Design a Safer Bicycle Helmet **Primary Audience: 6th – 10th Grade**

Description: Participants will explore the design of bicycle helmets to gain an appreciation for the role that helmet layers play protecting the head. They will design a bicycle helmet to meet a specific application, similar to how an engineer would approach the problem, analyze a product to determine the need it was designed to meet and the customer's it was meant to attract, produce, use, and evaluate a prototype of the design solution, describe the personal, impact of the designed product, and communicate the solution to a problem and justify decisions.

Keywords:

Concepts:

- Using a bicycle helmet helps to protect the brain and neck during a crash. In order to do this effectively helmets must have some sort of crushable material to absorb the shock of a collision and a strap system to ensure that the protection stays in place. The exact design of a helmet will depend on the needs and specifications of the user.

Materials:

- Per Demonstration:
  - 2 sample bicycle helmets
  - EPS (polystyrene) or Styrofoam approx. 10" square
  - Thin hard plastic (e.g. cut the plastic from a 2 liter soda bottle to lay flat)
  - One 5 pound weight
  - Scissors
  - Masking Tape
- Per Group:
  - EPS (polystyrene) or Styrofoam approx. 10" square
  - Thin hard plastic (e.g. cut the plastic from a 2 liter soda bottle to lay flat)
  - One 5 pound weight
  - Scissors
  - Masking Tape

Instructions:

Part 1A: THE STRUCTURE OF BICYCLE HELMETS

What's the problem? All helmets contain the same basic parts to protect the head in an accident.

However, helmets are not all alike. They may differ depending on who will use them and for what purpose.

Who wants to know? People who design and manufacture bicycle helmets need to know how to make a helmet protective, functional and marketable at the same time.

1. Ask the students what the purpose of a bicycle helmet is.
2. Ask the students to describe the parts of the helmet. Discuss the purpose of each part.
   - Hard-shell
   - Crushable liner
   - Layer of padding
   - Strap system
   - Vents
3. Pass around the sample bicycle helmets so that the students can identify the parts. Have the students note the sticker from the CPSC (Consumer Product Safety Commission) that shows that the helmet meets a safety standard, or the blue SNELL sticker indicating that the helmet has passed more stringent tests.
4. To reinforce the purpose of the hard shell, conduct the following experiment:
   - From shoulder height, drop the five-pound weight onto a piece of EPS.
   - Pass the EPS or Styrofoam around the class and have the students note the deformation.
   - Cut a piece of plastic (polyester terephthalate (PET)) from a soda bottle and tape it onto another piece of EPS or Styrofoam.
   - Once again drop the weight from shoulder height.
   - Pass this piece of EPS or Styrofoam around the class and have the students comment on the deformation.

Part 1B: DESIGNING A HELMET FOR AN APPLICATION

How can you help solve the problem? Think about the helmet characteristics that are desired for a certain application. By adding these characteristics to the basic helmet, the proper design can be determined for an application.

Part 2: CREATE A POSTER AND CLASS PRESENTATION

Have the students design a helmet to fit the application they are working on and prepare a 2-minute presentation. Each group should create a poster of their helmet design and should be prepared to discuss the choices they made during their presentation. Presenters or teachers will evaluate the project using the score sheet attached.

Will your suggestion(s) work? Examine bicycle helmets that are designed for specific applications. Decide if the classroom design is similar to the commercial product. Check web sites on bicycle safety to see if there are specially made helmets for these applications.

Who can help you solve the problem? Although expanded polystyrene (EPS) is still widely used in helmets, there have been several new types of foam introduced recently. Chemical engineers would be involved in the development of

these new materials. The problem of getting people to wear helmets is an important one. In this regard engineers must be involved in the sales side of the business and not just the design side.
Engineering Summary: Finish with a discussion about how students approached the problem like engineers.[1]

Part 3: Construction of a Safer Helmet Design

Have participants use their designs to construct helmets from various materials. Once completed, have groups test their designs using various dropped weights or dropping the helmets from a specified height. *(FYI: Placing a melon inside the helmet makes the testing even more exciting.)*

Possible Interactive Questions:

- How would you test bicycle helmets to ensure that they are safe?
- After an accident do you need a new bicycle helmet?
- How can the consumer tell if a helmet is safe?

What's Going On?
Each year, nearly 1,000 people die from injuries sustained in bicycle crashes, with head injuries accounting for over 60% of these deaths. In addition, many more people survive non-fatal head injuries resulting from bicycle crashes. While some of these survivors may experience only minor headaches or dizziness, others may suffer profound and disabling neurological difficulties.

One effective way to prevent head injury from these accidents is to use a bicycle helmet. Helmets generally consist of two parts: an impact protection system to absorb the force and a strap system to keep the protective layer in place.

Often three layers are used together to provide impact protection. The outer layer is generally a hard shell or a micro-shell made of fiberglass, Lexan or ABS plastic. This shell serves many purposes: it distributes the force of the collision over a larger area; it allows the helmet to slide thereby causing a slower deceleration; it provides a shield against penetration; and it holds the middle layer together. The middle layer is usually a crushable liner that absorbs the shock of the collision. This layer is generally made of expanded polystyrene, also known as EPS. The inner layer, which may be segmented, helps to ensure proper fit and comfort.

Further Exploration:

1. Have the students research other types of foam that have been used in helmets. These include expanded polyurethane and expanded polypropylene.

[1] Making the Connection, M. Cyr, Tufts University, CEEO, K.M. Samuelsen, Copyright © 2001 WEPAN All Rights Reserved.

2. If the students are more advanced they can design their own experiments to test bicycle helmets for impact resistance and strap strength. They could then test some low priced or used helmets.

Relevant Ohio Science Content Standards:

- Science and Technology K-2 A: Explain why people, when building or making something, need to determine what it will be made of, how it will affect other people and the environment.
    - 1.1: Explore that some kinds of materials are better suited than others for making something new (e.g., the building materials used in the Three Little Pigs).
- Science and Technology K-2 B: Explain that to construct something requires planning, communication, problem solving and tools.
    - 2.4: Communicate orally, pictorially, or in written form the design process used to make something.
- Science and Technology 3-5 B: Describe and illustrate the design process.
    - 3.4: Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions and design a solution).
    - 3.5: Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).
    - 4.3: Describe, illustrate and evaluate the design process used to solve a problem.
    - 5.2: Revise an existing design used to solve a problem based on peer review.
- Science and Technology 6-8 B: Design a solution or product taking into account needs and constraints (e.g., cost, time, trade-offs, properties of materials, safety and aesthetics).
    - 6.5: Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
    - 7.4: Design and build a product or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production or supply of materials and environmental effects).
    - 8.3: Design and build a product or create a solution to a problem given more than two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
    - 8.4: Evaluate the overall effectiveness of a product design or solution.