Square Patios

Strand: Functions

Topic: Representations of Functions

Primary SOL: A.7 The student will investigate and analyze linear and quadratic function families and their characteristics both algebraically and graphically, including

a) determining whether a relation is a function;
e) values of a function for elements in its domain; and
f) connections between and among multiple representations of functions using verbal descriptions, tables, equations, and graphs.

Related SOL: A.1; A.6b, c; A.9

Materials

- Building Square Patios activity sheet (attached)
- Construction paper
- Colored toothpicks
- Wooden toothpicks
- Miniature marshmallows
- Graph paper

Vocabulary

dependent variable, domain, function, independent variable, linear function, quadratic function, range, relation

Student/Teacher Actions: What should students be doing? What should teachers be doing?

Note: This lesson should be used after Functions 1 and Functions 2 activity.

1. Distribute the Building Square Patios activity sheet. Divide the class into groups, and give each group the materials listed on the activity sheet.
2. Have student groups complete the activity. *(Note: Students are to build only the first five patios, looking for patterns. They do not have enough materials to build larger patios. If a group is unsure and would like to check their rule by building a larger patio, allow two groups to combine materials in order to build a 6 x 6 or a 7 x 7 patio.)*
3. As students work, make sure they are making the connections between the different representations of the functions—table (incorporated throughout the activity), verbal descriptions (questions 2 and 6), equation (questions 4 and 8), and graph (questions 4 and 8). If students are having difficulty coming up with a verbal sentence, prompt them to look at what is changing in the patios or in the table. If students are having difficulty coming up with an equation, encourage them to look back at their verbal representation or the pattern in the table.

4. As students make their graphs, note whether they are connecting the points. This is a good time to question whether the data are continuous or discrete. It is also a good time to bring up ideas of domain and range.
5. As students work on finding a relationship between the side length and the number of frames and corners, you may need to suggest they look for hints in the patterns already completed. You may also suggest that they look at a graph to see whether it is more like the border stabilizers or the tiles.
6. Lead a whole-class discussion in which students summarize or share ideas on how to go from one representation to another, especially on how they arrived at their equations. Then, discuss questions 5, 9, 10, 11, and 12, which made connections between different representations of the same relationship and had students determine whether a relation represents a function as well as challenged them to a couple of patterns that were more difficult to generalize.

Assessment

- **Questions**
  - How did you take each pattern in the patio problem and turn it into an algebraic equation?
  - What is another situation that would have a pattern or graph like the relationship between the side length of a square patio and the number of tiles?
  - What is another situation that would have a pattern or graph like the relationship between the side length and the number of border stabilizers?
- **Journal/writing prompts**
  - Explain what information someone can gain from looking at each kind of representation (verbal, table, graph, and equation) explored in this task.
  - Given one representation of a function. How might you represent it in another way? *(Note: You may leave this prompt open ended or name a specific representation(s) for your students to relate.)*
- **Other Assessments**
  - Give students a variety of representations of several different situations. Have students match the verbal explanation, table, graph, or equation with each situation.

Extensions and Connections (for all students)

- Have students rewrite their equations using function notation. Then have students use them to solve for various domain values.
- Explore the domain and range values for each of the situations.
- Students can use graphing calculators to verify their equations using features that determine the curve of best fit for each table of values.
- Give other concrete patterns that will allow students to see the changes in each step and then transfer those ideas to other representations.

Strategies for Differentiation

- Have students divide a sheet of paper into four sections and label the sections "Verbal," "Table," "Graph," and "Equation." In each section, have students represent the same function in the specified representation.
- Depending on the needs of individual students, square patio questions can be reduced.
- Have students only find relationship between the side lengths and the number of tiles.
- Have the patio pieces already put together for the students.
- Allow students to use a graphing calculator to make and visualize their graphs.
- Arrange students in groups and scaffold the lesson. First, build the patio with only tiles and then complete the table. Second have students add the frame to each tile and complete the table. Third, add order stabilizers, then complete the table.

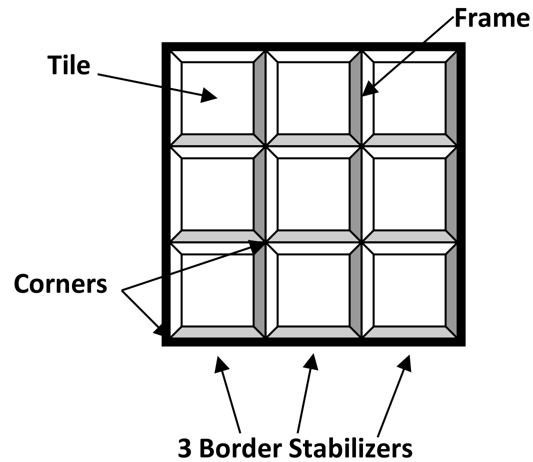
Note: The following pages are intended for classroom use for students as a visual aid to learning.

Building Square Patios

Name ___________________________________ Date________________________

Materials for each group

- 30 construction paper squares, each cut to the length of a wooden toothpick, to use as tiles
- 45 wooden toothpicks to use as frames on the inside of the square patio
- 40 miniature marshmallows to use as corners
- 30 colored toothpicks to use as border stabilizers on the outside edges of the square patio



Directions

1. Using the materials above, build models of the first *five* square patios listed in the chart below. Record your data in the chart.

Side length	Number of Tiles
1	
2	
3	
4	
5	
6	
7	
10	
x	

2. Looking at the number of tiles in each of your patios, predict and write in the chart how many tiles would be in a 6 x 6 patio, a 7 x 7 patio, and a 10 x 10 patio. Explain how you arrived at your answers.

3. Now, fill in the number of tiles needed for a square patio with a side length of x units, and explain how you arrived at your answer.

4. Create a graph showing the different side lengths and the number of tiles in each square patio. Which variable is independent, and which is dependent? Write an equation that uses x for the independent variable, y for the dependent variable, and relates the two.

5. You have created multiple representations for the relationship between the side length of a square patio and the number of tiles needed (table, graph, and equation). Is this relationship a function? How do you know?

6. Next, fill in the number of border stabilizers needed for each of the five square patios you built. Do you see a pattern? If so, use this pattern to predict the number of border stabilizers needed for a 6 x 6 patio, a 7 x 7 patio, and a 10 x 10 patio. Explain how you arrived at your answers.

7. Now, fill in the number of border stabilizers needed for a patio with a side length of x units, and explain how you arrived at your answer.

Side Length	Number of Border Stabilizers
1	
2	
3	
4	
5	
6	
7	
10	
x	

8. Create a graph showing the different side lengths and the number of border stabilizers needed for each patio. Which variable is independent, and which is dependent? Write an equation that uses x for the independent variable, y for the dependent variable, and relates the two.

9. You have created multiple representations for this relationship (table, graph, and equation). How could you use the graph and equation to predict the number of border stabilizers needed for a 16 x 16 patio?

10. Compare the two different graphical representations you have made. What do you notice?

11. Can you find a relationship between the side length and the number of corners? If so, what is the equation that relates the independent and dependent variables?

Side Length	Number of Corners
1	
2	
3	
4	
5	
6	
7	
10	
x	

12. Can you find a relationship between the side length of the square patio and the number of frames? If so, what is the equation that relates the independent and dependent variables?

Side Length	Number of Frames
1	
2	
3	
4	
5	
6	
7	
10	
x	