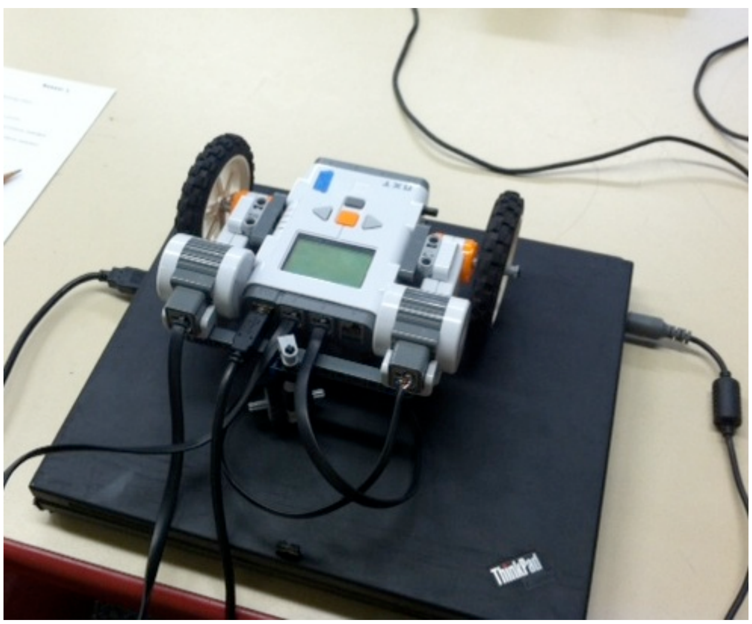
MIT Museum Robotics Workshop
Pre- and Post-Visit Activities
Recommended for Middle School

Introduction

The purpose of these activities is to help your students get the most out of the MIT Museum workshop Robotics Engineering: Programming Mindstorms. In the workshop, students will use LEGO Mindstorms and NXT- G Programming Environment to program robots to behave similarly to the vacuuming robot, the Roomba. In pairs or groups of three, students will work with one computer/robot setup (see photo below) to program the robot to move in various directions and sense when the robot is at the edge of the table. After this activity, students will have a tour of the *Robots and Beyond* gallery, which provides an overview of artificial intelligence research at MIT.

Through the pre-lesson "What is Programming?" students will become more familiar with the process and function of programming a robot. The post-lesson activities will encourage students to build on their knowledge of robot function and design, as well as the nature of artificial intelligence. Feel free to follow these lesson plans as strictly or as loosely as best suits your students and the role of the workshop in your curriculum.



Students will use laptops to program their robot to move forward, backwards, and to turn.

Pre-Visit Lesson: What is Programming?

<u>Purpose and Aim</u>

The purpose of this lesson is to introduce students to the basic concepts of programming a robot and the idea that robots are able to sense their environment and learn from that information. Through taking turns being the programmer and the robot, students will:

- experience the challenges of programming
- recognize the need for programming to be clear and specific
- explore the role of sensory observation and critical thinking in problem solving and the scientific process

Materials and Space

Materials:

- programming charts
- a programmer instruction sheet and a robot instruction sheet
- one copy of the discussion questions
- whiteboard/smartboard/large chart paper/overhead projector
- a version of the programming chart for students to fill out together during your demonstration

Space:

The introduction can take place while the students are seated at their desks. Students should have enough room to do the activity at their desks; pairs who would like more space may move to other areas of the classroom.

Procedure and Motivation

1. Begin the activity by asking students what a robot is. When the class has agreed on a definition--which should be something along the lines of "a machine that performs a task on its own and learns from its environment"--write that on the board/chart/overhead. As a class, make a list of things that robots do and characteristics of robots. For example, some things robots do can include vacuuming a room, putting things together in assembly lines in factories, help people who are paralyzed or otherwise disabled perform daily tasks, check buildings to see if there are people in them, distribute medication to patients, and socially interact with humans.

2. Tell the students that you are a robot, and pick one student to program you to clap your hands. Pick another student to record the commands on the programming chart, so the rest of the class can follow along. Try to interpret the student's commands as broadly or as narrowly as possible to ensure that the student does not get the desired result. For example, if the student says "raise your arms," raise them all the way up, over your head.

3. After the student succeeds in getting you to clap your hands, discuss with the class which commands were effective and which were ineffective and why. It might be helpful to make a list of qualities that effective commands have--for example, effective commands are short, simple, and specific.

4. Tell the students that they will get a chance to be a programmer or a robot, just like in the demonstration they just saw. Go over the general instruction sheet with the class, as well as instructions specific to robots and programmers. It may be helpful to make a short list of things to remember for both programmers and robots: for example, programmers should be thinking about the steps involved in completing a task, and robots should be thinking about how a robot would sense its environment.

5. Break the students into pairs and make sure each group has the necessary handouts. You may want to assign robots and programmers, or the students can decide that for themselves. Observe the students as they go through the activity.

6. Save time at the end of class for a few students to share their experiences with the activity as well as their responses to the discussion questions.

Evaluation

This activity provides many opportunities for informal and formal evaluation. Observing the students during the activity would give you an idea of who is fully engaged and who is having trouble with the concepts in the activity; this in turn can help you identify who might need additional support before the museum trip, and can give you an idea of where the class as a whole is. You can use these observations to inform future homework assignments and to determine if the class needs additional preparation before the workshop. Post-lesson discussion is another great way to evaluate students informally, as well as to give students a chance to ask any questions they had during the activity.

The students' programming charts would be a way to assess the students more formally. The charts should display a clear improvement in the students' commands, becoming increasingly specific as students figure out what types of commands are most effective for the students playing robots. The program and the types of revisions can indicate how well the students playing robots are adhering to their limitations; a robot responding to a command like "pick up the pencil" would not be acting like a robot.

Another form of formal assessment would be to have students write down responses to the discussion questions, or for them to write reflections on the activity. A written, more reflective assignment would allow students to more fully process the activity, and giving students the option to use the discussion questions as a guide would assist students who need a little more structure. A written assessment may also be a better way to assess certain students who do not feel as comfortable participating in a class discussion, or who need more time to sort out their thoughts.

Curriculum Standards for Grades 6-8

This activity covers the following Skills of Inquiry, Experimentation, and Design:

- Design and conduct an experiment specifying variables to be changed, controlled, and measured.
- Select appropriate tools and technology (e.g., calculators, computers, thermometers, meter sticks, balances, graduated cylinders, and microscopes), and make quantitative observations.
- Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations.
- Draw conclusions based on data or evidence presented in tables or graphs, and make inferences based on patterns or trends in the data.
- Communicate procedures and results using appropriate science and technology terminology.
- Offer explanations of procedures, and critique and revise them

From Massachusetts Science and Technology/Engineering Curriculum Framework, October 2006, pg 11

Subject Area	Standard	Connection
Physical Sciences and Chemistry Massachusetts Science and Technology/Engineering Curriculum Framework, October 2006, pg 68	Motion of Objects 11 Forms of Energy 13	While role-playing robots and programmers, students can explore the elements of motion, including the role those elements play in a robot's ability to carry out a specific task. Robots demonstrate the transition between potential and kinetic energy as they carry out commands.
Technology and Engineering Massachusetts Science and Technology/Engineering Curriculum Framework, October 2006, pp 87-89	Engineering Design 2.1, 2.2 Communication Technologies 3.2, 3.4 Bioengineering Technologies 7.1	Programmers have to adjust their commands to accommodate their robot's abilities; robots have to select their own specifications and carry out commands as best they can given their specifications. Programmers explore the best way to communicate with their robots. Students discuss the ways robots assist people in daily life, and experience a robot perform an everyday task through the programming activity.
Theatre Massachusetts Arts Curriculum Framework October 1999, pg 58 and pg 60	Acting 1.7, 1.9, 1.11 Reading and Writing Scripts 2.8, 2.10	Students commit to being a programmer or a robot, and carry out the activity within its given conditions (i.e., robots can't see and only understand certain words). The robot must follow the programmer's commands, similar to how an actor must follow a script.
English Language Arts and Literacy Massachusetts Curriculum Framework for English Language Arts and Literacy, March 2011, pg 79	Reading/Writing Standards for Literacy in Science and Technical Subjects 4, 5	Students write about the experiences of being a programmer and a robot when answering the discussion questions.

Post-Workshop Activities

Here are a few ideas for post-workshop activities that can be done during class time or as homework. Feel free to modify any of these activities as best fits your needs and the needs of your students.

1. After the workshop, students will have a tour of the robotics gallery, which contains an exhibit of robots whose designs were inspired by animals. Many of these robots were designed at the MIT Leg Lab, as seen in this video: http://www.youtube.com/watch?v=vHjVV7AWaGM. To further explore the idea of using animals as inspiration for robot design--especially in terms of how robots move--students can design a robot based on an animal of their choice. Students can draw or make models of their robots and write a brief essay explaining why they chose their animals, what elements of the animal was used in their robot designs, and the function of their robots. They can also write programs for their robots, or switch designs and write programs for their partners' robots. Additionally, students can compare designs with those who have selected the same animal or whose robots perform similar functions and compare their design choices. For further inspiration and reference, students can watch any of these videos of a cheetah robot (http://www.youtube.com/watch?v=jIei6tIYbP8 and http://www.youtube.com/watch?v=kKva13Y0RT0) or an earthworm robot (http://www.youtube.com/watch?v=EXkf62qGFII).

2. Students can select a household machine or appliance, determine if it fits the definition of a robot/artificial intelligence, and explain why it does or doesn't. Students can then redesign the appliance as a robot and write an explanation of their design process.

3. Students could select a simple household task--such as taking out the trash or washing the dishes--and write a program for a robot to complete that task, as they did for the human robot during their in-class activity. Students could draw a picture of the robot and write an explanation of why they chose that task and the place a robot that completes that task would have in the household. Students could think about what the robot would look like, what it would be made out of, and how that would affect its function. The next day, students could swap programs and mime carrying out the tasks to test the efficacy of the programs; ideally, anyone should be able to follow someone's program and be equally successful.

4. Students could read this NPR article (http://www.npr.org/blogs/alltechconsidered/2013/03/23/175127797/Four-Robots-That-Are-Learning-To-Serve-You) about four robots that currently exist and that may one day be more commonplace. Students could discuss this article in groups or as a class; they could each pick a robot and write about how people might use it, or what problem the robot solves and the connection between the robot's form and its function.

5. Students can watch the following youtube videos of LEGO Mindstorm robots and either write about or discuss them:

Robot playing the drums: http://www.youtube.com/watch?v=AV8HP2hcXPY
Robot drawing: http://www.youtube.com/watch?v=_ogQuLdEcBY
Robot playing Connect Four: http://www.youtube.com/watch?v=CHvJKdcNX6k
Robot playing Sudoku: http://www.youtube.com/watch?v=Mp8Y2yjV4fU

Students can answer/think about the following questions:

- What information does the robot need to have in order to complete its task?
- What kind of sensors would the robot need to obtain that information?
- What modifications were made to the robot's design to aid in completing its task? What other improvements could you make to the robot's design?
- Why is this particular task a good one for this particular robot, given what you know about its design and how it's programmed? What are the challenges in giving the robot this task?
- Do you think the robot performs its task as good as, better than, or worse than a person? What are the drawbacks and advantages to having a robot perform a task a human could do?

Students can also come up with a task they would give to a LEGO Mindstorm robot and describe what modifications they would make to the robot's design, why they chose that task, and write a program for the robot.

6. One of the robots in the MIT Museum robotics gallery is Cog, a humanoid robot. Students can explore the Cog website to learn more about Cog and humanoid robots in general: http://www.ai.mit.edu/projects/humanoid-robotics-group/cog/cog.html. Students can read about current projects involving Cog, watch videos of the robot, read publications by the Cog researchers, and learn more about the rationale behind the project and that the researchers hope to discover through working on a humanoid robot. Students can discuss or write about differences between a humanoid robot like Cog, robots that look like animals (such as many robots created by the MIT Leg Lab), and robots like Roomba or LEGO Mindstorm robots, which are not designed to look like anything living. Students can consider the following questions:
    - What can we learn about human behavior from humanoid robots?
    - What are the advantages of robot designs that are humanoid or look like recognizable animals? What are the advantages of robot designs that look clearly like machines?
    - What kinds of tasks would humanoid robots be better suited for? Animal robots? Robots that look like machines?
    - Do you think you would respond to a Roomba differently if it were a humanoid robot? What if it looked more like an animal?

7. Discuss the role of robots in popular culture and generate a list of robots the students are familiar with from movies, television, books, and video games. Students can select one robot and explain if it meets the definition of artificial intelligence (a machine that can perform a task on its own and can learn from its environment). Students can write about the robot's function; the relationship between its function and its design; if the robot is humanoid and why or why not; how it interacts with and senses its environment; how it interacts with humans; and what it would take for the robot to actually exist. Some well-known robots in popular culture include:

- R2-D2 and C-3PO (Star Wars)
- Marvin (The Hitchhiker's Guide to the Galaxy)
- K-9 (Doctor Who)
- Wall-E and EVE (Wall-E
- Bender (Futurama)
- Rosie (The Jetsons)
- The Cylons (Battlestar Galactica)

8. Introduce students to the programming language Scratch, developed by the Lifelong Kindergarten Group at the MIT Media Lab (http://info.scratch.mit.edu/). Students should have some time to explore the website on their own and become familiar with Scratch and the kinds of creations it can generate. Students may work individually, in pairs, or in small groups to create a range of different projects.

What Is Programming?
General Instructions

Materials

In this activity, you will write your own program for your partner and experience being programmed by her or him. Before you start, make sure you have the following:

- your partner
- 1 programming chart
- discussion questions
- 1 programmer instruction sheet
- 1 robot instruction sheet
- something to write with

Procedure

1. Read over your instruction sheets. As the programmer thinks of a task for the robot to carry out, the robot needs to select her/his specifications. Once the programmer has decided on a task, she/he should write it on the programmer chart.

2. When the programmer is ready, the programmer should decide if she/he wants the robot to begin the program standing or sitting, and tell the robot accordingly. The programmer can then tell the robot the program, one step at a time. With eyes still closed, the robot must follow the programmer's instructions as literally as possible, adhering to the robot's specifications. If the robot says "Error," the programmer must rephrase the instructions until the robot is able to process the instruction and complete the task. The programmer has to determine if the robot doesn't understand the command, or if the robot is physically unable to follow the command.

3. As the programmer gives commands to the robot, she/he should try to record as many of the commands as possible on the programming chart in the "Command" column.

4. When the robot has completed the task, go over the discussion questions. Together, create a revised version of the program that would let the robot better complete the task, and record it on the programmer chart under "Revised Command."

5. Finally, switch roles and run through the revised program (using the same robot specifications). If time allows, discuss if the revised program was easier or more difficult for the robot to follow, and why.

Programmer:__________________ Date:____________

Robot:________________________

What Is Programming?
Programmer Chart

Task:__________________________

Command	Revised Command
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

What Is Programming?
Discussion Questions

- What was the biggest challenge in programming the robot?

____

____

____

2. Pick one command you found particularly effective. What made it work so well?

____

____

____

3. Pick one command you found particularly ineffective. Why was it ineffective? How did you revise that command?

____

____

____

4. How did the specifications of the robot affect your program? How might you change the robot's design to more easily complete the task?

____

____

____

What Is Programming?
Instructions for Programmers

Create a task for your robot to complete. Some suggestions include:

- picking up a pencil and drawing a smiley face
- picking an object (such as a pencil) off the floor and carrying it across the room to give to the programmer
- doing a certain number of jumping jacks

You may use any of your own materials, or you may use no materials at all. Once you have a task, write your task on your programmer chart. As you think about how to program your robot to complete your task, keep in mind the following:

- Your robot does not have any prior knowledge or experiences. The only information it has is what it is currently experiencing and what it can determine from its environment. Because robots know so little, they are more successful at carrying out very simple tasks.

- Your robot has a set vocabulary. Your robot is able to understand the following types of words:

numbers
verbs (action words)
adverbs (words that describe verbs, like "quickly" and "slowly")
adjectives (words that describe nouns, like "fuzzy" and "smooth")
directions (up, down, back, forward, etc)
words describing size and weight (big, small, heavy, light)

The only nouns your robot understands are those referring to itself and its parts, such as hand, arm, leg, foot, and head. Your robot also understands the nouns "object" and "thing." You need to describe any other nouns in order for your robot to understand what you mean.

- Your robot does not have sensors enabling it to see its environment, so your program should avoid words and commands that assume being able to see.

- There are different models of robots in this room, all of which have different abilities. Your robot's abilities may make it difficult or impossible to carry out your program. You may have to make a lot of adjustments to your program to accommodate your robot's specifications.

What Is Programming?
Instructions for Robots

There are many different robot models, and each model has different abilities. The robot models in the classroom today differ in arm movement, hand movement, walking, turning around, and sound. Circle one option from each category to decide what model of robot you are. **All models lack visual sensors**.

Arm Movement
1. Arm moves up and down; elbow cannot bend
2. Arm moves side to side; elbow can bend

Hand Movement
1. Hand opens and closes; grip objects between all four fingers and thumb
2. Both hands remain open; grip objects between palms of both hands

Vertical Movement
1. Lower by bending at waist
2. Lower by bending knees

Walking
1. Steps are small
2. Steps are large

Turning
1. Turn by walking in a small circle; both arms at side
2. Turn by moving whole body to the side; arms stay raised

Robot Vocabulary
All robots are able to understand the following types of words:

numbers
verbs (action words)
adverbs (words that describe verbs)
adjectives (words that describe nouns)
directions (up, down, back, forward, etc)
words describing size and weight (big, small, heavy, light, etc)

The only nouns robot understand are those referring to themselves and their parts, such as hand, arm, leg, foot, and head. You also understand "object" and "thing." Your programmer will need to describe any other nouns in order for you to understand what she/he means.

If the programmer gives a command that you either do not understand or are unable to carry out, say "Error" and do not move until the programmer gives you a command that you are able to follow.