The Buzzing Mathematician: Discovering the Secrets of Honeybees

Materials Needed

- Paper (plain and graph/grid paper)
- Pencil, eraser, and colored pencils or markers
- Ruler and protractor
- Scissors
- Calculator (optional)
- Stopwatch or a phone with a timer function
- Small, uniform objects for tessellating (e.g., pennies, hexagonal nuts from a hardware store, or pre-cut paper shapes: squares, triangles, hexagons)
- Tape measure or yardstick
- Access to the internet for short video clips (optional, links provided)

Overall Learning Objectives

Upon completing all segments of this lesson, the student will be able to:

- Identify and describe the geometric properties of a hexagon and explain why it is an efficient shape for building.
- Apply knowledge of angles and coordinates to interpret and create maps based on bee communication (the "waggle dance").
- Use the formula for speed (Speed = Distance / Time) to solve real-world problems related to bee flight.
- Connect mathematical concepts to biological phenomena, fostering an appreciation for math in the natural world.

Corresponding IB Learner Profiles

- **Inquirers:** Students will develop their natural curiosity by asking questions and conducting hands-on investigations into the world of bees.
- **Knowledgeable:** They will explore concepts and ideas that have local and global significance, understanding the importance of bees in our ecosystem.
- **Thinkers:** Students will apply critical thinking skills to solve geometric and algebraic problems presented in the context of a beehive.
- **Communicators:** They will express their understanding of mathematical concepts through drawing, explaining their reasoning, and completing activities.

Segment 1: The Perfect Honeycomb (Geometry & Efficiency)

Duration: 30-45 minutes

Introduction (5 minutes)

Teacher: "Have you ever looked closely at a honeycomb? It's made of perfect six-sided shapes called hexagons. Bees are incredible architects! Today, we're going to be geometric detectives and figure out *why* bees choose the hexagon. Why not circles, or squares?"

Activity: The Shape Challenge (20-25 minutes)

1. **Preparation:** Use pre-cut paper shapes (squares, equilateral triangles, and hexagons of roughly the same area) or have the student cut them out. Aim for about 15-20 of each shape.
2. **The Task:** Ask the student to act as a "builder bee." Their goal is to create a honeycomb-like structure using each of the shapes, one shape at a time. The rule is that there can be no gaps between the shapes. This process is called "tessellation."
3. **Investigation:** As they build, ask guiding questions:
    - "Which shapes fit together perfectly with no gaps?" (The student should discover that squares, triangles, and hexagons tessellate.)
    - "Now, let's think about the building material, which for bees is wax. Which shape do you think uses the *least* amount of wax (perimeter) to hold the *most* amount of honey (area)?"
4. **Measurement:** Have the student take one of each shape (square, triangle, hexagon). They will measure the length of one side of each and calculate the total perimeter (sum of all sides). Discuss how the hexagon provides the most storage space for the shortest shared wall length, making it the most efficient and strongest shape. Bees figured this out millions of years ago!

Wrap-up and Discussion (10 minutes)

Review the findings. Conclude that the hexagon is the "winner" because it tessellates perfectly and is the most efficient shape for storing honey and building a strong hive. The student can draw their own perfect honeycomb using a ruler.

Differentiation:

- **Support:** Provide the shapes pre-cut and focus only on the tessellation part of the activity, visually demonstrating why the hexagon leaves no gaps compared to a circle.
- **Challenge:** Introduce the concept of interior angles. Have the student use a protractor to measure the interior angles of each shape and discover that tessellating shapes have angles that add up to 360 degrees when they meet at a vertex.

Segment 2: The Waggle Dance (Angles & Coordinates)

Duration: 30-45 minutes

Introduction (5 minutes)

Teacher: "How do you think a bee tells its friends where to find the best flowers? They can't talk or text! They do a special 'waggle dance.' It's a secret code that gives two pieces of information: the direction of the flowers and how far away they are. Today, you're going to learn to crack the code."

(Optional: Watch a 1-2 minute video of the bee waggle dance online).

Activity: Decoding the Dance (25-30 minutes)

1. **Set up the "Field":** On a piece of graph paper, draw a beehive at the center (the origin, 0,0). Draw a sun at the top of the page to represent the reference point.
2. **Explain the Code:**
    - **Direction:** The angle the bee dances away from a straight vertical line inside the dark hive represents the angle the other bees must fly away from the sun outside. For example, a dance 30° to the right of the vertical line means "fly 30° to the right of the sun."
    - **Distance:** The length or duration of the "waggle" part of the dance tells the distance.

We'll simplify this: 1 second of waggling = 1 kilometer (or 10 squares on our grid).

3. **Decoding Missions:** Give the student "field reports" from a dancing bee.
    - **Mission 1:** "The scout bee waggles for 2 seconds at an angle of 45° to the left of the vertical." The student uses a protractor to measure a 45° angle to the left of the sun's line and a ruler to draw a line 20 squares long (2 km) to find the location of the "poppy field." They can mark it with a colored dot.
    - **Mission 2:** "The scout bee waggles for 3.5 seconds at an angle of 90° to the right of the vertical." The student finds the "sunflower patch."
4. **Encoding Mission:** Place a sticker of a flower on the graph paper. Ask the student to figure out the dance moves (angle and duration/distance) the bee would need to perform to guide its friends there.

Wrap-up and Discussion (5 minutes)

Discuss how amazing it is that bees use a complex system of geometry and communication to work together. How is this similar to or different from how humans give directions?

Differentiation:

- **Support:** Pre-draw the angle lines on the graph paper and have the student only focus on measuring the distance along those lines.
- **Challenge:** Use more complex angles (e.g., 150°) and introduce the idea of a compass rose (N, S, E, W) in relation to the sun's position.

Segment 3: Bee Velocity (Speed, Distance & Time)

Duration: 30-45 minutes

Introduction (5 minutes)

Teacher: "We know where the flowers are, but how fast does a bee have to fly to get there and back? Bees are incredibly fast fliers. Today we'll become physicists and calculate the speed of bees, and even compare it to our own!"

Activity: How Fast is a Bee? (25-30 minutes)

1. **Formula Introduction:** Introduce the core formula: **Speed = Distance ÷ Time**. Explain each part. You can rearrange it too: Distance = Speed × Time, and Time = Distance ÷ Speed.
2. **Measure Your Own Speed:** Use a tape measure to mark a distance (e.g., 20 feet) in a hallway or outside. Use a stopwatch to time how long it takes the student to walk, then run, that distance. Use the formula to calculate their walking and running speed in feet per second.
3. **Bee Facts:** Share some data: A honeybee's average speed is about 15 miles per hour (which is about 22 feet per second).
    - **Comparison:** How does the student's running speed compare to a bee's flying speed?
4. **Problem Solving:** Provide word problems using the formula.
    - "If the sunflower patch from our waggle dance map is 3 miles away, how long would it take a bee flying at 15 mph to get there?" (Time = Distance / Speed -> 3 miles / 15 mph = 0.2 hours. How many minutes is that? 0.2 x 60 = 12 minutes).
    - "A bee has been flying for 30 minutes (0.5 hours). If it maintains its average speed of 15 mph, how far has it traveled?" (Distance = Speed x Time -> 15 mph x 0.5 hours = 7.5 miles).

Wrap-up and Discussion (5 minutes)

Review the calculations. Discuss the factors that might change a bee's speed (wind, carrying heavy pollen, tiredness). This connects the abstract math to real-world physics.

Differentiation:

- **Support:** Use a calculator for the computations and focus on understanding the relationship between the three variables. Use simpler numbers (e.g., a bee flies 10 miles in 1 hour, what is its speed?).
- **Challenge:** Introduce unit conversions. For example, convert miles per hour to feet per second to make a more accurate comparison with the student's own speed. (1 mile = 5280 feet, 1 hour = 3600 seconds).