Title: Inner Foam: The Science of Material and Packing Efficiency

Topics: geometry, packing efficiency

Related Disciplines: mathematics, engineering

Objectives:

A. Learn about bubbles and how spherical shapes like bubbles share walls and become faceted shapes when pushed together.
B. Discuss the minimization of material use and how that is useful and practical through real-world examples.

Lesson:

A. Introduction (20 minutes)

This is a scripted lesson plan. Pictures are included in the attached PowerPoint presentation. Feel free to adapt the script to best support the needs of your students.

- This lesson is about the mathematical patterns and efficient structures we find in nature.
- From geometry, we know that if we are trying to maximize surface area while minimizing the perimeter of a shape, we would select a circle.
- Does anybody have any guesses as to what the most efficient shape in three dimensions would be? (Answer: Sphere!)
- But, what happens when you have more than one object and you aren't interested in only one object's area, perimeter, or surface area? That's where packing efficiency comes in.
- When we pack circles together, we create gaps between the shapes. This wastes a lot of space!
- Have you ever looked at a beehive and wondered why the hive has thousands of hexagonal holes and not some holes based on some other shape, such as a circle or a square? This is because hexagons are a much more efficient shape for packing!
- Well, what happens if we want to pack shapes in three dimensions, not just two?
- In 1887, a man named Lord Kelvin asked how space could be partitioned into cells of equal volume with the least area of surface between them. He came up with the tetrakaidekahedron.
- Many modern packing structures use two other highly efficient 3D shapes: the dodecahedron and the Weaire-Phelan structure.
- Bubbles perfectly capture the magic of 3D packing efficiency. Let's watch this video to learn more: https://www.youtube.com/watch?v=GKvT1lRWhE0

B. Class Project (40 minutes)

Part One: Play with bubbles! If you are adventurous and want to figure out how to do the demo in the above video, it would be a very cool experience for your students.

Part Two: Have your students create paper models of dodecahedrons using the templates below. Then, glue or tape them together to illustrate packing efficiency. Note that the first template has no tabs for taping or gluing the model together, but the second template does include tabs to aid in construction.

C. Conclusion (10 minutes)

To conclude the class, ask for the students' input on the following questions:

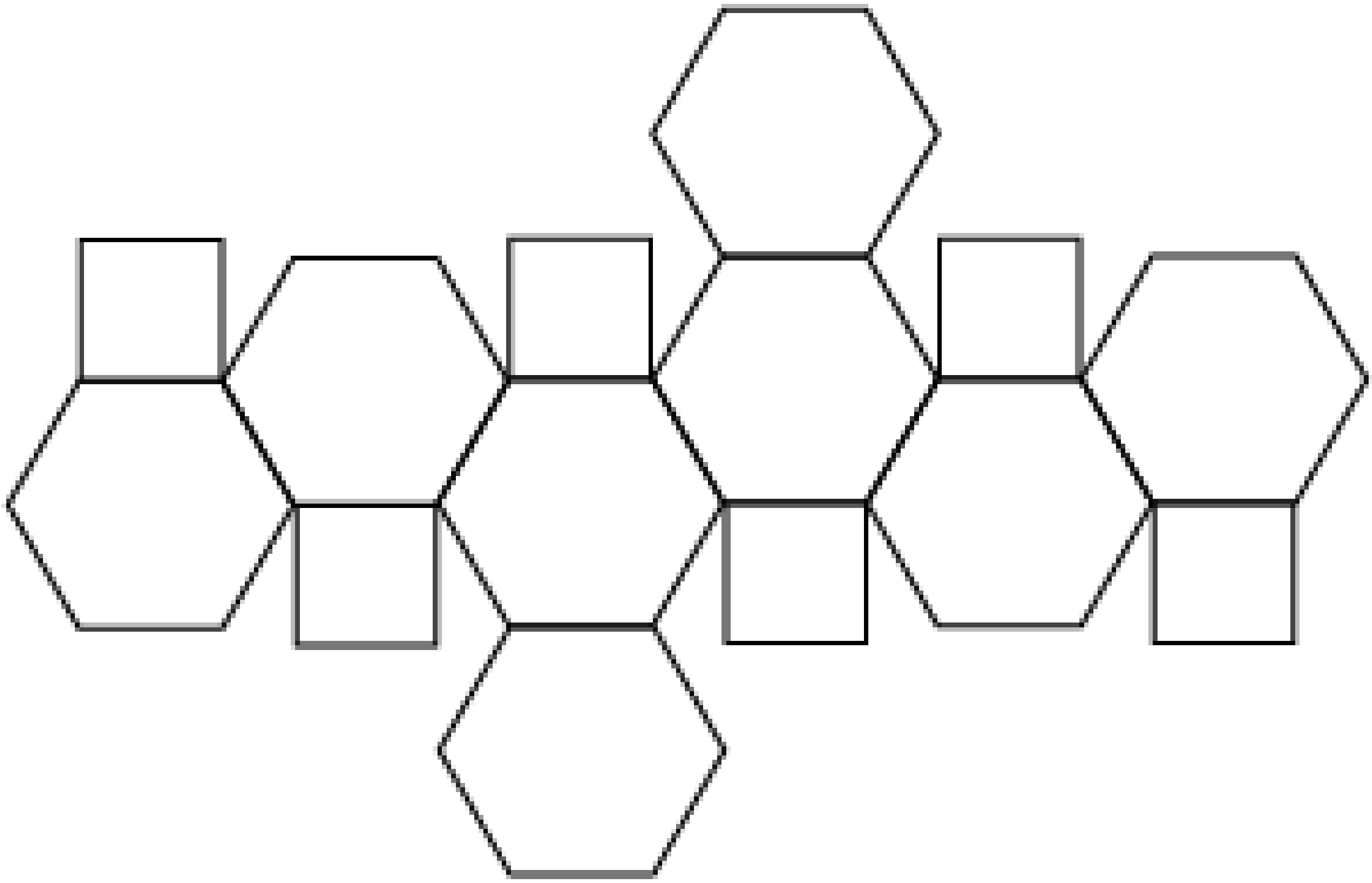
1. What was the most interesting thing you learned today?
2. Which activity did you like better?
3. What do you think happens when you pack shapes of unequal size?

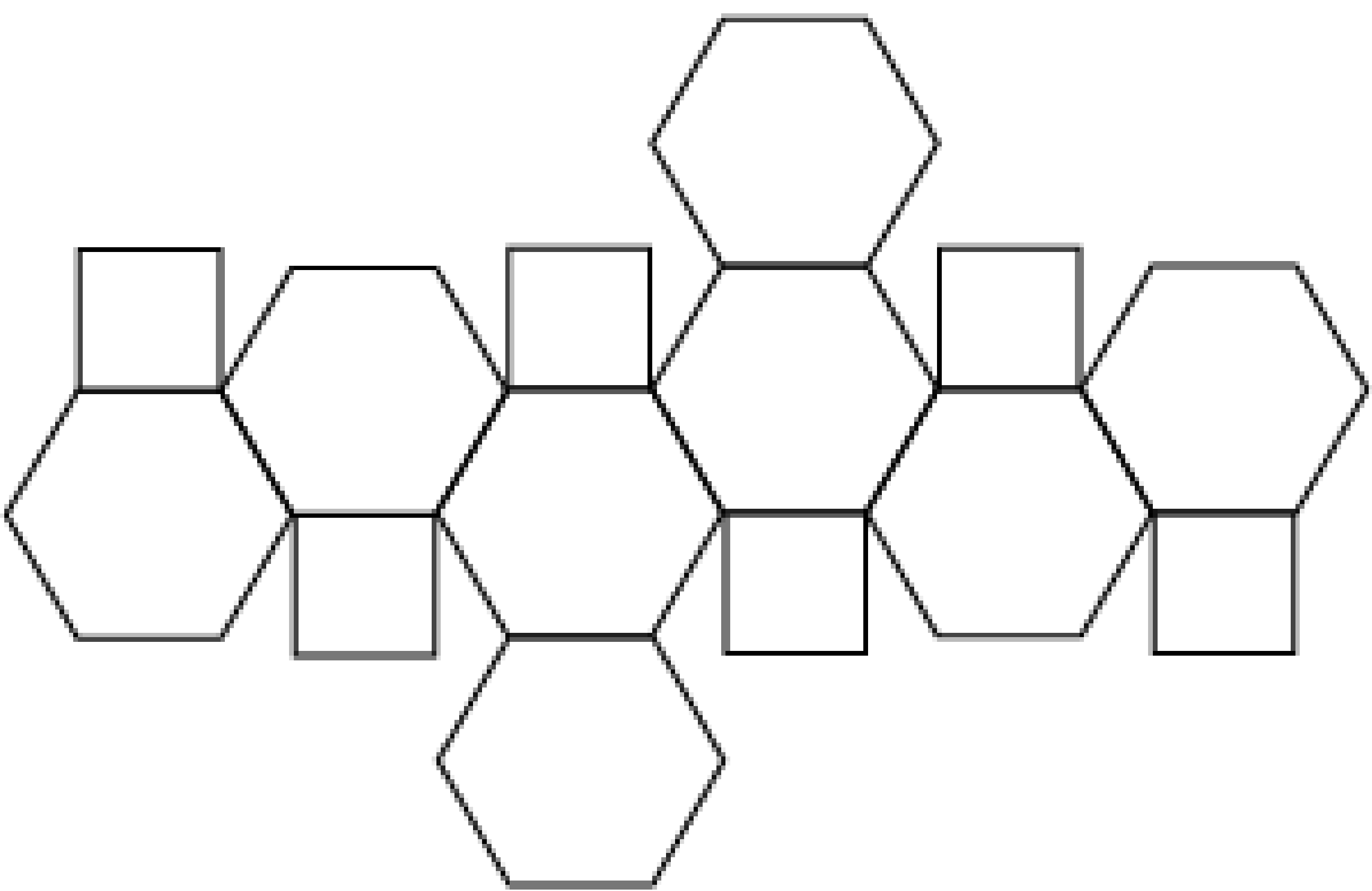
Homework:

1. Blow bubbles and see what complicated shapes you can make inside the bubbles.
2. Find a new complex shape and learn its history.
3. Research packing efficiency in beehives, atoms, and molecules.

Further Reading:

http://3.bp.blogspot.com/-nL9Wkd1PNaE/TYhS_S8_JtI/AAAAAAAAAO0/_qAnTc9aFqE/s400/jlcirclepackings \
https://st.hzcdn.com/simgs/28f145a307979c66_4-5993/transitional-decorative-objects-and-figurines.jpg





Truncated Octahedron