Lesson Plan: The Snack Pack Challenge - Optimising Volume & Surface Area

Materials Needed:

- A4 paper or thin cardboard (cereal boxes work well)
- Ruler
- Pencil
- Scissors
- Sticky tape
- Calculator
- A small, irregular item to be "packaged" (e.g., a handful of LEGO bricks, 20 marbles, a small toy car, a piece of fruit)
- Optional: A real-world example of a rectangular prism (e.g., tissue box) and a cylinder (e.g., a can of soup) for initial exploration.

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1. Learning Objectives

By the end of this lesson, the student will be able to:

- Calculate the surface area and volume of rectangular prisms, triangular prisms, and cylinders.
- Apply these calculations to solve a practical design problem.
- Analyse and compare the material efficiency of different 3D shapes.
- Justify a design choice using mathematical evidence.

2. Alignment with Australian Curriculum (ACARA) - Year 9 Mathematics

- **AC9M9M01:** Solve problems involving the surface area of right prisms and cylinders.
- **AC9M9M02:** Solve problems involving the volume of right prisms and cylinders.

3. Lesson Activities & Instructional Strategy

Part 1: The Hook - The Designer's Dilemma (10 minutes)

Teacher's Role: Present a scenario.
"Imagine you're a packaging designer for a brand new, popular snack. Your boss has given you a challenge: create a package that holds the product perfectly but also saves the company money by using the least amount of cardboard possible. Using less material is also better for the environment!"

Student Activity: Look at the two real-world examples (e.g., tissue box and soup can). Discuss:

- Which one do you think holds more? Why?
- Which one do you think uses more material to make? Why?
- How could we use maths to know for sure, instead of just guessing?

This introduces the core concepts of **Volume** (the space inside) and **Surface Area** (the material used to build it).

Part 2: Tool Up - Quick Formula Review (15 minutes)

Teacher's Role: Guide the student through a quick, practical review of the necessary formulas. Don't just write them down; connect them to a physical object.

Student Activity: Measure the dimensions of the tissue box and the soup can. Together, calculate the Volume and Surface Area for each.

- **Rectangular Prism (Tissue Box):**
    - Volume = length Ã— width Ã— height
    - Surface Area = 2(lw + lh + wh)
- **Cylinder (Soup Can):**
    - Volume = Ï€ Ã— radiusÂ² Ã— height
    - Surface Area = 2Ï€rÂ² + 2Ï€rh

Discuss the results. Was the initial guess from Part 1 correct?

Part 3: The Main Event - The Snack Pack Design Challenge (45-60 minutes)

Teacher's Role: Set the challenge parameters and act as a guide or "client" for the student's design firm.

The Challenge:

1. **Choose Your Product:** Select the item to be packaged (LEGOs, marbles, etc.). This item must fit snugly inside the final design.
2. **Design & Calculate (Round 1):** Design your first package on paper. It could be a rectangular prism or a triangular prism. Draw a 'net' (the flat, unfolded version of the shape). Calculate its predicted Volume and Surface Area.
3. **Build & Test (Round 1):** Cut out the net, fold it, and tape it together to create your 3D prototype. Does the product fit?
4. **Design & Calculate (Round 2):** Now, design a *different* shaped package for the same product. Try a cylinder or a different style of prism. Your goal is to keep a similar volume but *reduce the surface area*. Draw the net and calculate the new Volume and Surface Area.
5. **Build & Test (Round 2):** Build your second prototype.
6. **Analyse the Results:** For each design, calculate the **Volume-to-Surface-Area Ratio (V/SA)**. A higher ratio means a more material-efficient design!

Part 4: The Pitch - Justify Your Design (10-15 minutes)

Teacher's Role: Act as the "boss" from the original scenario.

Student Activity: Present your two prototypes.

- Explain which design is the most efficient and why.
- Use your calculations (especially the V/SA ratio) as evidence to support your choice.
- Discuss other factors a real company might consider. For example, a cylinder might be efficient, but a box is easier to stack on a supermarket shelf. A triangular prism looks unique but might waste space in a shipping carton.

4. Differentiation & Extension

- **For Extra Support:** Focus only on rectangular prisms. Provide pre-drawn nets that just need to be cut out and folded, allowing the student to focus on the calculation and comparison.

- **For an Advanced Challenge (Extension):**
    - Introduce cost. If cardboard costs $0.02 per square centimetre, calculate the exact cost of each package.
    - Design a package for a composite shape (e.g., a house shape made of a prism and a pyramid).
    - Investigate why spheres are technically the most efficient shape (highest volume for lowest surface area) and discuss why we don't see many spherical boxes.

5. Assessment

- **Formative (During Lesson):** Observe the student's process. Are they measuring accurately? Are they applying the formulas correctly? Use questioning to guide them if they get stuck.
- **Summative (End of Lesson):** The final "pitch" serves as the primary assessment. Evaluate based on:
    1. The accuracy of the Volume and Surface Area calculations for both designs.
    2. The logical reasoning used to justify the final design choice, supported by mathematical data (the V/SA ratio).
    3. The quality and thoughtfulness of the reflection on real-world design constraints (like stacking and marketing).