Introduction to LEGO MINDSTORMS NXT Field Trip Workshop

GRADE LEVELS:
Grades 6TH – 8TH

OBJECTIVES:
- Participants will work in small groups to program a LEGO MINSTORMS NXT Taskbot to complete a specific task.
- Students will gain a greater understanding of the presence of robots in their everyday lives as well as their usefulness and limitations.

ACADEMIC CONTENT STANDARDS:
- Physical Sciences 6-8 B: In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object.
    - 8.2: Explain that motion describes the change in the position of an object (characterized by a speed and direction) as time changes.
    - 8.3: Explain that an unbalanced force acting on an object changes that object's speed and/or direction.
- Science and Technology 6-8 A: Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life.
    - 6.3: Describe how automation (e.g., robots) has changed manufacturing including manual labor being replaced by highly-skilled jobs.
- Science and Technology 6-8 B: Design a solution or product taking into account needs and constraints (e.g., cost, time, trade-offs properties of materials, safety and aesthetics).
    - 6.5: Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
    - 7.4: Design and build a product or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production or supply of materials and environmental effects).
    - 8.3: Design and build a product or create a solution to a problem given more than two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
    - 8.4: Evaluate the overall effectiveness of a product design or solution.

VOCABULARY WORDS:
Application Program - A sequence of steps that specifies what jobs the robots will perform. The program can be personalized by the owner to fit specific designs.

Chassis - The parts making up a machine not including the body or casing. In the case of an automobile this would include parts such as the frame and engine but not the body surrounding these parts.

Gear Motor - Unique internally geared motor that makes your robots move.

Light Sensor - Input device that registers light from 0.6 through 760 Lux.

Manual Programming - The user physically sets specific tasks and limits on the robot.

EXTENSIONS AT COSI:

Gadgets Exhibition Area

- Spend some time with COSI's robots at the entrance to the Gadgets Exhibition Area. Can you identify the various programs which they are capable of performing? What types of work would these mechanical arms be useful for?

ADDITIONAL RESOURCES:

http://spark.irobot.com/index.php
www.robots.com (Presenting Sponsor of COSI's Robots)
http://www.legoeducation.us/global.aspx

SAMPLE TEST QUESTIONS:

1. _________ is a sequence of steps that specifies what jobs the robots will perform.
   a. Project
   b. Input
   c. Program
   d. None of the Above

2. _________ is a device that receives information about the body and the surrounding environment.
   a. Sensor
   b. Adaptor
   c. Engineer
   d. Program

3. _________ robots, are robots which can perform desired tasks in unstructured environments without continuous human guidance.
   a. Remotely Operated
   b. Autonomous
   c. Free-Thinking
   d. Fictional

Introduction to Robotics MINDSTORMS NXT Pre Visit Activities

<u>PB&J Programming</u> Primary Audience: All Ages

Description: This demonstration is designed to be presented in front of the whole class using two volunteers. The purpose of the demonstration is to let the students discover how specific (exact, precise, detailed) a computer programmer must be when programming a robot to do a task.

Keywords: Robot, computer, programming

Materials:

- 1 jar of peanut butter or anything else that could be put on bread to make a sandwich (jelly, lunch meat, lettuce, tomatoes, pickles, mustard)
- 2 slices of bread
- 1 blindfold
- 1 wooden spatula
- 1 pair of tongs
- Electrical or duct tape
- Table

Pre-Activity Preparation:
Using the electrical or duct tape, securely attach the spatula to the tongs as an extension of the tongs. Make sure your students don't see the props before the demonstration! If the robot knows what it is doing, the demo is not as effective.

Instructions:
One person will play the role of a robot, and one person will play the role of a computer programmer. The robot is blindfolded and does not know what task it will be asked to perform. The programmer must verbally instruct the robot to make a peanut butter sandwich. However, the programmer is not allowed to use the words peanut butter, bread or sandwich. Have robot start the demonstration with one pair of tongs in each hand, with hands resting on the table top. (You can refer to this starting position as the "home" position.)

To help transform the person into a robot, the programmer will refer to the robot's hands as "grippers" (the technical term for the claw at the end of a robotic arm).
The programmer should also refer to the spatulas as "instruments" or "tools" and the peanut butter and bread as "objects."

Possible Interactive Questions:

After all the peanut butter is cleared away, have students discuss ways to make it easier to program a robot.

1. Can the position of words in a sentence change the meaning of a sentence? (grammar) For example: "How many sandwiches are left on the table?" vs. "How many sandwiches are on the left of the table?"
2. Did the robot understand the words the programmer used? What other vocabulary words could the programmer have used?
3. What could you do to make sure the bread wasn't damaged by the robot?
4. If you had to make 100 sandwiches, how would you make sure the robot was putting the same amount of peanut butter on each sandwich?
5. What would happen if the peanut butter or bread ran out? Would the robot stop or keep going?
6. Are there some activities that require a certain sequence or order?

Relevant Ohio Science Content Standards:

- Science and Technology K-2 B: Explain that to construct something requires planning, communication, problem solving and tools.
    - 1.7: Explore that several steps are usually needed to make things (e.g., building with blocks).
- Science and Technology 3-5 A: Describe how technology affects human life.
    - 3.1: Describe how technology can extend human abilities (e.g., to move things and to extend senses).

Beach Ball Bytes

Primary Audience: All Ages

Description: Students will discover that robots and computers must be given explicit information to do a task. Computers store information in chunks called "bytes." Many tasks that human do would require massive instructions and "storage space" if a robot were programmed to do the same task. This is a classroom demonstration with one volunteer.

Keywords: Robot, computer, programming

Materials:

- 10-12 full size beach balls or play balls
- Chalkboard

Instructions:

Ask a student to be a volunteer robot. Ask the class what task they want the robot to perform.

Use the chalkboard to write your "program." A "program" is a list of instructions that tell the robot what to do. List all the steps the robot would have to do or know in order to complete the task. For each task listed, hand the students a ball. The balls represent "data" or bytes of information. After several steps you will discover that the student (robot) may have trouble handling and storing the data. The students will find it humorous when the robot experiences an information overload and blows a "circuit."

For instance, if the task was washing dished, your list may look similar to the following:

Task: Wash Dishes

1. Instruct robot where kitchen is located.
2. Instruct robot where sink is located.
3. Instruct robot how to turn on the water.
4. Instruct robot on how to plug the sink.
5. Instruct robot on how to add detergent to the sink.
6. Instruct robot on what a plate feels like.
7. Instruct robot on what a cup feels like.
8. Instruct robot on the proper way to wash a plate.
9. Instruct robot on the proper way to wash a cup.
10. Any other instructions.

Depending on the age group, you can make your list more or less detailed.

What's Going On?

Even with the microchip, computers cannot possibly compare with the memory of the human brain. Each one of us has the information needed to process huge amounts of information about our environment and make decisions.

Further Exploration:

1. Discuss with your students the ways humans store information and compare them to the way computers store information.
2. Create illustrations (frames of the steps of a procedure/ process) and see if your students can put the pictures in proper sequential order. Example: shooting a basketball or baking a cake. Note: if you have a hard time drawing, ask a student to try it!

Relevant Ohio Science Content Standards:

- Science and Technology K-2 B: Explain that to construct something requires planning, communication, problem solving and tools.
    - 1.7: Explore that several steps are usually needed to make things (e.g., building with blocks).
    - 2.4. Communicate orally, pictorially, or in written form the design process used to make something.

ROV Races Primary Audience: All Ages

Description: Participants will learn the challenges of operating a remotely operated vehicle (ROV) and problem solve solutions by using a hands-on simulation. They will also have the ROV pilot design and execute a series of commands that will guide a human ROV through a simulated underwater environment, allowing the ROV team to experience some of the challenges of tele-operating a robotic vehicle underwater.

Keywords: Robot, programming

Materials:

- Per Room:
  - Blindfolds
  - Obstacles (ramps, cones, etc.)
  - Stopwatch

Instructions:

1. Choose or draw names of students to form teams of six. One student will be designated as "the ROV pilot", one will be the "team timer", and another will be the "team judge". The remaining three students will become the ROV by hooking together in a line (both hands to the shoulders in front of them (O=O=O). The ROV will be guided by the driver through an obstacle course (simulated underwater environment).
2. The pilots will proceed through the course first, writing down the instructions that will guide the ROV through the course (i.e. 3 steps forward, stop, 1 step left, stop, etc.)
3. Once the pilots have recorded their upload sequences on their navigational sheets, the ROV races can begin. The ROV teams line up at the starling line. The three ROV members are blindfolded, as to not aid the pilot in executing their commands. The ROV members link up (to form the 3 sets of propulsion fans like the real ROV designs) with their hands on the shoulders of the person in front of them (it is fun to choose different-sized students to form a ROV, as the different sizes of steps taken by each is more evident). The judges will keep a tally of the number of foot faults that their ROV team makes by counting each time the front ROV person's footsteps on a red tile (artifact). The timer of each team will record the time it takes for their ROV team to make it through the course. (NOTE: remind the teams that accuracy, not speed is more important when piloting a robotic vehicle in an unfamiliar environment.)
4. The teams will all start at the same time, with the timers starting the team stopwatches when the facilitator indicates. The pilot may stand near their team to give the command sequences, but may not physically touch their ROV to help guide it (this is, after all, tele-operations!). They must guide their ROV by voice only. The ROV driver may not deviate from the commands that have been written in their previous trip through the course, even

if the ROV is going off course. Many times in robotic missions, sequences of commands are sent all at once. Changes have to be added later.

5. Allow time for all teams to complete the course. Gather the groups to debrief how the piloting went - the challenges and what they might change to do a better job the next time.
6. The participants might observe that their steps and those of the ROV people might need some type of calibration (i.e. "take baby steps" or "take giant steps"). Turns might be more accurate by saying, "turn 45 or 90 degrees". Flying a ROV with 3 axles is also different than walking a course singularly.
7. Repeat the activity as time permits, allowing the changes the participants brainstormed to be tested

Possible Interactive Questions:

- Was the course easier or harder to complete then expected? Why or why not?

What's Going On?

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

In most cases, the distance between the ROV and control panel is fairly short (few hundred feet) and, as a result, pilots can rely on "joy-stick" like controls.

Further Exploration:

1. Safety cones can be added to the course as return sample artifacts to be collected. When the ROV is in the proper position for the last person on in the ROV team to bend down (blindfolded) and pick up the cone, the pilot can command, "retrieve artifact sample". Once the cone has been retrieved, the cone can be passed to the middle ROV person to be carried.
2. A video camera and monitor could be set up, so that the pilot is in another room, allowing for a closer simulation to tele-operation. The pilot would have to interpret the images and piloting pathway with only the camera images (camera being held by the lead ROV person) to guide them. Commands could be sent via a "runner" student, simulating the wait time that occurs in long distance communication.
3. The tiles can be arranged in any design to make the course easier or more difficult (according to grade level or participant's ability.) If course is set up outside you might want to tape the underside of the tiles, to prevent the course being disturbed by any wind.
4. Talk about the time differences the teams took to complete the course. Are there advantages to taking it slower (more careful moves, less crashes) or perhaps the

power supply is getting low and more territory needs to be covered (faster).

Relevant Ohio Science Content Standards:

- Science and Technology 3-5: Describe how technology affects human life.
  - 3.1: Describe how technology can extend human abilities (e.g. to move things, extend senses).
- Physical Sciences 9-10: Explain the movement of objects by applying Newton's three laws of motion.
  - 9.22: Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.
  - 9.23: Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. (F net=ma. Note that weight is the gravitational force on a mass.)
  - 9.25: Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).

Introduction to Robotics MINDSTORMS NXT Post Visit Activities

<u>Accuracy and Precision</u>   Primary Audience: All Ages

<u>Accuracy</u>

Description: One reason why robots are so well qualified for the workforce is because of their ability to be accurate. Some robots are accurate within 1/10,000 of an inch! This means they can hit the target exactly as programmed. This demonstration is to be done by two volunteers for the class.

Keywords: Robot, programming, accuracy, precision

Materials:

- Bag of large marshmallows
- Goggles

Instructions:

Explain to the class that being accurate means hitting the target.

Have one volunteer put goggles on, and have another student try to toss marshmallows into the open mouth of the goggle volunteer. Depending on the age of your students, have them stand at a distance that makes the task difficult but not impossible.

Let the volunteer toss 5 marshmallows. You can chart the percentage of accuracy for the volunteer.

Further Exploration:

1. Discuss with the class when being accurate would be beneficial. What jobs require a high degree of accuracy? What factors affect humans in the ability to be accurate?
2. How can humans improve their accuracy? (Practice and conditioning improve accuracy.)

<u>Precision</u>

Description: Robots are often used in the workforce because they can do repetitious tasks

the same way without making mistakes. This can be very difficult for humans to do, especially when we are bored with the task. These precision activities can be done individually.

Materials:

- Activity #1
- Yellow highlighter
- Blue highlighter
- Sheet of paper
- Activity #2
- Cup
- Marbles

Instructions:

Activity #1:

Have students sign their names on a sheet of paper with the yellow highlighter. Have students sign their names again, over the first signature with the blue highlighter.

Examine the signatures. If the students were precise, the entire signature will be green. Most signatures, however, will have bits of yellow and blue where the signatures differed.

Activity #2:

Place a cup on the floor. From three feet above, how many marbles can you drop into the cup in 30 seconds?

Further Exploration:

1. This exercise demonstrates how humans vary in our ability to be precise, even with a task we do quite often. Discuss what jobs would require a high degree of precision. Why would a brain surgeon need to be precise? Why would a diamond cutter need to be precise?
2. How can humans improve their precision? (Concentration and slowing down when performing tasks.)

Research Activity Primary Audience: All Ages

Description: Research is a part of science. It involves collecting information to increase your understanding of the topic you're studying. Research also includes communicating that information to others. In this activity, participants will work on their own or in small groups to research their topic in further detail.

Research Materials:

- Paper, pens and pencils
- A computer with Internet access
- Books, journals, magazines or newspaper articles on the topic
- If available, access to experts on the topic to interview

Instructions:

Using whatever research materials are available to the students, encourage them to further explore an aspect of the given topic that they find interesting. As with any research project, they should not make it too broad in scope. Rather, they should pick a specific area of the topic that excites them.

For example, they might research a specific person who was influential in the advancement of their topic. They could choose to do a project involving a timeline of important events in the history of their topic. Or they could identify an issue, question, or problem related to their topic. The key is finding that thing about the topic that grabs their attention.

The final part of a research project is to share the results of the research with others. If time permits, have the students present their research to other classmates who participated in the workshop.

Possible Interactive Questions:

- What is it about this topic that is interesting to you?
- Is there a particular question about this topic that you could answer?
- How could you share the results of your research with your classmates?

Relevant Ohio Science Content Standards:

- Scientific Ways of Knowing 3-5 A: Distinguish between fact and opinion and explain how ideas and conclusions change as new knowledge is gained.
    - 5.1: Summarize how conclusions and ideas change as new knowledge is gained.
- Scientific Inquiry 3-5 B: Organize and evaluate observations, measurements and other data to formulate inferences and conclusions.
    - 3.2: Discuss observations and measurements made by other people.
    - 3.6: Communicate scientific findings to others through a variety of methods (e.g.,

pictures, written, oral and recorded observations).

- Scientific Inquiry 6-8 B: Analyze and interpret data from scientific investigations using appropriate mathematical skills in order to draw valid conclusions.
    - 8.3: Read, construct and interpret data in various forms produced by self and others in both written and oral form (e.g., tables, charts, maps, graphs, diagrams and symbols).