What shape do bees use to build their honeycomb? How is this shape efficient for bees?

STANDARD BENCHMARKS AND VALUES

**Science**
Next Generation Science Standards

5-ESS3-1 Earth and Human Activity
Obtain and combing information about ways individual communities use science ideas to protect the Earth's resources and environment.

Hawaii Content & Performance Standards
Standards 2: Nature of Science: Understand that science, technology and society are interrelated.

Unifying Concepts and Themes: SC.5.2.1 use models and/or simulations to represent and investigate features of objects, events and processes in the real world.

**Math**
Common Core State Standards

5.G.3 Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category. For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.

**Standards of Mathematical Practice (SMP)**

SMP 3 Construct viable arguments and critique the reasoning of others

SMP 4 Model with mathematics

SMP 7 Look for and make use of structure

**Art**
Hawaii Content & Performance Standards

Standard 1: Visual Arts: Understand and apply art materials, techniques and processes in the creation of works of art and understand how the visual arts communicate a variety of ideas, feelings, and experiences.

FA 5.1.1: Use the principles of art and design, including unity and harmony in works of art.

FA5.1.3: Analyze, use evidence, the characteristics of representational and/or non-representational art

FA5.1.4: Explain how an original artwork demonstrates a concept or idea from another discipline.

Nā Ala ‘Ike: ‘Ike Kuana‘ike (Worldview Pathway)
ENDURING UNDERSTANDING
• Honeycombs are geometrically designed.
• A honeycomb cell is geometrically designed for economical efficiency.

CRITICAL SKILLS AND CONCEPTS
At the end of the lesson, students should be able to:
• Determine and identify the best geometrical shape for a honeycomb.
• Explain why the honeybee uses a specific geometrical design.
• Explain how the hexagon is an economically efficient shape for the honeycomb.
• Create a honeybee hive/comb to demonstrate effective use of hexagonal design.
• Make conjectures and critique the mathematical thinking of others.
• Justify, construct and communicate arguments by using examples and non-example.
• Justify, construct and communicate arguments by using objects, drawings, diagrams and actions
• Critique the reasoning of others by listening, comparing arguments, identifying flawed logic and asking questions to clarify or improve arguments.
• See and understand how numbers and spaces are organized and put together as parts and wholes
• Recognize math in everyday life and use math to solve everyday problems.

AUTHENTIC PERFORMANCE TASK:
Demonstrate how various shapes result in different efficiency models.
Construct a honeycomb using a hexagonal design.

AUTHENTIC AUDIENCE:
Showcase honeybee combs and hives at Spring Showcase for the following: parents, teachers and students in other classrooms and grade levels.

OTHER EVIDENCE:
Science journals, diagrams, charts, models,
Pre and post test.
LEARNING PLAN

1. After several discussions about bees (e.g. bee anatomy, bee behaviors – bee dance, pollination, environmental impact and honey making) begin lesson on the bee honeycomb.

2. Ask, “How important do you suppose the shape of the cells in the honeycomb are for the bees?”

3. First address the shape of the bee’s body and the design of the cell. Demonstrate/show video of how a honeybee needs to fit into the honeycomb cell (https://blossoms.mit.edu/videos/lessons/why_beehive_honeycombs_have_hexagonal_shape). Then guide students to discover what shape the bee’s body best represents. Guide students to understand that the bee’s body is long and cylindrical.

4. Ask students, “What type of shape do you suppose would be the best shape to use for the cell of the honeycomb?”

5. Guide students to select the circle as the best shape because the bee’s body is long and cylindrical. Ask, “Would a circular cell design fit the body of a bee?” (Students should be able to realize that circles help the bee fit its body into the cell).

6. Now talk about efficiency for the bees. Explain that bees need to consume 8 oz. of honey to produce 1 oz. of wax so they need a design that could hold the largest possible amount of honey using the least amount of wax.

7. Have students align pieces of M&Ms (or any other circular candy such as Skittles or Reese’s Pieces) side by side. Talk about what they notice about how the candy aligns together. (Guide students with questions such as, “Do the M&Ms fit perfectly next to each other? Are there any spaces between the M&Ms?”)

8. If there were spaces, would this be the most efficient shape for the bees to use? Have students explain and justify their answer.

9. What other shapes could a bee use besides a circle? Have students come up with a variety of other shapes that do not have spaces between the shapes. Do they fit snugly together? In groups, have students play with different shapes of pattern blocks (except for the hexagon – take these out). Students can align the pattern blocks so they are next to each other and initiate a bee cell. Have students work in groups and use various shapes from pattern blocks and put the shapes together to form a honeycomb within a given area (put down a paper to show the size of the honeycomb you want) using the various shapes.

10. Ask them to look at their shapes, designs and think about the question about the shape of a bee’s body and the amount of wax and honey needed to make a cell. Then ask, “What shape would give the most space to store honey, and use the least amount of wax?”

11. Have students answer the following questions in their groups include their M&M circle design- “Would a bee choose any of these shapes as a good honeycomb design?” Make sure students are able to explain their responses. Students should be able to identify that the characteristics of the polygons does not fit the bee’s body (for example, the right angles of a square would not be viable for the bee to fit perfectly in. Or the angles of the triangle and the amount of sides constrict the bee’s body from fitting in the shape). Guide students to see that when circles are lined around each other, there are six similar circles around each circle. If the middle points of the empty spaces between them are connected to the points where they touch each other, we would have a hexagonal polygon.
12. Using the information that you discovered today (that bee’s bodies are cylindrical, that circle is the best fit for the body but doesn’t fit snugly next to each – there’s spaces between circles, that other shapes have edges and angles that help it to fit snugly like a puzzle), ask students “using the characteristics of other shapes, how could we modify the circle to make the most of the given space to fit the most efficient amount of cells in a given spot?” Guide them to modifying the circles to create edges. If they use the pattern blocks, they should be able to put 2 trapezoids together to form a hexagon. The hexagon looks the most like a circle.

13. Have students in groups share out their ideas. What did students discuss? Elicit them to justify their answers using the pattern block models or demonstrating in some way to explain their answer.

14. Explain that there are 3 potential shapes that self-tessellate: the square, triangle and hexagon. Have students calculate the area of the following shapes: a triangle, square, trapezoid.

**Formula for the area of a triangle:**
\[ \frac{1}{2} \text{ base} \times \text{ height} \]

**Formula for the area of a square:**
\[ \text{side} \times \text{side} \]

**Formula for the area of a hexagon:**
\[ 6 \left( \frac{1}{2} \times (\text{base} \times \text{height}) \right) \]

Calculations should show that the hexagon has the most storage space for honey. Also provide guiding questions for students to discover the formula for the hexagon is made up of 6 triangles. They can also look at the trapezoid formula as well since a hexagon is made up of 2 trapezoids.

15. Show video about maximum amount of space bees’ use within a given area.
   1) *Are Bees Nature’s Greatest Math Geeks?*
      Beekeeping with Maddie #4 url - https://www.youtube.com/watch?v=ebVCmXdvl44
   2) *Why do honeybees love hexagons?*
      Zack Patterson and Andy Peterson TED Ed. URL - https://www.youtube.com/watch?v=QEzlsjAqADA

16. Ask students to create a honeycomb using the hexagon pattern blocks.
PERFORMANCE TASK

1. Students will create/design their own beehive using paper mache to create the outside of their beehive
2. Cut a portion out of the beehive and have students create their hexagonal cells in the beehive using pattern blocks
3. Students can also create their own bees using pipe cleaners. They can create both queen bees, which have a longer body, and drone and worker bees to put inside and outside their hives.

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<th>Assessment</th>
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<td>• Taking data of the population of bees in their garden</td>
<td>• Application of natural resources and Human and Nature relationship</td>
<td>• Formative feedback from peers and teacher during class discussions</td>
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<td></td>
<td>• Graphing the population of bees</td>
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<td>• Presented evidence from data and graphs in groups and individual assignments</td>
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<tr>
<td>SC.5.2.1 - use models and/or simulations to represent</td>
<td>• Create structures that represent key concepts.</td>
<td>• Economical efficiency</td>
<td>• Group work: formative feedback on self reflections</td>
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<td>and investigate features of objects, events and</td>
<td>• Analyze information to make key connections.</td>
<td>• Tessellation</td>
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<td>processes in the real world.</td>
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<td>• Collaborative conversations</td>
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<td>5.G.3 - Understand that attributes belonging to a</td>
<td>• Synthesizes content and ideas using multiple resources.</td>
<td>• Mathematical designs in nature</td>
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<td>category of two-dimensional figures also belong to all</td>
<td>• Analyze the information to make key connections.</td>
<td>• Area</td>
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<td>• Characteristics of shapes</td>
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<td>Standard 1 - Visual Arts: Understand and apply art</td>
<td>• Appropriate use of art materials to demonstrate understanding of</td>
<td>• Tessellations</td>
<td>• Formative feedback during group work rubric.</td>
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<td>5-ESS3-1 Earth and Human Activity</td>
<td>Data was used appropriately from multiple resources to connect resources and environment to community.</td>
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<td>Data was used but connections are somewhat unclear.</td>
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<td>SC.5.2.1 - use models and/or simulations to represent and investigate features of objects, events and processes in the real world.</td>
<td>Able to understand the relationship between shapes of the honeycomb. Also is able to make connections between models and natural world and able to justify reasoning with evidence.</td>
<td>Able to understand the relationship between shapes of the honeycombs and can explain the relationship using models.</td>
<td>Able to understand the relationship between the shapes of the hives, but is not able to support their thinking with evidence.</td>
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<td>Able to calculate the area of each shape and determine the most efficient model. Also can explain and justify their reasoning with appropriate data.</td>
<td>Able to calculate the area of each shape and can determine and somewhat explain what the most efficient model is.</td>
<td>Able to calculate the area of a few shapes but is not able to determine and explain what the most efficient model is.</td>
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<td>Standard 1 - Visual Arts: Understand and apply art materials, techniques and processes in the creation of works of art and understand how the visual arts communicate a variety of ideas, feelings, and experiences.</td>
<td>Able to accurately demonstrate their understanding of hexagonal hives and is able to explain why the hive is efficient using multiple resources to justify their answer</td>
<td>Able to accurately demonstrate their understanding of hexagonal hives and can explain why the hive is efficient.</td>
<td>Able to accurately demonstrate their understanding of hexagonal hives but lacks a clear explanation of why the hive is efficient.</td>
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