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MATHEMATICS AND LEGOS: MATH-TEACHING ACTIVITIES

Grades 1-2

Odd Blocks 1

Grade Level: 1-2
Strand(s): Number Sense and Operations
Specific Concept(s): 2.N.5 Identify odd and even numbers and determine whether a set of objects has an odd or even number of elements
Materials Needed: Brick separators, Two cups, Two sets of bricks and plates: Set1: Ten 2x4 bricks. Set2: Thirty 2x4 plates and ten 2x4 bricks. Each set can fit in a cup.
Description: Build towers with different amounts of pieces but equivalent lengths in order to visualize basic multiplication facts. Use the definition of odd and even numbers to build stacks of even and odd amounts of pieces but equivalent lengths.
Procedure/Questions:

1. Take one brick from set1.
2. Stack together plates from set2 so that they are as tall as the one brick
    a. **Q:** How many plates from set2 can you stack together so that they are as tall as one brick?
3. Stack ten bricks from set1 to create a tower.
4. Build a stack of plates from set2 as tall as the stack of ten bricks.
    a. **Q:** After counting the number of pieces, how many plates tall is your set2 tower?
    b. **Q:** Can you think of a way that you could have found the number of plates before building the tower and counting?
5. Look at the tower of bricks from set1.
    a. **Q:** Can you break the tower into two towers that are each the same height?
    b. **Q:** Based on your answer, is 10 an even or odd number?
6. Neatly take apart the pieces in each tower using a brick separator and place the correct bricks back in set1 and the plates back in set2.
7. Stack seven bricks from set1 to create a tower.
    a. **Q:** Can you break the tower into two towers that are each the same height?
    b. **Q:** Based on your answer, is 7 an even or odd number?
8. Play around with building towers from each set with even or odd amounts of pieces.
    a. **Q:** What do you now know about odd and even numbers?

Building Fractions 1

Grade Level: 1-2
Strand(s): Number Sense and Operations
Specific Concept(s): 2.N.3 Identify and represent common fractions (1/2, 1/4) as parts of wholes; 2.N.7 Demonstrate an understanding of various meanings of addition and subtraction.

Materials Needed: Two 8x16 studded plates (which will be denoted plate1 and plate2), 24 yellow 2x2 bricks, 24 black 2x2 bricks, 128 yellow 1x1 bricks, 128 black 1x1 bricks, Brick separators
Description: Understand the basic fractions ½ and ¼ by covering the plate with different amounts of yellow and black bricks, ultimately in fun designs.
Procedure/Questions:

1. **Q:** How many studs are on the first plate, plate1?
2. **Q:** Without placing bricks on the plate, how many 1x1 bricks will fit on the plate?
3. Place 2x2 yellow bricks on plate1 so that the plate is covered and no bricks hang off the edge of the plate.
    a. **Q:** How many 2x2 bricks fit on the plate?
4. Remove half of the bricks using a brick separator.
5. Fill in the empty spaces with black 1x1 bricks.
    a. **Q:** How many yellow bricks are there? How many black bricks are there?
6. **Fun challenge 1:** Using 2x2 bricks, 1x1 bricks, or both, create a new design (not just with two rectangles) on plate1 that is ½ yellow and ½ black.
7. **Fun challenge 2:** Using 2x2 bricks, 1x1 bricks, or both, create a new design (not just with two rectangles) on plate2 that is ¼ black and ¾ yellow.
    a. Count the numbers of bricks of each color to make sure your designs follow the given fraction restrictions.

Grades 3-4

Odd Blocks 2

Grade Level: 3-4
Strand(s): Number Sense and Operations
Specific Concept(s): 4.N.7 Recognize classes (in particular, odds, evens; factors or multiples of a given number; and squares) to which a number may belong, and identify the numbers in those classes; 4.N.8 Use various meanings and models of multiplication
Materials: Brick separators, Two cups, Two sets of bricks and plates: Set1: Ten 2x4 bricks. Set2: Thirty 2x4 plates and ten 2x4 bricks. Each set can fit in a cup.
Description: Use multiplication and addition facts to build towers out of different amounts of pieces that have equivalent lengths. Use the definition of odd and even numbers to build stacks of even and odd amounts of pieces and equivalent lengths.
Procedure/Questions:

1. Take one brick from set1.
2. Stack together plates from set2 so that they are as tall as the one brick.
    a. **Q:** How many plates from set2 can you stack together so that they are as tall as one brick? **Note:** This number will be useful throughout the activity!
3. Stack ten bricks from set1 to create a tower.
    a. **Q:** Without building, how many plates from set2 would you have to stack in order to create a tower as tall as the ten brick tower? **Hint:** Use multiplication.
4. Build a stack of plates from set2 as tall as you think you should and check that it is the same height as the stack of bricks.
    a. **Q:** If it is not the same, where did you miscalculate? Were you close?
5. Look at the tower of bricks from set1.

    a. **Q:** Can you break the tower into two towers that are each the same height?
    b. **Q:** Based on your answer, is 10 an even or odd number?
6. Neatly take apart the pieces from each tower using a brick separator without mixing up the pieces and place the bricks back in set1 and the plates back in set2.
7. Stack seven bricks from set1 to create a tower.
    a. **Q:** Can you break the tower into two towers that are each the same height?
    b. **Q:** Based on your answer, is 7 an even or odd number?
8. Neatly take apart the pieces from this tower using a brick separator and place the bricks back in set1.
9. Pick an even number between 1 and 10 and build a tower that is that many bricks (from set1) high.
    a. **Q:** Can you use an odd number of plates and bricks from set2 to build a tower that is the same height as the tower from set1? Why or why not? Try it out. **Note:** The tower can't have pieces side by side. The pieces must be one on top of the other.
10. Neatly take apart the pieces from these two towers using a brick separator and place the bricks back in set1 and the plates back in set2.
11. Pick an odd number between 1 and 10 and build a tower that is that many bricks (from set1) high.
    a. **Q:** Can you use an even number of plates and bricks from set2 to build a tower that is the same height as the tower from set1? Why or why not? Try it out. **Note:** Again, the tower can't have pieces side by side. The pieces must be one on top of the other.
12. Play around with building towers from each set with even or odd numbers of pieces and come up with rules for adding odd and even numbers. Example: Odd + odd = _____.

Geometric Fishing

Grade Level: 3-4
Strand(s): Geometry; Measurement
Specific Concept(s): 4.G.2 Describe, model, draw, compare, and classify two- and three-dimensional shapes; 4.M.4 Estimate and find area and perimeter of a rectangle, triangle, or irregular shape using diagrams, models, and grids or by measuring
Materials Needed: LEGO Beams, LEGO Blocks, Connector pegs, Two RCX Motors, One long RCX wire, One magnet, Construction paper, Paperclips, Sting, Measuring tape, Tape, Pencils, White paper, One large gear, Popsicle sticks
Description: Use a LEGO fishing rod with a magnet to fish for paperclip fish by using different shaped reels. Calculate how many times you will have to turn the reel depending on what shape you are using. Then use this information to predict which shapes correspond to certain amounts of reel-turns.
Procedure/Questions:

Setup:

1. Build a sturdy fishing rod using beams, connector pegs, bricks, two RCX motors, and a long RCX wire.
2. Divide the students into groups of two so that they can work in pairs. Each pair can make one fishing rod together.

3. Create a square reel, a circular reel, a triangular reel, and a pentagonal reel using pieces from the RCX kit for the simpler shapes and construction paper for the more complicated shapes:
    a. Use one of the large tires as the circular reel.
    b. Create the square reel by stacking two 2x6 bricks on top of each other, then six 1x2 beams on top of that (so that there are two rows of three beams across, with the center beams having axle holes so that an axle can go through the center of the square), and finally two more 2x6 bricks below the beams.
    c. Create the triangular and pentagonal reels by using a beam with an axle hole, popsicle sticks, tape, and paper (if needed).
4. Place the string across the top motor and wind it around the reel so that it hangs off the top of the rod, like on a real fishing rod.
5. Tape the magnet to the end of the string.
6. Cut out small fish shapes from the construction paper.
7. Tape the fish shapes to the paper clips (one fish per paper clip) so that the magnet can pick up the fish.
8. Create a chart for each pair where they can record their data. Example:

Geometric Fishing Data			
Shape of Reel	**Circumference or Perimeter of Reel**	**Predicted Number of Rotations to the Fish**	**Correct? Yes or No.**
Square			
Circle			
Triangle			
Pentagon			

Procedure:

1. Take the square reel and measure and record the length of one side of the square.
    a. **Q:** What is the perimeter of the square?
    b. **Q:** What length must a piece of string be in order to fit around the square exactly once?
2. Place the square reel on your rod and wrap the string around it.
3. Hold your fishing rod at your belly button and have your partner measure the distance from the top of the rod to the fish on the floor using the measuring tape. **Note:** Make sure to be exact about how you hold the fishing rod each time.
    a. **Q:** If the magnet starts at the very end of the rod, how many times must you rotate the reel to reach the fish in the pond (on the floor)?
4. Take the circular reel and measure the diameter of the circle through the center.
    a. **Q:** What is the circumference of the circle?
    b. **Q:** What length must a piece of string be in order to fit around the circle exactly once?
5. Place the circular reel on your rod and wrap the string around it.
6. Have your partner stretch out the measuring tape at your previously measured distance and hold your fishing rod so that the top of it is exactly that distance away from the floor.

    a. **Q:** If the magnet starts at the very end of the rod, how many times must you rotate the reel to reach the fish in the pond (on the floor)?
7. Repeat this process of finding the circumference or perimeter of a reel and then predicting and testing the amount of times you need to rotate the reel in order to get to the fish using the triangular reel.
8. Repeat the process again using the pentagonal reel.

Building Fractions 2

Grade Level: 3-4
Strand(s): Number Sense and Operations; Measurement
Specific Concept(s): 4.N.4 Find equivalent fractions; 4.N.8 Use various meanings and models of multiplication and division of whole numbers; 4.M.4 Estimate and find area and perimeter of a rectangle
Materials Needed: Two 8x16 studded plates (which will be denoted plate1 and plate2), 24 yellow 2x2 bricks, 24 black 2x2 bricks, 128 yellow 1x1 bricks, 128 black 1x1 bricks, Brick separators
Description: Understand the basic fractions ½ and ¼ by covering a LEGO plate with various amounts of yellow and black bricks. Relate equivalent fractions, ultimately using fun designs of bricks.
Procedure/Questions:

1. **Q:** How many studs are on the longer edge of plate1?
2. **Q:** How many studs are on the shorter edge of plate1?
3. Calculate the perimeter of the plate by adding together the number of studs on the two larger edges of plate1 and the two shorter edges of the plate, without accounting for each stud more than once.
    a. **Q:** What is the perimeter of the plate?
4. Count the total number of studs across all four edges of the plate.
    a. **Q:** Does this number match the number you calculated for the perimeter of the plate?
5. Calculate the area of the plate by multiplying the number of studs on the longer edge of the plate by the number of studs on the shorter edge of the plate.
    a. **Q:** What is the area of the plate?
6. Count the total number of studs on the plate.
    a. **Q:** Does this number match the number you calculated for the area of the plate?
    b. **Q:** Using division, how many 2x2 bricks will fit on the plate?
7. Place 2x2 yellow bricks on plate1 so that the plate is covered and no bricks hang off the edge of the plate.
8. Count the number of bricks that fit plate1.
    a. **Q:** Does this match your previous answer?
9. Remove some of the bricks from plate1 using a brick separator so that plate1 is half covered by a rectangular shape of yellow bricks, saving the bricks that you remove.
    a. **Q:** How many bricks are left on plate1?
10. Place the bricks that you removed from plate1 on plate2 in a different rectangular shape.
    a. **Q:** Do the two yellow shapes on plate1 and plate2 have the same area? How can you tell?
    b. **Q:** What fraction of plate2 is now covered in yellow?

11. Cover the remaining empty spaces on plate1 with black 2x2 blocks so that the plate is half yellow and half black.
    a. **Q:** Can you think of two equivalent fractions? **Hint:** ½ and number of yellow/ total number of bricks… or number of black/ total number of bricks.
12. Cover the yellow 2x2 bricks with yellow 1x1 bricks.
    a. **Q:** How many 1x1 yellow bricks does it take to cover the yellow 2x2 bricks
13. Cover the black 2x2 bricks with black 1x1 bricks.
    a. **Q:** Can you think of another fraction, which is equivalent to the two equivalent fractions you already found? **Hint:** Number of yellow 1x1 bricks/total number of 1x1 bricks.
14. On plate2, remove half of the yellow bricks using a brick separator.
15. Fill in the empty spaces on plate2 with black 2x2 bricks.
    a. **Q:** What fraction of the plate is black?
    b. **Q:** What fraction of the plate is yellow?
16. Clear off both plates using a brick separator.
17. **Fun challenge 1:** using 2x2 blocks, 1x1 blocks, or both, create a new design (not just with two rectangles) on plate1 that is ½ yellow and ½ black.
18. **Fun challenge 2:** Using 2x2 blocks, 1x1 blocks, or both, create a new design (not just with two rectangles) on plate2 that is ¼ black and ¾ yellow.
    a. Count the numbers of blocks of each color to make sure your designs follow the given fraction restrictions.

Equivalent Fraction Towers

Grade Level: 3-4
Strand(s): Number Sense and Operations
Specific Concept(s): 4.N.3 Demonstrate an understanding of fractions as parts of unit wholes, as parts of a collection, and as locations on the number line; 4.N.5 Identify and generate equivalent forms of common fractions less than one whole
Materials Needed: 28 LEGO Bricks: 14 of the same color, 4 of another color, 4 of another color, 4 of another color, and 2 of another color.
Description: Use LEGO bricks to model various equivalent fractions.
Procedure/Questions:

Round 1: Fourths, Eighths, Halves, and Wholes

1. Stack 8 bricks of the same color on top of one another to create a tower. This is tower1.
    a. **Q:** How many towers do you have?
    b. **Q:** If each brick is 1/8 of a tower, how many eighths make up the tower?
    c. **Q:** What are two equivalent numbers that you have already modeled?
    d. **Q:** How many eighths make up half of the tower? **Hint:** You know how to divide 8 by 2.
    e. **Q:** Which is larger, 5/8 of the tower or ½ of the tower?
2. Stack 8 more bricks on top of one another to create another tower, but this time use 4 different colors of bricks so that the bricks are stacked in pairs of colors. For example, one possible arrangement could go *red, red, yellow, yellow, blue, blue, brown, brown.* This is tower2.
    a. **Q:** If each color is ¼ of the tower, how many fourths make up the tower?
    b. **Q**: What is another fraction that is equivalent to 1 and 8/8?

c. **Q**: How many fourths make up half of the tower? **Hint:** You know how to divide 4 by 2.
d. **Q**: What are two fractions that are equivalent to ½?

3. Place tower2 next to tower1.
    a. **Q**: Can you arrange the following numbers in order, as they would appear on a number line? 5/8, ½, 3/4, 1.

Round 2: **Thirds and Sixths**

1. Stack 6 bricks of the same color on top of one another to create a tower. This is tower3.
    a. **Q:** If each brick is 1/6 of a tower, how many sixths make up the tower?
    b. **Q:** What are two more equivalent numbers that you have already modeled?
    c. **Q:** How many sixths make up half of the tower? **Hint:** You know how to divide 6 by 2.
    d. **Q:** Which is larger, 4/6 of the tower or ½ of the tower?
2. Stack 6 more bricks on top of one another to create another tower, but this time use 3 different colors of bricks so that the bricks are stacked in pairs of colors. For example, one possible arrangement could go *red, red, yellow, yellow, blue, blue.* This is tower4.
    a. **Q:** If each color is 1/3 of the tower, how many thirds make up the tower?
    b. **Q**: What is another fraction that is equivalent to 1, 8/8, and 4/4?
    c. **Q**: Which is larger, ½ or 2/3?
    d. **Q**: What is 2/3 of tower4 equivalent to on tower3?
3. Place tower3 next to tower4.
    a. **Q**: Can you arrange the following numbers in order, as they appear on the number line? 4/6, ½, 2/3, 1.
4. **Q:** Can you arrange the following numbers in order, as they appear on the number line? 5/8, ½, ¾, 4/6, 2/3, 1.
    a. **Q:** Why can't we place all four towers next to each other to help us answer this question? Why would this not be accurate?

Estimating Fractions

Grade Level: 3-4
Strand(s): Number Sense and Operations
Specific Concept(s): 4.N.3 Demonstrate an understanding of fractions as parts of unit wholes, as parts of a collection, and as locations on the number line; 4.N.5 Identify and generate equivalent forms of common fractions less than one whole
Materials Needed: LEGO bricks
Description: Use LEGO brick towers to model and compare the values of fractions.
Procedure/Questions:

Setup:

1. Type up or write out a chart that looks like this:

Fraction	Is closer to 0	Is closer to 1
6/10		
3/10		
5/10		
5/12		

8/12		
6/12		
3/7		
5/7		
4/7		
7/11		
2/11		
9/11		

Round 1: 10ths

1. Stack 10 bricks into a tower. With the tower equal to one whole, each brick is equal to 1/10.
2. **Q:** Without counting bricks, is 6/10 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 10 bricks, and check off the correct box next to 6/10 on your chart.
3. **Q:** Without counting bricks, is 3/10 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 10 bricks, and check off the correct box next to 3/10 on your chart.
4. **Q:** Without counting bricks, is 5/10 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 10 bricks, and check off the correct box next to 5/10 on your chart.

Round 2: 12ths

1. Stack 12 bricks into a tower. With the tower equal to one whole, each brick is equal to 1/12
2. **Q:** Without counting bricks, is 5/12 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 12 bricks, and check off the correct box next to 5/12 on your chart.
3. **Q:** Without counting bricks, is 8/12 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 12 bricks, and check off the correct box next to 8/12 on your chart.
4. **Q:** Without counting bricks, is 6/12 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 12 bricks, and check off the correct box next to 6/12 on your chart.

Round 3: 7ths

5. Stack 7 bricks into a tower. With the tower equal to one whole, each brick is equal to 1/7
6. **Q:** Without counting bricks, is 3/7 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 7 bricks, and check off the correct box next to 3/7 on your chart.
7. **Q:** Without counting bricks, is 5/7 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 7 bricks, and check off the correct box next to 5/7 on your chart.
8. **Q:** Without counting bricks, is 4/7 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 7 bricks, and check off the correct box next to 4/7 on your chart.

Round 4: 11ths

9. Stack 11 bricks into a tower. With the tower equal to one whole, each brick is equal to 1/11
10. **Q:** Without counting bricks, is 7/11 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 11 bricks, and check off the correct box next to 7/11 on your chart.
11. **Q:** Without counting bricks, is 2/11 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 11 bricks, and check off the correct box next to 2/11 on your chart.
12. **Q:** Without counting bricks, is 9/11 closer to 0 or 1?
    a. Check if your answer is correct by looking at the tower of 11 bricks, and check off the correct box next to 9/11 on your chart.

Probability (LEGO) People

Grade Level: 3-4
Strand(s): Data Analysis, Statistics, and Probability; Number Sense and Operations
Specific Concept(s): 4.D.4 Represent the possible outcomes for a simple probability situation; 4.D.5 List and count the number of possible combinations of objects from three sets; 4.N.5 Identify and generate equivalent forms of common fractions less than one whole.
Materials Needed: LEGO Bricks, LEGO people
Description: Use a set of LEGO bricks and three sets of LEGO people parts to model the possible options in choosing an item out of a set.
Procedure/Questions:

Setup:

1. For each set of partners, create a set of LEGO bricks with five red bricks, ten black bricks, and fifteen yellow bricks. These colors can be changed as long as there are three different colors with those same amounts.
2. Give each set of partners three different LEGO people. If you do not have three different LEGO people, do something to the LEGO people so that each one is different. **Example:** you could put stickers on the bodies, different hats and hairdos on the heads, and different bricks or pieces onto the legs and feet.
3. Break apart the different parts of the LEGO people so that each group has three heads, three bodies, and three sets of legs.

Procedure:

Round 1: Probability and Bricks

1. Mix up the bricks in the set of LEGO bricks.
2. **Q:** How many total bricks are there in the set? (**A:** 30)
3. **Q:** How many red bricks are there in the set (**A:** 5)
4. **Q:** How many yellow bricks are there in the set? (**A:** 15)
5. **Q:** How many black bricks are there in the set? (**A:** 10)
6. **Q:** How can you figure out the probability of reaching into the set and choosing a specific color? (**A:** Color #/Total #)
    a. **Q:** What is the probability of choosing a red brick? Can you list two different ways of saying this fraction? (**A**: 5/30 or 1/6)
    b. **Q:** What is the probability of choosing a yellow brick? Can you list two different ways of saying this fraction? (**A:** 15/30 or 1/2)

c. **Q:** What is the probability of choosing a black brick? Can you list two different ways of saying this fraction? (**A:** 10/30 or 1/3)

Round 2: Combinations and LEGO People

1. Using your set of heads, your set of bodies, and your set of legs, create full people by connecting the pieces.
2. Each time you create a new person, write down that combination of parts.
3. **Q:** How many total different people can you create with the sets?
4. **Q:** What do you notice about this number? Can you think of another way you could have come up with this number without writing down every combination of heads, bodies, and legs?

Round 3: Combinations and LEGO People: Extension

1. **Q:** Imagine if you had four different options of heads, bodies, and legs. Can you imagine the different combinations of people you could make? Write these down.
2. **Q:** Could you figure out how many combinations of people you could make with four options of heads, bodies, and legs without writing down all of the combinations?
3. **Q:** What if you had four options of heads, three options of bodies, and five options of legs? How many different options of people would you have?

Grades 5-6

Build-by-Number 1

Grade Level: 5-6, Algebra 1
Strand(s): Geometry
Specific Concept(s): 6.G.3 Identify relationships among points, lines, and planes; 6.G.4 Graph points and identify coordinates of points on the Cartesian coordinate plane (all four quadrants)
Materials Needed: Two 32x32 LEGO plates per student, 1x1 LEGO bricks, Lined paper, Pencils, Tape
Description: Create a unique design on a labeled LEGO coordinate plane plate using LEGO bricks and write down the location of each colored block as ordered pairs as you build. Have your partner recreate your design on a blank plate using your directions.
Procedure/Questions:

Setup:

1. Mark the y-axis of the coordinate plane by placing a very thin line of tape down the center of the plate, splitting the plate in half vertically.
2. Mark the x-axis of the coordinate plane by placing a very thin line of across the center of the plate, splitting the plate in half horizontally.
3. Explain to the class that each stud on the plate is equivalent to one unit on the coordinate plane.
4. Divide the class into pairs of students.

Procedure:

1. On your piece of paper, draw a two-columned chart. Label the left column "Brick Color" and the right column "Ordered Pair." Example of the beginning of a chart:

Brick Color	Ordered Pair
Yellow	(1,1)
Blue	(-1,1)

Blue	(-2, 2)

2. On the back of the piece of paper, draw the design that you would like to create in a square frame. Don't let your partner see your design!
3. Draw vertical and horizontal lines across the design so that you can envision how to draw the design with square 1x1 bricks.
    a. **Q:** If you are building on a 32x32 studded plate, how many total 1x1 bricks will you need?
    b. **Q:** If the plate is divided into four equivalent quadrants, how many bricks will there be in each individual quadrant of the plate?
4. Using your plan, place the bricks onto the plate in order to create your design. As you place each brick, record the location of the colored brick on your chart.
    a. **Note:** Be sure to include the appropriate negative signs for ordered pairs in quadrants 2, 3, and 4.
    b. Make sure your bricks cover the entire plate.
    c. Again, don't show your LEGO design to your partner!
5. When you are finished with your secret LEGO design, give your partner your chart and have him or her re-create your design on a blank LEGO coordinate plane without looking at the back of your sheet.
6. Take your partner's chart and re-create his or her design without looking at the back of the sheet.
7. Reveal your four plates and see if your designs are the same!
    a. If your designs are not the same, look over your charts and plates together to find your mistake(s).

Build-by-Number 2

Grade Level: 5-6, Algebra 1
Strand(s): Geometry
Specific Concept(s): 6.G.3 Identify relationships among points, lines, and planes; 6.G.4 Graph points and identify coordinates of points on the Cartesian coordinate plane (all four quadrants)
Materials Needed: Two 32x32 LEGO plates per student, 2x2 LEGO bricks, Lined Paper, Pencils, Tape
Description: Create a unique design on a labeled LEGO coordinate plane plate using LEGO bricks and write down the location of each colored block as ordered pairs as you build. Have your partner recreate your design on a blank plate using your directions.
Procedure/Questions:

Setup:

1. Mark the y-axis of the coordinate plane by placing a very thin line of tape down the center of the plate, splitting the plate in half vertically.
2. Mark the x-axis of the coordinate plane by placing a very thin line of across the center of the plate, splitting the plate in half horizontally.
3. Explain to the class that each cluster of four studs on the plate is equivalent to one unit on the coordinate plane, so that one 2x2 brick is equal to one unit.
4. Divide the class or group into pairs of students.

Procedure:

1. On your piece of paper, draw a two-columned chart. Label the left column "Brick Color" and the right column "Ordered Pair." Example of the beginning of a chart:

Brick Color	Ordered Pair
Yellow	(1,1)
Blue	(-1,1)
Blue	(-2, 2)

2. On the back of the piece of paper, draw the design that you would like to create in a square frame. Don't let your partner see your design!
3. Draw vertical and horizontal lines across the design so that you can envision how to draw the design with square 2x2 bricks.
    a. **Q:** If you are building on a 32x32 studded plate, how many total 2x2 bricks will you need?
    b. **Q:** If the plate is divided into four equivalent quadrants, how many bricks will be in each individual quadrant of the plate?
4. Using your plan, place the bricks onto the plate in order to create your design. As you place each brick, record the location of the brick on your chart.
    a. **Note:** Consider each brick to be one unit. Thus, think of the plate as a 16x16 plate instead of a 32x32 plate. Label your bricks accordingly. For example, a brick in the top right corner would be labeled (8, 8) instead of (16, 16).
    b. Be sure to include the appropriate negative signs for ordered pairs in quadrants 2, 3, and 4.
    c. Make sure your bricks cover the entire plate and do not hang off the edge of the plate.
    d. Again, don't show your LEGO design to your partner!
5. When you are finished with your secret LEGO design, give your partner your chart and have them re-create your design on a blank LEGO coordinate plane without looking at the back of your sheet.
6. Take your partner's chart and re-create his or her design without looking at the back of the sheet.
7. Reveal your four plates and see if your designs are the same!
    a. If your designs are not the same, look over your charts and plates together to find your mistake(s).

Me, Myself, and Pi

Grade Level: 5-6
Strand(s): Measurement
Specific Concept(s): 6.M.5 Identify, measure, and describe circles and the relationships of the radius, diameter, circumference, and area
Materials Needed: Four different sizes of LEGO wheels, Rulers, String, Paper, Pencils, Calculator
Description: Measure the circumference and diameter of various sizes of LEGO wheels in order to discover the ratio of the circumference to the diameter.
Procedure/Questions:

1. Create a chart where you can record your data in inches. Example:

Wheel	Circumference (in)	Diameter (in)	C/D
Wheel 1			
Wheel 2			
Wheel 3			
Wheel 4			

2. Create a chart where you can record your data in centimeters. Example:

Wheel	Circumference (cm)	Diameter (cm)	C/D
Wheel 1			
Wheel 2			
Wheel 3			
Wheel 4			

3. Measure the circumference of the first wheel by fitting the string around the wheel and then measuring the length of that string (just the part that fit around the wheel) in inches against the ruler. Record your data.
4. Using the ruler, measure the diameter of the wheel in inches. The diameter of a circle is any straight line that passes through the center of the circle whose end points on are on the circle. Record your data.
5. Using your calculator, calculate the ratio of the circumference of the first wheel to the diameter of the wheel (so, circumference divided by diameter). Round this number to two decimal places. Record your data.
6. Repeat the measuring and recording process in inches for the other three wheels.
    a. **Q:** What do you notice about the numbers in the C/D column on your first chart?
7. Repeat the entire process of measuring the circumferences and diameters of the wheels, but this time in centimeters. Record your data on the second chart.
    a. **Q:** What do you notice about the numbers in the C/D column on your second chart?
8. **Q:** What is the number pi? Why is it important? What could we use it for?
9. **Note:** The exact number pi is actually an irrational number. **Q:** What does this mean?

Building Proportions

Grade Level: 5-6
Strand(s): Measurement; Geometry
Specific Concept(s): 6.M.3 Solve problems involving proportional relationships and units of measurement, e.g., same system unit conversions, and scale models; 6.G.1 Identify polygons based on their properties, including types of interior angles, perpendicular or parallel sides, and congruence of sides; 6.G.2 Identify three-dimensional shapes based on their properties, such as edges and faces; 6.G.8 Determine if two shapes are congruent by measuring sides or a combination of sides and angles, as necessary
Materials Needed: 32x32 plate, 2x2 bricks, Ruler
Description: Build cubes and rectangular prisms that are proportional in size.
Procedure/Questions:

1. Create a chart to record your data. Example:

Shape	Length	Height	Width
Cube 1			
Cube 2			
Cube 3			
Rectangular Prism 1			
Rectangular Prism 2			
Rectangular Prism 3			

2. Build a cube made out of bricks on the plate.
    a. **Q:** What are the length, height, and width of the prism?
    b. **Q:** Does your cube have all of the characteristics of a cube?
    c. **Q:** What 2-dimensional shape does your 3-dimensional cube correspond to?
    d. Record the measurements of your cube on your chart.
3. Build another smaller cube made out of bricks on the plate. Make sure this second cube is proportional to your first cube.
    a. Record the measurements of your second cube on your chart.
    b. **Q:** How do we know that the two cubes are proportional?
4. Build another larger cube made out of bricks on the plate. Make sure this third cube is proportional to your second cube.
    a. Record the measurements of your third cube on your chart.
    b. **Q:** Are all three cubes proportional? Why or why not?
    c. **Q:** What can we say is true about all cubes?
    d. **Q:** Is it possible to build a cube that is not proportional to these cubes?
5. Neatly clear off your plate so that you have more space to build more structures!
6. Build a rectangular prism made out of bricks on the plate. It CANNOT be a cube.
    a. **Q:** What are the length, height, and width of your prism?
    b. Record the measurements of your first prism on your chart.
    c. **Q:** How is the prism different from your cube? You weren't allowed to build another cube, but could a cube be a rectangular prism?
7. Build another smaller rectangular prism made out of bricks on the plate. Make sure this second prism is proportional to your first prism.
    a. Record the measurements of your second prism on your chart.
    b. **Q:** How do we know that the prisms are proportional?
    c. **Q:** Is it trickier to find proportionate prisms or proportional cubes? Why?
8. Build another larger rectangular prism made out of bricks on the plate. Make sure this third prism is proportional to your first prism.
    a. Record the measurements of your third prism on your chart.
    b. **Q:** Are all three prisms proportional to each other? Why or why not?
    c. **Q:** Is it possible to build a rectangular prism that is NOT proportional to the first prism? If so, build one!
    d. **Q:** What other 3-D shapes could you build with LEGOs?

Extension:

1. Build any shaped object, measure its dimensions, and then build a smaller object that is proportional to the original object.

Going the Distance 2: Road Trip

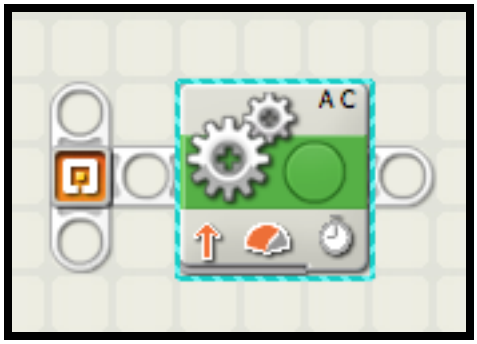
Grade Level: 5-6
Strand(s): Number Sense and Operations; Measurement; Data Analysis, Statistics, and Probability
Specific Concept(s): 6.N.3 Represent and compare very large positive numbers in various forms; 6.N.16 Estimate results of computations with whole numbers; 6.M.3 Solve problems involving proportional relationships and units of measurement (same system unit conversions); 6.D.2 Construct and interpret graphs
Materials Needed: One-motored NXT Car, Measuring Tape, LEGO Person, LEGO NXT Software, Tape, Graph Paper, Pencils
Description: Design and construct an NXT car and program it to run for varying lengths of time. Record and plot the distances that the car travels on a graph to determine how long the car will need to travel in order to stop next to a placed LEGO person. Then using different measurement conversions, determine how long the car would need to travel if the person was placed in exciting faraway locations.
Procedure/Questions:

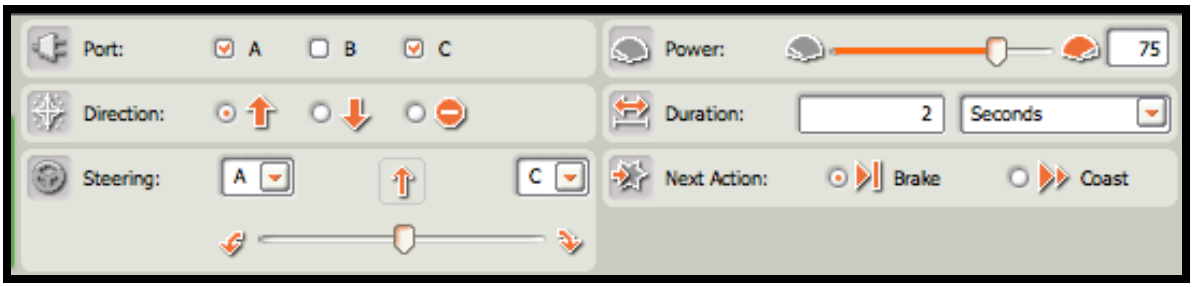
Setup:

1. Build a basic one-motored NXT Car:
    a. Take an NXT and attach a motor below the car using connector pegs, connector beams, and axles.
    b. Assemble the wheels and attach them to the motor.
    c. Wire the motor to output A.
    d. **Q:** What car movement would require the car to have more than one motor? In what manner will the car be able to move with one motor?
2. Check that your car passes the sturdy car shake test and drop test.
    a. Make sure you can gently shake your car without it falling apart.
    b. Make sure your car can survive dropping to the floor from your ankle.
3. Use tape to mark a starting line where the car will be placed before driving.
4. Place your LEGO person a distance away from your car and place tape on the ground under the LEGO person (incase the person gets knocked over).

Procedure:

1. Using the LEGO NXT Software, program the car to move forward.
    a. Set the controls to travel for 2 seconds.
    b. Example:





2. Collect a data point (x=time, y=distance) and plot it on a graph using graph paper in the following manner:
    a. Label your graph with "time" on the x-axis and "distance" on the y-axis.
    b. Plot the time (2 seconds) on the x-axis of the graph.
    c. Measure the distance the car traveled using measuring tape and plot that distance value on the y-axis of the graph.
3. Repeat the process of gathering data with the car running for 4 seconds and 6 seconds so that your final graph has three points.
4. Using the graph, determine how much time is required to run the car so that it stops within an inch of the LEGO person.
    a. Measure the distance from the starting point to the LEGO person.
    b. Draw a best-fit line through your three data points.
    c. Use this line to determine the time that the car would need to travel.
5. Pretend that each inch is actually a mile (so 1cm = 1mi). **Q:** Based on your plot and the following given distances, how long would it take to drive to your LEGO person friend if they were in these far away, fun locations? Use math on a separate piece of paper.
    a. Orlando, FL (Disney World, Kennedy Space Center, Harry Potter Theme Park): 1300 mi from Tufts.
    b. Hollywood, California: 3000 mi from Tufts.
    c. Washington, DC: 500 mi from Tufts.
    d. The Grand Canyon: 2600 mi from Tufts.

Final competition:

1. See who can program his or her car to drive the closest to the LEGO person.
    a. Before testing his or her car for the class, each student must pick a USA location where they would like to drive to visit their LEGO friend would visit and why (it can be a location not on the list).

Extension:

1. Without pretending that each inch is a mile, use the fact that there are 63,360 inches in a mile to calculate how long your car would take to drive to those places using a separate piece of paper.

(Number) Line Dancing

Grade Level: 5-6
Strand(s): Number Sense and Operations
Specific Concept(s): 6.N.6 Find and position integers, fractions, mixed numbers, and decimals (both positive and negative) on the number line; 6.N.10 Use the number line to model addition and subtraction of integers, with the exception of subtracting negative integers

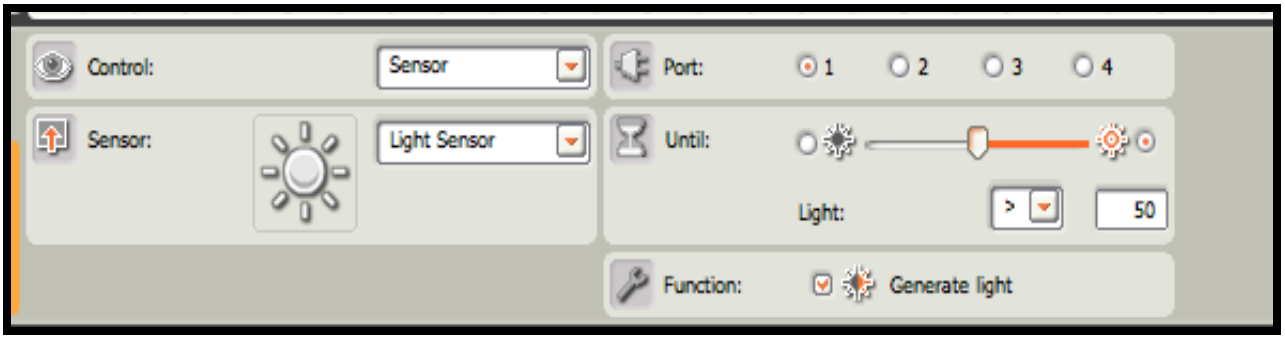
Materials Needed: One two-motored NXT Car, LEGO NXT Software, Solid-Colored Floor, Tape (opposite shade from the floor), One light sensor, One touch sensor, Number stickers, Dot stickers, Paper, Pencils

Description: Move an NXT car along a number line in order to visualize the positions of positive and negative integers on the line and to model addition and subtraction on the line.

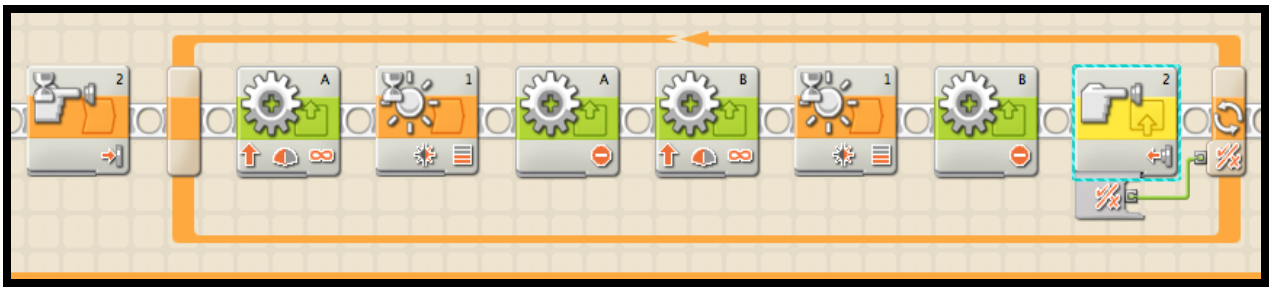
Procedure/Questions:

Setup: Building and programming the car

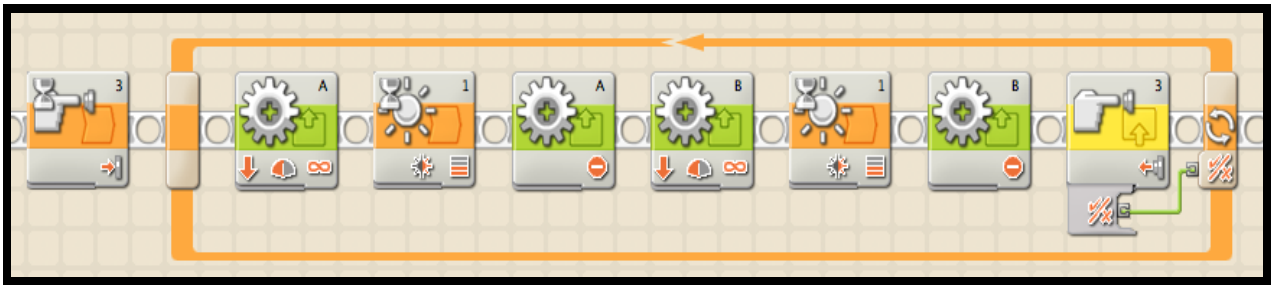
1. Build a front wheel assembly containing both a light sensor and a wheel capable of turning with a good turning radius.
    a. Use a skid plate instead of two front wheels in order to reduce friction.
    b. Make sure the light sensor is facing downwards and is as close to the floor as possible.
2. Attach the front wheel assemble to the front of the NXT car.
3. Attach two touch sensors to the car.
4. Wire the light sensor and the two touch sensors to the inputs of the NXT, and the motors to the outputs.
5. Place a long piece of tape across an empty space on the floor. This tape will act as a number line.
    a. Using the number stickers, mark 0, 5, 10, 15, 20, -5, -10, -15, -20.
    b. Using the dot stickers, mark all of the other integer spots.
6. Using the LEGO NXT Software, program your car to follow a line using the light sensor.
    a. Program the car to start when you press and hold down the first touch sensor.
    b. Within a logic loop, set the car to wait for dark and then wait for light, alternating between the two motors.
    c. Chose a reflected light value in between the dark and light parts of the floor (you can read these values on the tape and the floor by using the light sensor on the NXT and going to the "View" menu on the NXT). Make sure that you set the "wait for dark" block to wait for a light value greater than your chosen value and the "wait for light" block to wait for a value less than your chosen value.
    d. Example:



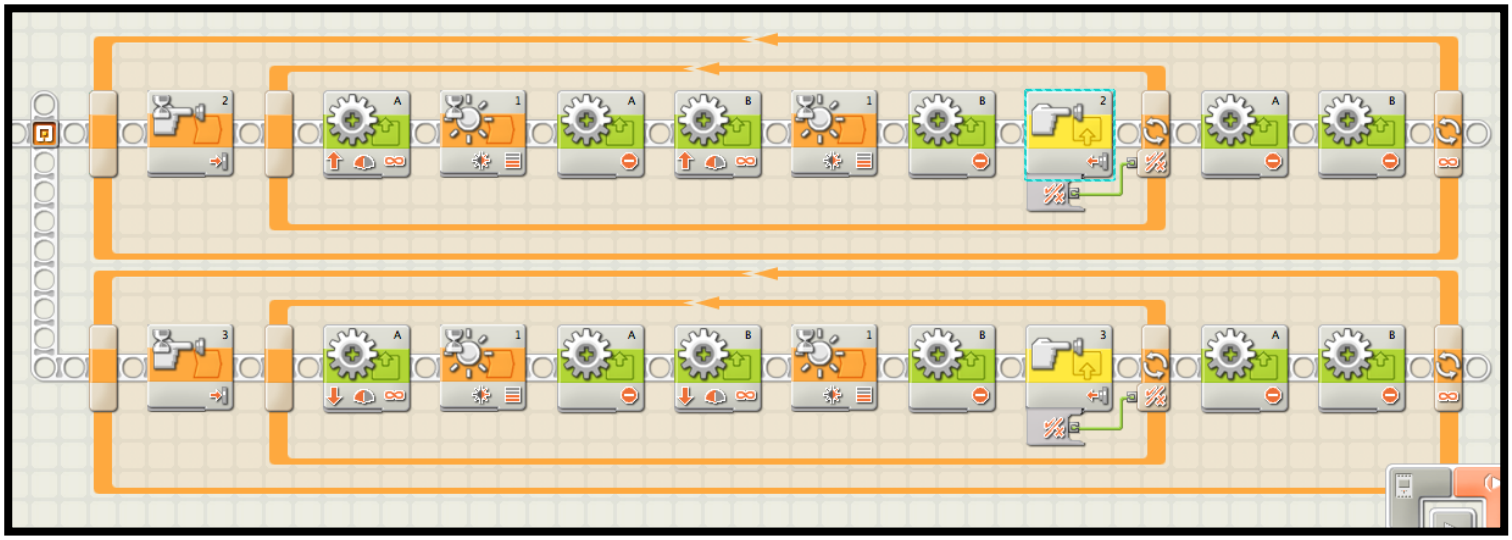
    e. Stop the car by releasing the first touch sensor.
    f. Example:



g. To make the car follow the line backwards, add another line of program using the second sensor and reversing the motor directions.
h. Example:



i. Complete program example:



Procedure:

1. Place the NXT on the 0 position on the number line with the front (where the light sensor is) facing the positive direction of the number line.
2. Drive the NXT along the number line using your forward and backwards touch sensors and the following directions to add and subtract single-digit numbers. After you complete each line of directions, record the number that you are on.
   a. Add 4. **Q:** What number are you on?

b. Add 5. **Q:** What number are you on?
c. Subtract 7. **Q:** What number are you on?
d. Subtract 5. **Q:** What number are you on?
e. Subtract 6. **Q:** What number are you on?
f. Add 8. **Q:** What number are you on?
g. Add 3. **Q:** What number are you on?
h. Subtract 2. **Q:** What number are you on?
i. **Q:** Are you back at the 0 position? If not, check your recordings and figure out where you made a mistake.

3. Place the NXT on the 0 position on the number line with the front (where the light sensor is) facing the positive direction of the number line.
4. Drive the NXT along the number line again, using the following directions to add and subtract single and double-digit numbers. After you complete each line of directions, record the number that you are on.
    a. Add 12. **Q:** What number are you on?
    b. Add 8. **Q:** What number are you on?
    c. Subtract 6. **Q:** What number are you on?
    d. Subtract 20: **Q:** What number are you on?
    e. Subtract 11: **Q:** What number are you on?
    f. Add 13: **Q:** What number are you on?
    g. Add 7: **Q:** What number are you on?
    h. Subtract 3. **Q:** What number are you on?
    i. **Q:** Are you back at the 0 position? If not, check your recordings and figure out where you made a mistake.
5. **Note:** Teachers may create more complicated patterns of adding and subtracting integers that do not necessarily end at the 0 position once the students have completed these two activities.

Grades 7-8

Combining Like LEGOs

Grade Level: 7-8, Algebra 1
Strand(s): Patterns, Relations, and Algebra
Specific Concept(s): 8.P.2 Evaluate simple algebraic expressions for given variable values
Materials Needed: Paper, Pencils, LEGO bricks of three different colors (for the sake of the activity we will use red, gray, and black) and all of the same size
Description: Rearrange Lego bricks by color in order to model the act of combining like terms in an expression.
Procedure/Questions:

1. Grab any random arrangement of red, gray, and black LEGO bricks and mix them up so that the three colors are spread out.
2. Stack the bricks in a tower using a mixed-color arrangement.
3. Pretend that each red brick represents an x^2 term, each gray brick represents an x term and each black brick represents a constant term.
4. On your piece of paper write an expression for your mixed-color brick tower keeping in mind what each color represents.

a. Example: for a *red, black, red, gray, black, black, gray, red, gray* tower, you would write $x^2+1+x^2+x+1+1+x+x^2+x$

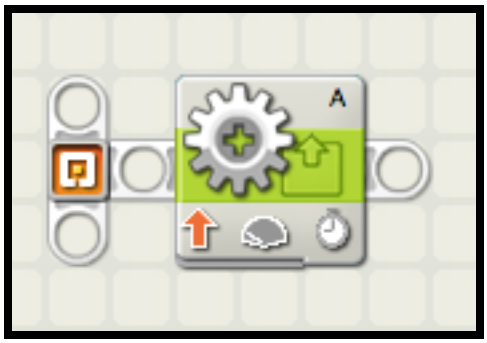
5. On your piece of paper, combine the like terms in your expression in order to create a new, shorter expression, with the x^2term first and then x and then the constants.
    a. For the above example, you would combine the terms in order to write the new expression $3x^2+3x+3$
6. Take apart your tower and re-stack the bricks so that the bricks are next to the other bricks of their same color.
7. On your piece of paper write an expression for your non-mixed brick tower keeping in mind what each color represents.
    a. **Q:** Is this expression the same as the expression you wrote when you combined like terms? If not, find your mistake.
8. Repeat the entire process using a different arrangement of bricks.

Turtle Racing

Grade Level: 7-8
Strand(s): Number Sense and Operations
Specific Concept(s): 8.N.3 Use ratios and proportions in the solution of problems, in particular, problems involving unit rates, scale factors, and rate of change
Materials Needed: One NXT car, Gears and other NXT kit pieces, Tape, LEGO NXT Software, Measuring tape.
Description: Use gear ratios to slow down an NXT car enough that it goes as slow as a turtle.
Procedure/Question:

Setup:

1. Build a basic NXT car.
2. Use the LEGO NXT Software to move forward at 20% power for 20 seconds.
3. Example:



Procedure:

1. Use a piece of tape to mark the starting point of your car.
2. Run the car (for 20 seconds) and measure how far it travels with the measuring tape.
3. Calculate the velocity of the car by dividing the distance of the car by the time traveled (20 seconds).
4. Reattach the wheels of the car using gears.
    a. **Q:** Based on the arrangement of the gears, how will the gears affect the velocity of the car? Can you answer this using exact numbers?
5. Run the car again, measure the distance of the altered car, and compare the two cars.

6. Repeat the process with various arrangements of gears.
7. Race the cars to see who can build the slowest car using gears.

Grades 9-10

Home Equations (Based on Early Algebra "Playground Construction")

Grade Level: 9-10, Algebra 1
Strand(s): Patterns, Relations, and Algebra
Specific Concept(s): 10.P.5 Find solutions to quadratic equations (with real roots) by factoring, completing the square, or using the quadratic formula. Demonstrate an understanding of the equivalence of the methods
Materials Needed: 32x32 Plate, 2x2 LEGO bricks, 2x1 LEGO bricks, LEGO people
Description: Use quadratic and linear equations to figure out how many materials you must use to build a new home under a restricted budget.
Procedure/Questions:

Round 1:

1. Imagine that in order to purchase a beautiful, green grass LEGO plot of land (the plate), you must pay $600.
2. Assume that you would like to build a new home for your LEGO friends out of LEGO bricks on your beautiful, green grass LEGO plate. First, you must lay down the fancy floor of your house using 2x2 bricks in a square shape.
    a. **Q:** If each 2x2 floor brick costs $300, what equation can we use to find the total cost of the floor bricks, assuming that the area of a square with an edge of length x is x^2? **Note:** the bricks are so expensive because they are quite large compared to the size of the LEGO person and the land is significantly less expensive than usual. (**A:** $y = 300x^2$)
3. Now, you have to build the walls of the house using 2x1 bricks. Each wall should be four bricks high and one brick thick.
    a. **Q:** If each 2x1 wall brick costs $50 and you must place the bricks outside the edge of the field (but NOT on the corners of the field), what equation can we use to find the total cost of the wall bricks? (**A:** $y = 4*4*50*x = 800x$)
4. **Q:** What equation can we use to find the total cost of the plot of land, the fancy floor bricks, and the wall bricks? We'll need this equation to figure out how many bricks we can use based on our budget! (**A:** $y = 300x^2+800x+600$)
5. Find the y-intercept of the equation.
    a. **Q:** What does this value mean given the scenario?
6. Imagine you must spend exactly $12,100.
    a. **Q:** How many bricks long can the edge of your house be? Build this house!
7. Imagine you have $40,000 to spend but do not have to spend all of it on the house.
    a. **Q:** How many bricks long can the edge of your house be? How many bricks would it take to build this house?
8. Imagine you have $140,000 to spend but do not have to spend all of it on the house.
    a. **Q:** How many bricks long can the edge of your house be?

Round 2:

1. Imagine that your LEGO people have a lot of LEGO relatives and that they need to build a guesthouse to allow them to visit. In order to have a building permit to build another house on your plot of land you will need to pay $200.
2. Now, you must lay down a less-fancy floor for the guesthouse in a square shape using 2x3 bricks.
    a. **Q:** If each floor brick costs $100, what equation can we use to find the total cost of the floor bricks? (**A:** $y = 100x^2$)
3. Now, you must build the walls of the guesthouse with the 2x1 bricks. Each wall should be two bricks tall.
    a. **Q:** If each wall brick costs $50 and you must place the bricks outside the edge of the field (but NOT on the corners of the field), what equation can we use to find the total cost of the wall bricks? (**A:** $y = 4*2*50*x = 400x$)
4. **Q:** What equation can we use to find the total cost of the building permit, the floor bricks, and the wall bricks of the guesthouse? (**A:** $y = 100x^2+400x+200$).
5. Find the y-intercept of the equation.
    a. **Q:** What does this value mean given the scenario?
6. Imagine you must spend exactly $3,400.
    a. **Q:** How many bricks long can the edge of your guesthouse be? Build this house next to your other house!
7. Imagine you have $10,000 to spend but do not have to spend all of it.
    a. **Q:** How many bricks long can the edge of your guesthouse be? How many bricks would it take to build this house?
8. Imagine you have $29,000 to spend.
    a. **Q:** How many bricks long can the edge of your guesthouse be? How many bricks would it take to build this guesthouse?

Baseball Park Equations (Alternate Version of "Home Equations")

Grade Level: 9-10, Algebra 1
Strand(s): Patterns, Relations, and Algebra
Specific Concept(s): 10.P.5 Find solutions to quadratic equations (with real roots) by factoring, completing the square, or using the quadratic formula. Demonstrate an understanding of the equivalence of the methods
Materials Needed: 32x32 Plate, 2x2 LEGO bricks, 2x1 LEGO bricks, LEGO people
Description: Use quadratic and linear equations to figure out how many materials you must use to build a baseball park under a restricted budget.
Procedure/Questions:

Round 1:

1. Imagine that in order to purchase a LEGO plot of land (the plate) for a baseball field, you must pay $600.
2. Assume that you would like to build a baseball park for your LEGO baseball team out of LEGO bricks on your LEGO plate. First, you must lay down the fancy grass squares (bricks) to create the grass of your baseball field.
    a. **Q:** What is the name of your LEGO baseball team and what city is the park located in? **Note:** this can be a real team or an imaginary team.

   b. **Q:** If each grass square costs $300, what equation can we use to find the total cost of the field, assuming that the area of a square with an edge of length x is x^2? (**A:** $y = 300x^2$)
3. Now, you have to build the walls of the stadium out of 2x1 bricks. Each wall should be 4 bricks high and 1 brick thick.
   a. **Q:** If each wall brick costs $50 and you must place the bricks outside the edge of the field (but NOT on the corners of the field), what equation can we use to find the total cost of the stadium wall bricks? (**A:** y = 4*4*50*x = 800x)
4. **Q:** What equation can we use to find the total cost of the plot of land, the field grass bricks, and the stadium wall bricks? We'll need this equation to figure out how many bricks we can use based on our budget! (**A:** $y = 300x^2+800x+600$)
5. Find the y-intercept of the equation.
   a. **Q:** What does this value mean given the scenario?
6. Imagine you must spend exactly $12,100.
   a. **Q:** How many bricks long can the edge of your stadium be? Build this stadium!
7. Imagine you have $40,000 to spend but do not have to spend all of it on the stadium.
   a. **Q:** How many bricks long can the edge of your stadium be? How many bricks would it take to build this stadium?
8. Imagine you have $140,000 to spend but do not have to spend all of it on the stadium.
   a. **Q:** How many bricks long can the edge of your stadium be?

Round 2:

9. Imagine that your LEGO baseball team has a rival team that has a smaller, less-nice stadium across the city. In order to build this stadium you must pay $200 for the land.
10. Now, you must lay down a less-nice grass field for the rival stadium in a square shape.
    a. **Q:** If each 2x2 grass square brick costs $100, what equation can we use to find the total cost of the field? (**A:** $y = 100x^2$)
11. Now, you must build the walls of the rival stadium using 2x1 bricks. Each wall should be two bricks tall.
    a. **Q:** If each wall brick costs $50 and you must place the bricks outside the edge of the field (but NOT on the corners of the field), what equation can we use to find the total cost of the stadium walls? (**A:** y = 4*2*50*x = 400x)
12. **Q:** What equation can we use to find the total cost of the land, the field, and the wall bricks of rival stadium? (**A:** $y = 100x^2+400x+200$).
13. Find the y-intercept of the equation.
    a. **Q:** What does this value mean given the scenario?
14. Imagine you must spend exactly $3,400.
    a. **Q:** How many bricks long can the edge of the rival stadium be? Build this stadium next to your team's nicer stadium!
15. Imagine you have $10,000 to spend but do not have to spend all of it.
    a. **Q:** How many bricks long can the edge of the stadium be? How many bricks would it take to build this stadium?
16. Imagine you have $29,000 to spend.
    a. **Q:** How many bricks long can the edge of the stadium be? How many bricks would it take to build this stadium?

Slope Skills

Grade Level: 9-10, Algebra 1
Strand(s): Patterns, Relations, and Algebra; Measurement
Specific Concept(s): 10.P.2 Demonstrate an understanding of the relationship between various representations of a line. Determine a line's slope and x- and y-intercepts from its graph or from a linear equation that represents the line. Find a linear equation describing a line from a graph or a geometric description of the line. Explain the significance of a positive, negative, zero, or undefined slope; 10.M.3 Relate changes in the measurement of one attribute of an object to changes in another attribute
Materials Needed: One basic RCX or NXT Car, One stack of text books, One strong wooden slab, Graph paper, Pencils, One stop watch, One ruler, One measuring tape
Description: Learn to calculate slopes of concrete objects (ramps) and of lines on a graph by sending LEGO cars down different sloped ramps and recording the distances they travel in specific times. Also, write the equation of a line on a graph in slope-intercept form and use an input-output chart to predict travel distances.
Procedure:

1. Create a chart to record your data. Example:

	Ramp 1	**Ramp 2**	**Ramp 3**
Time 1 Distance			
Time 2 Distance			
Time 3 Distance			
Horizontal length			
Height			
Slope			
Wooden Slab Length			

2. Draw three graphs on your graph paper, labeling the x-axis "time" and the y-axis "distance" on each graph.
3. Create the first ramp by leaning the wooden slab on one textbook.
4. Measure the vertical height of the book and the horizontal length from the edge of the book to the bottom of the ramp.
    a. Record these values on your chart.
5. Calculate the slope of the ramp by dividing rise over run, where rise is the height of the book and run is the horizontal length from the edge of the book to the bottom of the ramp.
    a. Record this value on your chart.
6. Measure the length of the wooden slab.
    a. Record this value on your chart.
7. Place the car at the top of the ramp. When you release the car, simultaneously click "start" on the stopwatch.
8. Watch your car and stopwatch closely. When the car gets to 1 second, mark where the car stopped.
    a. Measure and record this distance from the ramp under "Time 1" and "Ramp 1".
    b. **Note:** Be sure to include the length of the wooden slab in this distance.
9. Repeat this process of releasing and timing the car for 2 seconds and 3 seconds while measuring and recording the two distances on your chart.

10. Record this data on the first graph by plotting the three times and the travel distances so that each ordered pair (x, y) = (time, distance).
11. Using a ruler, draw the best-fit line through the three points on your drawn graph.
12. Calculate the slope of the best-fit line and write the equation of the line on your graph in slope-intercept form.
    a. **Remember:** Slope-intercept form: y = mx + b
    b. In this case, y = distance, x = time variable, m = the slope of the line, b = the y-intercept. The y-intercept is the y-coordinate of the point where the line crosses the y-axis. **Note:** The rate of change of distance on the graph is not the same as the slope of the ramp!
    c. **Q:** In this situation, what is the significance of negative slope? Positive slope? Zero slope? Undefined slope?
13. Repeat the entire process for ramps made with stacks of two textbooks and three textbooks, so that you ultimately have three separate graphs.
    a. **Q:** How do your three graphs compare to one another?
14. Using the equation of the line from one of your graphs, make a chart with "time" as the input and "distance" as the output.
15. Choose various values for "time" and see how far the car would travel in those times by plugging the values into the equation of the line. Record the input and output values on the chart.

Super Slope Skills

Grade Level: 9-10, Algebra 1
Strand(s): Patterns, Relations, and Algebra; Measurement
Specific Concept(s): 10.P.2 Demonstrate an understanding of the relationship between various representations of a line. Determine a line's slope and x- and y-intercepts from its graph or from a linear equation that represents the line. Find a linear equation describing a line from a graph or a geometric description of the line. Explain the significance of a positive, negative, zero, or undefined slope; 10.M.3 Relate changes in the measurement of one attribute of an object to changes in another attribute
Materials Needed: One basic RCX or NXT Car, One stack of text books, One strong wooden slab, Graph paper, Pencils, One stop watch, One ruler, One measuring tape
Description: Learn to calculate slopes of concrete objects (ramps) and of lines on a graph by sending LEGO cars down different sloped ramps and recording their travel time to a marked distance. Also write the equation of a line in slope-intercept form on a graph and use an input-output chart to predict travel times.
Procedure:

1. Create a chart where you can record your data. Example:

	Ramp 1	**Ramp 2**	**Ramp 3**	**Ramp 4**
Horizontal Length				
Height				
Slope				
Travel Time				

2. Draw a graph on your graph paper, labeling the x-axis “slope” and the y-axis “travel time”.
3. Create a ramp by leaning the wooden slab on one textbook.
4. Measure the vertical height of the book and the horizontal distance from the edge of the book to the bottom of the ramp.
    a. Record these values on your chart.
5. Calculate the slope of the ramp by dividing rise over run, where rise is the height of the book and run is the horizontal distance from the edge of the book to the bottom of the ramp.
    a. Record this slope value on your chart.
6. Place tape (a finish line!) a good distance away from the end of the ramp so that you have a reference point of where to stop timing the car’s travel.
7. Place the car at the top of the ramp. When you release the car, simultaneously click “start” on the stopwatch.
8. Click “stop” on the stopwatch when the car gets to the taped finish line.
    a. Record this time on your chart.
9. Record the car’s trip on the graph by plotting the slope of the ramp and the travel time so that each ordered pair (x, y) = (slope, travel time).
10. Repeat the entire process for stacks of 2 textbooks, 3 textbooks, and 4 textbooks so that you have four points on your graph.
11. Using a ruler, draw the best-fit line through the 4 points on your drawn graph.
12. Calculate the slope of the best-fit line and write the equation of the line on your graph in slope-intercept form.
    a. **Remember:** Slope-intercept form: $y = mx + b$
    b. In this case, y = travel time variable, x = ramp slope variable, m = the slope of the line, b = the y-intercept. The y-intercept is the y-coordinate of the point where the line crosses the y-axis. **Note:** The rate of change of travel time on the line is not the same as the slopes of the ramps!
    c. **Q:** How is this different from what we are used to plotting? What are other scenarios where time acts as the dependant variable?
    d. **Q:** In this situation, what is the significance of negative slope? Positive slope? Zero slope? Undefined slope?
13. Using the equation of the line, make a chart with “slope” as the input and “travel time” as the output.
14. Choose various values for “slope” and see how long the car would take to travel to the tape in that amount of time by plugging that slope value into the equation of the line. Record the input and output values on the chart.