Geoboard Squares

Lesson Topic

Squares and patterns

Grades

2–3

Lesson Length

50 minutes

NCTM Standards Addressed

- Make and test conjectures about geometric properties and relationships and develop logical arguments to justify conclusions.
- Build and draw geometric objects.
- Create and describe mental images of objects, patterns, and paths.
- Relate ideas in geometry to ideas in number and measurement.

Sample State Standards Addressed

- Compare measurable characteristics of different objects on the same dimensions (e.g., time, temperature, area, length, weight, capacity, perimeter).
- Determine the measurement of objects with non-standard and standard units (e.g., U.S. customary and metric).
- Name and label geometric shapes in two and three dimensions (e.g., circle/sphere, square/cube, triangle/pyramid, rectangle/prism).
- Build geometric shapes using concrete objects (e.g., manipulatives).
- Draw two- and three-dimensional geometric shapes and construct rectangles, squares, and triangles on the geoboard and on graph paper satisfying specific criteria.

Student Objectives

Students will:

- create squares of different sizes on a geoboard
- find and describe a pattern
- use the pattern to determine the number of squares possible on a 10-by-10 geoboard.

Grouping for Instruction

- Whole class for launch and closure
- Small groups of four or five for the investigation

Overview of Lesson

Students create squares with a horizontal base (and vertical sides) on a geoboard. They are guided to find a pattern to the number of such squares that can be created on a geoboard of various sizes (one-by-one, two-by-two, etc.). Students then use the pattern to predict how many such squares can be created on a four-by-four (five pin) geoboard. Their result can be tested using the geoboard. They then make a conjecture concerning how many such squares can be created on a 10-by-10 (11 pin) geoboard.

Background Information

Students should have played with a geoboard prior to this investigation. Students need to know what a square is and the concept of dimensions (length and width). They need to be familiar with the square numbers so they can recognize the pattern. (This could be accomplished prior to this lesson by using multi-link cubes to create representations of squares and being guided to discover that each square number is the sum of one or more consecutive odd numbers starting at one. For example, $9 = 1 + 3 + 5$.) Students need to be able to find larger square numbers.

Materials and Equipment

- At least one geoboard and rubber bands for each team
- Geoboard for overhead projector
- Overhead projector

Procedure

A. Motivation and introduction

1. Ask students: “Have any of you ever seen a ceramic tile floor?” (Wait for response.) Say: “Ceramic tiles are very hard. If the number of tiles needed to tile a floor does not fit perfectly you must break tiles to make them fit. This sometimes results in tiles that cannot be used because they do not break as planned. If possible, you want to tile the floor without having to break tiles to make them fit. In our next investigation we will look at how we can determine the number of different sized tiles you will need to tile various sizes of square rooms. We will simulate this situation using the geoboards. Since we may decide to tile only part of the floor and use hardwood flooring for the remainder of the room, we will also consider squares that do not tile the floor perfectly.”
2. Demonstrate how to create a square on an overhead geoboard.
3. Discuss the concepts of vertical and horizontal and state: “Since we want to tile the floor, we will only use square tiles with a horizontal base and vertical sides.”
4. Put on the overhead projector a square composed of 16 small squares. Ask: “How many squares do you see?” (A student will probably say 16.) Say: “If we use small tiles it

would take 16 small tiles to cover the floor. This will require a lot of work. Could we use larger squares?"

5. Place a colored two-by-two square over the transparency of the four-by-four grid. Show how sliding the two-by-two square around the grid shows other two-by-two squares "hidden" on the grid. Ask: "Do you see how you could use this approach to find the number of squares of various dimensions that could be created on the grid?"
6. Say: "Let's explore in teams and see if we can find a rule that can be used to determine the number of squares that can be made."

B. Development (including discussion points and feedback)

1. Place the students in heterogeneous cooperative groups of four or five students.
2. Assign a task to each person in a team (leader, recorder, reporter, etc.).
3. Distribute and discuss the project on geoboards and squares (Worksheet: Geoboards and Squares, page 92).
4. Ask each team to complete this project. Circulate among the groups, guiding them to complete the project.
5. Ask each group to report to the class what they did and what conjecture they made. Say: "Did you find any connections between this project and anything we learned earlier?" Generate discussion on how square numbers were used in this investigation.

C. Summary and closure

1. Ask students to complete a one-minute paper stating one thing they learned from this lesson.
2. Ask some students to share their responses.
3. Ask students which size squares could be used to completely cover the four-by-four geoboard. Have them explain their reasoning.

D. Assignment

Ask the students to consider how many rectangles could be formed on a four-by-four geoboard. They should bring their answers and how they found their answers to the next class.

Assessment

- Observe the students during the group project. Use note cards or adhesive notes to record how they are working in their group and whether the students made a connection to the previous work on square numbers.
- Grade the group work sample, the performance (presentations), or the homework.
- Ask students to respond about what they learned or what they found difficult about the project in their mathematics journal.

Worksheet: Geoboards and Squares

Problem Statement: Let the distance between pins on a row or column be 1. Then the dimensions of your geoboard are 4-by-4. How many squares with horizontal and vertical sides can you make on the geoboard? On a 10-by-10 geoboard?

1. **Define (understand) the problem**.

   Restate this problem in your own words.

2. **Devise a plan.**

   This is a very difficult problem. Create a similar, simpler problem. State the problem in the space below.

   Solve your similar, simpler problem.

   It may help to solve several similar, simpler problems and look for a pattern. Use part of your geoboard to find the number of different size squares with vertical and horizontal sides and total number of such squares for the different size geoboards shown in the table. Complete the table.

3. Carry out the plan.

Complete the table:

Geoboard Size	Square Dimensions				Totals
	1-by-1	**2-by-2**	**3-by-3**	**4-by-4**	
1-by-1	1	----------	----------	----------	1
2-by-2					
3-by-3					

Describe any patterns you found.

Use the patterns to find the total number of squares with vertical and horizontal sides that you can form on your 4-by-4 geoboard.

Use the patterns to find the total number of squares with vertical and horizontal sides that you can form on a 10-by-10 geoboard.

4. Looking back

How could you convince someone that your answer is correct?

What have you learned about problem solving from this investigation?