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Alberta Health Services

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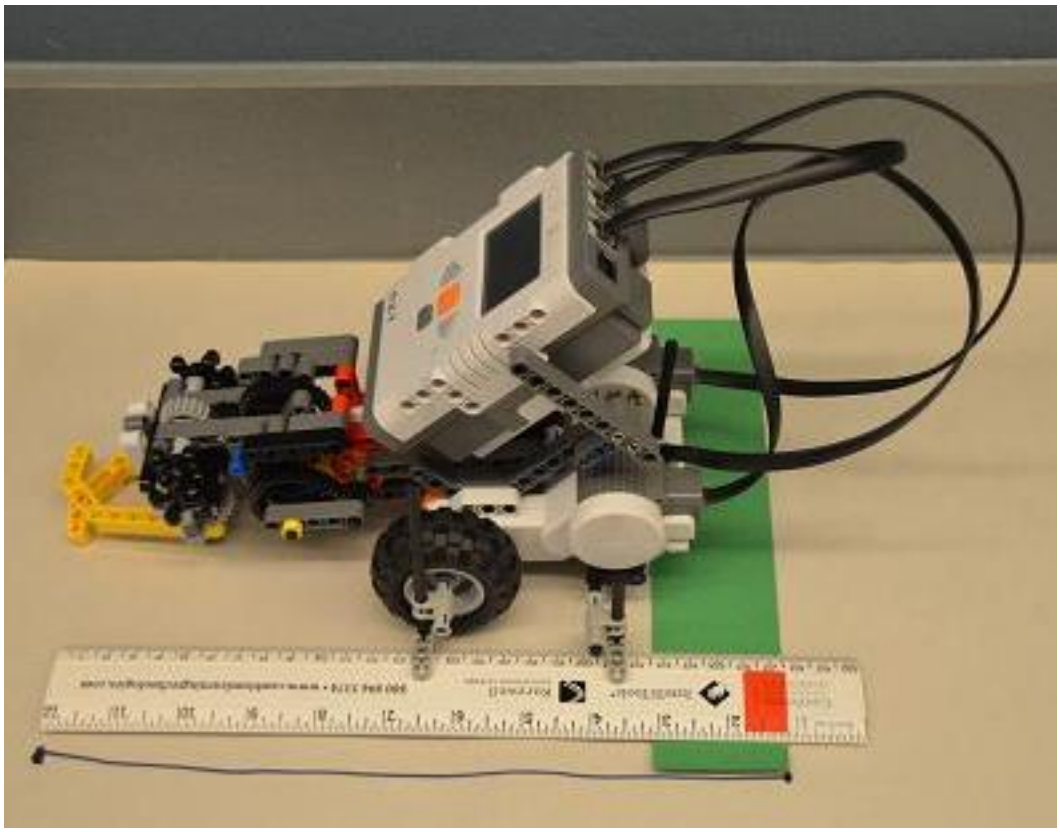
Making "Hands-On" Activities for Everyone

Math and The Lego Mindstorm Robot



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Contents

Introduction

As a means of including students with physical disabilities into math activities, we have paired a Lego Mindstorm Robot (NXT or EV3) with adapted Math Makes Sense activities. The Lego Robot is controlled via Bluetooth, allowing the student direct control of the Robot using available remote control devices. The adapted activities focus on the students independently using the Robot in measuring activities similar to those being done by their peers. By providing a means for the student to actively manipulate standard and non-standard units, it is believed that students with physical disabilities will gain a better understanding of measurement concepts. We also strongly believe that the Lego Robot is a viable option for providing "hands-on" opportunities for students with physical disabilities in many other academic learning activities as a means of increasing their participation and understanding. For more information, see: Adams, K., & Cook, A. (2013). Access to hands-on mathematics measurement activities using robots controlled via speech generating devices: Three case studies. Disability and Rehabilitation: Assistive Technology (Early On-line).

Communication Modalities

During the math activities, students are expected to indicate choice, answer questions, direct, predict, and make statements. How does a student with communication difficulties participate in this important component of these activities? ANSWER: Staff must provide the student with multi-modal ways of communicating. Below is a list of possible communication modality options.

NOTE: When considering a communication modality, it is important to balance the cognitive-linguistic load of the activity with the type of response required. If the activity is cognitively and linguistically challenging or new, the modality should require minimal physical effort or less conscious energy to perform. For example, when the student is driving the robot to line up their measurement units (a task with a high cognitive load), the communication modality selected should be relatively easy or 'automatic' for him/her to perform (e.g. two-hand choice making or eye gaze).

MODEL, MODEL, MODEL:
The student will benefit from observing adult modeling as the language and the modality(s) with which s/he is expected to use or emulate is new. Staff must repeatedly model the use of the language and communication modality throughout the math activities and optimally, in a variety of contexts across the school day. Students model what they see and will learn to use a variety of modalities if these are modeled for them in authentic contexts.

1. Non-verbal Yes/No
   If the individual has a reliable means of signaling YES and NO (for e.g. shaking/nodding his/her head, blinking, vocalizations, etc.,) she/he can use this signal

to answer yes/no questions, indicate agreement/disagreement or confirm a choice.

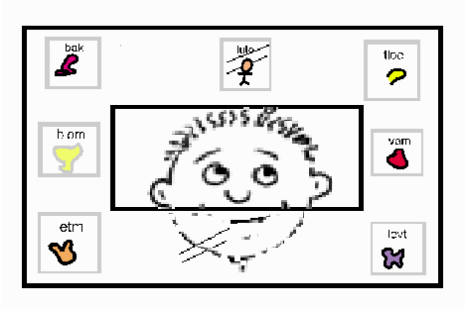
2. Eye gaze or Pointing
   If the individual is unable to directly select an item, picture symbol, word, etc., via finger pointing, eye gaze or pointing is a quick and less physically demanding means of indication. Once the individual indicates a choice, staff needs to provide feedback (for e.g. I see that you are looking at ____) and wait for confirmation (a YES/NO signal).

   YOUTUBE video: YOUTUBE video: http://www.youtube.com/watch?v=JEt4BswSl7U

   a. Two Hand Choice Making
   This approach involves naming 2 choices and staff using their hands as place holders for each choice. The student indicates their choice selection via eye gaze. For example, when asking the student where to start measuring an object, staff could ask "top" or "bottom" while indicating that her right hand represents *top* and her left hand represents *bottom*. If the student looks at the staff's right hand, she/he then clarifies: "You picked *top*, right?"

   b. Sticky Notes
   Key words or phrases could be written on sticky notes and arranged around the student's communication device, wheelchair tray or desk and accessed via eye gaze or pointing. Key phrases could include generic math terms (e.g. *longer, shorter, same as*, etc.,) as well as "survival vocabulary" (e.g. *I need help*, *I don't understand, Please repeat*, *Fix it*, etc.)

   c. E-Tran
   An eye-gaze or "e-tran" board allows for multiple symbols to be displayed at a time, thereby increasing the selection set of words for the student and staff to model and use.
   The student gazes at symbols or pictures, words, etc., attached to a transparent frame (see below) in order to make a selection. Staff then "reads" the

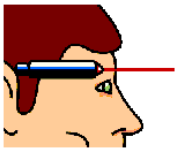


eye gaze from the other side of the frame and gives feedback.
Resource website:
http://www.bridgeschool.org/transition/multimodal/eye_gaze_boards.php

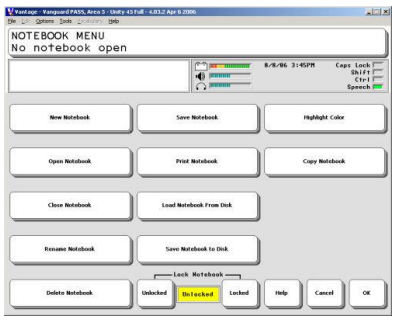
3. Individual Key Word/Phrase Board
   Similar to a word wall, key words and phrases can be placed on the student's individual word board. Words or phrases that could be used by the student to direct, comment or demonstrate understanding. These words would be arranged in grid format on a manila tag board. Symbols could be added to phrases or words that not part of the student's sight word vocabulary. Words or phrases chosen for the board could include vocabulary relating to the math activities (long, short, same) AND core words (put, want, get, help). Temporary words could be added to the individual Key Word Board using Sticky Notes (ex. Color words for the cars or strings).

4. Partner Assisted Scanning
   Partner assisted scanning involves giving the student a list of choices verbally and/or visually and letting them indicate the one s/he wants via a pre-determined signal (e.g. head nod, blinking, vocalizing, etc.) The important feature is that the student knows all the choices before expecting him/her to decide. For example, if the student has a choice of 4 possible answers to a question, staff lists all the choices first, then goes through them again, one at a time, pausing long enough for the student to indicate the one s/he wants. Staff should clarify after the student indicates a choice, (e.g. You picked 'later' – right?)
   http://www.youtube.com/watch?v=nGpSXQKrmR4

5. Laser Pointing
   Similar to eye gaze/pointing, a laser pointer could be attached to a baseball cap or hair band and used by a student with motor or physical limitations to directly select an object or key vocabulary. Student should have sufficient, reliable head control for accurate targeting.
   http://www.youtube.com/watch?v=4EyA9jabpnQ



6. Speech Generating Communication Device Those students who have a speech generating communication device can use this tool to answer questions, make comments and demonstrate their understanding of targeted vocabulary and concepts. This is especially the case if she/he has sufficient time in class to compose their response.



Another effective way of increasing their participation and understanding is to provide the student with some additional time prior and after a lesson to use their communication device to predict, plan, review or make a statement. Many devices have notebooks (see illustration) that can be used to save and collect written messages.

How to Help Students with Physical Delays and/or Communication Delays Count

- Staff points to the objects while the student counts in their head (Inner Voice)
- Staff points to the while the student counts aloud
- If the number is 5 or less, student may be able to count independently by looking at the objects (use Communication Modalities above as possible means for student to provide the answer)
- Use a number line, with staff tracing finger along the numbers. Student can indicate number choice by looking at staff
- Put number cards next to each non-standard unit as the staff counts

Strategies When Using the Robot

- As the wheels on the Robot are controlled by different motors, the wheels may behave differently causing the Robot to move off course. Staff should gently push the Robot to correct its path
- Aligning the Robot into the correct position requires precise driving skills that students may not have. When students have attempted to correctly position the Robot, but continue to have difficulty, staff can position the Robot by picking it up and moving it

into position. Staff should confirm with the student that the new position is where they want the Robot to be placed. (eg. Is the Robot at the Baseline?)

- Students have control of the Gripper and can open and close it independently. At time Gripper may not grasp the block correctly, staff can make adjustments to the object within the Gripper

- The spool attached to the peg at the back of the Robot works best when the string is carefully wound with no overlap. Staff may also need to add slack to the string when the Robot is driving

- The activities suggest many ways the student can participate using the Robot. For some students completing the activities as suggested may take longer than planned. Staff may need to provide more assistance with certain portions of an activity (Eg. When using the Gripper with non-standard units, staff may want to pick up the Robot and position it back at the starting position and bring the next non-standard unit to the Robot. VS The student driving the Robot to the pile of non-standard units and then driving to the starting position.)

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Training Protocol

All Grade Levels

Materials

- Robot with gripper
- Blocks or obstacles
- Straws (mounted on blocks)

Students with physical may have limited levels of experience controlling IR devices (including Lego Robots) using their communication device, therefore training needs to done prior performing the math activities. This training will assist the student in developing sufficient competencies in controlling the Robot before adding an academic expectation to the task.

The Robot Training Protocol is designed so that students can learn the skills required for performing the subsequent math activities with the Robot (e.g., maneuvering in two dimensions, manipulating items, and switching between Robot and communication modalities). Domains are introduced one at a time: first Robot control only, and then Robotic control with manipulation of items.

The protocol consists of familiarization sessions, and slalom and obstacle course sessions. Students may need three to four sessions of 30 to 60 minutes for each training activity. After training is completed, a warm-up session, using the Robot prior to each math activity is recommended. The grade and activity number is indicated next to the Training Tasks that are needed for those activities.

Familiarization Session

The student can spend time learning Robotic control by learning each Robot command one at a time (e.g. forward, reverse, left, right) through a variety of tasks. Repeat the tasks until the student has good Robot control. The tasks can be changed by placing toy animals or Mr. Potato Head parts instead of blocks, and the student drives to them to select them.

Task 1

- Student moves the Robot forward until it knocks over a stack of blocks. The student could press and hold their forward command selection to move the Robot forward and then release the switch to stop. See Figure 1

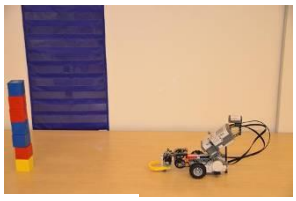

Figure 1

Task 2

- Student helps build a stack of blocks. They need to stop the Robot beside a pile of blocks to allow staff or peer to load a couple blocks onto the Robot See Figure 2

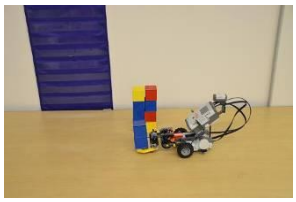

Figure 2

- Then they need to drive and stop the Robot where the stack will be built. Staff or peers will unload the blocks. Students can use the backward command if they go past the stop location. See Figure 3

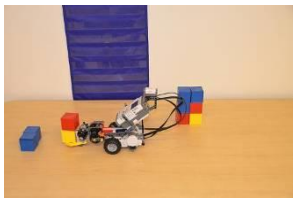

Figure 3

- Student repeats driving the Robot until all the blocks have been moved and stacked

- Student drives the Robot to knock down the stack

Task 3

- The third task involved two stacks of blocks located to the left and right with the Robot placed between them facing away from the student. See Figure 4

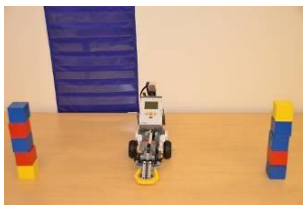

Figure 4

- The student needs to choose a pile (using eye gaze)

- Then drive the Robot to knock the pile down. To accomplish this, the student needs to use the appropriate left or right turn command to turn the Robot (either right or left), and then use the forward command to drive the Robot to knock over the blocks.
  See Figure 5

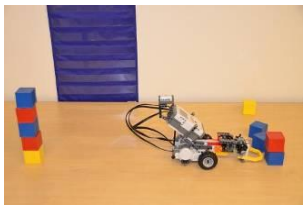

Figure 5

Task 4 Slalom and obstacle course

Slalom course training involves the student driving the Robot through a course (approximately 1 m long).

The complexity of the Slalom course can be increased through the addition of more obstacles. Small blocks or toys can be added.

Corresponding Math Lesson

- All lessons (stopping on a baseline)
- Grade 1 Activity 1 (maneuvering between items)

NOTE: It is important that the student knows that accuracy is more important than speed when doing training

- Drive around 1 obstacle
  See Figure 6
- Drive around 2 obstacles
- Drive around 3 obstacles
  See Figure 7

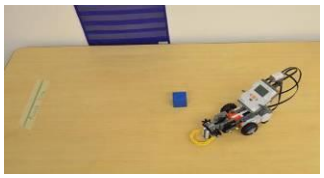

Figure 6

* Include stopping on a **finish line**

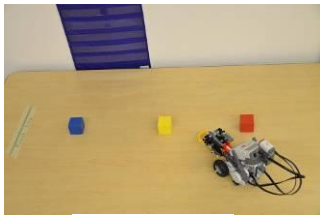

Figure 7

- Grade 2, Activity 1
- Grade 2, Activity 2
- Grade 2, Activity 3

Task 5 Line up blocks

- Drive around 2 obstacles while:
  - At the starting position, grasping a block placed in the gripper by the staff, then release the block at the finish line
  - Drive back to the starting position to grasp another block
  - Drive the second block and release it lined up **tip-to-tip** with the previous block
    See Figure 8

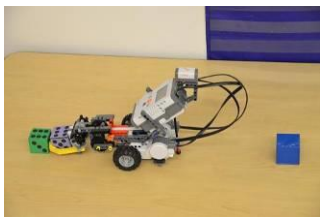

Figure 8

- Grade 2, Activity 1
- Grade 2, Activity 2
- Grade 2, Activity 3

Task 6 Line up blocks with straws

- At the starting position, grasp a straw (mounted on a block) placed in the gripper by the staff, then release the block at the finish line
- Drive back to the starting position to grasp another straw
- Drive the second straw and release it lined up **tip-to-tip** with the previous straw
  See Figure 9

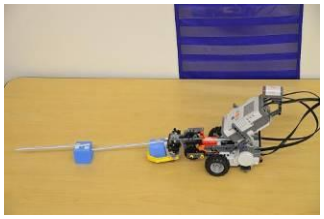

Figure 9

- Grade 2, Activity 3

Task 7 Using the pen in a straight line

- Lift the pen up and down to make a dotted line

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Alberta Program of Studies

Mathematics K – 9, 2007

GRADE 1

General Outcome

Use direct and indirect measurement to solve problems.

Specific Outcomes 1. Demonstrate an understanding of measurement as a process of comparing by: • identifying attributes that can be compared • ordering objects • making statements of comparison • filling, covering or matching. [C, CN, PS, R, V]	
Achievement Indicators	**Robot activities**
• Identify common attributes, such as length (height), mass (weight), volume (capacity) and area,that could be used to compare two given objects.	Grade 1 – Activity 3
• Order a set of objects by length (height), mass (weight), volume (capacity) or area, and explain their ordering.	Grade 1 – Activity 2 Grade 2 – Activity 1 Grade 1 – Challenge
• Compare two given objects, and identify the attributes used to compare.	Grade 1 – Activity 1 Grade 1 – Activity 3
• Determine which of two or more given objects is longest/shortest by matching, and explain the reasoning.	Grade 1 – Activity 1 Grade 1 – Activity 2 Grade 1 – Challenge

GRADE 2

General Outcome

Use direct and indirect measurement to solve problems.

Specific Outcomes 2. Relate the size of a unit of measure to the number of units (limited to nonstandard units) used to measure length and mass (weight). [C, CN, ME, R, V]	
Achievement Indicators	**Robot activities**
• Explain why one of two given nonstandard units may be a better choice for measuring	Grade 2 – Activity 3

the length of an object.	
• Explain why one of two given nonstandard units may be a better choice for measuring the mass (weight) of an object.	Grade 2 – Activity 1
• Select a nonstandard unit for measuring the length or mass (weight) of an object, and explain why it was chosen.	Grade 2 – Activity 2
• Estimate the number of nonstandard units needed for a given measurement task.	Grade 2 – Activity 2

Specific Outcomes 3. Compare and order objects by length, height, distance around and mass (weight), using nonstandard units, and make statements of comparison. [C, CN, ME, R, V]	
Achievement Indicators	**Robot activities**
• Estimate, measure and record the length, height, distance around or mass (weight) of a given object, using nonstandard units.	Grade 2 – Activity 2
• Compare and order the measure of two or more objects in ascending or descending order, and explain the method of ordering.	Grade 2 – Activity 1 Grade 3 – Activity 1 Grade 3 – Activity 2

Specific Outcomes Specific Outcomes 4. Measure length to the nearest nonstandard unit by: • using multiple copies of a unit • using a single copy of a unit (iteration process). [C, ME, R, V]	
Achievement Indicators	**Robot activities**
• Explain why overlapping or leaving gaps does not result in accurate measures.	Grade 2 – Activity 1,2 and 3
• Count the number of nonstandard units required to measure the length of a given object, using a single copy or multiple copies of a unit.	Grade 2 – Activity 2 Grade 3 – Activity 1 Grade 3 – Activity 2
• Estimate and measure a given object, using multiple copies of a nonstandard unit and using a single copy of the same unit many times, and explain the results.	Grade 2 – Activity 2 Grade 3 – Activity 1 Grade 3 – Activity 2
• Estimate and measure, using nonstandard units, a given length that is not a straight line.	Grade 2 – Activity 3

Specific Outcomes Specific Outcomes 5. Demonstrate that changing the orientation of an object does not alter the measurements of its attributes. [C, R, V]	
Achievement Indicators	**Robot activities**
• Measure a given object, change the orientation, re-measure, and explain the results.	Grade 2 – Activity 3

GRADE 3

General Outcome

Use direct and indirect measurement to solve problems.

Specific Outcomes 3. Demonstrate an understanding of measuring length (cm, m) by: • selecting and justifying referents for the units cm and m • modeling and describing the relationship between the units cm and m • estimating length, using referents • measuring and recording length, width and height. [C, CN, ME, PS, R, V]	
Achievement Indicators	**Robot activities**
• Provide a personal referent for one centimetre, and explain the choice.	Grade 3 – Activity 2 Grade 3 – Activity 3
• Provide a personal referent for one metre, and explain the choice	Grade 3 – Activity 3
• Match a given standard unit to a given referent.	Grade 2 – Activity 1 Grade 3 – Activity 2 Grade 3 – Activity 3
• Show that 100 cm is equivalent to 1 m by using concrete materials.	Grade 3 – Activity 3
• Estimate the length of an object, using personal referents.	Grade 2 – Activity 2 Grade 3 – Activity 2 Grade 3 – Activity 3
• Determine and record the length and width of a given 2-D shape.	Grade 2 – Activity 3 Grade 3 – Activity 1 Grade 3 – Activity 2 Grade 3 – Activity 3
• Determine and record the length, width or height of a given 3-D object.	Grade 3 – Activity 1 Grade 3 – Activity 2 Grade 3 – Activity 3
• Draw a line segment of a given length, using a ruler.	Grade 3 – Activity 1

[C] Communication	[PS] Problem Solving
[CN] Connections	[R] Reasoning
[ME] Mental Mathematics and Estimation	[T] Technology
	[V] Visualization

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Comparing Objects

Math

Grade1

Activity 1 (Adapted with permission from Math Makes Sense 1 Unit 4 Launch, Pearson Education Canada, 2007)

Objective

- To compare the length of multiple objects to one common referent object

Warm Up

Robot

- Training Protocols (see Training Protocol)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Introduce vocabulary (long/longer, short/shorter, same/difference)
- Model pathways on communication device or communication modalities for responding using the vocabulary
- As words are introduced, display the words where the student can see them (you may want to have student select through eye gaze or pointing)

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions throughout the activity)

Materials

- Robot with gripper
- Common objects divided into 2 groups (mounted on blocks)

  1) Referent Object (**craft sticks, paper clips, straws, toothpicks**)

  2) Comparison Objects (**scissors, tape, book, Lego block, ruler, tack**)
- Signs: Longer than, Shorter than, Same as (on construction paper)
- Paper to write answers on

Additional Activities

This activity can be extended to support the understanding of the concept

- Student chooses a referent object, then drives the robot on a table to compare other objects (ex. the size of peers' drinks, pencils etc.)

Introduce

Staff

- Chooses an object from referent objects, then select an item from the comparison objects
- Models and talks through comparing if it is *longer than, shorter than, same as*
- Models reporting if object is shorter than, same as, longer than the referent object
- Staff puts a different referent object and comparison object side by side and lined up

Student

- Indicates their choice (using selected pathway on communication device or communication modality)

Robot

Staff

- Places an object in front of student
- Grasps selected referent object with the robot.
- It's best to drive the robot from Left to Right in front of student (or Right to Left depending on student preferences). This will make it easier for them to line up the baseline, and clearly see the differences in length
- Explains how the robot will help with comparing the referent object to other objects
- Demonstrates and models:

  Driving the robot alongside each object. Using vocabulary to compare the objects

Figure 1

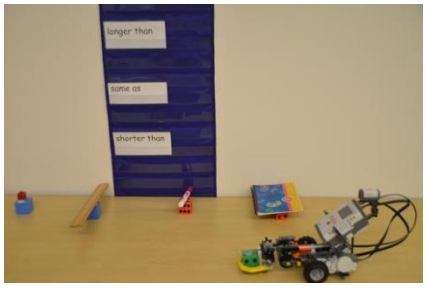

Figure 2

Student

- Grasps a different referent object placed in the gripper by staff. See Figure 1 and 2
- Predicts if the object on the table will be *shorter than, same as, or longer than*, the referent object

- Controls the robot to drive alongside the object. *If needed, staff can move the comparison object closer to reduce the amount of navigation needed.* See Figure 3

- Using any communication modality, identifies whether the object is *shorter than, same as, or longer than,* the object on the robot. Repeats comparison with other objects

Closing

After student has completed the activity, ask:

- What did you compare?

- What did you find out? Creates a comparison response (ex. longer than tape dispenser) for staff to scribe onto the chart

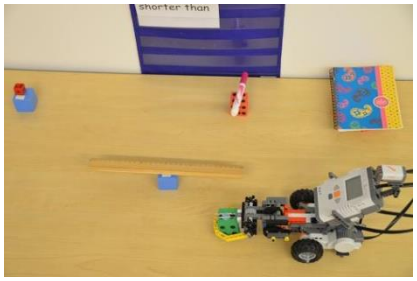

Figure 3

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Comparing Lengths

Math

Grade1

Activity (Adapted with permission from Math Makes Sense 1 Unit 4 Lesson 1, Pearson Education Canada, 2007)

Objective

- Compare the lengths of objects to one common referent

Warm Up

Robot

- Training Protocols (see Training Protocol)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Introduce vocabulary (*long/longer, short/shorter, same/difference, baseline/matchup*) using Word Wall chart
- Model pathways on communication device or communication modalities for responding using the vocabulary

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions throughout the activity)

Introduce

Staff

- Chooses 6 objects (2 *longer than*, 2 *shorter than*, and 2 *same as* the unsharpened pencil)

Materials

- Robot with gripper
- Referent: unsharpened pencil
- 3 bins (**labeled: shorter than, longer than, and same**)
- Classroom items (**markers, tape, a glue stick, scissors, paper towel roll, Lego, notebook**) mounted on blocks (minimum of 2 for each (longer than, same as, shorter than)
- Word Wall list

- Predicts which item is the *same size* as the unsharpened pencil
- Models and talks through by holding the first object alongside the pencil and matching up the "baseline". Emphasize "baseline": placing the end of the pencil alongside the end of the object (baseline)

  NOTE: A clear ruler can be used to mark the baseline on both objects
- Compares results with prediction

Student

- Chooses an object by communication modality and staff places in front of student
- Predicts if object is the same, longer or shorter than the unsharpened pencil. Staff compared the objects.
  NOTE: Staff should intentionally **not** use a common baseline and encourage the student to direct them to line up the objects using a baseline

<u>Robot</u>

Staff

- Places objects along the side of the table
- Tapes the bins and matching labels in 3 distinct areas hanging off the table See Figure 1
- Explains how the robot will help with comparing a chosen object to the objects placed on the table
- Demonstrates and models (if needed):

  1. Grasping an object with the robot and driving alongside the unsharpened pencil
  2. Using vocabulary to compare the objects
  3. Driving to the appropriate bin
  4. Releasing the object in or near the bin

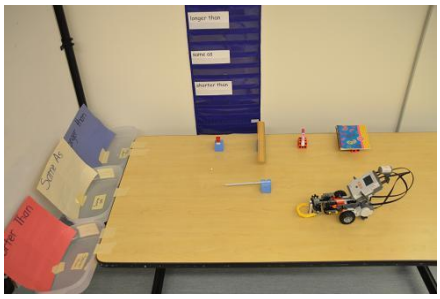

Figure 1

Student

- Drives to and grasps a comparison object with the robot from left to right or right to left, depending on students preferences

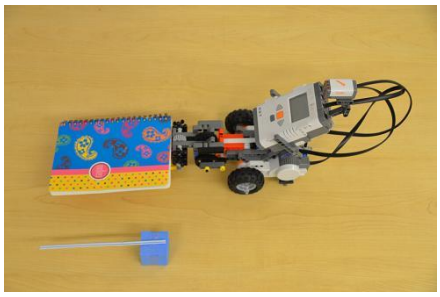

Figure 2

- Drives the robot alongside the unsharpened pencil. See Figure 2

Staff

- If the student has difficulty driving the robot to line up the two objects with a similar baseline, ask them if you can make adjustments so that they have a similar baseline. *Reinforce concept of baseline. This will allow them to line up the baseline, and more clearly see the differences in length
- Drives the object to the appropriate bin. See Figure 3
- Releases the object in or near the bin

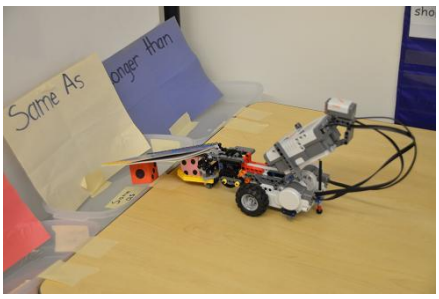

Figure 3

Closing

- Staff removes each item (one at a time) from the bins and measures them against the unsharpened pencil for the student to view. Together, determine if the object was categorized appropriately
- Make sentences with the word wall words

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Math

Grade1

Activity 3 (Adapted with permission from Math Makes Sense 1 Unit 4 Lesson 2, Pearson Education Canada, 2007)

Ordering Lengths

Objective

- Relating the concepts of distance and length
- Measuring the length/distances of toy cars with string
- Ordering objects according to length

Warm Up

Robot

- Training Protocols (see Training Protocols)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Review vocabulary (*long/longer, short/shorter, same/difference*) using Word Wall chart
- Quick review: Draw two lines of different lengths and in different colors. Ask the student to make a statement using the Word wall words and/or device (ex. The blue line is shorter)
- Introduce new vocabulary words (*Far/farther/furthest, long/longer/longest, short/shorter/shortest*)
- Model pathways on communication device or communication modalities for responding using the vocabulary
- As words are introduced, display the words where the student can see them
- Provide examples of when words are used (*to measure*

Materials

- Robot with gripper
- String/yarn on spools (3 different colors, if desired)
- Scissors
- Ramp
- Toy Cars
- Masking Tape
- Word wall list

things that travel). Provide one example of an object that travels (ex. Bus). Ask student if they know of other objects that travel.

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions throughout the activity)

Introduce

Staff

- Explains that the robot will help us determine which toy car travels the furthest

- Selects 3 toy cars and predicts which car will travel the furthest.

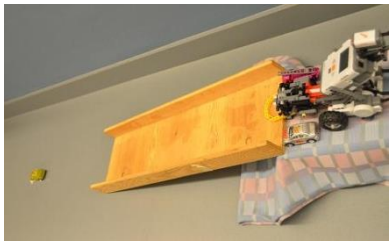

Figure 1

Robot

Staff

- Models and talks through using the robot to release each car at the top of the ramp.
- Emphasizing the start of the ramp is the baseline.
- Talks through and asks student how to solve the problem of the cars hitting each other and changing where they stopped. SOLUTION: Place a piece of tape, to indicate where the car stopped
- Talks through and expands on which car went the furthest.

Figure 2

Student

- Selects three toy cars
- Predicts which car will travel the furthest
- Using the robot gripper, grasps a car at the top of the ramp. Releases the car. See Figure 1
- Directs the staff to place a marker or piece of tape

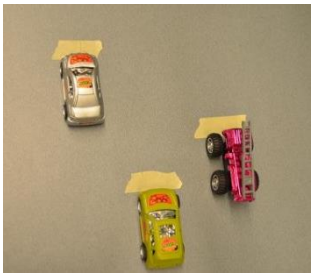

Figure 3

to indicate where the car stopped. See Figure 2

- Repeats with two remaining cars. See Figure 3

Staff

- Comparing the distance the cars travelled using string

    1. *Staff:* Places spool of yarn on the back of the robot. Tapes the end to the bottom of the ramp. See Figure 4
    2. *Student:* Drives the Robot to the location marked with a piece of tape. See Figure 5

       Staff may need to help unwind the string from spool of yarn
    3. *Staff:* Cuts the string and labels it.
    4. Repeat for other 2 cars and marked locations

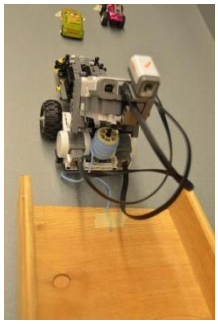

Figure 4

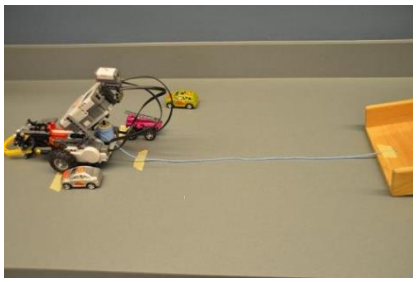

Figure 5

Staff

- Attaches one of the measured strings to the back of the Robot

Student

- Drives the robot pulling the string behind. Stops the robot where they want to create a baseline to measure the 3 strings
- Repeat for the other 2 strings (can use different color yarn, if desired)

  Staff: If needed, emphasize the concept of lining up the string on the baseline. The use of a clear ruler may be needed to mark the baseline.

Closing

Staff

- Asks student which car went the furthest and how they know.
- Talks through and expands on how to tell which car went the furthest.

- Directs staff to match Word wall words to label the string (*far, further, and farthest*)

- Makes sentences with Word wall words

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Comparing Length and Distance

Math

Grade1

Challenge (Adapted with permission from Math Makes Sense 1 Unit 4 Lesson 3, Pearson Education Canada, 2007)

Objectives

- "Using" objects to solve a problem about comparing lengths
- Relating the concepts of distance and length
- Ordering lengths and distances from shortest to longest/farthest

Warm Up

Robot

- Training Protocol (see Training Protocols)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Introduce vocabulary (*farther, farthest, longer, longest, short, shorter, same, different, how long, baseline= match line*)
- Model pathways on communication device or communication modalities for responding using the vocabulary
- As words are introduced, display the words where the student can see them (you may want to have student select through eye gaze or pointing)

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment, or

Materials

- Robot with gripper
- 3 different colors of String/Yarn
- Scissors
- Masking Tape
- Drawing sheet/Paper
- Word Wall Words

Additional Activities

- Student draws pathways after practicing using the Robot pen on a scrap piece of paper. Then measures the pathways with Robot and string. See Figure 1
- Student draws 3 different pathways then the Staff or other student measures and compares the lengths

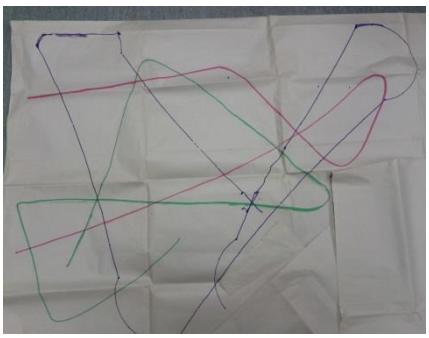

Figure 1

ask questions throughout the activity)

Introduce

Staff

- Refers back to the previous lesson: "Ordering Lengths" by asking,

  The red car went further than the blue car. "Which car would have a longer string?"

- Explains that instead of measuring the paths of cars, they will be measuring the paths/sidewalks of people and/or animals (what is drawn)

Figure 2

Student

- Predicts which pathway/sidewalk is the longest
- Responds to questions,

  "Why do you think it would be hard to guess which path is longer?" (*The paths are not straight*)

  "What so you think we can use to measure these paths?"(*String*)

Robot

Figure 3

Staff

- Explains how to measure pathways with string attached to the back of the Robot
- Asks students to measure one of the paths with the Robot. See Figure 2

  "Where should you start taping the string?"

  "Where should you stop measuring?"

Student

- Begins measuring one pathway by unwinding string with the Robot, indicating to the Staff where to tape. See Figure 3 & 4

Staff

- May need to untangle string or reinforce baseline concepts

Student

- Follows the same steps for other path using a different colored string. See Figure 5 & 6
- Once both paths are measured, responds to,

  "What should be our next step?" (*Straighten out the string paths*)

Staff

- Since the strings are long, you may want to leave them taped to the start position and only pull the ends straight

Figure 4

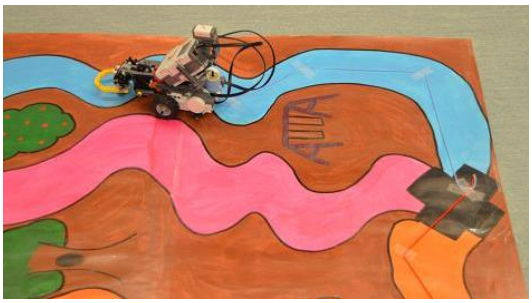

Figure 5

Closing

After student has completed the activity, ask:

- Which character/animal travelled the farthest distance? How do you know that?

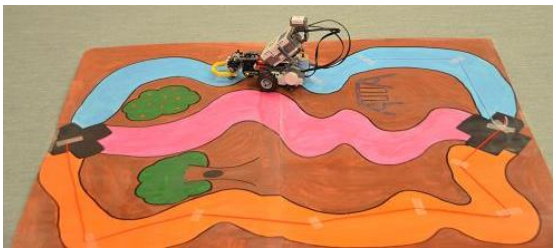

Figure 6

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Measuring & Comparing Lengths

Math

Grade2

Activity 1 (Adapted with permission from Math Makes Sense 2 Unit 4 Lesson 3, Pearson Education Canada, 2008)

Objective

- Measure length to the nearest non-standard unit using multiple copies of a unit, and compare and order objects by length and height using non-standard units

Warm Up

Robot

- Training Protocols (see page x)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions)

- Introduce vocabulary (*How tall? = Height, How long? = Length*)
- Model pathways on the communication device or communication modalities for responding using the vocabulary
- As words are introduced, display the words where the students can see them

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions throughout the activity)

Materials

- Robot with gripper
- Non-standard units **(craft sticks or if preferred, straws)** mounted on blocks
- String on a bobbin (2 different colors of string)
- Scissors
- Sticky Tack
- Giant Gingerbread man (Use template- LM7 (pg. 75) enlarged to approx. 120 cm)
- Signs: **How long?, length, How tall?, height** (Printed on construction paper)

Introduce

Staff

- Displays the gingerbread man and craft sticks/straws
- Asks student to predict how many craft sticks/straws tall the gingerbread man is
- Records the student's prediction
- Determins the baseline:
    1. Where should we place the first craft sticks/straws?
    2. With chosen communication modality student chooses to start measuring at "Top of the Head" or "Bottom of the Foot"

Learning how to measure

Staff

- Places craft stick/straws on the **gingerbread man** spaced out
- Poses the question: Is this right?
  Student answers using their non-verbal yes or no
- Discuss, why isn't this right?
- Places craft sticks/straws on the gingerbread man end to end, BUT in a crooked line
- Poses the question: Is this right?
- *Student* answers using their non-verbal yes/no
- Places craft sticks/straws end to end in a straight line
- Poses the question: Is this right?
- *Student* answers using their non-verbal yes/no

Measuring the Gingerbread man

Robot

Staff

- Places the **gingerbread man** on the table

Additional Activities

Using Snap Cubes as measurement tools

- Ask the student if it would be easier to measure using Snap Cubes instead of craft stick/straws? Yes, they link so there are no gaps or overlaps
- Have the student choose and measure 2 other objects (ex. Stapler, marker, hole puncher) they could measure using Snap Cubes

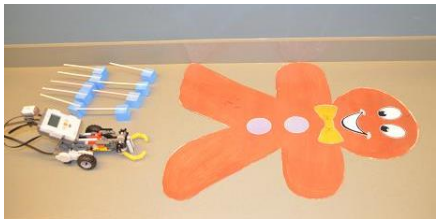

Figure 1

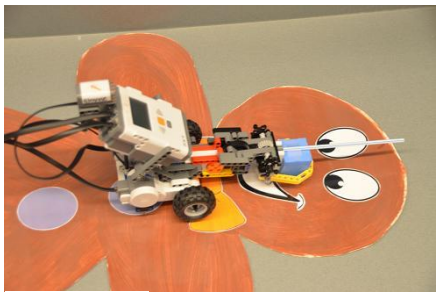

Figure 2

- Groups the craft sticks/straws on the table
- Explains how the robot will help with placing the craft sticks/straws on the **gingerbread man** so that we can determine "How tall he is"
- Talks aloud throughout the process of measuring to reinforce the concept
- Demonstrates and models (if needed):

  1. Places robot where student choose: top of head OR bottom of foot. See Figure 1
  2. Using robot grasp the craft stick/straws placed in the gripper by staff
  3. Drives the robot to the starting point (top of head or bottom of foot). Releases the craft stick. Secures the craft stick with sticky tack. See Figure 2
  4. Grasps another craft stick/straw with the robot held in the gripper by staff,(Figure 3) and drives it to the end of the last craft stick and releases it (Figure 4).
  5. Repeats driving the robot until the craft sticks /straws are at the end of the **gingerbread man**
  6. Talk aloud the need to place the craft sticks/straws end to end in a straight line and stop when at the baseline

- Counts and records the number of craft sticks on worksheet (See Introduction for Ways to Help Students Count) (Figure 5)

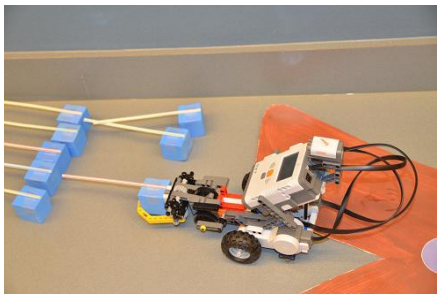

Figure 3

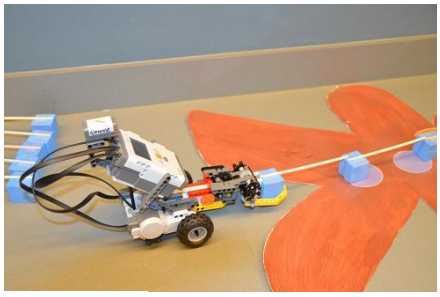

Figure 4

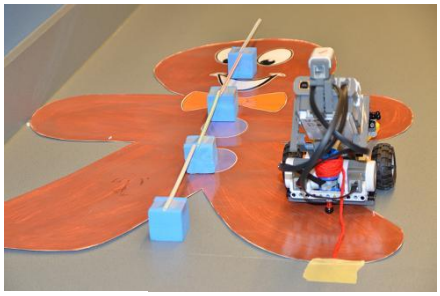

Figure 5

Student:

- Selects a non-standard unit (craft sticks or straws if preferred)
- Using the robot grasp the craft stick/straw placed in the gripper by the staff
- Drives the robot to the starting point. Releases the craft stick/straw

  Staff secures the craft stick/straw with sticky tack
- Moves the robot back to the group of craft sticks/straws

  Note: If going to the stack of units is too difficult for the

student, the staff can pick up the robot and put it at the start position and put the unit in the gripper

- Grasps another craft stick/straw with the robot held in the gripper by staff, and drives it to the end of the last craft stick and releases it.

  Staff secures the craft stick/straw with sticky tack. *Staff* When craft stick/straw is released, ask student if the ends are touching. If they are not touching, ask student if he/she can make adjustments so that they're touching. Reinforce the concepts for measuring objects.

- Repeats driving the robot until the craft sticks are at the end of the **gingerbread man**

- Counts the number of craft sticks (see Introduction on How to Count)

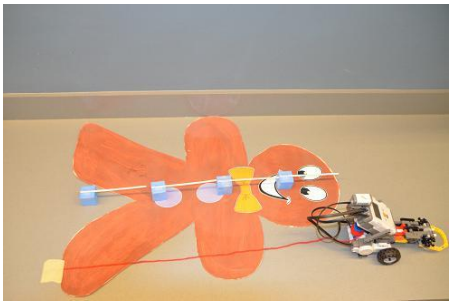

Figure 6

Discussion

- *Staff* displays the **gingerbread man** on the bulletin board, asks the student can you measure with the craft sticks on the bulletin board? NO

  We can represent **gingerbread man's** height with string

- *Staff* places **gingerbread man** on the table again

- Uses the robot to unwind string along the height of the **gingerbread man.** See Figure 6

Staff

- Attaches the bobbin with string to the robot

- Tapes one end of the string to the starting location on the **gingerbread man**

Student

- Drives the robot with the string along the same path as the craft sticks

  Staff may need to assist with unwinding the string from the spool

Staff

- Cuts the string
- Places each craft stick/straw alongside the string
- Verifies that the length of string measured in craft sticks is the same as length of **gingerbread man** in craft sticks

Student

- Counts the number of craft sticks. Verifies it is the same as what was written on the worksheet.

Staff

- Labels the string (Name: Gingerbread, # of craft sticks)

Measuring the Student

- Poses the question: Can we measure you using the Robot and craft sticks? NO, people are not flat
- What strategy can we use to make it easy to measure your height in craft sticks?
- *Staff* cuts a piece of string the same length as student
- Have the student predict how many craft sticks tall they think they are. Records the prediction.

Student:

1. Selects a non-standard unit (craft stick or if preferred straws)
2. The robot grasps the craft stick placed in the gripper by the staff
3. Drives the robot to the starting point of the **string**. Releases the craft stick.

   Staff secures the craft stick with sticky tack and moves the robot back to the group of craft sticks.
4. Grasps another craft stick with the robot held in the gripper by staff, and drives it to the end of the last craft stick and releases it.

   Staff secures the craft stick with sticky tack.

Staff When craft stick is released, ask student if the ends are touching. If they are not touching, ask student if he/she can make adjustments so that they're touching. Reinforce the concepts for measuring objects.

5. Repeats driving the robot until the craft sticks are at the end of the **string**
6. Counts the number of craft sticks (see Introduction on How to Count)

Staff:

- Writes the number on the worksheet
- Labels the **string** (Name: Student, Prediction, # of Craft sticks)
- Repeat for another student

Closing

- Complete and display the worksheet
- Using the worksheet
    - Who is the tallest?
    - How do you know he/she is the tallest? (It has the largest number)
    - Who is the shortest?
    - How do you know? (It has the smallest number)

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Estimating Lengths and Choosing Units

Math

Grade2

Activity 2 (Adapted with permission from Math Makes Sense 2 Unit 4 Lesson 4, Pearson Education Canada, 2008)

Objective

- Estimate, measure, and compare lengths, selecting appropriate non-standard units, and relate the size of unit used to the number of units needed

Warm Up

Robot

- Training Protocols (see Training Protocols)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions)

- Introduce vocabulary (*How tall? = Height, How long? = Length*)
- Model pathways on the communication device or communication modalities for responding
- As words are introduced, display the words where the students can see them.

Preparation

- Program the Robot for Part 1 to have giant and baby steps (See Controlling and Programming the Robots)

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions throughout the activity)

Materials

- Robot with gripper
- Non-standard units **(straw or toothpicks)** mounted on blocks
- String and Spool
- *Optional*: Magnetic Rods mounted on blocks
- Scissors
- Markers and tape
- Chart to write results on worksheet

Introduce

Staff

- explains to student the goal of the game is to determine the most appropriate size of Robot step to get from **Start** to **Finish** (From one end of the table to the other) without going off the table

- Demonstrates the Robot steps:

    1. Robot Giant step (Robot program g) = forward for 2 seconds
    2. Robot Baby step (Robot program b) = forward

- Places back of robot at end of table

Student

- Drives to the other end of the table by choosing Giant Steps or Baby Steps

Staff

- Asks student which step he/she would like to make, then changes to that program to make to run on the robot

- Reviews how student had to choose the long units at beginning of race, and short units close to end of table

Part 1: Estimating and Measuring

Staff

- Explains they are going to find out whose giant step is the longest

- *Review*: How string was used to represent the length of an object (Gingerbread man and person)

- Explains we need a piece of string the same length as the Robot Giant step and Robot Baby Step

Robot

Staff:

- Attaches the spool of string to the Robot. See Figure 1
- Tapes down the end of the string to the start line

Student:

- Drives the Robot one Robot Giant Step

Staff:

- Cuts the string at the spool. Labels string and tape to the table
- Repeat for Robot Baby Step. See Figure 2

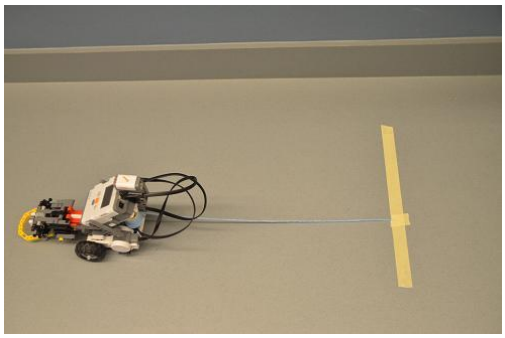

Figure 1

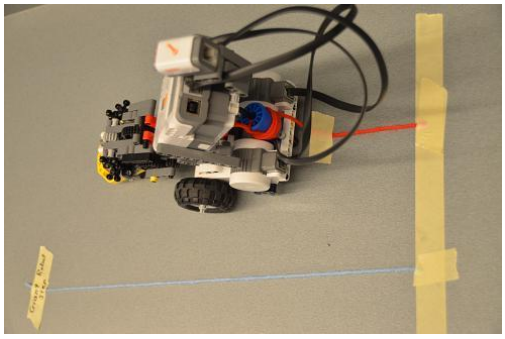

Figure 2

Discussion: Robot Giant Step

Staff asks:

- What non-standard unit could be use to measure the length of the Robot Giant Step? (Straws or toothpicks). Why? (Because you don't have to use as many)

  Note: If student has already demonstrated that they know the concepts of lining up tip to tip, use magnetic rods because they snap together and makes it easier to line up the units)

  Then explain: Though straws may be more appropriate to measure, it is recommended that the magnetic rods be used because they snap together, making it easier to line up tip to tip.

- *Estimate:* How many **units** (straws, rods) will it take to measure the Giant Robot step?
- *Staff* records answer on worksheet

Measure the string representing the Robot Giant step

Staff

- places robot at end of string

Student

- Using the robot, grasps the rod placed in the gripper by the staff, and drives to the appropriate location (start of string), then releases the rod.

  Staff secures the rod with sticky tack so it stands up and moves the Robot back to start position. See Figure 3

- Using the Robot, grasps another rod held in the gripper by staff, and drives it to the end of the first rod and releases it. See Figure 4

  Staff helps to snap the rods together

- Repeats driving the Robot carrying rods until the end of the strand of attached rods is close to the end of the Robot Giant Step

- Counts the number of rods in the strand (See How to Count in Introduction)

  Staff writes the number on the worksheet

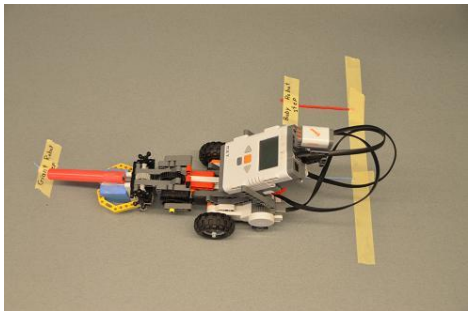

Figure 3

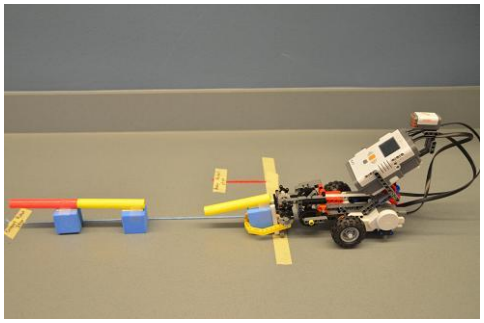

Figure 4

Discussion: Robot Baby Step

- What non-standard unit be use to measure the length of the Robot Baby Step (Toothpicks). Why? (The other units are too large)

- *Estimate:* How many **toothpicks** will it take to measure the Robot Baby Step?

- *Staff* record answer on worksheet

Measure the string representing the Robot Baby step

Staff

- places robot at start position

Student,

- Using the robot, grasps the **toothpick** placed in the gripper by the staff, and drives to the appropriate location (end of the string), then releases the **toothpick**.

  Staff secures the **toothpick** with sticky tack and moves the Robot back to start position.
  See Figure 5

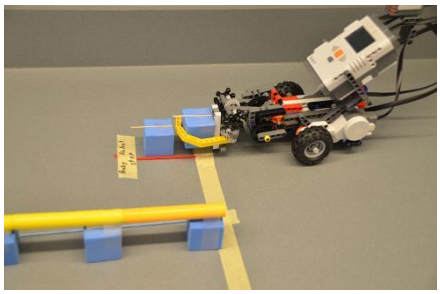

Figure 5

- Using the Robot, grasps another **toothpick** held in the gripper by staff, and drives it to the end of the first **toothpick** and releases it.

  Staff arrange the **toothpicks** together

- Repeats driving the Robot carrying **toothpicks** until the strand of attached **toothpicks** is close to the end of the Robot Giant Step

- Counts the number of **toothpicks** in the strand (See How to Count in Introduction)

- *Staff* writes the number on the worksheet

Part 2: Comparing and ordering (Robot Giant step with Friend's Giant step, Robot Baby Step with Friend's Baby step)

If this lesson is done with the whole class, students may have measured their steps using different non-standard units. Therefore, leading to the discussion relating to comparing objects measured with different non-standard units. If there are no other Giant and Baby steps measured with a different non-standard unit, Staff could "secretly" measure their step with a different non-standard unit.

Discussion

- Can we compare the measurement of the Robot Giant Step (ex. 9 rods) with the measurement of a Friend's Giant Step (ex. 4 straws)? (No)

- Why not? (Units are not the same)

- What do we need to do so that we can compare their measurements? (Measure the Friend's step using the same unit that we use to measure the Robot's step)
    - Measure the Friend's Giant Step and Friend's Baby Step with the Robot (same as above)
    - Record results on the worksheet

Closing

- Display the worksheet

- Using the worksheet, whose Giant Step is longest?
    - How do you know which one is the longest? (It has the largest number)
    - Which one is the shortest? How do you know? (It has the smallest number)

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Using One Copy of a Unit

Math

Grade2

Activity 3 (Adapted with permission from Math Makes Sense 2 Unit 4 Lesson 5, Pearson Education Canada, 2008)

Objective

- To measure length by using a single copy of a non-standard unit, estimate and measure a length that is not a straight line, and show that orientation does not affect length

Warm Up

Robot

- Training Protocols (see Training Protocol)

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions throughout the activity)

Preparation

- For measuring with one copy of a unit, the robot can be programmed to move ahead one unit (see Controlling and Programming the Robot)

Introduce

- Choose a random object in the classroom. Ask the student: "what non-standard unit is best for measuring the object?" (**Paperclip, toothpick, straw, rod, etc.)**
- Ask student to estimate the length in that unit
- Demonstrate measuring the item using multiple copies of the unit
- Ask: "What if I only have 1 copy of the chosen unit?

Materials

- Robot
  - ✓ with gripper
  - ✓ with pen
- Non-standard unit (**paperclip, toothpick**) (Mounted on blocks)
- 2 Pipe cleaners
- Blank paper and scotch tape

How could I measure the length?" (*You could use the same unit over and over*)

- Demonstrate measuring the item using only one copy of the unit, marking the end of the unit each time you move it along
- Before counting the number of units marked, **ask**:
    - Should the measurement with multiple copies be the same as the measurement with the single copy? (YES)
    - Why? (**We used the same unit both times**)
- Count the length of units of the object. If the two measurements are different, ask WHY? (There were gaps/overlaps with multiple units)

Discussion

- Today we are going to measure snakes made out of pipe cleaners. Most snakes can move in an S-shape or wavy shape, but some snakes like a Boa, sometimes travel with their body straight.
- We will measure the straight snake and wavy snake using copies of a unit and using a single unit

The Snakes

Student

- Selects two different colored pipe cleaners to represent the straight snake and wavy snake

  Staff: Tape the pipe cleaners to the paper (Cover the entire pipe cleaner with tape so it is easy to drive the robot over top of it). Label the pipe cleaner that will represent the straight snake. Bend the second pipe cleaner in an S shape to represent the wavy snake. Label the S-shaped pipe cleaner. See Figure 1

  Note: Staff may opt to make the curvy snake an easier shape for the student to measure with the robot (e.g. a wide open C)

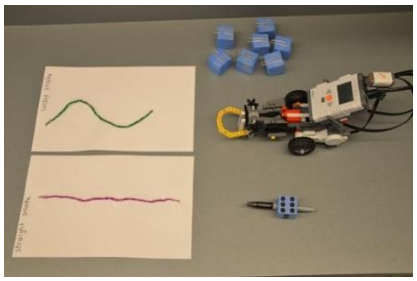

Figure 1

- Estimates the length in the unit for both the straight and wavy snake

- *Staff* Records estimations on the worksheet

Robot

Measuring the Straight Snake

We will measure the straight snake twice. First, using the robot and gripper and multiple copies of the unit. Secondly, using the robot and pen and a single copy of the unit.

NOTE: a distance of specific units (i.e. Toothpick, paper clip) should be programmed into the robot)

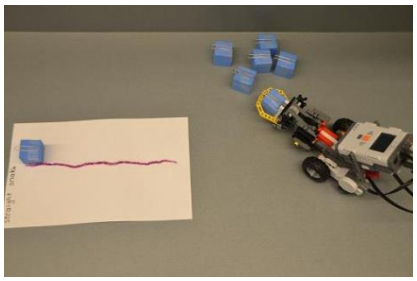

Figure 2

Using Multiple Copies of a Unit

Student:

- Using the robot, grasps the unit placed in the gripper by the staff, and drives to the appropriate location (end of straight snake), then releases the unit.

  Staff secures the unit with sticky tack and moves the robot back to the group of the units. See Figure 2

- Grasps another unit placed in the gripper by staff, and drives it to the end of the previous unit (block) and releases it. See Figure 3

  Staff secures it with sticky tack.

  Staff: To assist with lining up units, ask student if the ends of the units are touching. If they are not touching, ask them if you can make adjustments so that they're touching. Reinforce the concepts for measuring

- Repeats driving the robot carrying units until the unit are at the end of the straight snake.

- Counts the units (See in Introduction, for Ways to Help Count)

  Staff records number of units on the worksheet

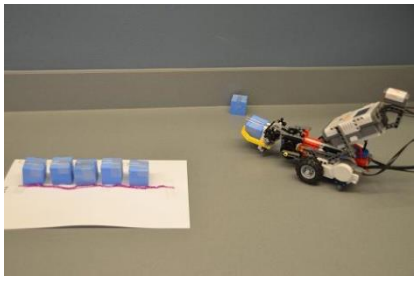

Figure 3

Using a Single Copy of a Unit:

Staff

- Program the robot the distance travelled to represent specific units (Toothpick, paperclip) (See Controlling and Programming the Robots)
- Shows student that the program makes the robot go forward the same length of the unit

Student:

- Places the pen in the gripper
- Drives the robot to the end of the straight snake
- Makes a pen mark by putting the pen down, then up again. See Figure 4
- Selects the appropriate program to move the robot forward one unit length (Staff selects that program and runs it on the robot)
- Makes a pen mark.
- Repeats until the robot reaches the end of the straight snake. Ending with a pen mark
- Counts the number of units

Staff record results on worksheet

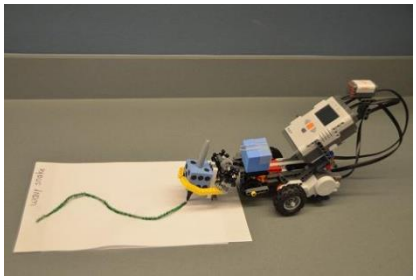

Figure 4

Robot: Part 2 Measuring the Wavy Snake

We will measure the wavy snake twice; the first time using the robot and gripper, and multiple copies of the unit, the second time using the robot and pen and a single copy of the unit

NOTE: a distance of specific units (i.e. Toothpick, paper clip) should be programmed into the Robot

Using a Single Copy of a Unit:

Since curvy snake requires fine robot control staff can help student by placing the robot so the student only has to drive straight. See Figure 5.

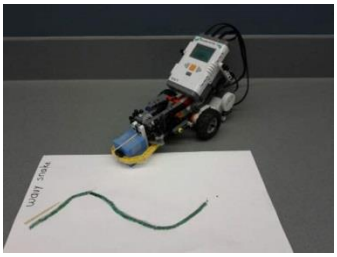

Figure 5

Student:

- Drives the robot to the closest end of the wavy snake.

- Makes a pen mark by putting the pen down, then up again
- Turns the robot slightly towards the snake
- Selects the appropriate program to move the Robot forward one unit length
- Makes a pen mark
- Repeats until the robot has reached the end of the wavy snake. Makes a pen mark
- Counts the units

  Staff records results on the worksheet

Using Multiple Copies of a Unit:

Note: Since curvy snake requires fine robot control staff can help student(s) by placing the robot so the student only has to drive straight

Student:

- Using the robot, grasps the unit (block) placed in the gripper by the staff, and drives to the appropriate location (end of the wavy snake), then releases the unit.

  Staff takes the unit off the block and places it next to the snake where the student had placed it
- Grasps another unit (block) held in the gripper by staff, and drives it to the end of the previous unit and releases it. See Figure 4

  Staff: To assist with lining up units, ask student if the ends of the units are lined up. If they are not lined up, ask them if you can make adjustment so that they are touching. Reinforce the concepts for measuring

  Staff takes the unit off the block and places it next to the snake and lined up tip to tip. See Figure 5
- Repeats driving the robot with the units until the unit are at the end of the wavy snake.
- Counts the units (See in Introduction, Ways to Help Counting)

Staff records results on the worksheet

Closing

- Display the worksheet

Discussion

- What did you notice about your measurements? (The wavy snake and straight snake are the same length)
- Was it easier to estimate the length of the straight snake or wavy snake? *(Straight snake)*
- Was it easier to measure with 1 copy of a unit or multiple copies of a unit? *(1 copy)*
- Does the measurement stay the same when the snakes change directions? *(Yes)*

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Math

Grade 3

Activity 1 (Adapted with permission from Math Makes Sense 3 Unit 4 Lesson 4, Pearson Education Canada, 2009)

Using a Ruler

Warm Up

Robot

- Training Protocol (see Training Protocol)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Introduce vocabulary words (*ruler, estimate, centimeter, length, How long? = Length, height, How tall? = Height*)
- Model pathways on communication device or communication modalities for responding using the vocabulary.
- As words are introduced, display the words where the student can see them

Main Activity

Introduce

Using a consistent measurement tool

Discussion:

- How could we find out how long this table is? (*We could line up straws, blocks, craft sticks*)
- Which tools are best for this job? (*Straws, because we would need fewer of them*)
- Is it OK for everyone to use a different measurement

Materials

- Scissors
- Objects to measure: E.g., desktop, markers and (thin) geometric shapes
- Strip of tag board (4cm by 40 cm)
- Green and red strips of paper (2cm by 5 cm) mounted on blocks
- Glue
- Robot (see building instructions)
  - ✓ With tagboard Ruler
  - ✓ With a cm Ruler (line up O with joint in gripper)
  - ✓ With pen (placed into the hole within the centre of a block) placed in the gripper
- Signs for: **Ruler, Estimate, Centimeter, Length, How long?, Height** (printed on

tool? (*No, we would have different numbers*)

construction paper)

- Posit it Durable page tabs
- Tape to help secure rulers

Robot

Create a Tag board Ruler

- We will make a ruler so we all have the same non-standard units to measure with.
- *Staff*: Tape the tag board background to the table

Student

- Grasps the strip of paper (Chooses green or red) placed in the gripper by the staff. See Figure 1
- Drives to the appropriate location (far end of the tagboard ruler), then releases the piece of strip paper. See Figure 2. Staff discusses with student the benefit of securing the piece with glue. Staff takes off the strip of paper from the block and secures it to the tag board with glue.

  Staff helps line up with the baseline

  Staff moves the Robot back to the group of strips of paper, if needed.
- Grasps the other colored strip of paper held in the gripper by staff, and drives it to the end of the last strip of paper and releases it.

  Staff: When colored strip is released, ask student if the ends are lined up. If they are not lined up, ask him/her if you can make adjustments so that they're lined up. Reinforce the concepts for measuring objects. Staff secures the strip of paper with glue. See Figure 3.
- Student repeats driving the Robot until the colored strip is at the end of the tagboard strip

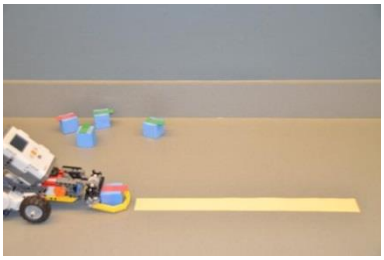

Figure 1

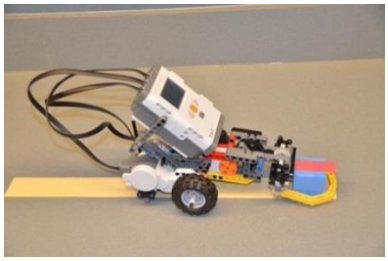

Figure 2

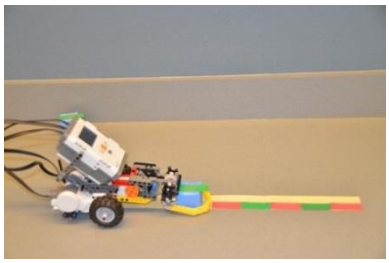

Figure 3

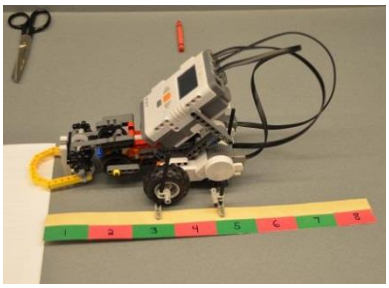

Figure 4

Use the Tagboard Ruler to Measure

Discussion:

- What can we do to our ruler so that we don't have to count the strips? (*Put numbers on the ruler*) See Figure 4

For items shorter than the ruler

Staff

- Attaches the Tagboard ruler on the side of the robot (See Building Instructions, Attaching Rulers to robot) Figure 4

Student

- Drives the robot so front of ruler lines up with object See Figure 5 & 6

Staff

- Assists the student with determining the end of the object and the ruler through the use of Post-It Page Flags or paper guide, if needed. See Figure 7.
- Records results on the Worksheet.

For items longer than the ruler:

- How can you measure an object that is longer than your tag board ruler? (Use a pen to mark the end of the ruler, then drive the robot until the other end of the ruler is at the pen mark)

Student:

- Drives the robot so the back end of the ruler is lined up with the end of the table. Like in Figure 10
- Makes a pen mark by putting the pen down then up again
- Drives the robot forward and lines up the end of the ruler with the pen mark. *Staff* can help with lining up (If needed, makes another pen mark)
- Repeats until the front of the tag board is aligned with

Figure 5

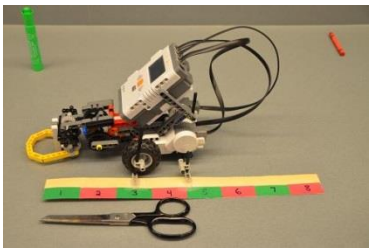

Figure 6

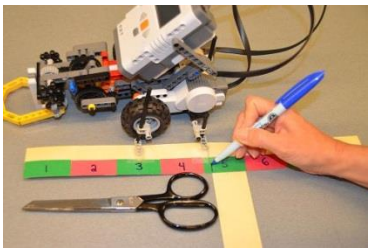

Figure 7

the end of the table. Like in Figure 11.

Staff

- Assists in highlighting the numbers on the ruler using the Post-it colored tabs or a paper guide, if needed
- Helps calculate the measurement (e.g. 8 + 4)
- Records results on the Worksheet

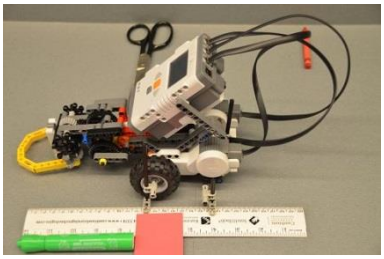

Figure 8

Use of a Centimeter Ruler to Measure

Discussion:

- How is a centimeter like your tagboard ruler? (*Both are marked off in units and are numbered*)
- How is the centimeter ruler different than you tagboard ruler? (*Units are smaller, numbers are at the end of the unit*)

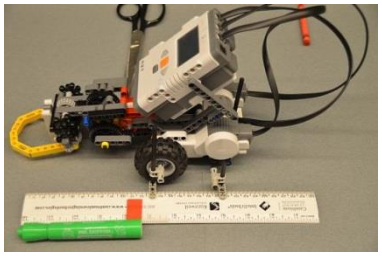

Figure 9

For Items Shorter than the Centimeter Ruler

Staff

- Attaches the ruler on the side of the robot
- Provide opportunities for the student to use the Robot and the centimeter ruler to measure the same objects they measured with their tagboard ruler. See Figures 8, 9.

Figure 10

Robot with Pen and Centimeter Ruler

For Items Longer than the Centimeter Ruler

Staff

- Attaches the ruler on the side of the robot, and puts the pen in the gripper.
- Provide opportunities for the student to use the Robot and the centimeter ruler to measure the same objects they measured with their tagboard ruler.

Staff

- Assists in highlighting the numbers on the ruler using the Post-it colored tabs or a paper guide, if needed. See

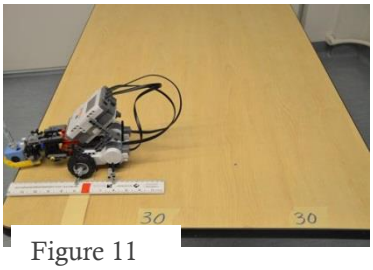

Figure 11

Figure 11.

-
- Helps calculate the measurement (e.g. 30 cm + 30 cm + 12 cm). See Figure 11

- Records results on the Worksheet

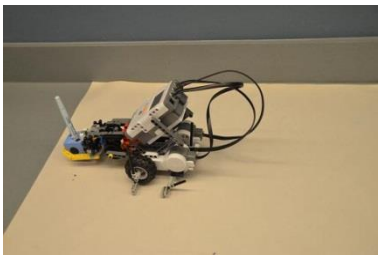

Figure 12

Additional practice: Draw lines on paper and then measure them (e.g., 10 cm long)

Staff:

- Places paper on the table on which the student can draw and measure lines. See Figure 12

Student:

- Drives robot backwards so he/she can see the line as he/she draws it. See Figure 13

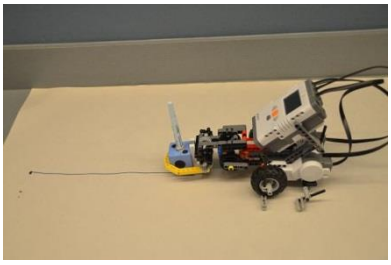

Figure 13

- Measures it to see how close they were to the intended length. See Figure 14

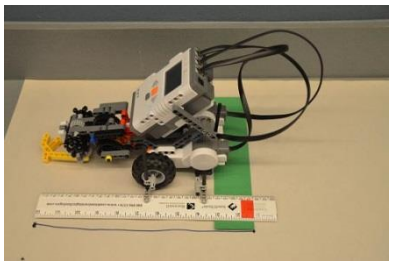

Figure 14

Closing

Reflect

- Why is it important to use centimeters? (*Standard unit and everyone would get the same answer*)

- Where do we start our measuring on the ruler? At the end of the ruler or at 0 (*At the 0 mark on the ruler*)

Additional Activities

Students may benefit from additional experiences with measuring height

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Estimating and Measuring with Centimetres

Math

Grade 3

Activity 2 (Adapted with permission from Math Makes Sense 3 Unit 4 Lesson 5, Pearson Education Canada, 2009)

Warm Up

Robot

- Training Protocol (see Training Protocols)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions)

- Introduce vocabulary words (*ruler, measuring tape, height, length, width, centimetre, referent*)
- Model pathways on communication device or communication modalities
- As words are introduced, display the words where the student can see them

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions throughout the activity)

Introduce

Using a consistent measurement tool

Discussion

Ask student(s) to estimate the length of a pencil

Materials

- Classroom objects (paper clips, scissors, a shoe, marker, pen, poster)
- Robot (see building instructions for how to attach these items)
  - ✓ Centimeter ruler (30 centimeters
  - ✓ Measuring tape held at back of robot
- Signs for: **Ruler, measuring tape, estimate, centimetres, width height, length, longer, shorter, referent** (printed on construction paper)
- Post-it Durable page flags
- Masking tape

- Demonstrate lining up the ruler with the 0 at the start of the pencil

- Model and talk aloud the process of determining between which two numbers on the ruler the pencil ends (ex. length should not be an exact number, ex. 12.3 cm so say it's between 12 and 13 centimetres)

- Talk through to determining that the pencil is closer to the 12 centimetres and reporting that the **pencil is a little more than 12 centimetres**.

- Using a chart, fill in the information about the pencil, including the estimation, and measurement

- How is a measuring tape like your ruler? *(Marked off in centimeters, can be used to measure longer objects)*

Robot

Measuring objects using a ruler
Staff

- Places an assortment of objects on the table (Stapler, pen, large paint brush, pencil, adult shoe, etc) See Figure 1

- As the numbers on a centimeter are small, highlighting the desired number on the ruler with Post-it Page flag or paper guide may be needed to assist with determining the measurement. See Figure 2

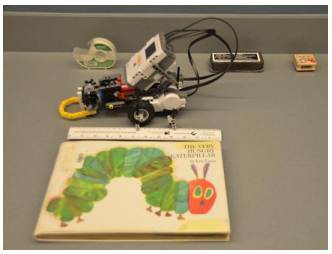

Figure 1

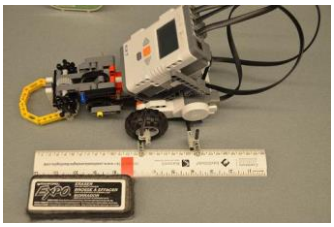

Figure 2

Student

- Estimates the length of an object
  Staff Records object name and estimation on chart

- Drives the robot alongside an the object stopping when the ruler's 0 is aligned at one end of the object

  Staff If the student tries but is not able to drive the robot to align precisely at one end of the object, ask them if you can make adjustments so that the 0 on the ruler is aligned to the end of the object. Reinforce the concepts for measuring from the 0 on the ruler, not at the end of the ruler.

- Determines which two measurement numbers on the ruler the object is between. (e.g. between 16 and 17)

- Determines which measurement the object is closest to.

- Creates a statement to state the result. (e.g. The shoe is 25 cm long)
  Staff Records results on the worksheet

- Repeat and measure the width of the object

Measuring objects using a measuring tape

Staff:

- Chooses an assortment of longer objects (Window, bench, poster, backpack)

- Attaches the measuring tape to the back of the robot See Figure 3

  Note: When choosing objects to measure with the measuring tape, ensure that the student is able to adequately see both the object and control the robot

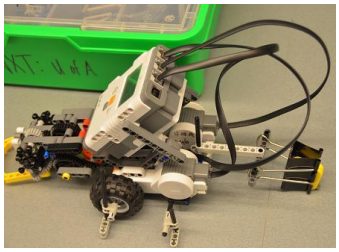

Figure 3

Student:

- Estimates the length of an object
  Staff Records object name and estimation on chart

- Drives the robot alongside an object with the end of the measuring tape aligned to one end of the object

  Note: If the student is not able to drive the robot to align the measuring tape precisely at one end of the object, ask them if you can make adjustments so that the 0 on the measuring tape starts at the end of the object. Reinforce the concepts for measuring from the 0 on the measuring tape, if needed.

  Staff Tapes the start of the measuring tape along the baseline of the object. See Figure 4.

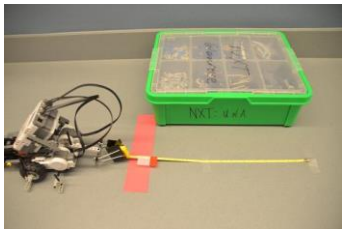

Figure 4

- Drives the robot to the other end of the object

  Staff Assists in highlighting the numbers on the measuring tape using the Post-it colored tabs, if needed As the numbers on a measuring tape are small and may not be at a level where the student is able to read them, highlighting the desired number with Post-it colored tape or marking the end position of the object on the measuring tape, may be needed to assist with measuring. See Figure 4

- Determines which two measurement numbers the object is between (e.g. 15 and 16)
- Determines which measurement the object is closest to
- Creates a statement to demonstrate the result

Staff Records results on the worksheet

Closing

Connect

- How could we use the measurements that we did to help us estimate the measurement of other objects? (*Use an object's measurement to help us estimate another object's measurement.* E.g. the marker is 13 centimetres and my hand is a little smaller than the marker.)

Additional Activities

Students may benefit from additional experiences with measuring objects and comparing objects to specified measurements

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Alberta Health Services

UNIVERSITY OF ALBERTA

Estimating and Measuring in Metres

Math

Grade 3

Activity 3 (Adapted with permission from Math Makes Sense 3 Unit 4 Lesson 6, Pearson Education Canada, 2009)

Warm Up

Robot

- Training Protocol (see Training Protocol)

Vocabulary

(see Communication Modalities for different communication modalities that students may use to respond, comment, or ask questions)

- Introduce vocabulary words (How tall = Height, How long? = Length)
- Model pathways on their communication device communication modalities.
- As words are introduced, display the words where the student can see them.

Main Activity

(see Communication Modalities for different communication modalities that students may use to respond, comment or ask questions throughout the activity)

Introduce

Using different measuring tools

Discussion

- What are some things you might measure with a metre stick? (longer objects: chalkboards or hallways)
- What are some things that are:

Materials

- Base Ten Rods on blocks
- Robot (see building instructions for how to attach)
  - ✓ With a centimetre ruler (30 centimetres)
  - ✓ With a metre stick attached (
  - ✓ With pen (placed into the hole within the centre of a block) in gripper
- Signs for: **ruler, metre stick, estimate, centimetre, metre , How long?, width, height, length, longer, shorter, referent** (printed on construction paper)

- Shorter than a metre? (*my arm, the top of my desk*)
- Taller than a metre? (*Tree, school, house*)

ROBOT

Comparing a metre to centimeters

Staff

- Sets up the table with a Base Ten Rod
- Attaches the metre stick to the holders on the side of the Robot. See Figure 1

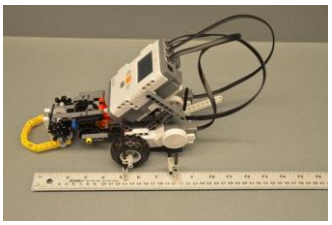


Figure 1

Student

- With the metre stick attached to the Robot, drives the Robot alongside a Base Ten Rod. See Figure 2

  **If the student is not able to align the Robot precisely at one end of the object, ask them if you can make adjustments so that the 0 on the ruler is at one end of the object. Reinforce the concepts for measuring from the 0 on the ruler, not at the end of the ruler

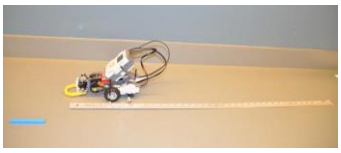


Figure 2

- Determines the measurement of the Base Ten Rod. (10 centimetres) See Figure 3

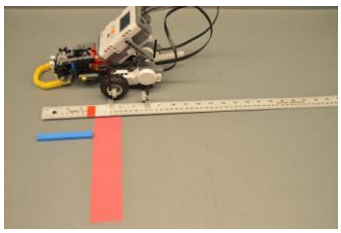


Figure 3

- Estimates how many Base Ten Rods are needed to measure the metre stick

How many centimetres in a metre?

Student

Figure 4

- Grasps the Base Ten Rod placed in the gripper by the staff, and drives to one end of the metre stick, and releases it. See Figure 4 & 5

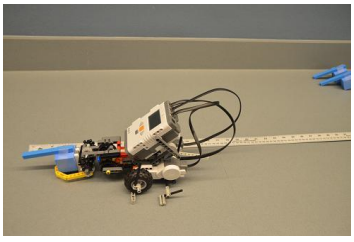


Figure 5

Staff

- Secures the Base Ten Rod with sticky tack

- Moves the Robot back to the group of Base Ten Rods, if needed

- Grasps another Base Ten Rod held in the gripper by staff, and drives it to the end of the last Base Ten Rod and releases it.

  Staff secures it with sticky tack. When Base Ten Rod is released, ask student if the ends are touching. If they are not touching, ask them if you can make adjustments so that they're touching. Reinforce the concepts for measuring objects.

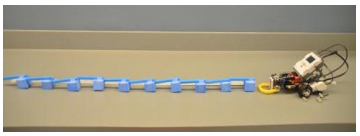


Figure 6

- Repeats driving the Robot with the Base Ten Rod until the Base Ten Rod is at the end of the metre stick
  See Figure 6

- Counts by 10s as staff touches each Base Ten Rod placed alongside the metre stick

- Creates a statement to demonstrate the result

  Staff Records results on the worksheet

Staff

- Attaches the metre stick or cm ruler to the holder on the side of the Robot, as directed by the student

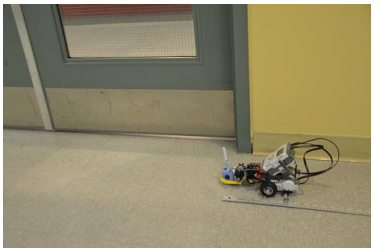
- Creates a list of classroom objects to be measured.

Student

- Selects an object to measure.

- Drives the Robot to the measuring tool they feel best suits the measurement of the selected item.

- Estimates the measurement of the selected object using the identified tool.



- For objects longer than 1 metre or 30 centimetres, grasps the pen held in the gripper by staff

- Drives the Robot to the start of the object

  Staff If the student is not able to align the Robot precisely at one end of the object, ask them if you can make

Figure 7

adjustments so that the 0 on the ruler/metre stick is at the end of the object (Baseline). Reinforce the concepts for measuring from the 0, not at the end of the ruler or metre stick.

- Makes a pen mark by putting the pen down then up again. See Figure 7
- Drives the Robot so that the end of the ruler/metre stick is at the previous pen mark. *Staff* may have to accentuate where the mark is with paper or something.
- Makes a pen mark by putting the pen down then up again (if not at the end of the object yet)
- Drives the Robot so that the "0" end of the ruler/metre stick is at the end of the object. See Figure 8

  Staff If the student is not able to align the Robot precisely at one end of the object, ask them if you can make adjustments so that the 0 on the ruler/metre stick is at the end of the object (Baseline). Reinforce the concepts for measuring from the 0, not at the end of the ruler or metre stick
- Determines the measurement by adding the 1 m to the measurement from the end of the object to the last pen mark (1 m + 37 cm.) See Figure 9

  **As the numbers on a ruler or metre stick are small, and/or if the object being measured with the Robot is not within the student's line of vision, highlighting the number (with Post-it Page Flag) may be needed to assist with measuring.
- Records estimations on the chart.

Figure 8

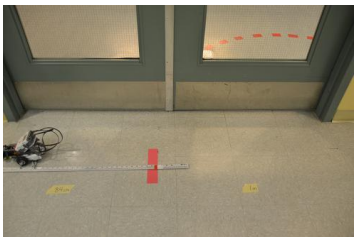


Figure 9

Additional Activities

Students may benefit from additional experiences with measuring objects and comparing objects to specified measurements

Closing

Connect

Model pathways on communication device/communication modalities.