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POLYTECHNIC INSTITUTE OF NEW YORK UNIVERSITY

About Accuracy and Approximation

Subject Area(s) Math, Measurement

Associated Unit None

Associated Lesson None

Activity Title: Accuracy and Approximation

Header Insert Image 1 here, center

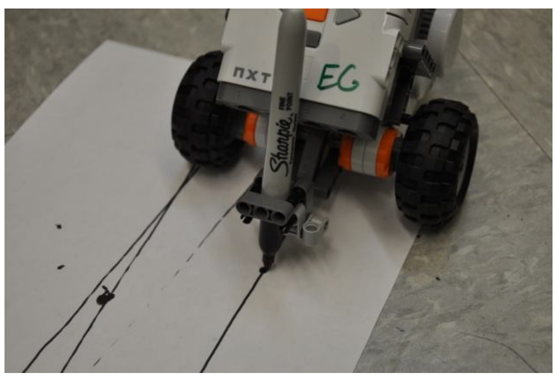

Image 1
ADA Description: Image of robot drawing a line on paper
Caption: None
Image file name: marker_robot_3.jpg
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Grade Level 6 (5 - 7)

Activity Dependency: None

Time Required: 30-45 mins.

Group Size: 5-7

Expendable Cost per Group: US $0

Summary

During this activity students will be learning about the concept of accuracy as it pertains to robotics. Students will be gaining insight into experimental accuracy and knowing how and when

to estimate values that they measure. Awareness of sources of error stemming from the robotic setup in conjunction with number rounding is explored.

Engineering Connection

Proper comparison of data is important for accurate measurements and troubleshooting of robotic machines for quality assessment. Interpretation of data also gives important insight to the accuracy of an experimental setup, which can negatively affect experimental data.

Engineering Category

Relates math concept to engineering/use of measurement tools

Keywords: Accuracy, error, approximation, rounding

Educational Standards

New York State Math, 2010, 5.M.3, 5.M.6. 5.M.11,5.PS.10

Pre-Requisite Knowledge

Decimals, use of a ruler, rounding basics, knowledge of units

Learning Objectives

After this activity, students should be able to:

- Learn how to deal with decimals in measurement estimations
- Learn how to compare data values and find percent error
- Make connections between circumference and linear measurement
- Identify possible physical sources of error in an experimental setup

Materials List

Each group needs:

- Lego Mindstorms NXT standard robot
    - Instructions to construct standard robot are included in Lego NXT kit instruction manual.
    - Robots are pre-built before class to save time.
- Sharpie marker
- Meter ruler
- Caliper (recommended for circumference measurements)
- Large piece of paper
- Rubber band

Note: If caliper is not available, use a ruler to measure the diameter of each wheel or use a string and wrap it around the wheel to measure the circumference.

Introduction / Motivation

No robot or machine that is made by human beings works perfectly. A machine may be able to write books, cut materials, and mass-produce millions of products that we use every day. This is obviously better than what each of us as humans can do alone. However, engineers and designers of these machines have to manage error in their machine design and function. What do we mean by error?

Let's give an example: a machine that cuts wooden beams is made to cut them to a certain width, such as 50 mm. However, this machine (or probably all other machines in existence today) may not cut it *exactly* to 50 mm. It may give you a beam of 51 mm thickness, and a beam of 49 mm thickness. This means that the machinery may be able to cut it close to 50 mm, give or take 1 mm. The differences may be due to how the machine cuts the wood, vibration of the machinery in motion, the type of saw used, etc. Therefore, it is important to consider any possible inaccuracies with the operation of the machine itself, and measure it by measuring the resulting product in terms of error.

Insert Image 2 here, center

Image 2
ADA Description: Pine lumber I-Beams
Caption: None
Image file name: images.jpg
Source/Rights: Copyright © Zhangzhou Lantian Wood Inc. (http://www.3ply-shuttering-panels.com/upload/200981415151175.jpg)

As in the example above, we can write a measured value along with its numerical error as follows: 50±1 mm. This simply means that the measured value is expected to be 50 mm, give or take 1 mm of difference, which is the error. Any measurement that falls in between 51 and 49 should be reasonable.

Let's say you used a tool that allows you to measure the thickness of these beams to the nearest ten thousandth mm (this isn't something that can be done with a regular ruler). When you measure a beam, it might give you a number: 50.7658. From looking at this number, you may just want to know if it clearly falls within the expected error of 50±1 mm. Therefore, you should round up to the nearest tenth. Given that the number in the hundredths place is a 6, we typically round the value up to 50.8. Now it is easy to see that 50.8 fits between 49 and 51.

As consumers, engineers, designers, or company workers, we can choose to accept or reject this amount of error, depending on what your job demands. Today, we will see how accurate the Lego Mindstorms NXT is when performing a simple task: drawing a line.

Vocabulary / Definitions

Word	Definition
Accuracy	How close a measured value is to the actual value
Error	Difference between a measured value and an expected value

Procedure

Before the Activity

- Build basic NXT robot as per the Lego kit instruction manual
- Lay down large sheets of paper for each group
- Place one robot, one sheet of paper, and a Sharpie at each group station
- Modify the robot slightly to accommodate placement of Sharpie marker, as shown in Figure 1.1.
- Program to robot to move forward, as shown in Figure 1.2

Insert Figure 1.1 here, center

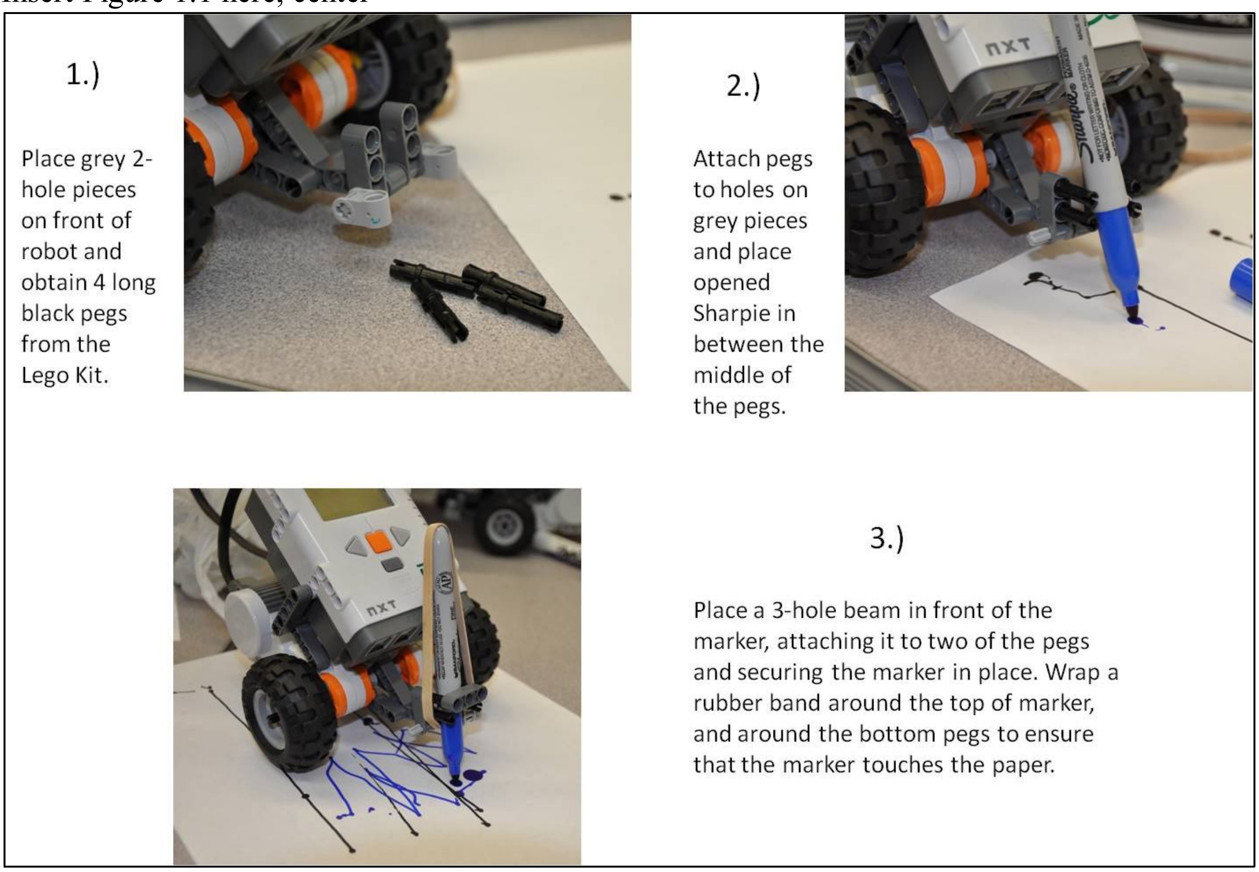

Figure 1.1
ADA Description: Instructions on how to attach marker to robot
Caption: None
Image file name: Marker_robot_instruction.jpg
Source/Rights: Copyright © Ronald Poveda 2010

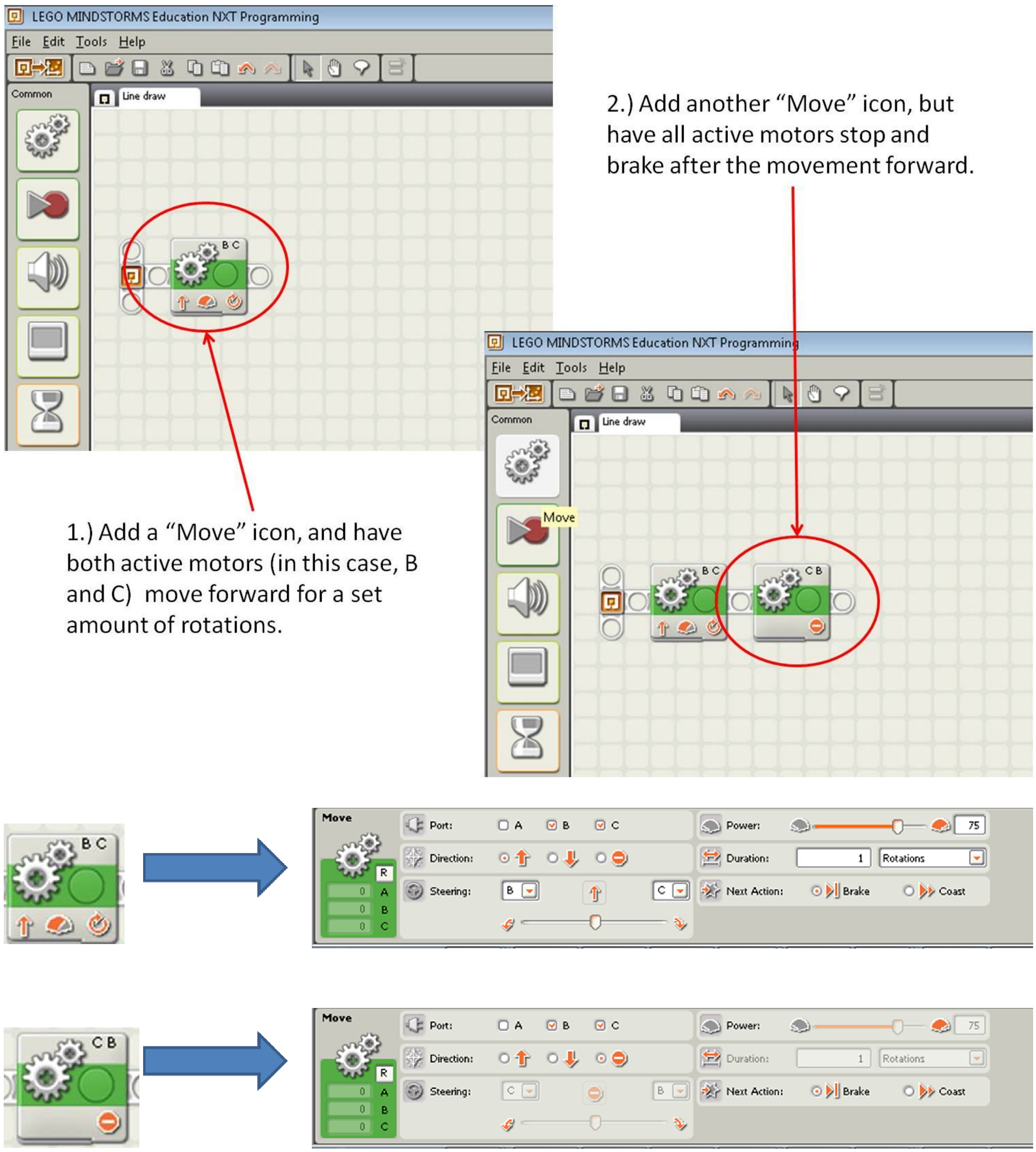

Figure 1.2
ADA Description: Programming instructions on how to move the robot forward
Caption: None
Image file name: Accuracy_programming_instructions.jpg
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With the Students

1. Have students complete a brief pre-evaluation:

   a. Refer to the pre-evaluation (Accuracy_pre-evaluation.docx.)

   b. Once students are finished, go over the assessment part of the activity to ensure that students understand the concept of circumference as it relates to linear distance that a wheel travels.

2. Give definition of accuracy and tell why it is important.

3. Go over the mathematical relationship between diameter and circumference of wheel.

4. Show diagrams of wheel motion with respect to circumference and linear distance

5. After discussion of pre-activity experiment, each group can start the activity

6. Allow each group to position robot with Sharpie marker on table.

7. Have the students calculate the distance that the robot moves forward after one rotation of its wheels, and then have the robot travel one rotation forward as it marks the sheet of paper.

8. Have the students measure the line drawn by the robot, either by ruler or caliper. Have them compare their calculated value and their measured value.

9. Using the percent error formula explained before, help them calculate the percent error of the trial run.

10. Repeat steps 7-9 twice; once for two rotations and once for three rotations.

11. Have the students fill out the included worksheet (see AAA_worksheet.docx) to keep the data organized for comparison purposes. *Have them round up their values to the nearest **tenth**.*

12. Have the groups compare data and discuss what is seen in terms of consistency.

13. Have the students complete a post-evaluation (Accuracy_post-evaluation.docx.) to assess what they have learned throughout the lesson.

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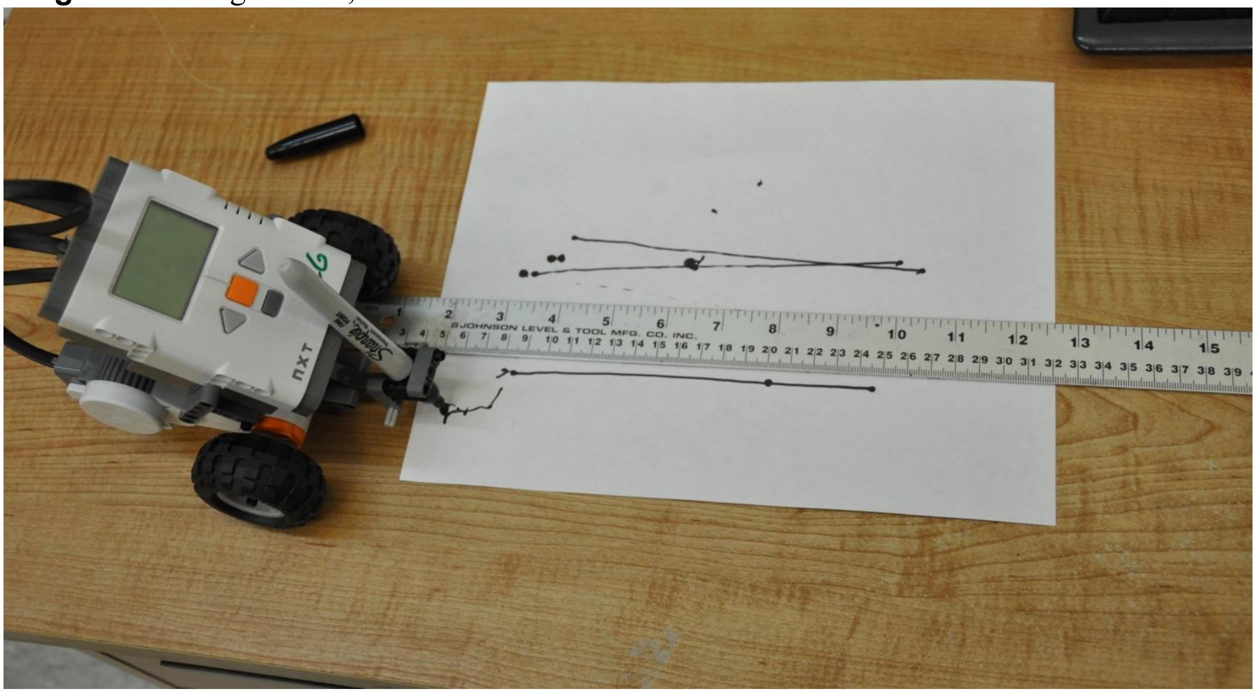

Image 3
ADA Description: Marker robot with meter stick for line measurements
Caption: None
Image file name: marker_robot_5.jpg
Source/Rights: Copyright © 2010 Ronald Poveda.

Safety Issues

- Carefully wrap the rubber band around the marker when attaching to the robot.

Troubleshooting Tips

- Ensure that the marker is touching the paper by loosening the front grey 3-hole piece attached.

Assessment

Activity Embedded Assessment

Analysis

There are two criteria that students should be evaluated on: conducting experimental measurements and interpretation of the resulting data with respect to applied circumference theory. When conducting experimental measurements, the groups should have the similar error difference results, given that the same robot was built for each group. When interpretation of data is conducted, students should be able to recognize what can physically affect the results measured from the trial runs, as well as gain insight as to how accurate a programmed NXT robot can be in conducting a simple operation.

Activity Extensions
None

Additional Multimedia Support
None

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Version: April 2010