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5-E CLASSROOM STEM ACTIVITY:
ROBOTS RUNNING MAZES & MAKING ICE CREAM

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Here are some ideas for how high school teachers could use this story as a launching point for integrated STEM learning. Our activities follow the 5-E Learning Cycle Model, and the activity below is intended to last two to three 1-hour class periods (although portions of the activity could be used in shorter periods).

Part 1: Engage

Have your students read the article on page 20, and then pose the following questions:

1. Ask students about what knowledge they think is needed to program robots, like the ones in the article, and how this relates to science, technology, engineering and mathematics.
2. Bring to class a loaf of bread, peanut butter, jelly and two knives. Tell the students that you are a robot, and they need to "program" you to make a peanut butter and jelly sandwich.
3. Have the students raise their hands to give you a command. You should take their commands literally (e.g., if they say "Put the peanut butter on the bread," you should place the can of peanut butter on top of the loaf of bread).
4. Eventually, students should determine a logical sequence of well-specified instructions that will bring you through all the steps of making the sandwich. Discuss with the students what they learned about programming a robot from this activity (e.g., it can't think for itself, so our commands cannot be ambiguous; it is important that the order of the commands is correct; etc.)
5. Show the class the TEDx Talks video "You Should Learn to Program": *http://tedxtalks.ted.com/video/You-Should-Learn-to-Program-Chr*

Part 2: Explore

1. Divide students into groups of 3, and tell each group to draw a simple maze on 1-cm graph paper with a start and end point. Make sure they do not make mazes that are too complex as this would increase the time length of the activity.
2. Have each group trade mazes with another group, and then give the groups the following task:

> *Your goal is to write a program that will allow a robotic mouse who is sitting at the start of the maze to successfully reach the end point of the maze where cheese awaits. The robotic mouse only knows 3 commands (you must place in a number for X):*
>
> *a. ROTATE X: The mouse will rotate itself X radians clockwise or counter-clockwise.*
> *b. MOVE X: The mouse will move forward (if X is positive) or backward (if X is negative) X revolutions of its wheels. The mouse's wheels have a diameter of 1 cm.*
> *c. SENSEWALL-TURN: The mouse will move forward. IF the mouse touches a wall, THEN the mouse will stop and rotate π radians.*

Groups must write the series of commands to give the mouse to navigate through the maze.

3. Students should give their finished written series of commands to the group that created the maze, and that group should test out their commands to see if they are correct. If they are not correct, the commands are returned such that the group who wrote them can debug their commands.

Part 3: Explain

1. Each student group should present their final program, describing in detail what their process was for generating it and debugging it, and what challenges they encountered.
2. Discuss with the students whether the IF...THEN statement was useful, and what other computer-controlled systems they see in their everyday lives that might use IF…THEN logic.
3. Ask students what other kind of logical statements they have heard about or that they think might be useful when giving commands to robots. If students do not generate it themselves, bring up AND, OR and NOT commands and give examples of each. (Refresh your own memory: *http://education-portal.com/academy/lesson/boolean-logic-operators-expressions.html*)

Part 4: Elaborate

1. Tell students you have a new robotics design challenge for them to solve:

NASA is designing a robot to serve people ice cream at their Space Center in Houston, TX. Each customer must choose how many scoops of ice cream they want (NUM = 1-3), what type of ice cream they want (TYPE = 1-6), and what topping they want on their ice cream (TOP = 1-6). They can only choose one selection from each of the three menus. See the table below.

Number of Scoops (NUM)	Type of Ice Cream (TYPE)	Topping (TOP)
1. 1 scoop	1. Chocolate	1. Gummy Bears
2. 2 scoops	2. Vanilla	2. Nuts
3. 3 scoops	3. Strawberry	3. Rainbow Sprinkles
	4. Swirl Frozen Yogurt	4. Raspberries
	5. Cookies n' Cream	5. Whipped Cream
	6. Peanut Butter	6. No topping

NASA would like $5 to be the base charge for the ice cream (PRICE = 5). However, they would like to program to robot to modify this price amount using IF…THEN statements of the form "IF (some condition is met) THEN (PRICE = __)." NASA has these requests for you:

a. "We would like to reward people for making healthy decisions. We would like the machine to offer a discount to people who make an effort to choose a healthier option.

b. "Some of the options involve ingredients that are more costly and more difficult to store. We would like to charge people a premium if they make these choices."

Write a series of IF…THEN statements using AND, OR, and NOT that program the ice cream machine to satisfy these criteria. A simple example of such a statement might be "IF (NUM = 1) THEN (PRICE = 3)." This would only charge people $3 if they only got one scoop. However, your statements should also make use of AND, OR and NOT.

2. During the course of the investigation, students may realize that some combinations will have the price increased or decreased multiple times because they fall under different guidelines (both a and b above). Students will need to brainstorm how to accommodate this – one solution would be to write assignment statements like "Price = Price + 1." In this case, it would be important to discuss with students how the equals sign is used differently in programming languages compared to in algebra.
3. (Optional): You can show students a video of NASA's actual ice cream robot at: *https://www.youtube.com/watch?v=8LeNyc8JPbE*

Part 5: Evaluate

Have each student write in their journal the two most complicated logical statements their group came up with for their ice cream robot. Then have students explain in their own words what the statement means in English, and how they used that statement to satisfy one of the design constraints given to them by NASA.

Standards:

Next Gen Science Standards

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Common Core Mathematics Standards

CCSS.Math.Content.HSG.MG.A.3. Apply geometric methods to solve design problems.

CCSS.Math.Content.HSS.CP.A.1. Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not").

NOTES


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