit and press one of the buttons to activate their programming. These robots are programmed to entertain and inform, but what do you think they could be used for in the real world?
- Against the curved wall at the rear of the exhibition along with a lineup of energy activities, you'll find circuits you can build. How can you connect multiple items together and still allow energy to flow successfully through the circuit?
- Energy is at work in the world around us wherever things light up, make noise, or move. Can you find something that lights up inside of Gadgets? Something that makes noise? Something that moves?

COSI's **ENERGY** exhibition challenges you to become an Energy Explorer to see how energy is at work in the Product Zone, the Home Zone, and the Transportation Zone.

- Follow the red track overhead to the Home Zone packed with appliances – microwaves, refrigerators, laptops, ovens, and more. Your goal in the exhibition is to predict which appliances you think are "energy vampires," using energy even when they're not in use. But which appliances are robots and which ones aren't?

COSI's **OCEAN** exhibition plunges you into the sea for an inside look at our planet's most precious resource – water – and our lifelong connection to stories of the ocean.

- Inside the undersea tunnels, take the path to the right to travel to the DSB Poseidon, a research sea base built around the wreckage of the *S.S. Indomitable*. How can we use robots (including remotely operated vehicles or ROVs) to explore the parts of the ocean too dangerous and too distant for humans? What jobs can robots do?

Additional Resources

- *The Three Little Aliens and the Big Bad Robot* by Margaret McNamara (Grades 1 – 2)
- *Norton and Alpha* by Kristyna Litten (Grades 1 – 2)
- *The Wild Robot* by Peter Brown (Grades 2 – 5)
- Robotics: A Brief History (https://cs.stanford.edu/people/eroberts/courses/soco/projects/1998-99/robotics/history.htmlWEB 2)
- Kinds of Robots (http://www.mind.ilstu.edu/curriculum/medical_robotics/kinds_of_robots.php)

Robotics I and II

ACTIVITY A: Human Programming

- **Objective:** Students will create, test, and refine a step-by-step set of instructions to program a "robot" to complete a simple task.
- **Time:** 15 – 20 minutes
- **Grade Levels:** Grades 5 – 8

Materials

- Chair
- Masking tape
- Paper
- Pencils
- Yard sticks / rulers

Key Words

Program – A program is a multi-step set of instructions coded for the automatic performance of a particular task.

Introduction

Robots don't always speak English. If we want a robot to do something, we need to give it directions in a way it understands. We call that **programming**. When we instruct a robot with a program, we give it a set of coded instructions to follow one-by-one.

What To Do

Explain to students that, today, they're going to learn how to program robots by programming *you*, the teacher! Their mission is simple: to get you to sit down in a chair. At the front of the room, set out a chair and use masking tape to mark off its position, then stand several feet behind it and use tape to mark your "starting" position.

Have students pair up. Instruct them to work together to develop a step-by-step program to get you to sit down in the chair. Remind them that you can't do anything impossible, like vault over the chair or fly. You may also provide a hint that they should number their steps and that the last step should be "Sit."

Stand in place and allow students to work together for 3 – 5 minutes to develop their program. Call one pair at a time to read their program aloud. You may wish to have the pair move to a set of chairs in the back of the room facing away from you, instructing them to read word-for-word without watching what you do (so that they don't alter their program as they go).

As students read one step at a time, you should act it out. However, when students say "take three steps," take three ENORMOUS steps; if they say "turn right," spin in a clockwise circle; when they say "take two steps," take two tiny, itty-bitty steps. When they say "sit," sit wherever you are! Reset yourself to the starting point marked out on the ground after each attempt and select another pair to read their program aloud word-for-word.

Allow a few pairs to try this.

Importantly, stop the session for a moment to question students about what they see.

If you tell a robot to take three steps, how far does it go? Is a giant step a step? Is a tiny step a step? Yes! Both are "steps," and a robot doesn't know what we mean by "step." What does a robot do when we say to turn to the right or left? It just spins in place! We haven't told it when to stop!

Now, have students flip the paper over and work with their partner to re-write their program, this time encouraging them to be specific. It may help to give an example of walking x number of floor tiles, or giving students yard sticks to physically come up and measure. Test with a few students.

Conclusion

If we want a robot to do something, we need to give it directions in a way it understands. We call that **programming**. When we instruct a robot with a program, we give it a set of coded instructions to follow one-by-one… but we have to be specific! We have to define what we mean by "move," "turn," or "go."

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ACTIVITY B: Memory Bytes

- **Objective:** Students will examine the many steps required to conduct a simple behavior and the limitations of robots' memory.
- **Time:** 10 – 15 minutes
- **Grade Levels:** Grades 5 – 8

Materials

- Chalkboard
- 10 – 12 playground balls / beach balls

Introduction

Robots don't have brains the way that humans do, but their microchips and processors can function a lot like a human brain. That includes having a **memory**. However, a robot's memory is stored in data units called **bytes**, and even the most sophisticated and advanced computers have limited bytes available for processing and memory.

What to Do

Explain to students that in order for a robot to understand a program, it must have enough memory to compute and "remember" all of the steps.

Select a student to come up to the front of the classroom. Task this student with being a "robot" who will learn a program. As a class, decide a seemingly-simple task you'd like to program the robot to accomplish. You may have the class vote among making a peanut butter and jelly sandwich, making a pizza, washing dishes, or writing the letter M or Z or B.

As a class, work to develop the program by writing it step-by-step on the board. For each task listed, hand the student a playground ball. Each ball represents data, or bytes of information. As more and more data is added, the "robot" will begin to be unable to process it and will drop the data.

Explain to students that even with a microchip storing massive amounts of data in a small space, computers cannot compare with the memory of the human brain. Each one of us has the ability to process enormous amounts of information about our environment, our senses, and memories, and our decisions. Consider, how do humans store information differently than robots?

Repeat the experiment as desired with different tasks and different students.

Conclusion

The development of microchips allowed robots to hold large amounts of data and processing power in a tiny space, literally allowing smart phones, cameras, and computers to become the essential devices we have today. However, even the most sophisticated computers have limited storage available.

The Bee-Bots we use in COSI's Beginner Robotics can hold up to 40 commands!

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ACTIVITY C: Rover Races

- **Objective:** Students will explore the challenges of operating remotely operated vehicles (ROVs) and problem solve solutions using a hands-on simulation.
- **Time:** 15 – 20 minutes
- **Grade Levels:** Grades 5 – 12

Materials

- Blindfolds
- Obstacles (Chairs, cones, ramps, balls, etc)
- Stopwatch
- Paper and pencils

Introduction

Robots are tools used in science to do work that's too dirty, too dangerous, or too distant for people to do. Can you think of a robot that does work that's too dirty for a person? What about a job that's too dangerous? How about too far away? One way we use robots is through remotely operated vehicles (or ROVs) that can explore places too dirty, dangerous, or distant while a human operator controls the robot from afar.

What to Do

Set up an "obstacle course" of chairs, cones, or other physical obstacles and explain the "course" to students. For example, it may be an underwater shipwreck with a relic to retrieve at the end.

Explain to students that in order to learn how remotely-operated vehicles work, they're going to pretend to become an ROV themselves to pilot through the course and retrieve the artifact.

Group students into teams of six and assign a role to each team member:

1. Team Navigator
2. Team Timer
3. Team Judge
4. ROV Member 1
5. ROV Member 2
6. ROV Member 3

First, the Team Navigator should proceed through the obstacle course, using the paper and pencil to record step-by-step directions (i.e. 3 steps forward, stop, 2 steps left, etc.)

Once the Team Navigator has recorded their sequence on the sheet, the first team's ROV will step forward with the three ROV Members in a line, hands on the shoulders of the person in front of them. Once the three ROV Members are in place, blindfold them.

To begin the experiment, the Team Navigator will call out their directions verbatim as written on the page, and the blindfolded ROV will proceed through the course. (NOTE: Instruct the Team Navigator that they'll need to read word-for-word, even if the ROV drifts off course! In many ROV missions, once the sequence of commands is sent, it's set - meaning that changes will need to be made later!)

The Team Timer will record the amount of time it takes to complete the course, and the Team Judge will watch for and record any "foot faults" – any time an ROV member touches an obstacle. Ask students watching, which is more important – speed, or accuracy? What would a scientist piloting an ROV say?

After team's initial test runs, re-try the course (or rebuild it in a new formation with a new item to retrieve) and begin again with the Team Navigator again, but this time, help them consider, how can we be more accurate when we describe? Encourage them to use "heel-to-toe" steps or say "turn 90 degrees right" or "turn 90 degrees left." How is driving a three-piece ROV different from walking the course alone?

Conclusion

Many participants think that remotely operated vehicles can be flown much like they drive their toy radio-controlled cars. They imagine a ROV pilot watching a computer screen showing the ROV in an underwater environment and moving a joystick to make it go. The reality isn't quite that simple! For some ROVs, the time it takes for a command to reach the ROV deep below the surface varies with the distance between the control panel and the ROV involved. This can prevent "joy-stick" driving in real time!

Would this have been easier or harder if the Team Navigator was in another room and couldn't walk through the course at the beginning and still had to come up with a program of steps? Consider that that's the reality of exploring the ocean or the moon with ROVs! If you're able to actually use a camera and monitor to act out this scenario, you may position a "Runner" student to bring the messages from the Team Navigator to the ROV Members, simulating the real communication delay experiences from here to the moon.

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ACTIVITY C: Build-a-Bot

- **Objective:** Students will explore how robots help scientists do work that's too dirty, too dangerous, or too distant for homes.
- **Time:** 30 – 45 minutes
- **Grade Levels:** Grades 5 – 12

Materials

- Cardboard
- Duct tape
- Scissors
- Glue
- Recyclables (cardboard tubes and bottle caps)
- Straws
- Markers

Introduction

Robots are tools used in science to do work that's too dirty, too dangerous, or too distant for people to do. Can you think of a robot that does work that's too dirty for a person? What about a job that's too dangerous? How about too far away? One way we use robots is through remotely operated vehicles (or ROVs) that can explore places too dirty, dangerous, or distant while a human operator controls the robot from afar.

What to Do

As students are brainstorming ideas about dangerous situations, write them down and put them in a bowl.

Explain to the students that they will be working in groups of 3 or 4 people to design a robot that needs to perform a specific task for humans.

Each group will draw a task from a bowl, then have about 20 minutes to design and build a small model of their robot using the materials provided.

They can present their robot to the class and explain the task they were given, some challenges they were faced with, and what special features they added for their robot to be able to perform its job. Is the robot able to go under water, extend its arms, or perform difficult maneuvers?

Conclusion

These robots are able to save lives by keeping humans from danger or hazardous material. They are also able to advance science by exploring distant places humans cannot go. Are there any examples of robots doing jobs that humans are able to do, but don't anymore? Why do we have robots perform these jobs for us, even though little to no danger is present? There are many reasons, like efficiency, reliability, and saving costs to name a few.