

# Robotics WOW! Unit Plan

This curriculum is an adaptation of one originally taught by Albert Danysh, Lyren Brown, and Nicole Dimucci in Bedichek, Texas.

Robotics is a rapidly growing field in computer science. This apprenticeship teaches basic robot design to middle school students. Through applied knowledge of computer programming (NXT), research and design, developed problem-solving skills, and intense collaboration with team members, students construct their own basic robots. They also learn to demonstrate knowledge of how and why such robots operate the way they do. Included in this curriculum are explicit connections to career options and educational experiences necessary to fulfilling a career in robotics design.

## KEY SKILLS AND OUTCOMES FOR STUDENT LEARNING

Computer Science and IT Standards	21 <sup>ST</sup> Century Skill(s)
<p><b>CS.CSITS.2: Citizen schools students will <u>use abstraction to develop models and simulations of natural and artificial phenomena</u> that solve problems and make predictions.</b></p> <p>a. I can <b>describe the processes involved</b> in a <i>self-designed</i> computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.</p> <p>b. I can <b>explain the differences between different data types</b> and <b>select appropriate ones</b> to solve given problems.</p> <p>c. I can <b>apply multiple levels of abstraction</b> while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)</p> <p>d. I can <b>create a functional relationship or algorithm</b> using my own words, formulas, and symbols.</p> <p>e. I can <b>summarize how to design and operate</b> a robot, computer game, or other computational artifact that uses functions to solve problems. (WOW!)</p> <p>f. I can <b>design and present computational models of artificial and natural phenomena</b> (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)</p>	<p><b>Oral Communication:</b> The ability to speak to an audience with confidence using eye contact and body language speaking to groups, demonstrating confidence, speaking more comfortably in front of an audience, developing coherent and well-organized content.</p> <p><b>Technology:</b> The ability to identify and use technology as a tool</p> <p><b>Leadership:</b> The ability to make decisions, establish goals, volunteer to help other students, role model by focusing on and completing work, following directions, and guiding others to do so.</p>
<p><b>CS.CSITS.3 Citizen schools students will collaborate and effectively work in teams to produce computational artifacts</b></p> <p>a. I can <b>compare and contrast the different team roles</b> important in designing, building, and improving computational artifacts.</p> <p>b. I can <b>collaborate with other team members</b> to complete computer science projects.</p> <p>c. I can <b>effectively provide feedback</b> to group partners on a computer science project as a tool to facilitate its completion.</p> <p>d. I can <b>constructively evaluate my and others'</b></p>	

**performance** in a particular team role.

**CS.CSITS.5 Citizen schools students will compare and contrast the ways in which computing enables innovation in other fields.**

a. I can **make comparisons between skills learned and identified careers in computing**, including - but not limited to - information technology specialist, Web page designer, systems analyst, programmer, and CIO.

#### COLLEGE/CAREER CONNECTIONS

For this apprenticeship, college/career connections are specifically emphasized on Weeks 7-8 (see Scope and Sequence below). Though such connections are not specifically referenced as standards or objectives for each week, Citizen Teachers are strongly encouraged to make connections as the opportunities to do so present themselves in their weekly interactions with students.

#### GUIDING QUESTIONS

<i>What makes something a “robot?”</i>
<i>What role does team work play in programming and constructing a robot?</i>
<i>What role does team work play in programming and constructing a robot?</i>
<i>What role does team work play in programming and constructing a robot?</i>
<i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i>
<i>In what ways can robots be used to solve certain problems</i>

#### WOW! DESCRIPTION

Using Lego Mindstorms Kits, students will construct robots and program them, in teams, to perform chosen functions. At a minimum these robots will be able to move around and interact with their environment in some way (solving a problem). For the WOW! Ceremony, they will orally demonstrate their understanding of robot construction (e.g., programming involved) and showcase the operations of their team-built robots.

#### MATERIALS

1. Lego Mindstorm Kits (1 per group of students)
2. [Human Robot Program Instructions](#) (see Lesson 1)
3. \_\_\_\_ computer per student (x number of computers)

4. Large poster board signs with Motor, Sensor, and Processor
5. Developed list of “review questions” that pertain directly to what WOW! and class expectations discussed with students.
6. 7-8 instruction cards for human robot game.
7. Bag of multi-colored Starbursts.
8. Robot for demonstration & laptop to change programming
9. WOW! Introduction Information, Class Expectations Overview
10. Team Notebooks (1 per team)
11. Example programming activities (Lesson 3 Supplement)
12. Robotics Terminology Worksheet (Supplement)
13. Pre-developed list of 6-8 statements characterizing the role of either the builder, programmer, or scribe of a robotics construction team (Lesson 2)
14. Large posterboard cards labeled “B” (Builder) , “P” (Programmer), and “S” (Scribe)
15. Demonstration Robot (Robot that can move independently, interact with environment, and demonstrate an advanced feature)
16. Planned Field Trip/Speaker that will cover the following content:
  - *What are 4-5 different careers for individuals interested in robotics and computer science?*
  - *What are 2-3 steps **necessary** to complete a career in robotics or computer science?*
  - *How are the skills I have learned thus far connected to a career in robotics or computer science?*

The “Teaching Robotics” PowerPoint is a great resource in terms of introducing students and teachers to the fundamentals of teaching a robotics curriculum. The PowerPoint offers suggestions for managing resources, (including time, money, and staff) and it additionally offers example robotics programming activities and slides to be potentially used with students for various lessons.

BASIC WOW! PLAN	
Week	WOW! Connection
1	Students will be introduced to three components of robotic control and how programming determines functionality. Students will also be allowed to interact with robots in “remote control” mode to facilitate basic familiarity.
2	Students will be introduced to kits and software that will be used to construct and operate robots for WOW!. Students will perform several exercises to facilitate familiarity with kits. Students will also be assigned to semester teams and become familiar with the specific roles on their respective teams.
3	In teams, students will decide on they type and function of the robots they would like to present for WOW!. Students will also begin developing computer-programming skills crucial for successful completion of robot.
4	Students will initiate team construction of robots to be presented for WOW!. Staff will begin to demonstrate and model important process of programming, building, testing, and refining actions of robots.
5	Students will continue team construction of robots to be presented for WOW!.. Students should have robots self-navigating and independently moving by the end of the session.

6	Students will continue team construction of robots to be presented for WOW!. Students will successfully use their knowledge of program design to have their robots move, navigate, and use its sensors to interact with environment in some way (e.g., grab a ball.) Students will also need to know how to orally explain the way basic programming concepts were used to make this robot feature happen.
7	Students will work with teachers to complete the last remaining programming and construction on their team robots. All teams should have basic robots fully completed. Teams will be challenged to add a unique advanced feature to their designs (e.g., a robot that finds the ball, grabs it and brings it to you, or turns around and puts the ball <i>back</i> , a robot that navigates a simple obstacle course using multiple strategies).
8	Field Trip
9	Students will finalize last details of their respective team's robots (including building and programming), identify the specific role that they will have for the WOW! presentation and begin formal rehearsals of those parts.
10	Students will apply their understanding of their respective WOW! roles, robotic construction, and programming through clear presentations for ceremony (as individuals and cohesively as groups.)

## LESSON PLANS AT A GLANCE (SCOPE AND SEQUENCE)

Week	Learning Objectives By the end of the lesson, each student will be able to:	CS Standards & 21 <sup>st</sup> Century Skills	Specific Activities & WOW! Connection
<p><i>What makes something a "robot"?</i></p> <p><b>1</b> Learn new skills <i>Model</i></p>	<ul style="list-style-type: none"> <li>▪ <b>Identify</b> and <b>explain</b> the major aspects of the Robotics apprenticeship. (e.g., expectations for WOW!)</li> <li>• <b>Explain</b> the <b>major</b> concepts of how to design a robot and how they operate.</li> <li>• <b>Explain</b> class expectations for apprenticeship sessions.</li> <li>• <b>Differentiate</b> the three basic components of robot control (perception, processing, and action).</li> </ul>	<p>Oral Communication Technology</p> <p>CS.CSITS.2 a</p>	<ol style="list-style-type: none"> <li>1. Opening ritual</li> <li>2. Review agenda, expectations &amp; WOW!</li> <li>3. Lego Mindstorm Robot (Demonstration)</li> <li>4. Human robot game!</li> <li>5. Assessment</li> </ol> <p><b>WOW! Prep:</b> Students will be introduced to three components of robotic control and how programming determines functionality. Students will also be allowed to interact with robots in "remote control" mode to facilitate basic familiarity. This familiarity will be required for the successful design, operation, and presentation of their final</p>



				robots.
<p><i>What makes something a robot?</i></p> <p><i>What role does team work play in constructing a robot?</i></p>	<p><b>2</b></p> <p>Learn new skills <i>Model</i></p>	<ul style="list-style-type: none"> <li>▪ <b>Identify and explain the major roles of each team member</b> for the completion of WOW! product and presentation.</li> <li>• <b>Summarize the major steps necessary</b> to building a basic robot with Lego's (whole-class introduction).</li> </ul>	<p>Oral Communication Technology</p> <p>CS.CSITS.2 a, e,</p> <p>CS.CS.3 a,</p>	<ol style="list-style-type: none"> <li>1. Review Agenda, Expectations &amp; WOW! Review</li> <li>2. Opening Ritual – KWL</li> <li>3. Team assignments</li> <li>4. Introduction to Mindstorm Lego kits</li> <li>5. Whole group building construction lesson.</li> <li>6. Assessment ("L" in KWL)</li> <li>7. Connection to Guiding Question: Team work and definition of robot</li> <li>8. Clean up</li> </ol> <p><b>WOW! Prep:</b> Students will be introduced to kits and software that will be used to construct and operate robots for WOW!. Students will perform several exercises to facilitate familiarity with pieces and parts of kits. Students will also be assigned to semester teams and become familiar with the specific roles on their respective teams.</p>

<p>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</p> <p>In what ways can robots be used to solve certain problems?</p>	<p><b>3</b></p> <p>Learn new skills <i>Model</i></p>	<ul style="list-style-type: none"> <li>• <b>Summarize</b> the ways in which basic NXT programming certain dictates robotic operations.</li> <li>• <b>Compare and contrast</b> action, sequence, loops, and conditionals as basic programming principles.</li> <li>• <b>Apply basic knowledge of algorithms</b> and logical sequencing to complete NXT programming exercises as a form of problem-solving.</li> </ul>	<p>Oral Communication Technology</p> <p>CS.CSITS.2 a, c, d, e, f</p>	<ol style="list-style-type: none"> <li>1. Review Agenda, Expectations &amp; WOW!</li> <li>2. Opening Ritual (Becoming Familiar With Robot Designs)</li> <li>3. Intro to Basic Programming Principles</li> <li>4. NXT programming exercises</li> <li>5. Choose WOW designs!</li> <li>6. Refining Definitions (Assessment)</li> <li>7. Clean up</li> </ol> <p><b>WOW! Prep:</b> After becoming familiar with basic robot types in teams, students will decide on types and function of the robots to present for WOW!. This week, students will also be developing computer programming skills crucial for successful completion of robot. Immediate feedback</p>
<p>What makes something a "robot?"</p> <p>What role does team work play in programming and constructing a robot?</p> <p>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</p>	<p><b>4</b></p> <p>Produce <i>Scaffold</i></p>	<ul style="list-style-type: none"> <li>• <b>Explain the required components</b> of robots to be presented at WOW! presentation.</li> <li>• <b>Apply</b> basic knowledge of algorithms and logical sequencing to complete NXT programming used for robot operations.</li> </ul>	<p>Oral Communication Technology</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<ol style="list-style-type: none"> <li>1. Review, agenda, and expectations for WOW!</li> <li>2. Final team decisions on robot designs and actions.</li> <li>3. Build/program robots in teams</li> <li>4. Clean up</li> </ol> <p><b>WOW! Prep:</b> Students will initiate team construction of robots to be presented for WOW!. Staff will begin to demonstrate and model important process of programming, building, testing, and refining actions of robots.</p>

<p><i>What makes something a "robot?"</i></p> <p><i>What role does team work play in programming and constructing a robot?</i></p> <p><i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i></p>	<p><b>5</b></p> <p>Produce Scaffold</p>	<ul style="list-style-type: none"> <li>• <b>Apply basic knowledge of algorithms</b> and logical sequencing to complete NXT programming used for robot operations.</li> <li>• <b>Refine their definition</b> of "robot" by distinguishing between a robot in its most basic form and some of its advanced existences.</li> </ul>	<p>Oral Communication Technology Leadership</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<ol style="list-style-type: none"> <li>1. Review agenda, expectations for WOW!</li> <li>2. Group progress and feedback.</li> <li>3. Demonstration of "independent" robot.</li> <li>4. Build/program robots in teams</li> <li>5. Clean up</li> </ol> <p><b>WOW! Prep:</b> Students will continue team construction of robots to be presented for WOW!. Staff will begin to demonstrate and model important process of programming, building, testing, and refining actions of robots. Students should have robots self-navigating and independently moving by the end of the session.</p>
<p><i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i></p> <p><i>In what ways can robots be used to solve certain problems?</i></p>	<p><b>6</b></p> <p>Practice Scaffold</p>	<ul style="list-style-type: none"> <li>• <b>Apply basic knowledge of algorithms</b> and logical sequencing to complete NXT programming used for robot operations.</li> <li>• <b>Develop and refine algorithms</b> to use that will direct more humanlike actions of robots. (e.g., use its sensors and interact with its environment in some detectable way like move a ball).</li> </ul>	<p>Oral Communication Technology Leadership</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<ol style="list-style-type: none"> <li>1. What Have You Learned About Robots?</li> <li>2. Status of groups, expectations, and robot demonstration (environment interaction)</li> <li>3. Build/program robots in teams</li> <li>4. Clean up</li> </ol> <p><b>WOW! Prep:</b> By the end of the session, students will successfully use their knowledge of program design to have their robots move, navigate, and use its sensors to interact with environment in some way (e.g., grab a ball.) This will be a very important step in preparation for the WOW! program. Students will also need to know how to explain the way algorithms were used to make this robot feature happen.</p>

<p><i>What makes something a "robot?"</i></p> <p><i>What role does team work play in programming and constructing a robot?</i></p> <p><i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i></p> <p><i>In what ways can robots be used to solve certain problems?</i></p>	<p><b>7</b></p> <p>Practice Coach</p>	<ul style="list-style-type: none"> <li>• <b>Apply basic knowledge of algorithms, loops, conditionals, sequencing, and actions</b>, to complete NXT programming used for robot operations.</li> <li>• <b>Refine knowledge of programming</b> to have robot perform advanced features.</li> </ul>	<p>Oral Communication Technology Leadership</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<ol style="list-style-type: none"> <li>1. How to begin a career in robotics?</li> <li>2. Status of groups, expectations, and robot demonstration (environment interaction)</li> <li>3. Group decisions on WOW! ceremony roles</li> <li>4. Build/program robots in teams</li> </ol> <p><b>WOW! Prep:</b> In this lesson, students will work with teachers to complete the last remaining programming and construction on their team robots. All teams should have basic robots fully completed. Teams will be challenged get creative and add something unique to their designs. CTs will help teams create advanced robot designs and programs. (Ex. a Robot that finds the ball, grabs it and brings it to you, or turns around and puts the ball <i>back</i>, a robot that navigates a simple obstacle course using multiple strategies.)</p>
	<p><b>8</b></p>	<ul style="list-style-type: none"> <li>▪ <i>What are 4-5 different careers for individuals interested in robotics and computer science?</i></li> <li>▪ <i>What are 2-3 steps <b>necessary</b> to complete a career in robotics or computer science?</i></li> <li>▪ <i>How are the skills I have learned thus far connected to a career in robotics or computer science?</i></li> </ul>	<p>CS.CSITS.5 a</p>	<p><b>WOW! Prep:</b> N/A</p>

<p><i>What makes something a "robot?"</i></p> <p><i>What role does team work play in programming and constructing a robot?</i></p> <p><i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i></p> <p><i>In what ways can robots be used to solve certain problems?</i></p>	<p><b>9</b></p> <p>Practice Fade</p>	<ul style="list-style-type: none"> <li>• <b>Apply basic knowledge of algorithms</b>, loops, conditionals, sequencing, and actions, to complete NXT programming used for robot operations.</li> <li>• <b>Fully develop</b> (build and program) a robot to be presented for WOW! ceremony.</li> <li>• <b>Apply their understanding of their respective WOW! roles</b> by individually performing basic rehearsals for ceremony.</li> </ul>	<p>Oral Communication Technology Leadership</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<p>1. Status updates and objectives for project completion 2. Build/program robots in teams (final edits.) 3. Individual and group rehearsals for WOW! ceremony 3. Clean Up</p> <p><b>WOW! Prep:</b> Students will finalize last details of their respective team's robots (including building and programming), identify the specific role that they will have for the WOW! presentation and begin formal rehearsals of those parts.</p>
<p><i>What makes something a "robot?"</i></p> <p><i>What role does team work play in programming and constructing a robot?</i></p> <p><i>How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?</i></p>	<p><b>10</b></p> <p>Practice Fade</p>	<ul style="list-style-type: none"> <li>▪ <b>Apply their understanding</b> of their respective WOW! roles, robotic construction, and programming through clear presentations for ceremony (as individuals and cohesively as groups.)</li> </ul>	<p>Oral Communication Technology Leadership</p> <p>CS.CSITS.2 a, c, d, e, f</p> <p>CS.CSITS.3 a, b, c, d</p>	<p>1. Rehears as needed</p> <p><b>WOW! Prep:</b> Apply their understanding of their respective WOW! roles, robotic construction, and programming through clear presentations for ceremony (as individuals and cohesively as groups.)</p>

# Robotics - Lesson 1

This lesson introduces the apprenticeship to students. Through discussions and other informal activities, students become familiar with class expectations, the basic concept of robotics operation, and expectations for the WOW! Presentations.

## Objectives

- **Identify** and **explain** the major aspects of the Robotics apprenticeship. (e.g., expectations for WOW!)
- **Explain** the **major** concepts of how to design a robot and how they operate.
- **Explain** class expectations for apprenticeship.
- **Differentiate** the three basic components of robot control. (Perception, processing, and action)

## Lesson Snapshot:

1. Opening ritual
2. Review agenda, expectations & WOW!
3. How a Lego Mindstorm robot works
4. Human robot game!
5. Closing ritual

## Vision for Student Mastery:

Various oral assessments will be given throughout the lesson as consistent “check points” for understanding. At the end of the lesson, students will be given a “mini-quiz” of answers to review questions. These will serve as their “exit slips” out of class. (Students should turn in completed answers to teacher upon their exit of the classroom.)

## Materials and Pre-Planning

1. Large poster board signs with Motor, Sensor, and Processor
2. Developed list of “review questions” that pertain directly to what WOW! and class expectations discussed with students.
3. 7-8 instruction cards for human robot game.
4. Bag of Starbursts.
5. Robot for demonstration & laptop to change programming
6. WOW! Introduction Information, Class Expectations Overview



## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

“I Can” Skills:

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.

## Connection to Guiding Questions

*What makes something a “robot?”*

## WOW! Scaffolding

Students will be introduced to three components of robotic control and how programming determines functionality. Students will also be allowed to interact with robots in “remote control” mode to facilitate basic familiarity. This familiarity will be required for the successful design, operation, and presentation of their final robots.



## The Hook/Introduction - 15 minutes

Get to know you game – Starburst (What's Your Flavor?) - With your bag of starbursts, have each student pick two starbursts from the bag, but tell them they may not eat the starburst yet. Go around the classroom & ask each student to say their name and share their interesting fact based on the starburst color that they picked

Red: Favorite movie  
Yellow: Favorite food  
Orange: Favorite Superhero  
Pink: Favorite band

**Transition:** *Now that we know each other a bit better, let us talk about robots to get things started...*

### Hook

Discuss with students the following questions by having 3 -4 *different* student volunteers answer the following questions:

- (1) *What kind of robot would you be and why?*
- (2) *What are you really excited to learn in this apprenticeship?*

**Transition:** *Great. It sounds like you all are going to get a lot out of this apprenticeship, and I am just excited to help you all do many of those things you mentioned. I want to take some time to tell you, specifically, what the apprenticeship and WOW! are going to involve, and what we have to do to get there....*

(Note: Another variation of this is to have 3-4 robot models to quickly demonstrate around the room. After you all demonstrate their features, you might say to them, "By the end of 10 weeks, you will use all of your new knowledge to create one of these!" This is a good way to lead into a discussion of the specifics regarding the WOW! Presentation")

### Student Action

Students will participate in Starburst game (or any other opening ritual).

Students will actively discuss with teacher answers to the provided questions.

## Modeling - 15 minutes

At this time, the teacher should discuss with the students what the WOW! is going to be. You should use the information on the unit plan as a guide to help you talk through the main points of what students will be expected to do for the WOW! and the major steps they will be taking to get there.

The last part of this discussion should be the "ground rules" or "class expectations." Be sure to emphasize that these will be important for successfully completing the final product and presentation.

Oral Assessment: *Just to make sure you all are on the same page, let's do a quick review.*

At this time, ask questions from your pre-developed list to ensure that students understand important points surrounding class expectations and the WOW!. You may choose to call on students at random or select volunteers.

**Transition:** *Now that we all understand what the expectations are, let's take our first step. We have to answer the basic important question, "How does a robot work? What makes a robot a "robot?"*

### Student Action

Students should pay close attention to teacher as expectations for WOW! Product is explained.

During this time, students will be either actively listening (eyes on speaker) or answering the questions provided, as called upon.



## How A Robot Works ("I Do" Cont'd.)

At this time, the teacher should give a very brief introduction to robots: What are they? What do some of the most basic ones do, and what do some of the most advanced ones do? Your discussion should end with the this main take-away point: ***All robots have three basic components, from the most basic to the most advanced:***

### 1. Perception (Sensors)

What do they **perceive or feel** in the environment?

### 2. Programming/Processing (NXT Program)

How do they process information from environment? What actions are they **programmed** to do in response?

### 3. Action (Motors)

What do they actually **do in response** to what is perceived in the environment.

## Assessment:

### "Take A Stand"

Ask a series of 5-6 "True/False" questions regarding robotic design and control that are rooted in your brief discussion of robots. For example, "A robot reverses its direction after sensing an object in front of it. Reversing the direction is an example of an action allowed by its motors. True or False?" or "A \_\_\_\_\_ is an example of a robot." Explain to students that if the statement is "True", they should stand if they believe it to be. Encourage students sitting or standing to explain their belief, and help them refine their answers as necessary. This should take no more than 6-8 minutes.

**Transition:** *To help us understand this information even better, let's see these things in action...*

## Student Action

Students should pay close attention to teacher as basics of robotic design and programming is explained.

During this time, students will be either actively listening (eyes on speaker) or answering the questions provided, as called upon.

## "Scaffolding" - 20 minutes

Using 2-3 robots as an example with students separated into groups, demonstrate the relationship between what the robot perceives, how it is programmed to react, and what it actually does to react in a step-by-step fashion.

While the robot is active, do this 2-3 times. After that, have students voluntarily explain the processes of the robot. (What is it sensing in its environment? How is it programmed to react? What does it actually do to react to information gathered from the environment?)

To drive the home this point, the teachers might also quickly alter the programming of the robot (using suggestions from the students) that would cause the robot to either perceive something different, react in a different way, etc. Demonstrate the robot in this new fashion, and have students again identify the perception, reaction, and programming processes exemplified in the demonstration.

**Transition:** *To make this point that much clearer, YOU all are now going to act as robots in teams...*

## Student Action

Students should actively explain the role that perception, programming, and actions are playing in the robots being demonstrated. Participation from several different is ideal. They should also orally offer suggestions to the teachers for how to change up the robotic operations.

### Human Robot Game!

The teacher should have three volunteers come up in front of the group.

Each volunteer in the group should be assigned either as motor, sensor or processor. Use the large labeled sheets to tape these roles to the corresponding student.

The sensor and motor are attached together. The motor is blind-folded.  
The processor stands aside and reads the instruction card with his/her back turned to sensor and motor.

The team progressively works through verbal communication to accomplish task stated on instruction card.

After first group of volunteers completes task, lead students in a debrief discussion of the actions and processes that made completing the task successful:

#### Debrief questions might include:

*What is the relationship between the motor and the sensor?*

*Why is the programmer off to the side with their back turned?*

Next, divide the students into groups of three and have each group take on the role of either Processor, Sensor, or Motor. Give them all task to complete as well. This activity should take no more than 20 minutes.

**Transition:** *Okay, so what does all of this have to do with your WOW! presentation? How does what we learned today help us get there?*

### Student Action

Volunteer students will be actively involved in completing the task as described. During this time, all other students will be either actively listening (eyes on volunteers) or answering any questions that come up during the activity.

At this point, students will raise the hands to answer the debrief questions.

## Connection to Wow! and Closing Ritual (Assessment) - 15 minutes

**Connection to WOW!** - *As you will be expected to program and present your robot in action, you have to know what the relationship is between (What are the three things of a robot?). That's right: Processor, Programming, and Sensor. If, for example, you want your robot to be able to pick up a red ball, you will have to know how to program your robot to sense that information, and use its motor to act appropriately. Furthermore, you have to be able to explain your robot to everyone else. So knowing this information will be especially important. You can't forget it! We're going to end class with one final review:*

### Assessment (Closing Ritual):

Exit Ticket:

*On your note card, write your name at the top, and then answer these questions (It might be easier to have these questions already developed and posted somewhere):*

1. *What three things must a robot include to operate?*
2. *How do these three things work together to operate a robot? (The sensor does \_\_\_\_, the processor does \_\_\_\_, etc.)*
3. *Summarize what you will be doing for your WOW! presentation.*
4. *Name one class expectation that we will have to remember to get there.*

Upon collecting these exit slips before the student leaves, the teacher should review the note cards to determine if there is any concept that needs to be clarified the next day for particular students.

# Robotics - Lesson 2

This lesson focuses on differentiating team roles responsibilities in building and programming robots and developing familiarity with Lego kits through practice. As students become more familiar with robotic design, this lesson also challenges students to think critically about the question of what counts as a robot.



## Objectives

- **Compare and contrast the major roles of each team member** for the completion of WOW! product and presentation.
- **Summarize the major steps necessary** to building a basic robot with Lego's (whole-class introduction).

## Lesson Snapshot:

1. Review Agenda, Expectations & WOW! Review
2. Opening Ritual – KWL
3. Team assignments
4. Introduction to Mindstorm Lego kits
5. Whole group building construction lesson.
6. Assessment ("L" in KWL)
7. Connection to Guiding Question: Team work and definition of robot
8. Clean up

## Vision for Student Mastery:

Students will demonstrate their learning of team member roles and basic steps for robot construction through an oral discussion using the KWL (Know, Want to Know, Learned) formula at the beginning and end of class as well as a note card activity involving matching descriptions with appropriate team roles. Once in their teams, students will apply new knowledge to refine their definition of "robot" by developing a clear and concise written definition with their team members. Upon sharing, this definition will be further refined by teacher and other class members.

## Materials and Pre-Planning

1. **Developed experiment directions for testing robot sensors (Teacher Developed)**
2. Lego Mindstorm Kits (1 per group of students)
3. \_\_\_ computer per student (x number of computers)
4. Team Notebooks (1 per team)
5. Robotics Terminology Worksheet (Supplement)
6. Pre-developed list of 6-8 statements characterizing the role of either the builder, programmer, or scribe of a robotics construction team.
7. Large posterboard cards labeled "B" (Builder), "P" (Programmer), and "S" (Scribe)

## CSITS Standards

### CS.CSITS.2, CS.CSITS.3

**CS.CSITS.2:** Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

a. I can **describe the processes** involved in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.  
e. I can **summarize how to design and operate** a robot, computer game, or other computational artifact that uses functions to solve problems. (WOW!)

**CS.CSITS.3** Citizen schools students will **collaborate and effectively work in teams to produce computational artifacts**

a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.

## Connection to Guiding Questions

*What makes something a robot?*

*What role does team work play in constructing a robot?*

## WOW! Scaffolding

Students will be introduced to kits and software that will be used to construct and operate robots for WOW!. Students will perform several exercises to facilitate familiarity with pieces and parts of kits. Students will also be assigned to semester teams and become familiar with the specific roles on their respective teams.

## The Hook/Introduction - 20 minutes

### KWL

Select random students to answer the following questions:

1. What do we **KNOW** about robots at this point?

As a part of this discussion, the teacher should be sure to review major concepts taught during last lesson; for example, three basic components of robot.

2. What do we **WANT** to know about robots?

Teacher should field answers from students not called upon for the first question. The teacher should be sure to treat each question equally by acknowledging the curiosity and interest evident in each question (as opposed to responses such as, "We won't get to that in apprenticeship.")

**Transition:** *Keep these things in mind, because what we do today will touch on what you already know and might even touch on what you want to know about robots; if not today, then perhaps in the future. But first, let's review what we are steadily working on for the WOW! Ceremony.*

*Remind me, what will you all be producing and presenting for your WOW! ? Let me hear some of the expectations for what it's going to take to get there? (Review from last session).*

**Transition:** *Good, so today's lesson will introduce you all to the robots, themselves. You will each be assigned to teams, and in those teams, we're going to begin practicing how to build these robots.*

### Student Action

On being called upon, students will answer questions prompted by teachers.

## Modeling - 15 minutes

### Team roles and assignments

Orally explain to students what the role will be for different members on each team.

*In each team, there will be a*

**Builder** : Assembles robot parts according to instructions

**Programmer** : In charge of instructions and software, writes programs for NXT.

**Scribe** : Tracks WOW progress in team notebook; collects and writes down ideas for building and designing robot.

**Oral Assessment:** *Let's see if we can tell the difference. I'm going to pass out a letter to you that stands for one of these roles. (Teacher passes out one letter to each student.) I'm then going to read a statement. If what I read describes the job of whatever letter you have (for example "B" for builder), you should raise your hand high. Does everyone understand?*

Teacher proceeds to read the statements and clarify any misconceptions about which responsibilities fall under each role as is evidenced by incorrect letter raises.

### Student Action

Students should first listen attentively. They will then use knowledge from the discussion of team roles to appropriately match descriptions with team roles (using note cards).

### ("Modeling" Cont'd.)

**Transition:** *Now that we understand what the three different roles are, you all will be divided into the teams in which you'll be working to build and present your robots.*

Divide students into teams in which they will be working for the remainder of the semester. (The teacher should decide how best to facilitate this process based on class numbers, class personalities, etc.)

After students are in their groups, instruct students with the following:

*In your groups, introduce yourselves. Based on your individual interests, you all should each decide what role you will take on your team (builder, scribe, and programmer - if the teacher thinks it necessary to assign the specific roles, do so). Finally, you should select your team's name. (Teacher should visit each group to ensure that these three steps are completed by each group.) The scribe's first assignment is to record the name of the their team in their notebooks.*

Teacher should then have each team announce the team name they came up with.

**Transition:** *Now that we're organized into our teams, let's get started!*

### Student Action

Students will form their teams and identify what specific roles they will each take on their given team. Students will also come up with team names, which will be recorded by each team's scribe. Team names will be announced for the class.

## "Scaffolding" - 20 minutes

### Introduction to kits: (10 min)

Teacher should distribute one Lego Mindstorm kit to each team to use and proceed to explain ground rules used for kits **before**.

Teacher should explain ground rules for using kit: (teacher should add as necessary)

1. *Do not damage the kit parts in anyway, and respect the kits as they were your own*
2. *Do not trade or mix parts with other kits, and keep parts from your kit in your kit.*
3. *Never force pieces to fit when you think they should*
4. *Respect other team members and their team roles. Sometimes, you may have to share responsibilities. For example, the scribe will most likely have to help with programming or building when they, not recording ideas. As long as each member is fulfilling their responsibility, it's okay to help each other out!*

Have students remove the components from the kit.

**Transition:** *Listen carefully to what we want you to do with the kits so you don't get lost...*

### Whole group construction lesson:

Teacher should explain each team member role for this activity:

**Programmer** is in charge of flipping computer slides to match along with the class.

**Scribe** is responsible for finding the parts needed on each slide and recording how each step in the experiment concludes.

### Student Action

Students should listen attentively to the directions.

**Builder** (along with help from team members) puts the parts together.

First, we're going to discuss some terminology you need to know for the various parts of the kits.

**Teachers should reference Robotics Terminology sheet and select appropriate terms for students to remember, define, use (teacher discretion). These terms will come up again, so be sure to pay close attention as I explain what each one means.**

Teacher explains what each term means - and if possible shows the students a picture of the term to match with the definition.

Now we're going to use our new knowledge of this terminology to do some activities along with the kits.

### "Coaching" - 25 minutes

Teacher should lead students in building an experiment to test the various sensors included with the kits. Note: **Anytime that it is possible to incorporate a vocabulary word just explained in this discussion, do so!**

*As each step is completed, I want each team member raise your head to indicate that you have completed that step.*

Continue going through steps until all of the students complete tasks. Teacher should float from team to team to check in and help if needed.

Students begin, and teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Teacher should call for end to work on programming activities.

**Oral Review:** *We want to end our activity with a discussion of these questions. Use the activities we just completed to help you answer the questions:*

*What counts as a robot? What makes a robot different from a human?*

*What role does team work play in constructing a robot?*

*Why is it helpful to have different team members perform different roles in constructing a robot?*

### Student Action

Students should listen attentively to the directions and explanations

Students, in their teams should begin to following the directions of the teacher, acting in their assigned role.

After each guided step of the sensor experiment is concluded, the scribe of each group should record in their notebooks how that particular step in the experiment concluded.

Students should discuss answers to question provided by teachers and listen attentively to responses of other students.

*What does all of this have to do with the WOW!? Based on what you know your WOW! presentations will be, why was it necessary for us to learn what we did? What skills learned today will you use going forward?*

Student answers should include:

- how to collaborate with team members.
- acquiring building skills necessary to have to complete a robot to build for WOW!

(This may require some prompting or scaffolding by teachers; for example, asking "What about teamwork?" as a way to encourage students to think specifically about team collaboration.)

**"L" of the KWL chart.**

**Transition:** *Remember that at the beginning of class, I asked you all what you knew about robots and what you wanted to know. To end, what were some of the things we **LEARNED** about robots (specifically programming)? Did any of what we did today answer what some people wanted to know about robots?*

**Enduring Question:** *Based on what we have learned thus far, what can we say "counts" as a robot? What does something have to include to be a robot?*

*In your teams, come up with a good, short, and clear definition of what a robot is. Have your scribe write this definition down.*

Give team members 5 minutes to come up with a definition

*Have a team representative share your definition of what a robot is based on the knowledge we have gained these past few weeks.*

As the teams share their definitions, it is crucial for the teacher to clarify any misconceptions or misunderstandings of what constitutes a robot based on what is presented. For example, after some definitions, teacher might ask the class: "Does a robot *always* have to include/do that?" This is to refine students' understandings of the technical knowledge of robotics. Remind them to incorporate knowledge from last session. What are the basics of a robot? (Action, Sensor, and Processor/Programmer). It will not be necessary for student so mention specifically how programming works for robots, as this is knowledge that will be developed further into the semester.

**Point out to students** that we're going to be constantly refining our definition of a robot, so this is just to give them a good start.

**All remaining time should be left to clean up materials and store as necessary. Teacher should plan this accordingly.**

## Student Action

Students should discuss answers to question provided by teachers and listen attentively to responses of other students. Students should also listen attentively as WOW! connections are explained.

In groups, students will work on discussing and developing their definition of a robot. To ensure that all students are working, at least one part of the definition should be articulated and written by one of the group members. The end product should include contributions from every group member.

Each team should elect a representative to share their developed definitions. After each team shares their definition, student will participate in teacher-led discussion to compare and contrast the definitions developed by all of the teams



# Robotics - Lesson 3

This lesson introduces teaches students important vocabulary pertaining to robotics and skills using NXT programming. Students also research basic robotic designs on which to model the construction and designs of the robots their respective teams will be building.

## Objectives

- **Summarize** the ways in which basic NXT programming certain dictates robotic operations.
- **Compare and contrast** action, sequence, loops, and conditionals as basic programming principles.
- **Apply basic knowledge of algorithms** and logical sequencing to complete NXT programming exercises as a form of problem-solving.

## Lesson Snapshot:

1. Review Agenda, Expectations & WOW!
2. Opening Ritual (Becoming Familiar With Robot Designs)
3. Intro to Basic Programming Principles
4. NXT programming exercises
5. Choose WOW designs!
6. Refining Definitions (Assessment)
7. Clean up

## Vision for Student Mastery:

To indicate that students have learned this skill, students will successfully complete the NXT programming exercises and will orally extrapolate how some of the basic programs will be useful for their own robotic operations and design. Some students will also have the opportunity to begin applying these programming skills to their own robotic designs.

## Materials

1. Lego Mindstorm Kits (1 per group of students)
2. \_\_\_ computer per student (x number of computers)
3. Team Notebooks (1 per team)
4. Programming Activities (Lesson 3 Supplement)



## CSITS Standards

CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.

c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)

d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.

f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

## Connection to Guiding Questions

*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*

*In what ways can robots be used to solve certain problems?*

## WOW! Scaffolding

After becoming familiar with basic robot types in teams, students will decide on types and function of the robots to present for WOW!. This week, students will also be developing computer programming skills crucial for successful completion of robot.



## The Hook/Introduction - 10 minutes

Teacher should very briefly review agenda for the day's lesson (refer to snapshot)

*As I stated, we're going to begin today's lesson by browsing some basic robot designs, some of which might give your team ideas about how you want to construct/design yours.*

<http://www.nyx.net/~librown/robots2008/robots.html>

***If/When you see identify something in your research that relates to one of the vocabulary words we discussed yesterday, let us know so that we can share it with the rest of the class!***

**Transition:** *Before we jump into our robotics programming exercises, let's do some more quick review of some things we learned last session*

**Oral Review:**

- What are the three different roles of each team?
- What is the specific responsibility of each role? (Who can tell me?)
- What are the 3 basic parts of a robot? Who can tell me one and what it does? The other?
- Who can recall and explain one of the vocabulary words discussed on last week?

**Transition:** *Let's get to the new knowledge we're learning today.*

Teacher should pass out "Programming Basics" Sheet to for students to use read along as the teacher provides an explanation.

### Student Action

Students go to website and begin browsing basic robot designs

Sitting near their team members, students should carefully look at the various robot design, point out the features that appeal to them, **identify and use robotics terminology as appropriate**, and orally discuss this with their other group members. Teacher should circulate room and facilitate student/group discussion in both aspects.

Students should discuss answers to question provided by teachers and listen attentively to responses of other students.

## Modeling - 23 minutes

*NXT Programming is what we'll be using to help you all program your Lego robots. (Again, what is the role of programming for the robot?) We have to program in the robot certain actions it should take when it interacts with the environment in a certain way. For example, when we encounter a scary situation, our brain is programmed to tell our heart to pump blood faster.*

*You can program your robots to perform complex tasks like following a line or solving a maze, but you will need to understand some **basic programming principles first**. You can enter basic programs into the NXT just using the screen and the buttons on the NXT. To create more complex programs, you will need to connect the NXT to a computer. Some of you will get to this in programming your own robots.*

*Programs are just a collection of basic programming elements. Some of the elements include:*

**Actions** - *An action tells the NXT to perform some task like rotating a motor or reading a sensor.*

**Sequences** - *A sequence is a series of actions that occur one-at-a-time right after each other.*

### Student Action

Students should listen attentively to explanations provided by teachers.

## "Modeling" Cont'd.

**Conditional** - A conditional compares two values and performs one sequence of actions if the comparison is true and another if it is false. For example, you could tell the NXT to move forward if the distance to the object in front of it is greater than 10cm, but stop if it is less than or equal to 10cm.

This can also be called an **algorithm**. An algorithm is a set of rules used to solve a problem.

**Remember that algorithms:**

1. are a specific set of rules
2. solve problems by giving directions to robots.

Here is an example program:

- Move forward 1cm.
- Measure the distance to the object in front of us. This could be anywhere from 0cm to 1000cm.  
Remember this value as X.
- Compare X to 10cm. If  $X > 10\text{cm}$  then go to step 1, otherwise go to step 4.
- Stop.

**Ask and discuss the question prompt with the students.** (What is an example of a conditional in the provided example, etc.)

This will make better sense as you all look at more robotic programs and even begin to design your own.

**Transition:** We're going to now get some practice using the NXT software to practice developing algorithms and basic programs for robots. We will be answering the following questions in this activity: "What does a program look like for a robot? How do we identify actions, sequences, loops, and conditionals in a given program? What are the differences between these things?"

### Student Action

Students should pay close attention to teacher as basics of robotic design and programming is explained.

During this time, students will be either actively listening (eyes on speaker) or answering the questions provided, as called upon.

## "Scaffolding" - 15 minutes

### NXT programming exercises

*At this time, I am going to demonstrate some basic computer programming exercises for you. Through this, you will begin to understand how these exercises will be useful for your own robotics programs.*

Using NXT software, show students the exercise and orally speak through each step you take. You should point out, specifically, some of the basic programming principles explained (loop, sequence, conditional, etc.) or examples of algorithms as they come up in the exercise. You should complete about 3-4 of the exercises in detail to demonstrate method. End your direct instruction with review questions.

Answer any questions from students, as they come up throughout the demonstration.

**Transition:** Now it's your turn to try your hand at programming. Remember, you will have to have these skills in order to program and explain your robots for WOW!

As you complete your programs, you will also be answering the following questions in your team notebook. Each team member should be responsible for writing in the notebook at least one question and answer pair.

### Student Action

Students should listen attentively to explanations provided by teachers.

**“Scaffolding” Cont’d.**

Questions:

Which step of the program is a conditional?  
 Which steps are part of a loop?  
 Which steps are part of a sequence?  
 Which steps are actions?  
 What would your robot do if you gave it this program?  
 What are two ways to enter programs into the NXT?

(NOTE: What might help this activity is if these questions are posted in large print somewhere in the space for students to refer back to.)

**Student Action**

Students should discuss answers to questions provided by teachers and listen attentively to responses of other students.

**Coaching - 50 minutes**

As students begin to individually complete exercises, teacher should float around the room to answer questions and guide completion both of programming exercises and the question prompts below.

As all teams complete the exercises, conduct a quick oral review of the major programming concepts learned.

**Assessment:** *At this time, I want to hear from each team one example of each basic programming principle that they identified in the programming exercises. Team\_\_\_\_, what was your example of sequencing? (Continue in this way with each team until all major concepts of programming were covered.*

**Transition:** *With these things in mind, you need to now choose a basic robot from the ones we browsed at the beginning of class on which to base your group design.*

**Choose basic robot project from Web site (15 min)**

*In your groups, decide on one of the following robotic designs that you want to inspire your own robot. Remember that your robots need to be autonomous and able to move around easily.*

(All of these are on the indicated website at the beginning of the lesson)

Scorpion	Tribot	Hammer Car	Spinner Bot	Ball Hunter
Castor Bot	Line Follower	Claw Car	Puppy	

**Student Action**

Students will individually work on completing the NXT programming exercises with teacher guidance. Students will also be answering the four prompting questions

Each team should discuss and finalize the kind of robot they want to build and what they want them to do for the WOW! presentation. The scribe of each team should record these ideas in the team notebook. (Type of robot on which they want to base their model and what they want them to do.) Teacher should float around room to help guide each team's discussion and ensure that ideas are being recorded in organized fashion.

**Connection to WOW! and Assessment - 15 minutes**

Assessment Activity:

*To end class, we're going to build on and change anything about the definitions of a robot we came up with during the last session. I want you to especially think about these questions:*

*What counts as a robot? What makes a robot different from a human?  
 How does a robot make decisions?  
 How does programming help a robot make decisions?  
 What basic programming principles are incorporated into robotic design?*

Answers should be recorded in team notebook.

**Take-away point:** *A robot is a machine that resembles a human in that it is programmed to perform certain actions when it interacts with its environment in a certain way.*

Clean up

**Student Action**

In groups, students will work on discussing and developing their definition of a robot. To ensure that all students are working, at least one part of the definition should be articulated and written by one of the group members in the team notebook. The end product should include contributions from every group member.

# Robotics - Lesson 4

This lesson will be mostly devoted to students building and programming robots to be featured at the WOW! ceremony.

## Objectives

- **Explain the required components** of robots to be presented at WOW! presentation.
- **Apply** basic knowledge of algorithms and logical sequencing to complete NXT programming used for robot operations.

## Lesson Snapshot:

1. Review, agenda, and expectations for WOW!
2. Final team decisions on robot designs and actions.
3. Team construction and programming
4. Clean up

## Vision for Student Mastery:

To demonstrate that they have learned the above, students will Successfully use their knowledge of program design to have their robots move and navigate. Students will also orally explain the required components of robots to be presented at WOW! presentations.

## Materials

1. Lego Mindstorm Kits (1 per group of students)
2. \_\_\_ computer per student (x number of computers)
3. Team Notebooks (1 per team)



## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

### CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role.

## Connection to Guiding Questions

*What makes something a "robot?"*

*What role does team work play in programming and constructing a robot?*

*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*

## WOW! Scaffolding

Students will initiate team construction of robots to be presented for WOW!. Staff will begin to demonstrate and model important process of programming, building, testing, and refining actions of robots.



## The Hook/Introduction - 18 minutes

Briefly review class agenda for the day's lesson (refer to quick snapshot above).

Inform/remind students of where they are on track to completing WOW! (For example, *You've all started robot construction and we have only five more sessions to complete it!*)

### Review what was learned during the last session:

*As we began refining our definition of what a robot is, we discussed the role of algorithms, conditionals, sequencing, loops, and actions. Remind of what these things are. What is an example of one from the NXT programming?*

In reviewing these, teacher should get an example of each of these from a different student each time.

**Transition:** *The same skills we learned to do the NXT programming exercises on the last session, we will be using to program our robots.*

*We are first going to have each team share with the other team members what design they chose for their robot and what functions they will have their robots perform for the WOW! presentations.*

Students should use the notes recorded in their team notebooks as a reference when reporting

*Remember that the requirements for the basic robots to be presented are:*

- a. *It has to be able to move easily and change course.*
- b. *It has to operate autonomously (by itself, independent)*

*These requirements will make more sense as we get into building our robots.*

**Transition:** *Now we are going to start building and programming! We will be using the building instructions for each kit. Let me also remind you of what your different team roles are:*

*Scribes/Programmers/Builders raise your hands! What is each of your responsibilities?*

### Student Action

Students should listen attentively to the directions and explanations from teachers.

Students should discuss answers to question provided by teachers and listen attentively to responses of other students.

Team representatives share with the other class members their finalized decisions on robot designs and functions, and their team names.

Students will actively discuss answers to questions prompted by teachers.

## Modeling - Scaffolding - Coaching - 70 minutes

### Start building basic robots (70 min) 4:45 pm

Each team should open the building instructions on multiple computers.

This is important because it allows each team member to build different parts of their robots in parallel. (Most of the robot designs allow for this.) (Note: To **model**, teachers should give an example of how a particular team might divide roles and parts. To **scaffold**, teachers should support student work on various parts of the robots as necessary. The ultimate goal is for students and teams will work on their own.

### Student Action

On individual computers, each team member will begin to follow the building instructions to complete construction for their selected part of the robot.

Students will need to decide, in their teams, who will begin building what parts of the robots. (Again, remind them that this does not preclude their responsibilities in their particular team member roles.)

From this point on, the building of the robots will be self-directed. As you circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from members?
2. Is the scribe of each team keeping track of which steps their team has completed?
3. How are students thinking abstractly about constructing and programming the robot? (particularly in their use of basic programming principle).

Students should get as far as possible in designing and programming robot.

### Student Action

Students will continue to construct their part of the robot for the team. **It is important that the scribe of each team, under a dated entry, record the progress of the team at the end of the session.** (Questions for the scribe to consider might include, "Did any of our team members complete their part of the robot?" or "Is each team member about half done?" , etc.)

## Connection to Wow! and Assessment - 10 minutes

**Connection to WOW!** - *Today, you all began constructing what will actually be your product for the WOW! Some of you made some really good progress, and that shows me several things - you have a good understanding of team work and your team roles and how algorithms and programming works.*

*We're done for today. So at this point, I want the scribes in each group to be sure they've recorded where their team is in their progress (according to instructions).*

### Assessment (Closing Ritual):

Understanding of robotic construction and programming will be confirmed by progress made by groups in building and constructing robots.

### Clean up

### Student Action

Students should listen attentively to teachers' explanations of WOW! Progress and plan.



# Robotics - Lesson 5

This lesson challenges students to go beyond the construction of the robot and apply NXT computer programming concepts that allow it to self-navigate and move independently.

## Objectives

- **Apply basic knowledge of algorithms** and logical sequencing to complete NXT programming used for robot operations.
- **Refine their definition** of “robot” by distinguishing between a robot in its most basic form and some of its advanced existences.

## Lesson Snapshot:

1. Review agenda, expectations for WOW!
2. Group progress and feedback)
3. Demonstration of “independent” robot.
4. Group construction of robots
5. Clean up

## Vision for Student Mastery:

To demonstrate that they have learned the above, students will successfully use their knowledge of program design to have their robots move and navigate on their own. At the end of the lesson, students will also orally reflect on the role that computer programming concepts play in having robots having certain operations.

## Materials and Pre-Planning

1. Demonstration robot (moving independently)
2. Lego Mindstorm Kits (1 per group of students)
3. \_\_\_ computer per student (x number of computers)
4. Team Notebooks (1 per team)

## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

### CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role.

## Connection to Guiding Questions

*What role does team work play in programming and constructing a robot?*

*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*

## WOW! Scaffolding

Students will continue team construction of robots to be presented for WOW!. Staff will begin to demonstrate and model important process of programming, building, testing, and refining actions of robots. Students should have robots self-navigating and independently moving by the end of the session.



## The Hook/Introduction - 15 minutes

### Review agenda, expectations & WOW!

**Transition:** *We've already begun construction on our robots, and today we're going to make some specific goals about where we want to be by the end of the session. Today's objective is to have your robots move around and navigate on its own. Before we get started, I want each team to report how they have progressed so far in constructing and building their robots...*

### Opening ritual

*We are going to have each team share with the other team members where they are in the construction and programming of their robots.*

Students should use the notes recorded in their team notebooks as a reference.

The teacher might facilitate this discussion using the following questions:

*What has worked well for some of you as you've begun to design your robot? What has not worked so well? What feedback can you all offer to the other students to help speed the process of robot construction? What has been successful/unsuccessful for some of you as you have worked in teams?*

**Transition:** *Let's use some of the great ideas just heard to begin construction and programming of our robots. Remember, today's objective will be to have your robots able to independently move and self-navigate.*

### Student Action

Students should listen attentively to the directions and explanations from teachers.

Team representatives share with the other class members what progress they have made thus far in constructing robots.

## Modeling - 10 minutes

*Let me show you what I mean when I say that robots should be able to move independently.*

The teacher should use a demo robot to demonstrate what the objective is and answer any student inquiries. If there are no questions, teachers should randomly call on a student to explain what is meant by a robot moving independently (to assess their knowledge of what the objective is).

**Transition:** \_\_\_\_\_, *what do I mean I say that a robot should move independently? Great, now it's your turn to make this happen in your groups. Remember, this feature is a requirement for your WOW! Presentations, so let's make sure we work hard!*

### Student Action

On individual computers, each team member will begin to follow the building instructions to complete construction for their selected part of the robot.



## “Scaffolding” - “Coaching” - 60 minutes

In groups, students continue building basic robots.

Again, each team should open the building instructions on multiple computers.

This is important because it allows each team member to build different parts of their robots in parallel. (Most of the robot designs allow for this.)

Students begin, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members? team has completed?
2. How are students thinking abstractly about constructing the robot?
3. Is the scribe of each team keeping track of which steps their teammates have completed?
4. **How did your team use algorithms and/or computer programming concepts to make your robot move? (Especially important)**

Since knowing how algorithms/programming work together as a central component of robotic operations, the teacher should especially help students “flesh out” and answer the last question as they continue programming and construction on team robots.

### Student Action

Students will continue to construct their part of the robot for the team. **It is important that the scribe of each team, under a dated entry, record the progress of the team at the end of the session.** (Questions for the scribe to consider might include, “Did any of our team members complete their part of the robot?” or “Is each team member about half done?” , etc.).

## Connection to Wow! and Assessment - 5 minutes

**Connection to WOW!** - *Most of you were able to have your robots move independently and self-navigate. Great job! This is especially important because it's one of the major features in presenting and explaining your robots for the WOW! Speaking of that, let's answer the question presented to each group: How did you use algorithms to make your robot move?*

Lesson will conclude with teachers fielding responses from students describing how they incorporated basic compute programming concepts into their robotic designs.

### Assessment (Closing Ritual)-

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the point of self-navigation and independent movement. Doing so is evidence of at least some mastery of content, including successful team collaboration, and knowledge of algorithms. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students.

### Clean up

### Student Action

Students should discuss answers to question provided by teachers and listen attentively to responses of other students.

Students will collaborate to clean and organize whatever materials need to be.

# Robotics - Lesson 6

This lesson challenges students to go beyond the construction of the robot and apply NXT computer programming concepts that allow the robot to interact with the environment in some way (e.g., move a ball.)

## Objectives

- **Apply basic knowledge of algorithms** and logical sequencing to complete NXT programming used for robot operations.
- **Develop and refine algorithms** to use that will direct more humanlike actions of robots. (e.g., use its sensors and interact with its environment in some detectable way like move a ball).

## Lesson Snapshot:

1. What Have *You* Learned About Robots?
2. Status of groups, expectations, and robot demonstration (environment interaction)
3. Build/program robots in teams
4. Clean up

## Vision for *Student Mastery*:

To demonstrate that they have learned the above, students will successfully use their knowledge of program design have their robots move, navigate, and use its sensors to interact with environment in some way (e.g., grab a ball.)

## Materials and Pre-Planning

1. Demonstration robot (environment interaction)
2. Lego Mindstorm Kits (1 per group of students)
3. \_\_\_ computer per student (x number of computers)
4. Team Notebooks (1 per team)

## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

### CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role.

## Connection to Guiding Questions

*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*

*In what ways can robots be used to solve certain problems?*

## WOW! Scaffolding

By the end of the session, students will successfully use their knowledge of program design to have their robots move, navigate, and use its sensors to interact with environment in some way (e.g., grab a ball.) This will be a very important step in preparation for the WOW! program. Students will also need to know how to explain the way algorithms were used to make this robot feature happen.

## The Hook/Introduction - 20 minutes

**Opening ritual** - *In your team notebooks, I want you to answer the following:*

- Name three things you have learned about building robots so far.*
- Name one thing your robot can do, one thing it can't yet but will eventually, and one thing you wish it could do if it could do anything!*
- List and explain at least 5 computer science and/or robotics terms we have learned or discussed in the past.*

**Share out** - *I want each team to have a representative share with the group the answers they came up with to these questions. (Limit to two vocabulary words per group.)*

**Transition:** *Hopefully, by the end of the session, most of your robots will be doing something that it can't yet but eventually will...*

*Last week our goal was to have each team's robot able to move around and navigate.*

Teacher should briefly report statuses of the different groups. Have the scribe of each team use the team notebook to confirm the teacher's report. For example,

*Team \_\_\_\_\_ was able to complete the goal of basic movement and navigation for their robots. The other team, \_\_\_\_\_, has this as their goal to complete this week, etc. Is this correct according to the team's notes?*

*To achieve this, I (or other teachers) will be especially helping those teams so that they can catch up.*

*For those of you that are up to date, our goals this week:*

*By the end of the week, each team should be able to complete their basic robots. In addition to navigation and movement the robot should be able to use its sensors and interact with its environment in some way (ie. grab a ball).*

**Transition:** *Let show you what I mean...*

### Student Action

Students will work with their group members to answer the provided prompts.

Students will listen attentively to the group status updates.

## Modeling - 15 minutes

*I want to show you what I mean when I say that robots should be able to use its sensors to interact with the environment in some way.*

With an example robot, teacher should demonstrate the type of action that exemplifies the objective for today; that is, having the robot interact with the environment (e.g., move a ball, navigate an obstacle, etc.)

*As with having your robots move, it will also be important that you know how algorithms were used to make this action happen. Any questions about what your objective is for today?*

**Transition:** *Let's get started...*

### Student Action

Students should listen and watch attentively as teacher demonstrates robot interaction with environment.

### Build/Program Robots

In groups, students continue building basic robots, particularly focusing on developing programming that would have robots interact with the environment in some way.

Again, each team should open the building instructions on multiple computers.

This is important because it allows each team member to build different parts of their robots in parallel. (Most of the robot designs allow for this.)

Students begin, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

Again, the building of the robots will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. Is the scribe of each team keeping track of which steps their teammates have completed?
4. **Asking groups to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

### Student Action

Students will continue to construct their part of the robot for the team. **It is important that the scribe of each team, under a dated entry, record the progress of the team at the end of the session.** (Questions for the scribe to consider might include, “Did any of our team members complete their part of the robot?” or “Is each team member about half done?” , etc.)

### Connection to Wow! and Assessment - 15 minutes

**Connection to WOW!** - *Most of you were able to have your robots interacting with the environment in some way. Great job! This is especially important because you're well on your way to having the product finished for the WOW! presentations! Since we did with the session last week, I want us to discuss the question we did on last week: How did you use algorithms to make your robot interact with the environment? Compare and contrast the logic you had to use in programming your robot to interact with the environment. (How was it the same and/or different from the programming used for your robots on last week?)*

### Assessment (Closing Ritual):

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the point of interacting with the environment in some way. Doing so is evidence of at least some mastery of content, including successful team collaboration, and knowledge of algorithms. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students.

### Clean up

Note: At this point of the apprenticeship, some of your cleaning routines might include checking around the space for kit pieces still out and put them away, secure the kits themselves and put them away, robots placed carefully in boxes, saving programs on flash drives or another secure location, and logging/shutting off computers.

### Student Action

Students will collaborate to clean and organize whatever materials as needed.

# Robotics - Lesson 7

In this lesson, students will conclude the major steps necessary to complete their team robots. They will be challenged to use NXT programming to equip their robot with an advanced feature to be showcased during the WOW! ceremony.

## Objectives

- **Apply basic knowledge of algorithms, loops, conditionals, sequencing, and actions**, to complete NXT programming used for robot operations.
- **Refine knowledge of programming** to have robot perform advanced features.

## Lesson Snapshot:

1. How to begin a career in robotics?
2. Status of groups, expectations, and robot demonstration (environment interaction)
3. Group decisions on WOW! ceremony roles
4. Build/program robots in teams

## Vision for Student Mastery

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the extent that it is able to demonstrate an advanced feature. Doing so is evidence of at least some mastery of content, including successful team collaboration and knowledge of algorithms and basic principles of programming. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students as they attempt to complete this objective.

## Materials and Pre-Planning

1. Demonstration robot (advanced feature)
2. Lego Mindstorm Kits (1 per group of students)
3. \_\_\_ computer per student (x number of computers)
4. Team Notebooks (1 per team)



## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

### CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role.

## Connection to Guiding Questions

*What makes something a "robot?"*  
*What role does team work play in programming and constructing a robot?*  
*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*  
*In what ways can robots be used to solve certain problems?*

## WOW! Scaffolding

In this lesson, students will work with teachers to complete the last remaining programming and construction on their team robots. All teams should have basic robots fully completed. Teams will be challenged get creative and add something unique to their designs. CTs will help teams create advanced robot designs and programs. (Ex. a Robot that finds the ball, grabs it and brings it to you, or turns around and puts the ball *back*, a robot that navigates a simple obstacle course using multiple strategies.)



## The Hook/Introduction - 15 minutes

Have students read the following article:

How to begin a career in robotics found at <http://www.helium.com/items/1410404-robotics-career/print>

*After each of your teammates reads the article, discuss the questions (below) and write the answers in your team journal:*

What classes should you take in high school to prepare for additional education in college?

What are three paths to a robotics career?

After the students discuss and answer the questions with their teammates, the teachers bring the class back together, have volunteers from three different groups answer the questions, and verify that answers are correct.

**Transition:** *With most of you close to being finished building and designing a robot, you're well on your way to a successful career if that's a path you choose for yourself. However, we still have some work to get to done to get ready for our WOW! presentation. Here's where we are and our plan for moving forward:*

At this point, the teacher should announce the status of each team and discuss the specific steps each team needs to take to complete their robots. S/he might also suggest which teaching fellows or

### Student Action

Students should spend approximately 5 minutes reading through the article and 10 minutes answering the questions with their teammates.

Students should listen attentively to the status updates provided by the teachers.

## Modeling - 10 minutes

*For those of you that have finished, the objective today is to have you go beyond the initial requirements and have your robot do something even more advanced. For example, program/build a robot that not just finds the ball, but also that grabs it and brings it to you, or turns around and puts the ball back.*

*Let me show you an example of what I mean:*

At this time, the teacher should use/program a robot that demonstrates an "advanced" feature" to which the students might aspire with their robots.

**Transition:** *Let's get started.*

### Student Action

Students should listen attentively to the explanations and examples demonstrated by the teacher.

## "Scaffolding"- "Coaching" - 50 minutes

### Build/Program robots

In groups, students continue building basic robots, particularly focusing on developing advanced features (for those that have already completed the more basic features.)

Again, each team should open the building instructions on multiple computers.

This is important because it allows each team member to build different parts of their robots in parallel. (Most of the robot designs allow for this.)

After students begin, teachers circulate room to facilitate process as needed and gradually allow students to work on their own in teams. **The latter is the ultimate goal.**

### Student Action

Students will continue to construct their part of the robot for the team. **It is important that the scribe of each team, under a dated entry, record the progress of the team at the end of the session.**

## “Scaffolding” - “Coaching” - 60 minutes (cont'd.)

Again, the building of the robots will be self-directed. As the teachers circulate amongst the teams and monitor the progress, key things to address include:

1. What evidence is there of collaboration and feedback from team members?
2. How are students thinking abstractly about constructing the robot?
3. **Asking groups to explain: How did you use algorithms or other basic principles of programming (sequencing, loops, etc.) to make your robot interact with the environment? (Especially important)**

As knowing how algorithms/programming work together as a central component of robotic operations, teacher should especially help students flesh out and answer the last question as they continue programming and construction.

Teams that are behind will have a chance to finish their basic robots and teams that are on track or ahead can customize their robots and modify their robots to be more advanced.

### Student Action (cont'd.)

(Questions for the scribe to consider might include, “Did any of our team members complete their part of the robot?” or “Is each team member about half done?” , etc.)

## Connection to Wow! and Assessment - 15 minutes

**Connection to WOW!** - *Each of you will have a different role for the WOW! presentation. Each group will need to have someone different who will:*

1. Provide an **introduction**– what are their names, what robot they built, functionality summary.
2. **Demonstration of building process** using the building instructions; what major steps were performed to build the robot.
3. **Provide an explanation of their robot’s characteristics**, where the sensors are, what they will use them for.
4. **Programming** – Describe what every part of their program does.
5. Show how it works !

### Q&A

*At this time, I want you to take 5 minutes to discuss in your teams who would be most interested in performing what role. Something key to remember is that though a different person will be doing each (or maybe 2) of these things, each team member needs to have complete knowledge of all, something that will be useful for the Q&A session. The point is that you all have particular expertise in your assignment, but that’s not all. **Please be sure that you write down in your team notebooks who has volunteered to perform what role in the WOW! ceremony. I then want everyone to sign their name beside the role that they agreed to take.***

### Assessment (Closing Ritual):

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the extent that it is able to demonstrate an advanced feature. Doing so is evidence of at least some mastery of content, including successful team collaboration, and knowledge of algorithms and basic principles of programming. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students.

### Student Action

Students will continue to construct their part of the robot for the team

**Shout-Outs and WOW! Announcements (Cont'd.)**

Teacher should use the time to praise individual students or groups and their progress. This can be done via different recognition activities learned in CT training. (1-2-3-NICE!, etc.). As the WOW! ceremony nears, this positive encouragement might be especially helpful.

**Clean up**

Note: At this point of the apprenticeship, some of your cleaning routines might include checking around the space for kit pieces still out and put them away, secure the kits themselves and put them away, robots placed carefully in boxes, saving programs on flash drives or another secure location, and logging/shutting off computers.

Students will collaborate to clean and organize whatever materials as needed.

# Texas Robotics - Lesson 8

This lesson activity is designed to give students the opportunity to connect the content knowledge and skills gained from apprenticeship thus far to educational pathways and potential careers in computer science and/or robotics.



## Objectives

- *What are 4-5 different careers for individuals interested in robotics and computer science?*
- *What are 2-3 steps **necessary** to complete a career in robotics or computer science?*
- *How are the skills I have learned thus far connected to a career in robotics or computer science?*

## Field Trip

### Lesson Guide

An important part of this apprenticeship is allowing students to make the connections between the skills they have learned in a particular field and a professional career that utilizes those same skills.

Thus an optional, albeit important, lesson of the curriculum is the first-hand exposure of students to such a career; that is, a fieldtrip, speaker, or related activity. The fieldtrip should be to a workplace or organization that most strongly connects to the skills that the students have developed, themselves, at this point of the robotics apprenticeship. A field trip might include a trip to a robotics laboratory, a computer-programming site, a related toy manufacturing company, etc. The speaker might be an individual whose day-to-day professional activities cover one or a combination of these fields.

Because these activities for students largely depend on random variables like available resources and site location, they are certainly not “formal” lessons to be implemented. As all of the lessons of this curriculum have key objectives for student learning, a field trip session should be no less the case, however. After a field trip or class speaker, students should have a better understanding of the following, at minimum:

- What are 4-5 different careers for people interested in robotics and computer science?
- What are 2-3 steps **necessary** to complete a career in robotics or computer science?
- How are the skills I have learned thus far connected to a career in robotics or computer science?

If it is highly unlikely that any such activities would be possible, another might option might be a web exploration of sorts that relate to careers in robotics and/or computer science. A website you may use as a reference point can be found at this web address: <http://sites.google.com/site/bedichekbots/careers>.

## CSITS Standards

### CS.CSITS.5

**Citizen schools students will compare and contrast the ways in which computing enables innovation in other fields.**

“I Can” Skills:

- a. I can **make comparisons between skills learned and identified careers in computing**, including - but not limited to - information technology specialist, Web page designer, systems analyst, programmer, and CIO.

## **Curriculum Scheduling:**

In this particular unit, this “lesson” is scheduled near the end of the apprenticeship (Lesson 8). This was designed to give teachers adequate time to plan and to give students time to develop basic knowledge and skills of the profession to use as a reference point for exploring related professions.

Factors like speaker availability, planning, or limited resources, however, also might affect when such activities would be possible during the apprenticeship. The teachers should use their discretion to insert this activity at the point of the curriculum that best fits with their scheduling. In addition, efforts should be made to schedule a speaker or field trip activity when the teachers feel students’ learning would be the most benefitted.

## **Pre-Planning**

It will be important for the teachers to determine when specifically a field trip, speaker, or career web search will be appropriate at the beginning of the apprenticeship. After the seventh session? At the beginning? Doing so will ensure adequate time for preparation. This is especially true regarding the logistical planning for a field trip or speaker. Beyond the logistics, it will also be important for the students to come into an experience with some form of preparation themselves. What kinds of questions should students ask of a speaker or factory tour guide? What are they most interested in learning by visiting a particular field trip site or hearing from a speaker? What are the learning objectives expected of them? Having these explicit conversations with students before the activity (i.e., one of the sessions before) will probably be most helpful for them and their learning.

# Robotics - Lesson 9

The focus of this lesson is on completely finishing the team robots and rehearsing designated roles for WOW! ceremony.

## Objectives

- **Apply basic knowledge of algorithms**, loops, conditionals, sequencing, and actions, to complete NXT programming used for robot operations.
- **Fully develop** (build and program) a robot to be presented for WOW! ceremony.
- **Apply their understanding of their respective WOW! roles** by individually performing basic rehearsals for ceremony.

## Lesson Snapshot:

1. Status updates and objectives for project completion
2. Build/program robots in teams (final edits.)
3. Individual and group rehearsals for WOW! ceremony
3. Clean Up

## Vision for Student Mastery:

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the extent that it is able to demonstrate an advanced feature. Doing so is evidence of at least some mastery of content, including successful team collaboration and knowledge of algorithms and basic principles of programming. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students as they attempt to complete this objective. **This day should be the last day to complete construction of robots.**

## Materials

1. Lego Mindstorm Kits (1 per group of students)
2. \_\_\_ computer per student (x number of computers)
3. Team Notebooks (1 per team)



## CSITS Standards

### CS.CSITS.2

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

### CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role

## Connection to Guiding Questions

*What makes something a "robot?"*

*What role does team work play in programming and constructing a robot?*

*How can algorithmic thinking and robotic design be used to develop logical thinking and problem-solving skills?*

*In what ways can robots be used to solve certain problems?*

## WOW! Scaffolding

Students will finalize last details of their respective team's robots (including building and programming), identify the specific role that they will have for the WOW! presentation and begin formal rehearsals of those parts.

## The Hook/Introduction - 5 minutes

*Today is the last day we want to spend constructing and programming robots. At this point, teacher should give class update on where everyone stands. We want to spend first 45 minutes doing any last minute edits we need to for our robots. During the last 45 minutes, we will begin rehearsing for the WOW! presentation. Today's two objectives:*

1. *Create the final version of our robot.*
2. *Familiarize ourselves and be able to explain what will be expected from everyone for the WOW! ceremony. That is, what is my role, and how do I perform it well?*

*If you have already completed your robots, then you have two options:*

1. *You can choose to help any other group that needs help making final edits to programs or construction.*
2. *Begin rehearsing your role for the WOW! ceremony.*

### Student Action

Students should listen attentively to explanations, status updates, and objectives of the day from teachers.

## “Coaching” – 45 minutes

### Build/Program robots

Teams that are behind will have a chance to finish their basic robots and teams that are on track or ahead can customize their robots and modify their robots to be more advanced. All final edits should be made within this time frame.

Teachers should provide specialized attention to each group to ensure that each one is on track to being complete and operating.

**Transition:** *With everyone's robot complete, we're going to now begin rehearsing for the WOW! ceremony.*

### Student Action

Students will report to teams and finalize all of the last programming and construction details of their robots.

## “Modeling” - 45 minutes

*Each of you will have a different role for the WOW! presentation. Each group will need to have someone different who will:*

1. Provide an **introduction**– what are their names, what robot they built, functionality summary.
2. **Demonstration of building process** using the building instructions; what major steps were performed to build the robot.
3. **Provide an explanation of their robot's characteristics**, where the sensors are, what they will use them for.
4. **Programming** – Describe what every part of their program does.
5. Show it work!

Q&A Session.

*At this time, I want you to open your notebooks to confirm the role that each person will be taking in each team. We will be divided up according to our roles, first. We're going to talk about what all of the people doing the introduction, for example, should do and practice. We'll do this with each role. Then we'll come back together as a large group to try and put it all together.*

### Student Action

Students should listen attentively to teachers' explanations of different roles expected to be performed for the WOW! ceremony.

**Modeling and Scaffolding (Cont'd.)**

At this time, the teachers should divide themselves to lead four different groups according to student roles. One teacher might work with those doing the "Intros", another teacher "Demos", etc.

Teacher should then divide students accordingly. *"If you will be doing the "Intro", go with \_\_\_\_\_", etc.*

Within each group, the teacher should 1) explain how long and what the contents should be of their role 2) model what will be expected of them in that particular role, and 3) give them the individual opportunity to practice for the group.

**Transition:** *Now that everyone's had the opportunity to get a little bit of practice, we're going to end class with you all performing your roles in your groups.*

**Student Action**

Students will report to their respective group depending on their roles. In those groups, students will practice their roles.

**"Coaching" - 20 minutes**

Each team should come back together and spend the last 20 minutes of the session rehearsing their roles in their entirety (in order.)

The teachers should circulate the room to listen in on rehearsals and clarify presentations as needed. At the minimum, students should get two full rehearsals completed.

**Transition:** *Let's recap.*

**Student Action**

In their groups, students will each perform their roles as part of one cohesive group performance.

**Connection to Wow! and Assessment - 15 minutes**

**Connection to WOW!** - *Today, each group has completed their robots, and we also officially started rehearsing for our WOW! ceremony. Again, something key to remember is that though a different person will be doing each (or maybe 2) of these things, each team member needs to have complete knowledge of all, something that will be useful for the Q&A session. The point is that you all have particular expertise in your assignment, but that's not all. Next week's session will be devoted entirely to rehearsing.*

**Assessment (Closing Ritual):**

The major assessment tool of today is to have each group complete the objective of constructing/programming their robot to the extent that it is able to demonstrate an advanced feature. Doing so is evidence of at least some mastery of content, including successful team collaboration and knowledge of algorithms and basic principles of programming. As the different groups continue trying to master the objective, it will be important for the teachers to circulate the room and clarify any respective misunderstanding from students as they attempt to complete this objective. **This day should be the last day to complete construction of robots.**

**Clean up**

Note: At this point of the apprenticeship, some of your cleaning routines might include checking around the space for kit pieces still out and put them away, secure the kits themselves and put them away, robots placed carefully in boxes, saving programs on flash drives or another secure location, and logging/shutting off computers.

**Student Action**

Students will collaborate to clean and organize whatever materials as needed.



# Robotics - Lesson 10

The focus of this lesson is on completely finishing the team robots and rehearsing designated roles for WOW! ceremony.

## Objectives

- **Apply their understanding** of their respective WOW! roles, robotic construction, and programming through clear presentations for ceremony (as individuals and cohesively as groups.)

## The Lesson:

Instead of a formal lesson to implement, teachers are advised to use this session in whatever ways necessary to ensure sufficient WOW! preparation. Some things to keep in mind:

1. Part of the preparation for the WOW! ceremony will need to include setting up the obstacles for each team's robot. For example, if a robot will be following a line as its feature, lines of painters tape should be placed on poster board for line followers. (Note: These poster boards could be tiled so they could be interchangeable and create a variety of courses, by reordering the tiles.). If a robot will be interacting with a ball, balls should be placed in necessary places.
2. Teachers and students should make last minute changes and confirmations for programming, enhancement features, etc. (Is every feature of each robot working properly?)
3. Teachers should be sure to test students' understanding and ability to explain how they built their robot (building instructions), what its specific features include (processor, sensor, action), how it was programmed (sequencing, looping, conditionals, role of algorithms), and be able to effectively demonstrate what their robot can do *and* the significance of its action (For example, what is scientifically allowing it to do what it is doing?). Students should also practice being adept at answering a range of questions that pertain to these things.
4. Students should have adequate time to present and practice as teams (with their robot) repeatedly (at least three times a team.)
5. All robots and other necessary materials should be properly stored in a safe location until the WOW! ceremony.



## CS.CSITS.2

## CSITS Standards

Citizen schools students will use abstraction to develop models and simulations of natural and artificial phenomena that solve problems and make predictions.

- a. I can **describe the processes involved** in a *self-designed* computational model of natural or artificial phenomena (e.g., robots, computer programs) addressing a problem.
- c. I can **apply multiple levels of abstraction** while engaging with computational systems (e.g., using a programming formula to predict future behavior, replicate mathematical operations, find examples to prove a formula incorrect.)
- d. I can **create a functional relationship or algorithm** using my own words, formulas, and symbols.
- f. I can **design and present computational models of artificial and natural phenomena** (e.g., robots, computer programs) that demonstrate and communicate various concepts. (WOW!)

## CS.CSITS.3

Citizen schools students will collaborate and effectively work in teams to produce computational artifacts

- a. I can **compare and contrast the different team roles** important in designing, building, and improving computational artifacts.
- b. I can **collaborate with other team members** to complete computer science projects.
- c. I can **effectively provide feedback** to group partners on a computer science project as a tool to facilitate its completion.
- d. I can **constructively evaluate my and others' performance** in a particular team role.



# Robotics 101:

Starting a robotics project  
and the use of LEGO  
Mindstorms NXT® Robotics  
Kits to Facilitate Experiential  
Learning in Science and  
Technology

A. M. Habib  
*University of Wisconsin Cooperative Extension*  
Dr. Clyde Clarke  
*John Hopkins University*  
Tanisha English  
*University of Maryland Cooperative Extension*

CYFAR 2009

# + Workshop Overview



- Background
- Technology overview
- Introduction to programming a robot using Mindstorms NXT ®
- Group exercises and programming challenges
- Starting your own robotics club or program
- Wrap up and evaluation



**“It’s learning that is fun.”**

-Youth member of FIRST LEGO League robotics team



# + One Million New Scientists, One Million New Ideas

- Robotics is an integral part of National 4-H's SET initiative
- National 4-H has recently signed an MOU with FIRST Robotics



# + Excerpts from Interviews of youth participating in Wisconsin's robotics programs



## *The most important thing I've learned:*

- To be a good team - find out what everyone is good at, let them choose and be successful at their skill
- I've learned that the robot must be designed to be versatile and to be able to fix any mistakes, because they *will* happen.
- When you work as a team, you get a lot farther
- I learned social skills and researching skills. And also that working with a team can be a lot of fun.

Some of the most effective ways, in my experience, to getting team together and staying focused are: to set specific goals for the time the team is together and on their own, and to have “report-backs”, telling the other team-members what you accomplished and sharing ideas for better ways of getting something done.

All youth interviewed are less than 14 years old

## + Excerpts from Interviews of youth participating in Wisconsin's robotics programs (contd.)

I would join the team next year because it teaches valuable design and presentation skills, teaches participants to work under pressure, and it can be very exciting and is a great way get to know other people.

Well, my computer skills helped me to learn how to write downloads and things better. And I've actually learned how to become a computer designer, where I design things on the computer, which is a good kind of start.

Q: Do you think because of this class you would be more likely to become an engineer or a scientist?

A: Yeah, I think I will, because it's fun to do and I like doing it.

All youth interviewed are less than 14 years old



# + Why Study Robotics?



- Robotics is an excellent way to introduce the students to integrated STEM areas (science, technology, engineering, and mathematics)
- Students participating in robotics learn about STEM careers and experience the same activities as professionals solving real-world problems
- Everyone – girls and boys alike – should get a chance to see how much fun it is learning engineering skills this way!





# Basic Development Process



- Create a Lego construction with
  - Lego pieces
    - Either traditional bricks or newer Technic parts
  - NXT Micro-controller
- Motors / Lights
  - Robot controlling output
    - Sensors
      - Input from the environment the robot is operating in
- Create Program on the Computer
- Download program to the NXT via USB or Bluetooth



# What is LEGO MINDSTORMS™ Robotic Invention System™



# + Not JUST a Toy

- Design and program real robots
- Build Lego creations to perform actions
- Program using a graphical programming language blocks





NXT Brick: the robot's 'brain'

# Technology Overview: Brick & Sensors



Light Sensor



Sound Sensor



Touch Sensor



Ultra-sound Sensor



# Technology Overview: Lamps and motors



Interactive Servo motors



Lamps

## + More on the brick

- To turn on the NXT: Press the orange button
- To turn off the NXT, press the dark gray button till you see “Turn off” on the screen. Then press the orange button again
- There are three file folders on the NXT:
  - “My files” that you download from your computer
  - “NXT files” that you program on the NXT
  - “Sound files”

Output ports for  
motors & lamps

USB port

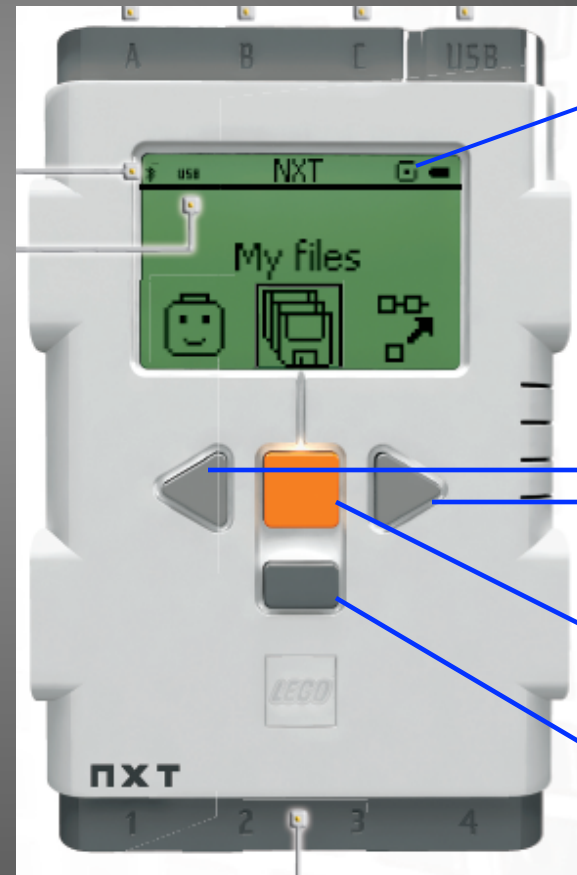
Running  
icon

Navigation

On/Enter

Clear/Go  
Back

Input ports for sensors



# + Group Exercise 1

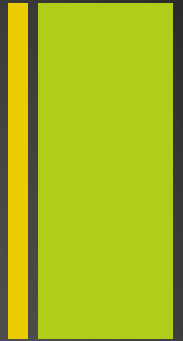
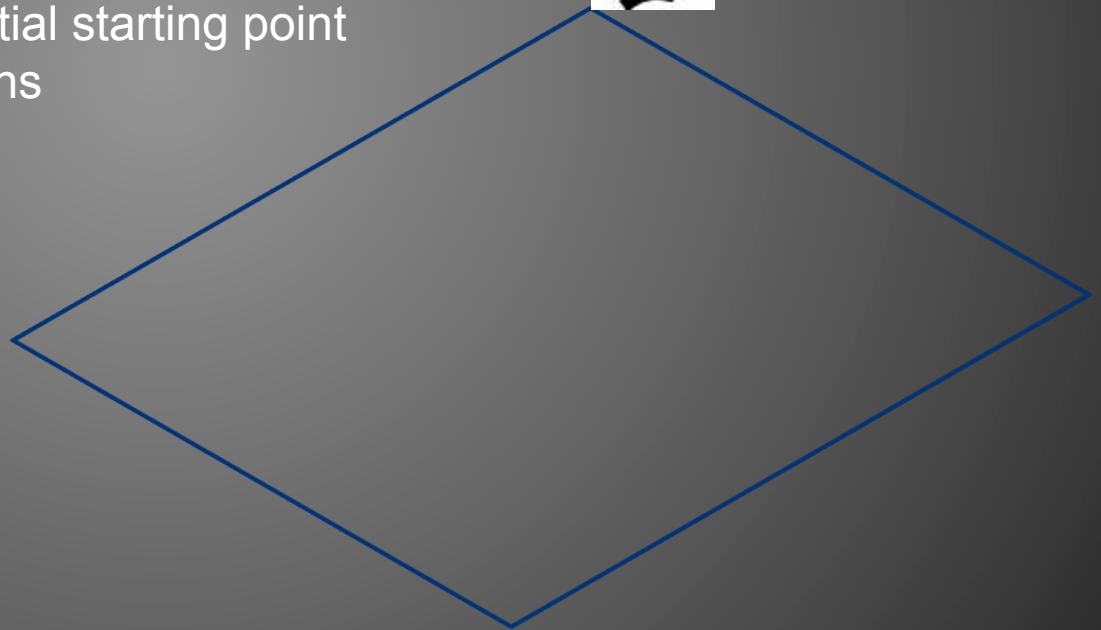
## Introduction to Programming

How do I move around the square if I can't see and have only my team members voices to guide me?

### Challenge:

Get your team member to their initial starting point  
Using only the following instructions

- 1) Move Forward
- 2) Move Backward
- 3) Turn Left
- 4) Turn Right
- 5) Stop





# + Sense-Plan-Act

- Sense
  - Seeing
  - Touching
  - Hearing
  - Distance
- Plan
  - Use sensory information to decide on an action
- Act
  - Actuation moving the motors of the robot to complete the plan





+

# Planning

- Programming - The act of setting a series of steps to be carried out or goals to be accomplished



# + Programming your robot: a problem-solving process



- What do you want the robot to do?
- How must the robot behave to complete the task?
- Create the program – review and download
- Run the program
- Did the NXT behave as required (doesn't do task)?
  - Check the robot first. If there's a problem, can you fix it?
  - Next, check the program. Problem? Can you fix it?
  - Last, go back to the beginning and reread the task. Does your program really tell the robot what it's supposed to do?

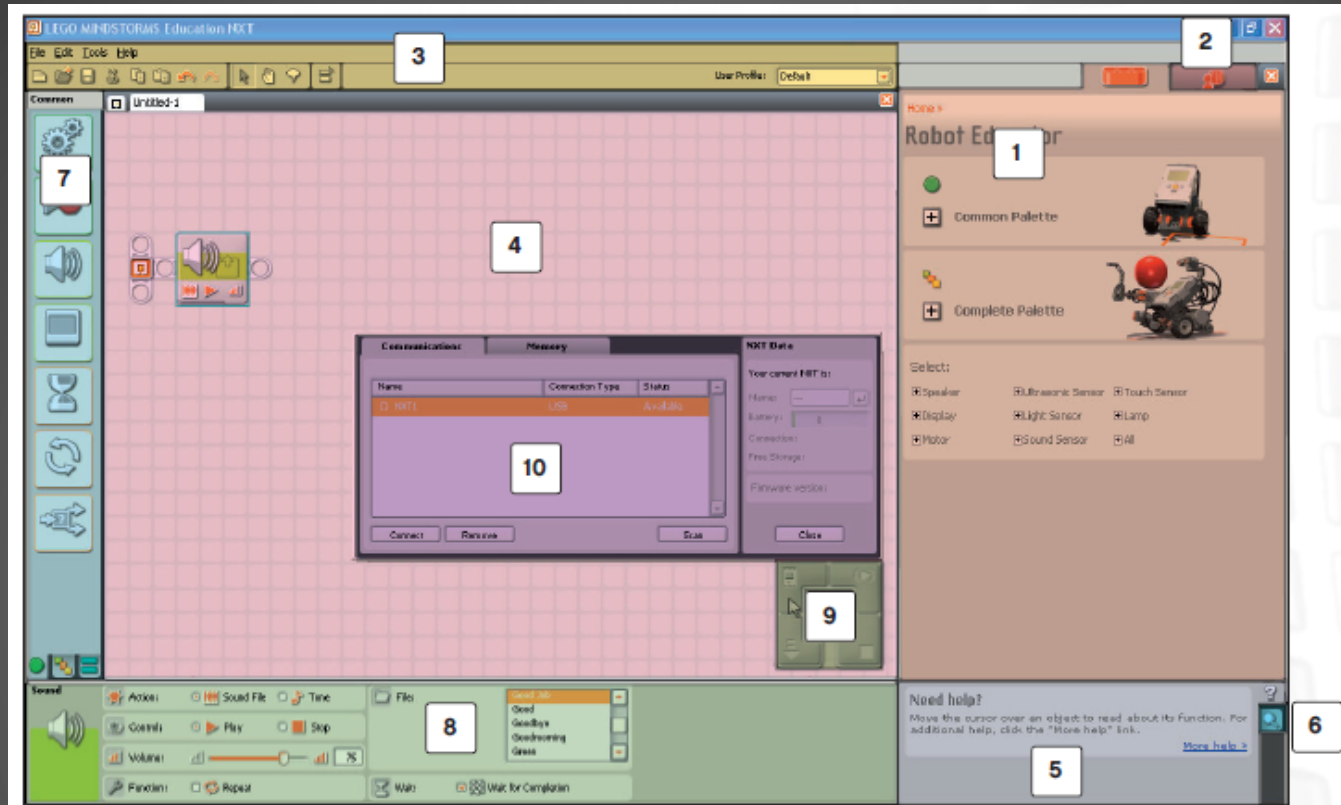


# + Your first program



Click on the icon

# + Software User Interface



1. Robot Educator
2. My portal
3. The tool bar
4. The work area
5. Little help Window
6. Work area map
7. The programming palette
8. The configuration panel
9. The controller
10. The NXT Window

# + Programming Palette



Contains all of the programming blocks you need to create programs.

There are three palette categories

- The Common Palette
- The Complete Palette
- The Custom Palette

# + Common Palette



## Sound block

The Sound block enables your robot to make sounds, including pre-recorded words.



## Display block

The Display block enables you to control the display on the NXT. You can type, show icons or even draw through your program.



## Record/Play block

The Record/Play block enables you to program the robot with physical movement - and later play back the movement elsewhere in the program.



## Move block

The Move block makes your robot Motors move or Lamps turn on.



## Wait block

The Wait block makes your robot wait for sensor input, such as a sound or a time interval.

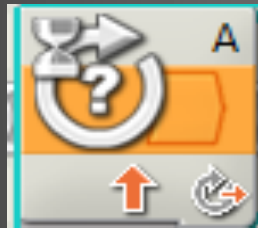


## Switch block

The Switch block enables the robot to make its own decisions, such as going left when it hears a loud sound and turning right when it hears a soft sound.

# + Get Your Move On!

## Programming Concepts



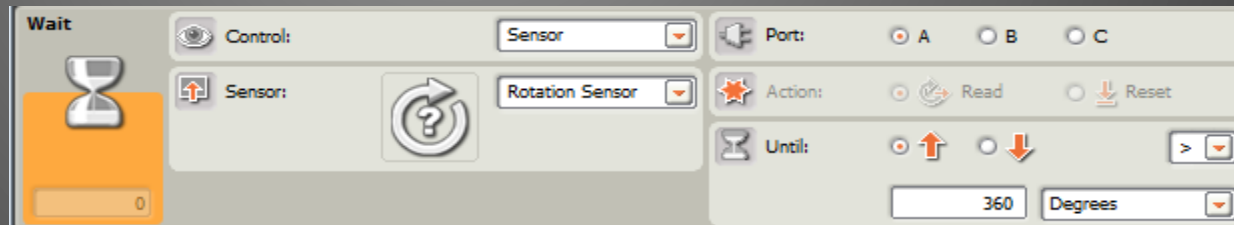
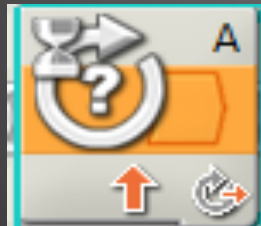
- Wait for.....
  - Sensor (rotation, touch etc.)
- Motor
  - Duration
  - Direction

# + Configuration Panel

Move



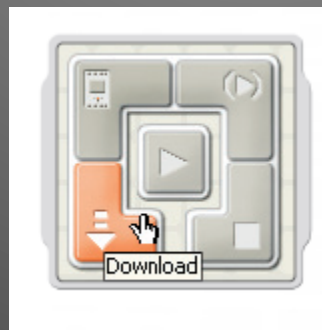
Wait for...





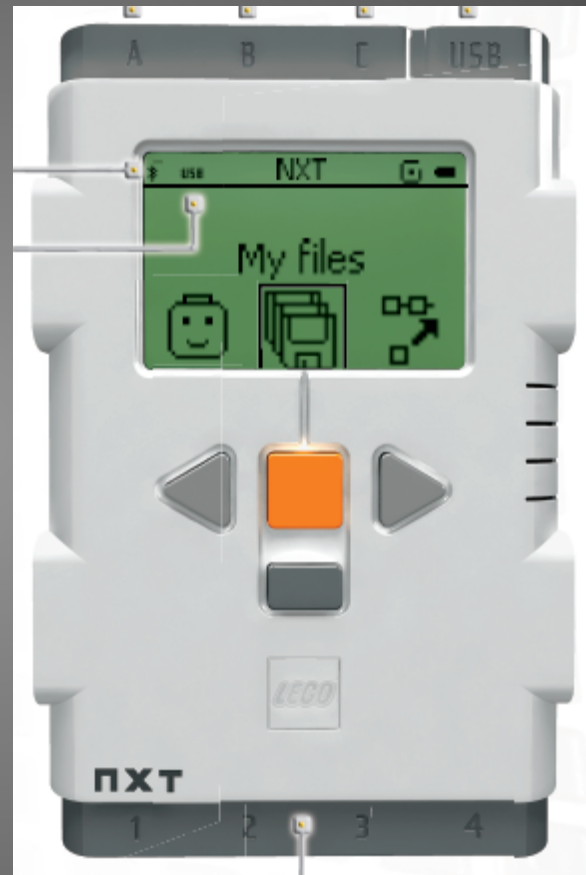
# + Downloading a program on your NXT

- Make sure your NXT is turned on
- Connect the NXT to your computer
- Press 'download' on your Controller



# + How to run your program...

- Press the orange button when the screen says “My Files”
- When you see the name of your program appear on the screen, press the orange button again



# + Programming Challenges



## a) Get your move on!

- 1) Move Forward a Distance
- 2) Point Turn Left
- 3) Point Turn Right

## b) Move in a Square

- 1) The hard way
- 2) Learn your loops



## Challenge 1: Get A Move On!

1. Create and test a program to make the robot go forward in a straight line for exactly 1 second
2. Create and test a program to make the robot go right 90 degrees
3. Create and test a program to make the robot go left 90 degrees
4. Save as three separate programs as your first name and Line (e.g., File→Save as Group#\_Challenge#→Enter)
5. Create and test a program to make the robot go right 720 degrees (go round in a circle twice, clockwise)
6. Create and test a program to make the robot go left 720 degrees (go round in a circle twice, counter-clockwise)

# + Get A Move On! Forward

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

*Click on the blocks to learn more*



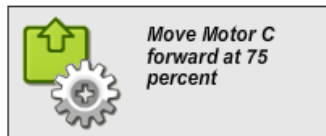


# Get A Move On!

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Reset



Port:	<input type="radio"/> A <input type="radio"/> B <input checked="" type="radio"/> C	Control:	<input type="checkbox"/> Motor Power
Direction:	<input checked="" type="radio"/> ↑ <input type="radio"/> ↓ <input type="radio"/> ↻	Duration:	360 Unlimited
Action:	Constant	Wait:	<input type="checkbox"/> Wait for Completion
Power:	75	Next Action:	<input checked="" type="radio"/> Brake <input type="radio"/> Coast

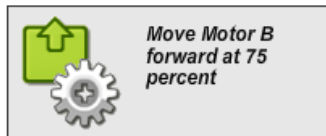


# Get A Move On!

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Reset



Port:	<input type="radio"/> A <input checked="" type="radio"/> B <input type="radio"/> C	Control:	<input type="checkbox"/> Motor Power
Direction:	<input checked="" type="radio"/> ↑ <input type="radio"/> ↓ <input type="radio"/> ↻	Duration:	360 Unlimited
Action:	Constant	Wait:	<input type="checkbox"/> Wait for Completion
Power:	75	Next Action:	<input checked="" type="radio"/> Brake <input type="radio"/> Coast

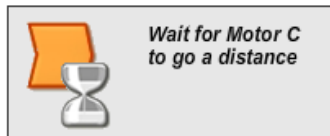


# Get A Move On!

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Reset



Control:	Sensor	Port:	<input type="radio"/> A <input type="radio"/> B <input checked="" type="radio"/> C
Sensor:	Rotation Sensor	Action:	<input checked="" type="radio"/> Read <input type="radio"/> Reset
		Until:	<input checked="" type="radio"/> Up <input type="radio"/> Down <input type="button" value="&gt;"/>
			720 Degrees





# Get A Move On!

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Reset



Port:	<input type="radio"/> A <input type="radio"/> B <input checked="" type="radio"/> C	Control:	<input type="checkbox"/> Motor Power
Direction:	<input checked="" type="radio"/> ↑ <input type="radio"/> ↓ <input type="radio"/> ↻	Duration:	360 Unlimited
Action:	Constant	Wait:	<input type="checkbox"/> Wait for Completion
Power:	75	Next Action:	<input checked="" type="radio"/> Brake <input type="radio"/> Coast



# Get A Move On!

## Move Forward

Robot moves forward then stops after one motor has rotated 720 degrees

Reset



Port:	<input type="radio"/> A <input checked="" type="radio"/> B <input type="radio"/> C	Control:	<input type="checkbox"/> Motor Power
Direction:	<input checked="" type="radio"/> Up <input type="radio"/> Down <input type="radio"/> Reverse	Duration:	360 Unlimited
Action:	Constant	Wait:	<input type="checkbox"/> Wait for Completion
Power:	75	Next Action:	<input checked="" type="radio"/> Brake <input type="radio"/> Coast



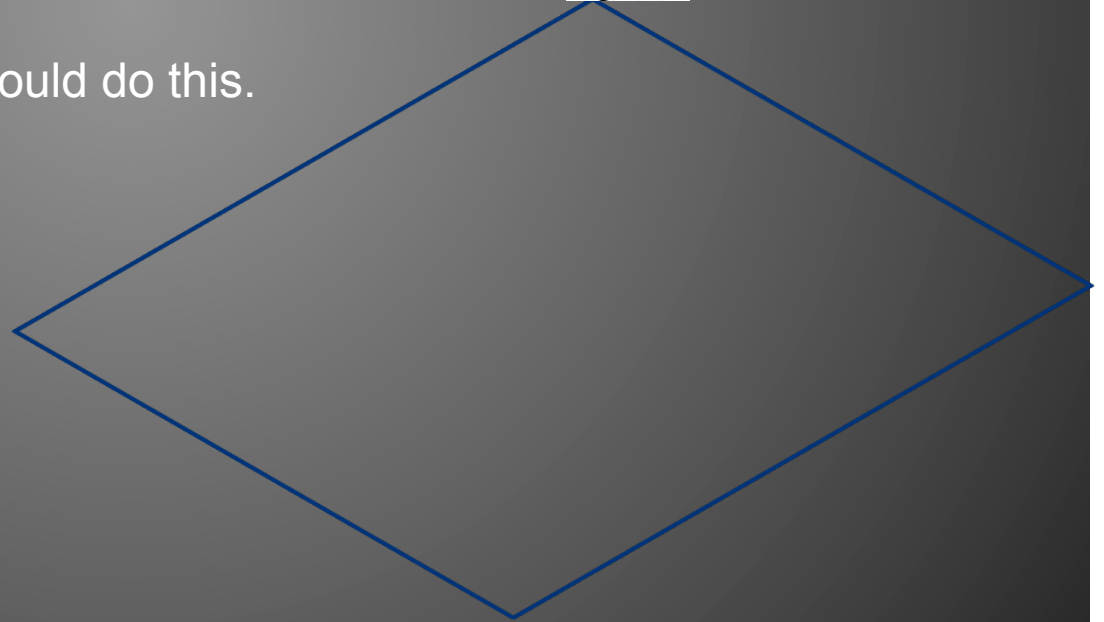
## Group Exercise 2

How do I move around the square using less instructions?

### Challenge:

Find a way to use less instructions to help your team mate navigate around the square

Brainstorm several ways that you could do this.





## Challenge 2: Learn Your Loops

- Create and test a program to make the robot go in a square
- Save your program as your group name and Square





# + Configuration Panel



Loop



**Loop**

 Control:

 Until: Seconds:

 Show: ☐  Counter

# + Challenge 2: Learn Your Loops

The image displays a programming environment window titled "Untitled-1". On the left is a "Common" sidebar with icons for gears, a play button, a speaker, a monitor, a timer, a loop, and a sequence of steps. The main workspace contains a sequence of blocks connected by a blue line:

- A "Wait" block (orange square with a clock icon).
- A "Move" block (green square with a gear icon). Its properties are: Port: B, C; Direction: Up; Steering: C; Power: 75; Duration: 1; Rotations: 1; Next Action: Brake.
- A "Move" block (green square with a gear icon). Its properties are: Port: B, C; Direction: Down; Steering: B; Power: 75; Duration: 10; Rotations: 1; Next Action: Brake.
- A "Loop" block (orange square with a circular arrow icon). Its properties are: Control: Count; Until: Count: 4; Show: Counter.

Arrows point from the "Loop" block to the two "Move" blocks, indicating that the "Move" blocks are repeated 4 times. The "Loop" block's "Until" field is set to "Count: 4".

Below the workspace, there are two detailed views of the "Move" block's configuration:

**Move Block Configuration 1:**

- Port: ☐ A ☒ B ☒ C
- Direction: ☒ Up ☐ Down ☐ Left ☐ Right
- Steering: ☐ C ☒ B ☐ A
- Power: 75
- Duration: 1
- Rotations: 1
- Next Action: ☒ Brake ☐ Coast

**Move Block Configuration 2:**

- Port: ☐ A ☒ B ☒ C
- Direction: ☐ Up ☒ Down ☐ Left ☐ Right
- Steering: ☐ C ☒ B ☐ A
- Power: 75
- Duration: 10
- Rotations: 1
- Next Action: ☒ Brake ☐ Coast

At the bottom right, there is a small navigation panel with a play button and a stop button.

+ Ok, now that you know how to  
program a bot.....



How to start a robotics project in your county?



# Starting your Own Robotics Project



## Models for a program:

1. Staff driven
2. Volunteer driven, staff supported



# + What will you need?



- LEGO NXT robotics kit (\$ 270-280)  
(Includes everything to build one robot)
- LEGO NXT software (comes with training tutorials, included in robotics kit)
- Computer - mac or pc (OS XP, 800 MHz, 256 MB of RAM or higher for pc and Mac X for a Mac)
- Internet connection (optional)
- Curriculum (optional)

# + Money, Money, Money....



- Local tech based businesses usually give small grants or are willing to sponsor a club
- Utility companies do provide educational grants
- NASA Space Grant Consortiums fund outreach programs
- Local School districts can provide grants
- Most 4-H Leader's Associations have funds for project-start up....you just need to sell the idea to them



## Examples of County Robotics Programs





# Baltimore City 4-H Robotics Club

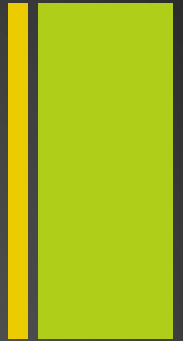
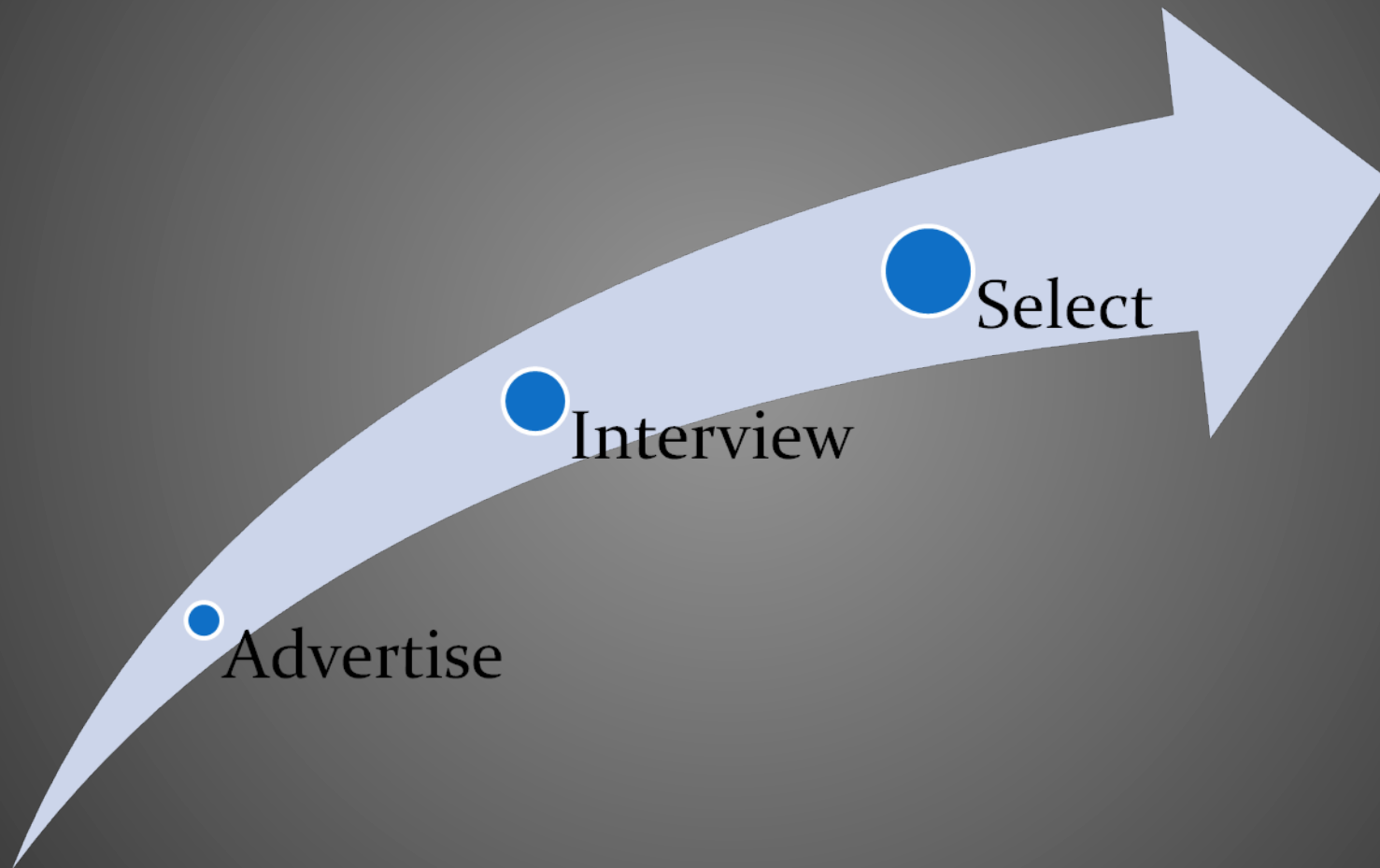


## + Objective



- To allow youth in Baltimore City to expand their knowledge, interest, and connection to engineering and science concepts and careers through a hands-on learning atmosphere

# + Site Selection



# + Responsibilities

## 4-H

- Trained volunteer
- LEGO NXT Robotics Kits
- Robotics Curriculum
- Fieldtrip

## School

- Computers
- Journals
- Recruitment
- Purchasing 2 replacement technology kits
- Snacks
- Transportation for 1 field trip



## + Club Description

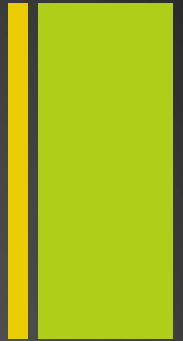


- 10 youth, ages 11-13
- Youth apply to be in the program (based on interest)
- Meet once a week from Mid January-Early June
- After school program at a local middle school
- Close interaction with professional scientist
- Fieldtrip





# Club Activity Calendar



## BUILDING

- January-February
- SET Abilities: Build/Construct, Communicate, Collaborate, Compare

## PROGRAMMING

- February- May
- SET Abilities: Use tools, Collaborate, Predict, Hypothesize, Observe, Measure, Collect Data, Analyze, Redesign, Optimize, Model/Graph/Use Numbers

## WRAP UP

- May-June
- SET Abilities: Compare, Communicate,

# + Programming

- Introduction of Programming Concept + Short Activity to Reinforce Concept
- Incremental adding of Concepts each week
  - i.e. Motor, Moving Forward, Turning, Sensors, Loop, Threshold



# + Programming

## Challenges

- Longer activities that incorporate programming knowledge & skills with problem solving skills



## + Field trip



Their Mission: “to foster innovative robotics science and engineering research” ([https://lcsr.jhu.edu/Main\\_Page](https://lcsr.jhu.edu/Main_Page))

Our Goal: To create opportunities for youth to connect club activities to real world research and activities

## + Future Goals

- Expand to more Sites
- Connect club activities with local or national competitions
- Train current club members to facilitate robotics learning of the next cohort





# Waukesha County, Wisconsin's Robotics Program

- County-wide project
- About 40 youth members
- Robotics is a project offered within the traditional club setting
- Youth participate in the FIRST LEGO League Challenge





# FIRST LEGO® League (FLL)



- FLL is the result of a partnership between FIRST (For Inspiration and Recognition of Science and Technology) and The LEGO Group
  - “FIRST LEGO League (FLL) is an exciting and fun global robotics program that ignites an enthusiasm for discovery, science, and technology in youth ages 9 to 14. Each year FLL teams embark on an adventurous Challenge based on current, real-world issues. Guided by a team coach and assisted by mentors, the youth:
    - Research and solve a real-world problem based on the Challenge theme
    - Present their research and solutions
    - Build an autonomous robot using engineering concepts”
- [<http://www.usfirst.org/what/fll/default.aspx?id=390>]



# FIRST LEGO® League (FLL) (contd.)



- Youth have 8 weeks from the time the challenge is announced to the tournament
- Twenty to forty local teams compete in regional tournaments
- Teams that qualify in the regional tournaments move on to compete at the State level. There are also National and International level tournaments.



# + The FLL Challenge

- Robot game
  - Design, build and program a robot prior to the tournament
- Project
  - Conduct research on project topic
  - Create a proposed solution on a problem related to the topic
  - Present the research, problem statement and solution during the tournament



# + Guidelines

- Boys or Girls
- Ages 9-14yrs old
- A student less than 9 yrs old can participate if they are socially and academically comfortable with the older group
- Maximum of 10 kids
- Minimum 1 coach (yeah right)
- Neither the youth nor the coaches need to have a science background
- Exhibit “gracious professionalism”



# + What do they learn/How do they grow?

- Life skills
- Problem solving skills
- Working with a team
- Designing skills
- Research & presentation



## + What do they learn/How do they grow?

To assess the youth's skill-level increase in robot design and building, programming and computer technology, as a result of participating in the FLL program; at the end of the season, youth were asked to compare their skill levels in each area before and after the FLL season. Given a four point scale, with choices ranging from 'poor' to 'excellent,' youth skill-level gain is summarized as follows:

	Increase by 1 level	Increase by 2 levels	Increase by 3 levels	No change
<b>Computer skills</b>	25%	17%	0%	58%
<b>Programming using Mindstorms</b>	50%	17%	25%	8.33%
<b>Designing &amp; building a robot</b>	30%	20%	0%	50%
<b>Presentation before an audience</b>	45%	9%	0%	45%
<b>Conduct a research project</b>	40%	20%	0%	40%
<b>Problem solving skills</b>	45%	9%	0%	45%
<b>Interest in taking SET classes</b>	64%	0%	0%	36%
<b>Interest in SET career</b>	50%	0%	0%	50%

# + Sample FLL Budget

Costs				
#	Description	Type	\$ / team	Notes
1	Team Registration with FIRST	Annual	200	
2	Regional Registration for tournament	Annual	50	
3	Field Setup Kit	Annual	65	
4	Robot Set (NXT)	One Time	325	
5	NXT Touch sensor	One Time	17	
6	NXT light sensor	One Time	17	
7	Table/Field	One Time	80	Approx
8	Tackle box for storage	One Time	60	Optional
9	Postage		50	Approx
10	Project Cost	Annual	Varies	Poster board, glue etc.
11	Handouts	Annual	Varies	Optional
12	T-Shirts	Annual	Varies	Optional
	<b>TOTAL</b>		<b>864</b>	<b>Min</b>





# FLL International General Timeline



Month	Activity
■ May - September	■ Team registration on FLL website
■ August – Mid-September	■ FLL kits begin shipping
■ Mid-September	■ Challenge announced
■ October – November	■ FLL season
■ Mid-October	■ Tournament registration
■ November - December	■ Tournaments

# + Things to keep in mind (for any robotics program):

Expensive kits with small parts:

- Need to set a minimum age for participation (usually nine)
- Need to have stringent guidelines for usage
- Need to keep a strict inventory of all parts, checking them each time a kit is taken out and used
- Fishing tackle boxes highly recommended for keeping the small parts organized

## + Good Partners



- School or school district for funding, premises and perhaps teachers
- After school programs
- Local home school network



# + My involvement with FLL

- One of the 4-H parents was coaching a home schooled team
- His team gave a demonstration at the Family Fun Night
- When I was hired 2 months later, the 4-H Leaders Association (association of 4-H Volunteers) told me that I had to start FLL teams for 4-H youth
- The Leader's Association agreed to help fund starting the new teams
- Teams were sponsored by GE Healthcare & Rockwell Automation. Any team coached by employees of these two tech based corporations receive funding from them.



# + Available curriculum (for any robotics program):

- National 4-H Cooperative Curriculum System's Robotics series (RCX based) **This curriculum is now outdated.**

<http://www.4-hcurriculum.org/robotics.aspx>

- Carnegie Mellon Robotics Academy's Robotics Engineering vols 1 & 2

<http://www.education.rec.rh.cmu.edu/>

- FIRST LEGO League Challenge Curriculum (available only to FLL teams)

<http://www.usfirst.org/>



## Available curriculum (for any robotics program):



- University of Nebraska robotics program curriculum: GEAR-Tech-21 (GEospatial And Robotics Technologies for the 21st Century)  
<http://4hset.unl.edu/itest/index.php>
- Some LEGO Education Kits have supporting curriculum  
<http://www.legoeducation.com/store/>
- The Unofficial LEGO Mindstorms NXT Inventor's Guide, by David Purdue (can be ordered from the LEGO Education site)



# Available Web Resources



- NXPprograms.com: a free web resource for building and programming

<http://www.nxtprograms.com/>

- Companion website to the book The Unofficial LEGO Mindstorms NXT Inventor's guide

<http://nxtguide.davidjperdue.com/>

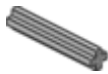


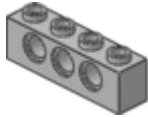






- Additional software can be found at the Robotics Academy (<http://www-education.rec.ri.cmu.edu/>)



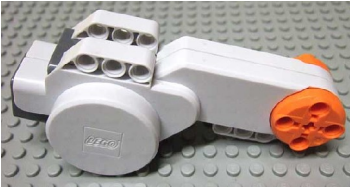







Questions? Comments?



Thank You !

Name	Description	Image
Axle	Central shaft for rotating <b>wheel</b> or <b>gear</b>	
Beam	Structural element that withstands loads by resisting <b>bending</b>	
Belt	Loop of flexible material that transfers <b>torque</b> among rotating machines	
Brick	A structural element with studs and voids that can <b>interlock</b> with other parts	
Bush	Surrounds an <b>axle</b> to prevent lateral motion, provide a round surface or spacing	
Cable	Two or more <b>wires</b> running side by side and bonded to form a single assembly	
Crown Gear	Rotating machine with teeth that transfers torque at <b>right angle</b>	
Gear	Rotating machine with <b>teeth</b> that transfers <b>torque</b>	
Joiner	Attaches two or more <b>axles</b> or <b>rods</b>	
Light Sensor	Device to measure <b>light</b> and convert it into a <b>signal</b> which can be read by the NXT brain	

Name	Description	Image
Motor	A machine that uses <b>electrical</b> energy to produce <b>mechanical</b> energy through the interaction between <b>magnetic fields</b> and <b>electric currents</b>	 A LEGO motor assembly consisting of a white motor block with a grey top, a white gear, and an orange connector.
Pin	A structural element that inserts into a cavity and remains held in place by <b>friction</b>	 A small black LEGO pin with a grey head.
Rotation Sensor	Device to measure <b>angle</b> and convert it into a <b>signal</b> which can be read by the NXT brain	 A LEGO rotation sensor assembly consisting of a white sensor block with a grey top and an orange connector.
Worm Screw	Rotating machine with <b>helical threads</b> that transfers torque	 A black LEGO worm screw with a grey head.
Sound Sensor	Device to measure <b>sound</b> and convert it into a <b>signal</b> which can be read by the NXT brain	 A LEGO sound sensor assembly consisting of a grey sensor block with three orange connectors.
Touch Sensor	Device to measure <b>contact</b> and convert it into a <b>signal</b> which can be read by the NXT brain	 A LEGO touch sensor assembly consisting of a grey sensor block with an orange connector.
Turntable	Combination of <b>gears</b> and <b>joiners</b>	 A LEGO turntable assembly consisting of a black gear with a grey center and a black connector.
Ultrasonic Sensor	Device to measure <b>distance</b> and convert it into a <b>signal</b> which can be read by the NXT brain	 A LEGO ultrasonic sensor assembly consisting of a grey sensor block with two orange connectors.



# Human Robot instructions

## Program #1

1. What does sensor see in front of them?

If sensor does **not** see ball then do #2

If sensor sees ball then do #3

2. Motor turns until sensor sees ball in front of them

3. Motor moves forward until ball is directly in front

4. Motor grabs ball

5. What color ball do you have?

If Sensor sees red ball do #6

If Sensor sees blue ball do #7

6. Motor turns left 90 degrees, move forward 3 steps and put ball down.

7. Motor turns right 90 degrees, move forward 3 steps and put ball down.

# Additional Online Resources

Look here for additional resources that can be used with this curriculum!

<http://www.nyx.net/~librown/robots/>

<http://www.nxtprograms.com/NXT2/explorer/index.html>

<http://www.nxtprograms.com/NXT2/segway/index.html>

<http://www.lego.com/education/school/default.asp?>

[locale=2057&pagename=softu&l2id=3\\_2&l3id=3\\_2\\_4&l4id=3\\_2\\_4\\_2](http://www.lego.com/education/school/default.asp?locale=2057&pagename=softu&l2id=3_2&l3id=3_2_4&l4id=3_2_4_2)