The 2012 National Science Experiment, *4-H Eco-Bot Challenge*, explores how robots can be used to preserve and protect the environment, while offering a glimpse into the future of science, technology, engineering and math.
Introduction

In October 2012, millions of young people across the nation will become scientists for the day during the fifth annual 4-H National Youth Science Day (NYSD). NYSD is the premiere national rallying event for 4-H Science year-round programming. It brings together thousands of youth, volunteers and educators from the nation’s 111 land-grant colleges and universities to simultaneously complete the National Science Experiment.

The 2012 National Science Experiment, 4-H Eco-Bot Challenge will explore robots and how technology can be used to preserve and protect the environment.

Why Robots?

Robots have a huge impact on society and affect our lives every day. We use robots to assemble cars, manufacture cookies and create computer parts. They can be programmed to carry out dangerous missions or complete repetitive, boring chores — even give us directions when we are lost!

Exposing students of all ages to robotics through classroom and science projects can help them experience first-hand how robots and robotic technology works. It can help them discover new interests and career options, plus give them a taste of how this technology impacts and benefits human life today and in the future.

Exploring the capabilities and applications of robots offers a glimpse into the future of science, technology, engineering and math. It gives youth an opportunity to put inquiry science techniques into practice and grow more familiar with the engineering design process. Participants will experience firsthand what it’s like to work with the process tools scientists and engineers use each and every day to solve real-world problems.

4-H PLEDGE

I pledge my **Head** to clearer thinking, my **Heart** to greater loyalty, my **Hands** to larger service, and my **Health** to better living, for my club, my community, my country and my world.
The Experiment

The 4-H Eco-Bot Challenge is an engaging engineering design experiment that provides participants the opportunity to program an autonomous robot to clean up a simulated environmental spill — a mission that in real life would be too difficult or dangerous for humans to carry out.

Part One: Build Your Bot

Youth will assemble their own Eco-Bot, discover how it functions, what it can do well, as well as what it can’t.

Part Two: The Goal is Control

Youth will design a set of control surfaces to program the Eco-Bot to perform a simulated environmental cleanup project.

Part Three: Make a Clean Sweep

Youth will measure the effectiveness of their control surface by recording how much of the spill is “swept up” by the Eco-Bot.

Objectives and Outcomes

1. Increase interest in science and engineering through hands-on experiments that model robotics, programming and problem solving
2. Recognize what robots can do, how they are controlled and the role they serve in solving environmental problems
3. Employ the engineering design process by applying it to create control surfaces that mimic an Eco-Bot’s program
4. Evaluate the effectiveness of cleanup designs by measuring and monitoring the robot’s performance

Using this Guide

The facilitator guide for 4-H Eco-Bot Challenge features content found in the Youth Guide as well as additional information that can assist you in teaching and overseeing each part of the experiment.

Throughout the guide you will find:

Talk About It

Questions that can be used to facilitate group discussions and inquiry

LEADER NOTES

Additional background information and tips for facilitating each experiment

Take the Lead

Instructions for performing specific tasks related to the experiment.
GETTING STARTED

Take the Lead: The Challenge
Introduce the challenge by announcing to the group that they are all now robotic engineers who have been tasked with designing a solution for a very serious problem that recently took place on Bailey Beach:

Bailey Beach was the site of an unfortunate toxic spill. An old barrel that stored used insulation from fishing boat motors has rusted through and is beginning to spill out onto the surface of the beach. The Environmental Protection Agency (EPA) needs your help to establish a containment area on site. A containment area is a designated area in which a toxic material is held in order to prevent further contamination.

Since the spill is lightweight, there is concern that it will continue to move toward the water, which will pose a danger to the fish and plant life around the beach. Because the concentration of toxins in the barrel is unknown, there is also concern for the well-being of those who might attempt to clean up the spill.

Your fellow engineers have been talking and they think a new robot called an “Eco-Bot” might be able to help clean up the toxic spill.

Your challenge is to create a containment area and discover how to build an Eco-Bot that solves this environmental problem.

Let’s Talk ‘Bots

Take the Lead
Explain that they will “sweep” up the spill at Bailey Beach using an Eco-Bot, an autonomous robot that they will build and program themselves. However, before they start the experiment, it’s helpful to talk about robots in general.

Robots: What Are They? How Do They Work?
A robot is a machine that can be programmed to perform physical tasks or imitate some of the things that a person can do. Scientists developed the first industrial robots in the 1950s, and today they can be programmed to do almost anything — from vacuuming the house, to defusing bombs, to exploring the moon.

Some robots are programmed to do repetitious tasks, such as drill oil, assemble cars and manufacture cookies. Others are programmed to carry out missions that are too dangerous or impossible for humans to carry out, such as a space voyage or an environmental cleanup.

Some robots, such as robotic arms used in surgery, are monitored and controlled remotely by humans. Others robots, known as autonomous robots, are programmed to perform tasks on their own.
**TALK ABOUT IT**

*What do you know about robots?*

*How do robots “know” what to do?*

*What kinds of things have you heard or seen robots do?*

*What are things we haven’t used a robot for yet?*

*What are the possibilities?*

---

**The Science of Spills: Robots & the Environment**

On the surface, it may appear that robots have little in common with the environment. However, robots significantly contribute to the environment in a number of positive ways. They can clean asbestos from pipes, safely strip paint from ships, easily navigate through smoke and high temperatures and, as we will in explore in this experiment, clean up after a toxic spill or nuclear disaster.

A toxic spill is an unintended release of toxins into the environment that is capable of causing death or serious harm to humans, animals and/or plants. Toxic spills and accidents range from big to small and can occur anywhere chemicals are found, from oil drilling rigs and factories, to your local dry cleaner or tool shed. Although we usually think of a spill as involving a liquid, a chemical spill can also be a toxic gas or solid.

Because of their different chemical and physical components, toxins vary greatly in their severity, ranging from minor damage (such as a bee sting) to almost immediate deadly effects (such as botulinum toxin, one of the deadliest toxins known to man).

Toxic spills are bad news — both for humans and the environment. They can devastate wildlife and damage precious water sources. They can have lasting, negative effects on the air, water and soil as well as the humans and animals that inhabit the area.

Some toxic spills are immediately dangerous to wildlife and humans, causing burns, poisoning or physical harm upon contact. Other spills work more slowly, causing long-term illnesses and environmental problems. What starts off as a spill of toxic industrial chemicals can be washed away by floodwaters or other ground water and impact drinking water sources and compromise ecosystems way beyond the original spill.

Cleanup efforts are critical, but they can be also extremely dangerous to humans if people do not wear protective gear and follow adequate safety precautions. That’s where robots fit in.

From sniffing out toxins to collecting data from dangerous and hazardous locations, robots are increasingly being used to help scientists understand, combat and clean up toxic spills. In this experiment participants will create a simulation, or model, of how robots work to clean up spills.

---

**TALK ABOUT IT**

*Where are some places robots can go that humans cannot?*

*What dangerous or difficult problems can robots solve?*

*Can you think of how you might adapt a robot to better clean up toxins?*
Think Like an Engineer:

Engineers design solutions to problems. Robotics engineers design robots. At the heart of their work is the engineering design process, a highly flexible process used by engineers to produce solutions and develop systems and products.

The Engineering Design Process

The engineering design process includes seven basic steps:

1. **Identify the problem**

2. **Generate ideas:**
   Brainstorm possible solutions that might address those constraints.

3. **Evaluate and compare possible solutions:**
   Decide which of the possible solutions are the most logical or make the most sense.

4. **Build a prototype:**
   A prototype is a first attempt at a design and is built to test your hypothesis.

5. **Test the prototype:**
   Conduct a series of experiments to see if your prototype works.

6. **Tell your story:**
   Record your data to share what you learn with others.

7. **Refine your design:**
   Explore how you can use what you’ve learned to improve or change your design.

As part of the engineering design process, engineers may repeat these steps over and over again - refining and changing their designs until they get it just right.

As part of the 2012 National Science Experiment, participants will use the engineering design process to program their Eco-Bot.

The Experiment

Take the Lead: Setting Up

*Build an Eco-Bot before the session to use for demonstration.*

- Provide ample space for participants to assemble, play with and observe their Eco-Bot.
- In Parts Two and Three, work will be done in pairs or teams. Make sure participants have enough room to comfortably work and collaborate.
- Post steps of the engineering design process visibly in the room and have large newsprint or flipcharts on hand to record brainstorming and questions.*
BUILD AN ECO-BOT

Time Required: 30 minutes

OBJECTIVE

Have youth build an Eco-Bot in pairs. Allow them to discover how it functions and what it can do.

MATERIALS YOU WILL NEED:

The 4-H Eco-Bot Challenge supply kit contains:

- Oral-B CrossAction® Pro Health® manual toothbrush
- 10 mm pager vibrator motor with wires attached
- 3 cm piece Scotch® Foam Mounting Double-Side Tape #110
- 1 cm piece Scotch® Foam Mounting Double-Side Tape #110
- LR44 1.5 volt Button Cell Watch Battery
INTRODUCTION

Remind Youth of the Facts:

- Bailey Beach was the site of an unfortunate toxic spill and it is too hazardous for humans to clean.
- The EPA needs your help to establish a containment area to hold the toxic spill in place.
- They are proposing that a special robot, called an “Eco-Bot,” be used to solve this problem.

As engineers who will program an Eco-Bot to clean a simulated environmental spill, it is important for participants to understand what an Eco-Bot is and what it can do.

Take the Lead: Know Your Parts

Using the Eco-Bot you built earlier, demonstrate how it works on a large table or open space on the floor. Explain that all Eco-Bots have the following parts, each one designed to perform a particular function:

- **Scrubber** – Also known as a toothbrush head, it will be used to “sweep up the spill”
- **Motor** – Controls the scrubber
- **Foam mounting tape** – Holds each of the parts in place
- **Watch battery** – Acts as the power source for the motor
- **Red and black wires** – Connect the power source to the motor (Note: For best results, the insulation on each wire should be stripped back to .5 cm)
Understand How it Moves

A pager motor has an off-centered weight that unbalances the rotating part of the motor, causing it to vibrate. These vibrations pulse downward through the toothbrush’s angled bristles, causing them to “push off” and move the Eco-Bot forward.

**TALK ABOUT IT**

*How does the Eco-Bot work?*
*What parts are moving?*
*Which parts do you recognize?*

**Step 1: Bring Your ‘Bot to Life.**

Explain to the group that as robotic engineers, the first step is to build your Eco-Bot. Give each pair the supplies needed to build an Eco-Bot and explain how to put it together.

**Eco-Bot Assembly**

Remove the backing from one side of the 3 cm piece of foam tape and firmly stick it on the flat side of toothbrush head.

Remove the backing from the other side of the tape and gently push the motor on top of it with rotating part hanging off the back-end of toothbrush. This will allow the motor to spin without touching the tape. The wires should be positioned toward the head of the toothbrush.

Gently push the watch battery (+) side up onto the tape with the red wire underneath.

Turn the Eco-Bot on by pressing the black wire onto the battery with the 1 cm piece of foam on top.

**Step 2: Observe What It Does.**

Encourage participants to observe the action for 3-5 minutes and then ask everyone to turn off their Eco-Bots.

Explore that an Eco-Bot is an autonomous robot that is engineered to do only one thing — move forward. Its continuous forward movement is affected by touching the control surfaces. As the Eco-Bot encounters a control surface, it responds by turning, shifting position, or even falling over.

**TALK ABOUT IT**

*What did you observe about how your Eco-Bot moves?*
*What problems did you encounter?*
*What controls the movements of your Eco-Bot?*
*What sort of tasks do you think the Eco-Bot could be used to accomplish?*

**LEADER NOTES**

Establishing scientific habits of inquiry is essential, but requires practice and repetition. Make it fun, while promoting collaboration and communication within the group.

As the group works, be consistent in initiating discussions and encouraging them to ask questions.

Break from the activity regularly to give participants an opportunity to reflect on what they are doing, but keep the conversations short.

**Good inquiry questions to ask include:**

*What happened when you _____?*
*Why did you choose to use that (technique, material, method)?*
*What would you do differently?*
THE GOAL IS CONTROL

Time Required: 30-45 minutes

OBJECTIVE

Working in pairs, use the engineering design process to create a set of control surfaces to optimize your Eco-Bot’s performance in “sweeping up” the toxic spill on Bailey Beach.

MATERIALS YOU WILL NEED:

For each pair of participants you will need:

**Challenge Mat for Bailey Beach**

Suggested materials for testing environment:

- Piece 8.5 x 11 in. copy paper
- Piece 8.5 x 11 in. card stock
- Scissors
- (10) Flexible straws
- (10) 3-oz paper cups
- One 11 inch piece of masking tape
INTRODUCTION

In this experiment, we will create a “containment area” for the toxic spill. Control surfaces meant to contain the spill and direct the Eco-Bot are tested using straws, cardstock, and paper cups. The turning angles and the amount of friction and barriers that the Eco-Bot encounters are the variables participants can manipulate in programming the Eco-Bot to solve the simulated toxic spill challenge.

Take the Lead: The Role of Control

Before participants begin exploring how they might program their autonomous robot, initiate a conversation about control surfaces. Discuss what they are and what they can and cannot do.

Control Surfaces as Programming

All robots require programming or commands in order to complete tasks. One way that robots are programmed is through the use of control surfaces. Control surfaces are materials that restrict and redirect movements of a robot. They are a metaphor for the command structure of a computer program.

Autonomous robots have the ability to “sense” their environment (for example, through touch, sound, temperature or chemical changes). The robot’s movement can be programmed by what it touches, hears or feels, and then adapt its behavior accordingly. The Eco-Bot is “programmed” through touch when it comes into contact with the control surfaces.

TALK ABOUT IT

How can we program our Eco-Bots to go where we want them to go?

What are the control surfaces that might be involved for a robot that is programmed to vacuum, mow the lawn or work in a factory?

How might autonomous robots work in toxic spill cleanup situations?

The Engineering Design Process in Action

Explain to the group they will apply the engineering design process to do a simulated environmental cleanup. Review the steps in the entire engineering design process BEFORE students begin to work.

LEADER NOTES

Consider using these tips to encourage successful inquiry:

Allow time after each of the engineering design process steps to allow for reflection, observation and questions.

There are no right or wrong ways to do things. Help participants see the choices they make and understand their reasons for making them.

Do not solve their problems or give explanations. Instead assist them by asking questions such as: What works? What doesn’t? What have you tried and what happened? What has worked for other teams?
Step 1: Identify the Problem.
Show the group the Challenge Mat and revisit the details you presented earlier about the toxic spill on Bailey Beach.

TALK ABOUT IT
Where is the spill?
Why is it important to contain it?
What control surfaces will you use to program your Eco-Bot to cover the spill area?
What challenges do you have in containing the spill?

Step 2: Generate Ideas.
Encourage the pairs to brainstorm ideas for how to control the movement of their Eco-Bot by introducing control surfaces using straws, cardstock, and cups. This is an opportunity to test ideas using the materials, as time permits. Provide a few questions to help stimulate brainstorming:

TALK ABOUT IT
How can I “program” my Eco-Bot so that its movements will cover the entire area of the spill within the containment area?
Imagine what kinds of control surfaces you will design in order to program the Eco-Bot to cover this entire spill area.
How do the different materials affect the movement of the Eco-Bot?

Step 3: Evaluate and Compare Possible Solutions.
Ask each pair to choose their best ideas and create a plan for cleaning up the spill. Walk around and offer assistance and encouragement as each pair designs their plans.

Step 4: Build a Prototype.
Once they have sketched a drawing of their plan and you have approved it, give them a Challenge Mat, straws, cardstock, cups, a pair of scissors and a 11 inch piece of masking tape so that they can build their prototype. Remind them they can only use the materials they have been given.

Step 5: Test the Prototype.
Let the sweeping begin! Working in pairs, participants will determine how effective their materials are as control surfaces for their Eco-Bot. Place the Eco-Bot into the containment area and allow participants to observe the movements of the Eco-Bot and evaluate the success of their design.

LEADER NOTES
This is a good time to take photos of each pair of participants and capture their “solution” to the challenge.
Give each group 10 minutes to experiment. Remind them that they will have a chance to refine the design later in the engineering design process. Discuss the exercise as a group, recording any key observations and/or questions on a flip chart.
Step 6: Tell Your Story.

When it appears that most groups have built and tested a prototype, take a break. Gather everyone together to discuss their experiences and share their best ideas.

**TALK ABOUT IT**

- How did you use the materials to create control surfaces?
- What challenges did you experience?
- What other materials would you like to try?
- What questions do you have?

**LEADER NOTES**

Invite each pair or team to contribute their “best idea” and write it on a piece of newsprint. Encourage them to incorporate the ideas they like into their own designs.

**Examples might include:**

- Use two straws to create higher walls so the Eco-Bot cannot “jump” over.
- Create tunnels or mazes with cardstock.
- Divide the containment area in two parts and use two Eco-Bots to sweep simultaneously.

Step 7: Refine your Design.

Using the design process, ask a new question like: How can we make our Eco-Bot move more efficiently over the toxic spill? Explain that the engineering design process is like a circle. It repeats over and over as you work to refine and make adjustments to solve a problem.

**TALK ABOUT IT**

- How well does your design work?
- What problem would you like to fix?
- What could you do to improve the cleanup ability of your Eco-Bot?
Part 3

MAKE A CLEAN SWEEP

Time Required: 45-60 minutes

OBJECTIVE

How effective is your Eco-Bot? Can it clean up the toxic spill? Working in pairs, measure how much of the spill is “swept” by the Eco-Bots.

MATERIALS YOU WILL NEED:

Challenge Mat with control surface in place

(1) tablespoon of bird seed or rice

(2) Eco-Bots

Timer

Masking tape

Calculator (for calculating percentages)
3. Decide who will be the **Eco-Bot Analyst** (the person who operates the timer and serves as the recorder) and who will be the **Eco-Bot Engineer** (the person who can “touch” and monitor the Eco-Bot).

4. Review the Rules for the Eco-Bot Engineer.

**Rules for the Eco-Bot Engineer**

1. Only one team member can be an Eco-Bot Engineer.

2. If the Eco-Bot falls over, you must wait 3 seconds to pick it back up.

3. If the Eco-Bot gets stuck, you must wait 3 seconds to tap it or move it.

4. If the Eco-Bot leaves the containment area, you must wait 3 seconds to put it back.

5. You may only touch your Eco-Bot a total of 5 times during the 2-minute challenge.

**LEADER NOTE**

When youth have finished experimenting, consider the environment. Feed the birds your leftover birdseed or dump the rice in a compost pile.

**INTRODUCTION**

The Challenge Mat and Eco-Bot robot serve as models that are meant to show the appearance of something, and to help youth to understand the potential for using autonomous robots to cleanup a real spill.

**Take the Lead**

Participants will use birdseed to represent the toxic spill. When the Eco-Bot “sweeps” it out of the way, it can be assumed the spill has been “cleaned.” The grid on the Challenge Mat will allow participants to use a ratio to measure the amount of spill that has been cleaned.

In this experiment, the only independent variable is the control surface. It can be manipulated to influence the robot’s performance. The remaining variables are fixed variables that cannot be manipulated. In this way, as in real scientific experiments, participants will change only one variable at a time and compare the outcome.

**Step 1: Set Up the Simulation.**

*Encourage participants to work in pairs and set up their testing area:*

1. **Tape the Challenge Mat to a table or a flat surface.**

2. **Add one tablespoon of birdseed to the containment area within the control surfaces you created. Spread it evenly over each spot.**
LEADER NOTES

Explain that in this simulation, “touches” are considered “malfunctions.” Discuss what these malfunctions might mean in a real-world situation:

- An out-of-control robot
- A timing delay
- A need for human intervention
- Extra costs

Discuss why a robot that experienced no malfunctions and cleaned 80% of the spill area might be a better prototype than a robot that cleaned 90% of the spill area but had three malfunctions. This could be viewed as a trade-off in reliability versus capacity.

Step 2: Start Your Eco-Bot!

**Invite participants to begin testing their Eco-Bot:**

1. Place the Eco-Bot at any location on the Challenge Mat.
2. Set the timer for 2 minutes.
3. Turn on the Eco-Bot and start the timer.
4. Observe the movement of the Eco-Bot and follow the rules if it falls over, gets stuck or leaves the containment area.
5. Remove the Eco-Bot at the end of 2 minutes.

Step 3: Measure Your Eco-Bot’s Effectiveness

1. Instruct participants to collect their data:
2. Count the number of times the Eco-Bot Engineer touches the Eco-Bot.
3. Count the number of black spaces that are “swept” or completely clear of the contaminant.
4. Use the following ratio to calculate the amount of the spill that was cleaned. This will give a percentage (a fraction or ratio with 100 as the understood denominator) that expresses the effectiveness of the Eco-Bot.

\[
\frac{X}{125} \times 100 = \text{___________}% \text{ of effectiveness}
\]

- \(X\) = number of black spaces free from birdseed after 2 minutes.
- 125 = approximate number of spaces that are in the containment area.

Step 4: Repeat, Repeat.
Ask participants to repeat the Steps 1-3 two more times. Encourage participants to switch roles, allowing everyone the opportunity to be an Eco-Bot Analyst and an Eco-Bot Engineer.

**Step 5: Average It Out.**

Compute the average of the percentages and the number of malfunctions.

**Step 6: Share the Results.**

<table>
<thead>
<tr>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>_________%</td>
<td>+ _________%</td>
</tr>
</tbody>
</table>

+ Test 3
divided by 3

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>_________%</td>
<td>= _________%</td>
</tr>
</tbody>
</table>
Collect the results from all of the pairs or groups and calculate an average group percentage.

**TALK ABOUT IT**

**Discuss the amount of “touches”:**

*How do these touches represent malfunctions?*

*Were the touches necessary due to the design of the robot? Or the control surface?*

*How could you reduce the amount of touches/ malfunctions?*

*Examine the most successful designs. What do they have in common?*

*Collect ideas for next steps. What other tests could be done?*

**LEADER NOTES**

If you plan to do the Experiment Extension (page 20), now would an appropriate time to introduce the exercise.

**Step 7: Review Your Performance**

Encourage participants to share what they observed, what they learned and what they would do differently. This is also a great time to revisit the various lists and brainstorming the group created at earlier stages in the experiment. Discuss and explore how their thinking and understanding of robots has changed and evolved throughout the process.

**TALK ABOUT IT**

*What changes would you make to your control surfaces?*

*What characteristics/abilities does an autonomous robot need in order to complete a task like this one?*

*In what ways is this a realistic simulation? What makes it unrealistic?*

*How did the engineering design process help you when completing this challenge?*

*What role did you play during this activity that was particularly interesting to you? How could this be related to a future career or area of interest?*
Experiment Extension: THEORIES AND QUERIES

Time Required: 30 minutes
Remind the group that the engineering design process is a circular, never-ending process in which there is always an opportunity to design, test and observe new approaches, new ideas and new technologies. Encourage participants to spend a little time exploring different methods for improving the Eco-Bot’s performance.

**Step 1: Make a Scientific Guess**

Hypothesize cleanup efficiency results given the following modifications:

**LEADER NOTES**

<table>
<thead>
<tr>
<th>Modification</th>
<th>Hypothesis</th>
<th>Data and Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Two Eco-Bots cleaning at the same time.</td>
<td>5</td>
<td>62</td>
</tr>
<tr>
<td>2. Two Eco-Bots connected together using a 2 cm piece of foam tape.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Designing and adding a blade or wing to one Eco-Bot using a 3.5 x 5 cm 3M Post-it Note.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What ideas do you have?

Help them understand that they will compare the results of the modified Eco-Bot with the original test results to answer the question: Will this modified Eco-Bot be more effective? Yes or no?

**Step 2: Test Your Hypotheses**

Encourage participants to choose two modifications from the chart and repeat the experiment in Part Three. Collect the data and discuss whether their
hypotheses were correct.

**TALK ABOUT IT**

*What modifications were successful in increasing efficiency?*

*Were your hypotheses correct? Why or why not?*

*What redesign would you like to try?*

**Going beyond: Additional Activities**

Choose one of these activities for an additional engineering challenge, and to further apply and reinforce what youth have learned. Invite participants to choose an additional challenge to further apply and reinforce what they learned:

**Make it reality.** Find an opportunity for participants to participate in a local community cleanup effort and invite them to offer engineered solutions for making the cleanup easier or automated.

**Consider reducing materials to reduce costs and improve efficiency.** Redesign the control surfaces and provide engineering constraints by giving each team a budget. Charge “money” for tape, straws, cups and cardstock.

*Which design is the cheapest?*

*Does this impact the effectiveness?*

• Which design is the cheapest AND the most effective?

**Design your own challenge mats.** Create new measuring grids and use other materials.

**Spread the knowledge.** Encourage participants to educate others about autonomous robots by sharing this activity with younger children.

**Supersize the experiment.** Connect the challenge mats from end-to-end and use multiple robots to simulate a large-scale toxic spill.

**Explore career opportunities.** Investigate the role of engineers in robotics, environmental cleanups and chemical engineering. List the potential careers in each of these areas.

**GLOSSARY**

*Area* - the size of a surface, the amount of space
inside the boundary of a flat object. \( \text{Area} = \text{Length} \times \text{Width} \)

**Autonomous robot** - robots that perform tasks without continuous human guidance

**Control Surface** - materials (in this case straws, cups, cardstock) that restrict and redirect movements of the Eco-Bot

**Containment Area** - determined area in which a toxic material is held in order to prevent further contamination

**Efficient** - performing or functioning in the best possible manner with the least waste of time and effort

**Effective** - adequate to accomplish a purpose; producing the intended result, functioning at a set level

**Engineering design process** - a highly flexible process used by engineers to produce solutions and develop systems and products

**Hazmat** - hazardous materials

**Hypothesis** - an educated guess that uses information that we already know in order to estimate or predict the expected outcome

**Optimize** - to make as effective as possible or as useful as possible

**Model** - a representation, generally in miniature, that shows the construction or appearance of something

**Percentage** - a proportion or share in relation to a whole or part; a fraction or ratio with 100 as the understood denominator; for example, 0.65 equals a percentage of 65

**Programming** - in regards to robotics, these are commands given to a robot to complete, tasks

**Ratio** - shows the relative sizes of two or more values; for example in this case, 65 black spaces cleaned out of a total of 125 black spaces that need to be cleaned

**Robot** - a mechanical agent that can perform tasks automatically or with guidance, typically by remote control

**Simulation** - to imitate, pretend; set up a situation as a model

**Toxic spill** - an unintended or accidental release of toxins into the environment that is capable of causing death or serious harm to humans, animals, and/or plants

**Toxin** - a poisonous substance that is capable of causing sickness, harm or disease on contact

**Variable** - a factor or condition that is subject to change, especially one that is allowed to change in scientific experiment to test a hypothesis
For more than 100 years, 4-H has been at the forefront of teaching youth about science, engineering and technology. 4-H National Youth Science Day is an annual event. It is part of 4-H’s national One Million New Scientists. One Million New Ideas. campaign, which has a bold goal of attracting one million new youth to science, engineering and technology programs by the year 2013.

Learn more about 4-H

www.4-H.org

www.facebook.com/4-H

The 4-H Name and Emblem are protected by 18 USC 707.

Produced by the National 4-H Council Marketing and Communications Team ©2012 NATIONAL 4-H COUNCIL

The 2012 National Science Experiment was designed in partnership with The Ohio State University, part of our nation’s Cooperative Extension System. Thanks to Windell Oskay of Evil Mad Scientist Laboratory for use of his “BristleBot” design.

4-H is a community of six million young people across America learning leadership, citizenship, and life skills. National 4-H Council works to advance the 4-H Youth Development movement, building a world in which youth and adults learn, grow and work together as catalysts for positive change. National 4-H Council partners with the Cooperative Extension System of Land-Grant Universities, 4-H National Headquarters located at the National Institute of Food and Agriculture (NIFA) within USDA, communities, and other organizations to provide technical support and training, develop curricula, create model programs and promote positive youth development to fulfill its mission.

National 4-H Council also manages National 4-H Youth Conference Center, a full-service conference facility, and National 4-H Supply Service, the authorized agent for items bearing the 4-H Name and Emblem. National 4-H Council is a nonprofit 501(c)(3) organization. National 4-H Council is committed to a policy that all persons shall have equal access to its programs, facilities and employment without regard to race, color, sex, religion, religious creed, ancestry or national origin, age, veteran status, sexual orientation, marital status, disability, physical or mental disability. Mention or display of trademark, proprietary product or firm in text or figures does not constitute an endorsement by National 4-H Council or National 4-H Headquarters and does not imply approval to the exclusion of suitable products or firms.