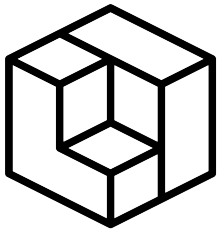


bricklayer.org

Three Bricklayer Challenge Sets

Kate Sherwin

Contents

1 Shapes on the Coordinate Plane

1.1 Concepts and Terminology

Definition 1. ***Coordinate Plane*** *– a plane spanned by the x-axis and y-axis in which the coordinates of a point are its distances from two intersecting perpendicular axes; also called Cartesian Plane, Cartesian Coordinate System.*

- *Origin* – The point (0,0) where the two axis of a coordinate plane intersect.
- *Quadrants* – Each of four parts of a coordinate plane divided by two lines (the x-axis & y-axis) at right angles.
- *x-axis* – The horizontal line number on a coordinate plane.
- *y-axis* – The vertical line number on a coordinate plane.
- *Ordered Pairs* – A pair of numbers used to locate a point on a grid. The first number tells the left-right position, and the second number tells the up/down position.

Definition 2. *A* ***polygon*** *is a 2 dimensional shape*[1] *consisting of a sequence straight lines connected to one another. The straight lines form the sides of the polygon and angles describe how adjacent lines are connected. The word polygon is the composition of two Greek words* "poly" - many *and* "gon" - angle.

- A *regular polygon* is a polygon where all angles are equal in measure and all sides have the same length.
- *Faces* – Any of the individual surfaces of a solid object.
- *Edges* – A line segment that joins two vertices (corners).
- *Vertices* – A point where two or more lines meet. (singular = vertex)
- *Congruent* – Same size and shape.
- *Symmetrical* – The same on both sides.
- *Line Segment* – A part of a line that is bounded by two distinct endpoints, and contains every point on the line between its endpoints.
- *Endpoints* – A point or value that marks one of the ends of a line segment.
- *Circumference* – The distance around a circle.

[1]The term **shape** is used to describe the form of an object not its substance. Basic two dimensional shapes include triangles, circles, and rectangles.

- *Radius* – A straight line from the center to the circumference of a circle.
- *Diameter* – A straight line passing from side to side through the center of a body or figure, especially a circle.

Definition 3. *A **composite shape** is a figure (or shape) that can be divided into more than one of the basic figures (or shapes).*

1.2 Congruence

Create a red square with 2 congruent rectangles (one blue, one green) inside. Make sure you can see the outline of the red square after you place the 2 rectangles inside.

Reflect on the Process:

1. Which quadrilateral did you have to program first, and why?
2. How did you figure out the dimensions (length & width) of your rectangles?
3. How did you figure out where to place the rectangles on the grid?

See Figure 1 for a possible solution to this problem.

1.3 Circles

Create a red circle with a white circumference. Make a black line segment marking the radius and a blue line segment marking the diameter.

Reflect on the Process:

1. How did you decide to construct your circumference? Did you use a circle function or a ring function? Why?
2. Does it matter which you program first, the circle or the circumference? Why or why not?
3. How did you figure out the endpoints of the radius line segment?
4. How did you figure out the endpoints of the diameter line segment?

See Figure 2 for a possible solution to this problem.

1.4 Line Segments

Use 4 line segments to create a rectangle.

Reflect on the Process:

1. Which 2 line segments did you program first? Why?
2. How did you figure out the coordinates for the 3rd line segment?
3. How did you figure out the coordinates for the 4th line segment?

See Figure 3 for a possible solution to this problem.

1.5 Composite Shapes

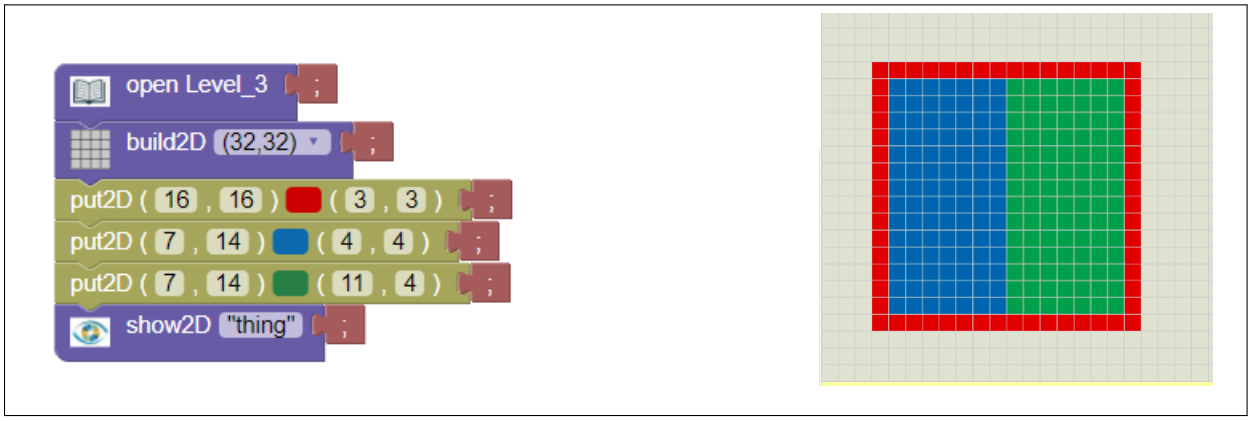
Create a composite shape that looks like the letter "H" made up of 2 congruent squares (one red & one blue) and 2 congruent rectangles (one green & one yellow). Your "H" must be symmetrical.

Reflect on the Process:

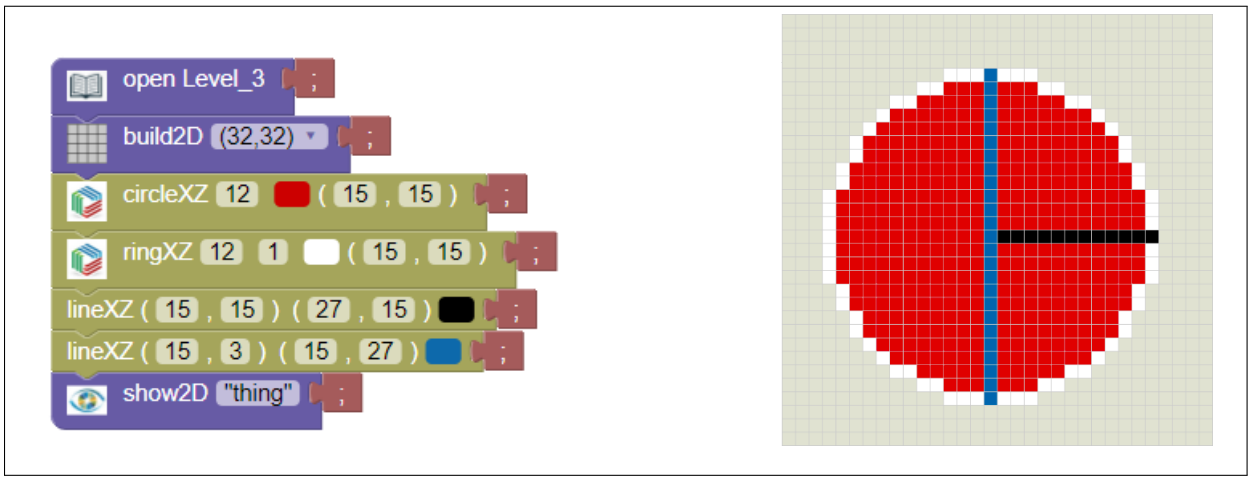
1. Which 2 line segments did you program first? Why?
2. How did you figure out the coordinates for the 3rd line segment?
3. How did you figure out the coordinates for the 4th line segment?

See Figure 4 for a possible solution to this problem.

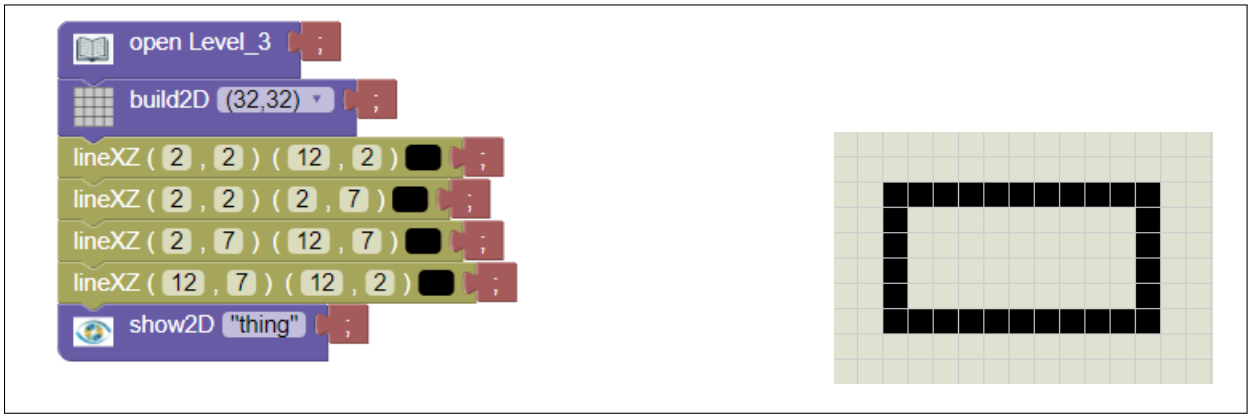
1.6 Possible Solutions



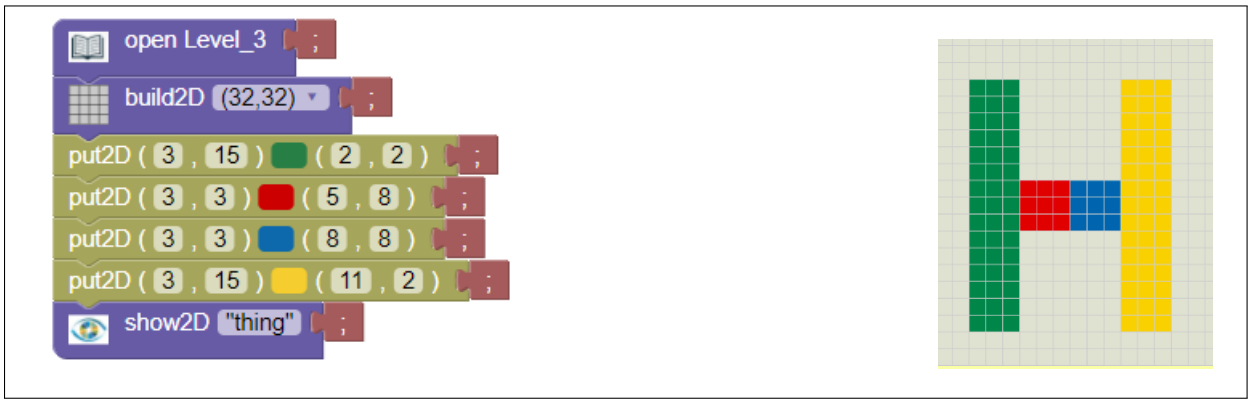
Picture 1: Possible solution for the Congruence Challenge (Section 1.2).



Picture 2: Possible solution for the Circles Challenge (Section 1.3).



Picture 3: Possible solution for Line Segments Challenge (Section 1.4).



Picture 4: Possible solution for Composite Shapes Challenge (Section 1.5).

2 Transformations

2.1 Concepts and Terminology

Definition 4. *The term **(geometric) transformation** refers to a class of manipulations used to modify properties of an (geometric) object. The four basic transformation are (1) rotation, (2) translation, (3) reflection, and (4) dilation. The original shape of the object is called the **pre-image** and the final shape and position of the object is the **image** under the transformation.*

- *Translation* - moving or "sliding" a figure.
- *Rotation* - A circular movement. The figure moves around the center of rotation.
- *Center of Rotation* - The fixed point around which a two-dimensional figure is rotated.
- *Angle of Rotation* - The measure of degrees that a figure is rotated about a fixed point.
- *Order* - The number of times a figure matches up with itself when it's rotated around 360°.
- *Reflection* - A transformation in which a figure is reflected across a line, creating a mirror image.
- *Line of Symmetry* - The line which a figure is reflected across to create a reflection.
- *Rotational Symmetry* - When an image can be rotated and still look exactly the same.
- *Similar Transformation* - Two figures are similar if all distances in the pre-image are multiplied by the same scale factor to get the image.
- *Congruent Transformation* - Transformations preserve size, area, angles and line length.
- *Dilation* - To resize something. A dilation enlarges or reduces the size of a figure.
- *Scale Factor* - The ratio of any two corresponding lengths in two similar geometric figures.
- *Tessellation* - An arrangement of shapes closely fitted together, especially of polygons in a repeated pattern without gaps or overlapping.

2.2 One Tile Tessellation

Create a tessellating pattern using one type of shape and one type of transformation.

Reflect on the Process:

1. Which shape did you choose? Why?
2. What transformations did you choose to use? Why?
3. What challenges did you run into?
4. How did you solve them?

See Figure 5 for a possible solution to this problem.

2.3 Two Tile Tessellation

Create a tessellating pattern using two different shapes and two different types of transformations.

Reflect on the Process:

1. Which shapes did you choose? Why?
2. Which transformations did you choose to use? Why?
3. What challenges did you run into?
4. How did you solve them?

See Figure 6 for a possible solution to this problem.

2.4 Rotational Symmetry

Create an image that has order 4 rotational symmetry.

Reflect on the Process:

1. Which shapes did you choose? Why?
2. Which transformations did you choose to use? Why?
3. What is the degree of rotation for your image?
4. What challenges did you run into?
5. How did you solve them?

See Figure 7 for a possible solution to this problem.

2.5 Dilation

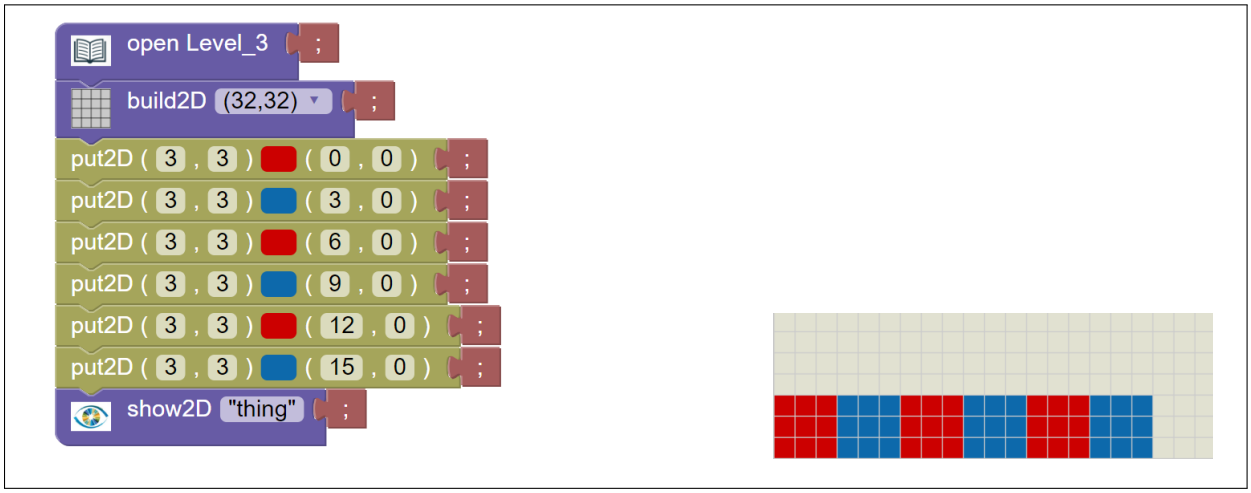
Create 2 similar composite figures with a scale factor of 5.

Reflect on the Process:

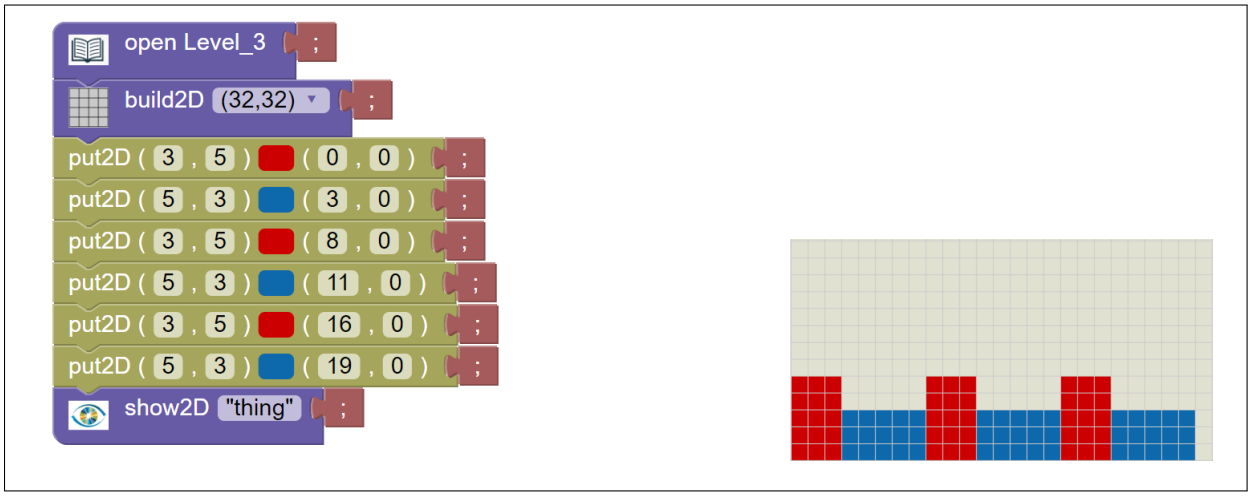
1. Which shape(s) did you choose to construct your composite figure? Why?
2. How did you use scale factor to code your second figure?
3. What challenges did you run into?
4. How did you solve them?

See Figure 8 for a possible solution to this problem.

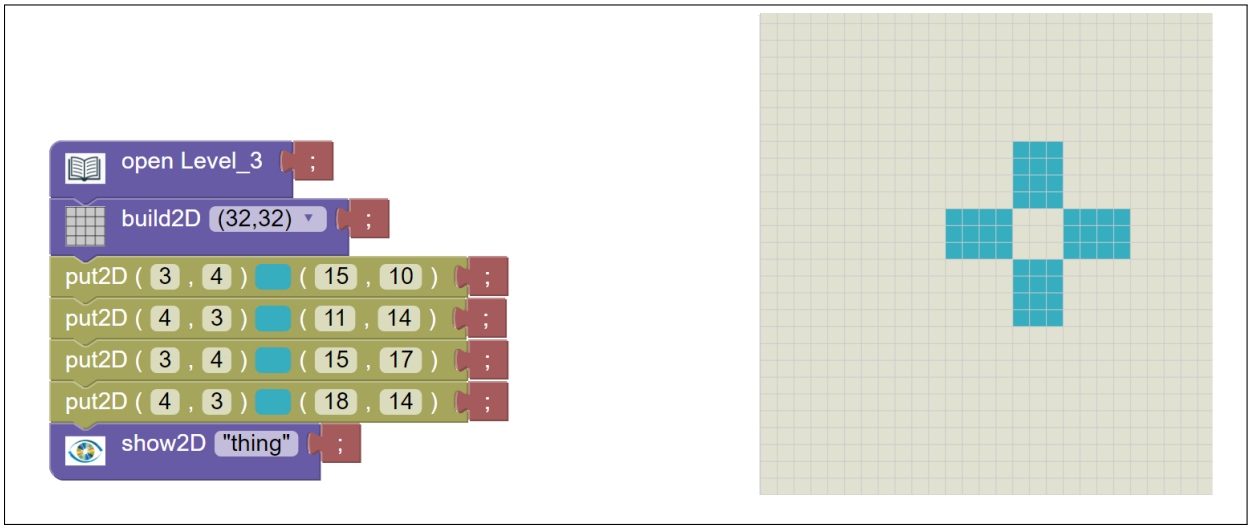
2.6 Possible Solutions



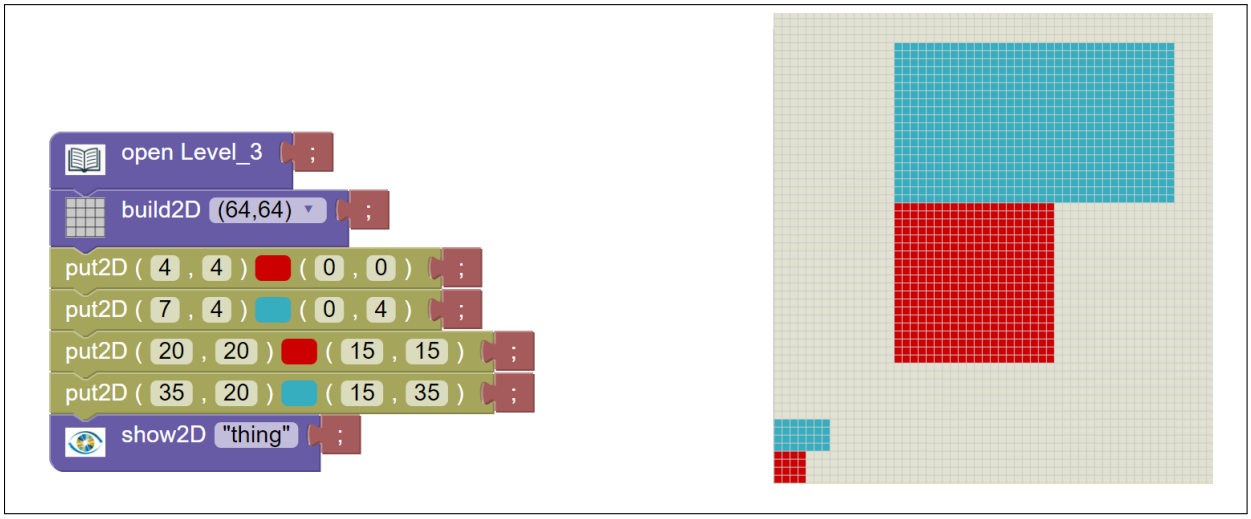
Picture 5: Possible solution for the One Tile Tessellation Challenge (Section 2.2).



Picture 6: Possible solution for the Two Tile Tessellation Challenge (Section 2.3).



Picture 7: Possible solution for the Rotational Symmetry Challenge (Section 2.4).



Picture 8: Possible solution for the Dilation Challenge (Section 2.5).

3 Measurements

3.1 Concepts and Terminology

- *Midpoint* - The exact middle point of a line segment.
- *Slope* - How steep a line segment is.
- *Perpendicular* - At an angle of 90° to a given line, plane, or surface.
- *Parallel* - Side by side line segments that have the same distance continuously between them.
- *Perimeter* - The continuous line forming the boundary of a closed geometric figure.
- *Circumference* - The enclosing boundary of a circle.
- *Radius* - A straight line from the center to the circumference of a circle.
- *Diameter* - A straight line passing from side to side through the center of a circle.
- *Pi* - The ratio of a circle's circumference to its diameter.
- *Area* - The extent or measurement of a surface.

Midpoint Formula	$\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$
Distance Formula	$\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$
Circumference Formula	$C = 2\pi r$ $C = \pi d$
Area of a Circle	$A = \pi r^2$
Area of a Rectangle	$A = length \times width$
Slope Formula	$m = \frac{y2-y1}{x2-x1}$

Table 1: Useful Formulas for this set of Challenges.

3.2 Midpoint, Distance, and Slope

Use the slope formula to code 2 lines that are parallel and 2 lines that are perpendicular. Use the coordinates to calculate the following:

1. The midpoint of each line segment.
2. The distance of each line segment.
3. The slope of each line segment.

Reflect on the following:

1. Describe what you noticed about the slope of the parallel lines.
2. Describe what you noticed about the slope of the perpendicular lines.

3.3 Area and Perimeter I

Code a square, a rectangle, and a circle. Use the coordinates to calculate the following:

1. Perimeter/Circumference of each shape.
2. Area of each shape.
3. Radius and diameter of the circle.

Reflect on the following:

1. Describe what you noticed about the slope of the parallel lines.
2. Describe what you noticed about the slope of the perpendicular lines.

3.4 Area and Perimeter II

Code a circle, and then code the smallest square that is able to enclose the circle. Use the coordinates to calculate the following:

1. Perimeter/Circumference of each shape.
2. Area of each shape.

Reflect on the following:

1. Did you notice any relationships between any of the circle's measurements and any of the square's?

A Geometry Challenges Using Bricklayer – Lesson Plans

- Differentiated, Customizable Project-Based Learning Units For Upper Elementary, Middle School, and High School Students
- Curriculum aligned with ISTE and NE Mathematics Standards

Shapes on the Coordinate Plane

Overview & Purpose:

Students will gain knowledge and understanding of two-dimensional shapes on the coordinate plane and how to use Bricklayer-lite Level 3 to code.

NE Mathematics Standards Addressed:

7.3.1.b, 11.3.1.h, 5.3.2.a, 6.3.2.a, 5.3.2.b, 6.3.2.b, 6.3.2.c, 6.3.2.d

Objectives:

Students will:

- Code horizontal, vertical, and diagonal line segments using Bricklayer-lite Level 3.
- Code and identify the defining features (number of sides, vertices, etc.) of two-dimensional shapes (quadrilaterals, circles, rings, triangles, and other polygons) using Bricklayer-lite Level 3.

Materials Needed:

- Computers with internet access (access to Bricklayer)
- Step-by-step directions for using Bricklayer-lite Level 3 (with pictures)
- Concepts and Terminology
- Template for students to use while creating their own Stage 1 Challenges
- Template for students to use while solving others' Stage 1 Challenges

Building Background Knowledge/Introductory Activities:

- Classification of two-dimensional shapes. Khan Academy
- Constructing and deconstructing composite figures. Math Interactives

Directions:

Step 1. (30-45 minutes). Teacher-led, hands-on demonstration of how to use Bricklayer-lite Level 3 with step-by-step directions to get students acquainted with the program.

Step 2. (30-45 minutes). Students practice their coding and geometry skills (identifying and describing quadrilaterals, circles, rings, triangles, and other polygons) by trying to code, or solve, teacher-created Bricklayer artifacts, or Challenges, using Bricklayer-lite Level 3.

Step 3. (45-60 minutes). Students create their own Challenges using Bricklayer-lite Level 3 to code and describe composite figures.

Step 4. (45-60 minutes). Students solve other students' Challenges while describing composite figures

Formative Assessments:	**Summative Assessments:**
• Building Background Knowledge activities completed by students • Teacher-created Challenges solved by students (Step 2)	• Student-created Challenges (Step 3) • Solutions to Challenges created by other students (Step 4)

Transformations

Overview & Purpose:

Students will perform and describe various transformations on the coordinate plane using Bricklayer-lite Level 3.

NE Mathematics Standards Addressed:

8.3.2.a, 8.3.2.c

Objectives:
Students will:

- Perform and describe positions and orientation of shapes under multiple transformations including rotations, translations, and reflection on the coordinate plane.
- Find similar two-dimensional figures and define similarity in terms of a series of transformations.

Materials Needed:

- Computers with internet access (access to Bricklayer)
- Step-by-step directions for using Bricklayer-lite Level 3 (with pictures)
- Concepts and Terminology
- Template for students to use while creating their own Stage 2 Challenges
- Template for students to use while solving others' Stage 2 Challenges

Building Background Knowledge/Introductory Activities:

- Transformations on the coordinate plane practice activities, lessons & quizzes Khan Academy
- Practice similarity and transformations Khan Academy

Directions:

Step 1 (30-45 minutes). Teacher-led, hands-on demonstration of how to use Bricklayer-lite Level 3 with step-by-step directions to get students acquainted with the program.

Step 2 (30-45 minutes). Students practice their coding and geometry skills (performing and describing positions and orientation of shapes under multiple transformations & defining similarity in terms of a series of transformations on the coordinate plane) by trying to code, or solve, teacher-created Bricklayer artifacts, or Challenges, using Bricklayer-lite Level 3.

Step 3 (45-60 minutes). Students create their own Challenges using Bricklayer-lite Level 3 to code and describe transformations of two-dimensional shapes using coordinate geometry.

Step 4 (45-60 minutes). Students solve other students' Challenges while describing transformations of two-dimensional shapes using coordinate geometry.

Formative Assessments:	**Summative Assessments:**
• Building Background Knowledge activities completed by students	• Student-created Challenges (Step 3) • Solutions to Challenges created by other students (Step 4)

Measurements

Overview & Purpose:

Students will perform and compare measurements and apply formulas.

NE Mathematics Standards Addressed:

11.3.2.a, 11.3.2.b, 11.3.2.d, 6.3.2.e, 7.3.3.c

Objectives:
Students will:

- Apply the midpoint formula.
- Use coordinate geometry to analyze linear relationships to determine if lines are parallel or perpendicular.
- Apply the distance formula.
- Calculate vertical and horizontal distances in the coordinate plane to find area and perimeter.
- Determine the area and circumference of circles both on the coordinate plane.

Materials Needed:

- Computers with internet access (access to Bricklayer)
- Step-by-step directions for using Bricklayer-lite Level 3 (with pictures)
- Concepts and Terminology
- Template for students to use while creating their own Stage 3 Challenges
- Template for students to use while solving others' Stage 3 Challenges

Building Background Knowledge/Introductory Activities:

- Midpoint formula practice Khan Academy
- Distance formula practice Khan Academy
- Calculating area, perimeter & circumference on the coordinate plane practice Khan Academy
- Parallel & perpendicular lines from equations practice Khan Academy

Directions:

Step 1 (30-45 minutes). Teacher-led, hands-on demonstration of how to use Bricklayer-lite Level 3 with step-by-step directions to get students acquainted with the program.

Step 2 (30-45 minutes). Students practice their coding and geometry skills (using coordinate geometry to apply the midpoint and distance formula, analyze linear relationships & find area and perimeter/circumference of quadrilaterals, triangles, and circles) by trying to code, or solve, teacher-created Bricklayer artifacts, or Challenges, using Bricklayer-lite Level 3.

Step 3 (45-60 minutes). Students create their own Challenges using Bricklayer-lite Level 3 to code and apply formulas to calculate the area and perimeter/circumference of two-dimensional shapes using coordinate geometry.

Step 4 (45-60 minutes). Students solve other students' Challenges while applying formulas to calculate the area and perimeter/circumference of two-dimensional shapes using coordinate geometry

Formative Assessments:	**Summative Assessments:**
• Building Background Knowledge activities completed by students • Teacher-created Challenges solved by students (Step 2)	• Student-created Challenges (Step 3) • Solutions to Challenges created by other students (Step 4)