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Bombs Away: Egg Drop Experiment

Summary

Students design and build devices to protect and accurately deliver dropped eggs. The devices and their contents represent care packages that must be safely delivered to people in a disaster area with no road access. Similar to engineering design teams, students design their devices using a number of requirements and constraints such as limited supplies and time. The activity emphasizes the change from potential energy to kinetic energy of the devices and their contents and the energy transfer that occurs on impact. Students enjoy this competitive challenge as they attain a deeper understanding of mechanical energy concepts.

Engineering Connection

Natural disasters happen all over the world and can cause extreme damage and loss of life. The safe and accurate delivery of life-sustaining supplies to disaster relief efforts or military supply locations is an unpredictable real-world design challenge. Using the engineering design process, limited supplies, and an egg to represent perishable supplies, students design, create and test their devices in an effort to investigate problems associated with supply delivery in remote regions. They mimic the process engineers use when designing devices for airdrop supplies.

Learning Objectives

After completion of this activity, students should be able to:

- Explain what natural disasters are.
- Explain that engineers design and build devices to help people.
- Explain why supplies might need to be dropped from a plane rather than delivered by a car or truck.
- Identify materials that cushion impact.
- Explain the difference between kinetic and potential energy.
- Understand the engineering design process.

Educational Standards

Do you know what natural disasters are? Have you ever experienced one? Natural disasters are natural events like floods, earthquakes, and hurricanes that cause significant damage and

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sometimes even loss of life. These natural disasters can make basic human needs like food, water, and shelter inaccessible due to compromised infrastructure.

Have you ever heard of disaster relief supply package drops? (Listen to student responses.) Disaster relief groups and the armed forces must deliver life-sustaining and sometimes delicate supplies of food and equipment to people in areas very difficult to reach, often where no nearby roads, trains or airports are located.

These supplies must reach designated landing areas accurately and intact. When things do not go as planned, bags of food can burst from the impact, and sometimes supplies completely miss the target landing areas.

Your engineering challenge today is to apply what you know about the engineering design process and energy (potential, kinetic, conservation of energy) to attempt to solve this real-life problem by testing techniques for dropping precious supplies (hold up an egg), as represented by a fragile raw egg, accurately and safely from a designated height. Let's get started!

Procedure

Before the Activity

- Find a good spot from which to make the test airdrops. Ideally, drop the devices from three or four different heights such as 3, 6 (if the teacher, parent, or guardian holds it above their head), 15 feet (a second-story window), and higher, if possible. (Parent/Guardian supervision).
- Mark a target directly beneath the drop point (such as the second story window). If the landing area is soft, place a piece of plywood or concrete blocks under the target to make the drop surface harder. For safety and uniformity reasons, have the teacher make (or at least closely monitor) all the airdrops.
- Gather materials and prepare equal supplies for each group. Refer to the Activity Scaling section for ideas on limiting supplies and creating more constraints that mimic real-world conditions.
- Decide on a time limit for students to design and create their projects, based on your classroom time constraints. This also mimics real-world conditions and usually helps students get focused to work quickly. Allow at least 25-30 minutes. Generally, the more time provided, the better the projects.

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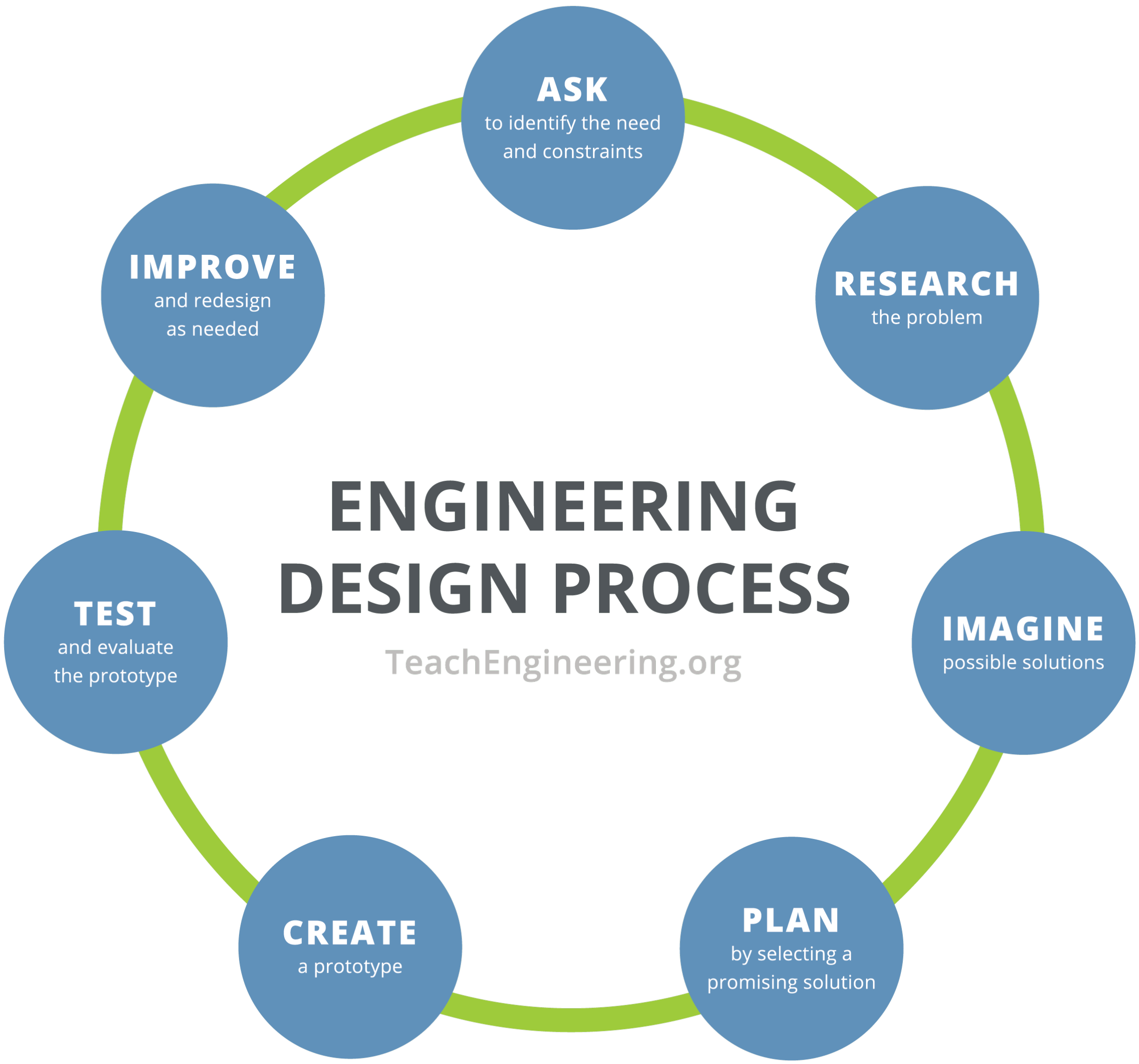

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1. Divide into groups of two students each (activity can be done independently).
2. Introduce the engineering design process by showing the students the image below, or write out the seven steps in a circle on the board. Explain that engineers use the engineering design process to solve problems and that the process is iterative and helps th then learn from failure.
3. Present the Introduction/Motivation content.
4. **EDP Step 1: Ask to Identify the Needs and Constraints**. Inform students that engineers solve problems by first identifying the design requirements and constraints. For this design challenge, the **requirements and constraints** are:
5. Design "something" that will protect your egg, which represents fragile relief supplies, so it survives the airdrops.
6. Not only must the dropped egg remain intact, but it must land close to the target area.
7. Your building supplies are limited to what you are provided by the teacher.
8. Your egg protection system will be tested from more than one height. (Tell students the heights.)
9. You must leave some way for the teacher to check after each test drop to determine whether the egg is intact or has cracked. One simple method is to leave an opening or some access where the teacher can poke the egg with a finger. Feeling something wet or a flexing shell indicates that the egg has broken.
10. You have __ minutes.
11. **EDP Step 3: Imagine Possible Solutions**. Direct students to brainstorm in their teams and then design their devices by making drawings along with short paragraphs that describe what they want to do and why. This is what engineers do. Doing this also encourages students to communicate their ideas to others, which is important when they work in groups, and helps them to analyze their ideas for merit.
12. **EDP Step 4: Plan by Selecting a Promising Solution**. Ask students to revisit the needs, constraints, and research from the earlier steps, compare their best ideas, select one solution, and make a plan to move forward with it.
13. Hand out the supplies, including the eggs. Warn students to be careful with the fragile cargo. Inform them that if they accidentally break an egg, they face a penalty (such as a loss of a few minutes of working time or loss of materials, in addition to cleaning up the mess).
14. **EDP Step 5: Create a Prototype**. Have students work together to create the design they decided on with the materials they have available.

15. **EDP Step 6: Test and Evaluate the Prototype**. When the prototyping/building time is up, ask teams to bring their designs to the drop location. Perform the egg drop from the 3-foot height. Be sure the entire apparatus is above the required height. Test for broken eggs and ask students to measure and record the distances from the target.
16. Egg packages that survive the first height move on to the second height. If the teacher drops the egg, be sure to have the students indicate the desired way to drop it, as it may require a certain orientation to be most effective. Drop the eggs and test for broken shells. Ask students to help measure and record the distances from the designated target. Repeat until either all the eggs are broken or you run out of heights or rounds.
17. Have each group discuss what they did and how their designs were intended to protect the eggs and ensure they landed close to the target. Make sure they describe what did and did not work about their designs, as well as what they might do to make them better. Ask them to relate their explanations to kinetic and potential energy and discuss how their designs dissipated energy without cracking the eggs. The most successful group is the one that survived the longest and achieved the least total distance from the target.
18. Have each group discuss how they could alter and improve their prototype to work in the aftermath of a natural disaster.

Vocabulary/Definitions

- *acceleration:* The rate of change of velocity with respect to time. The measure of how fast the velocity of an object increases or decreases.
- *energy:* The capacity to do work. Several different types of energy include: mechanical, heat, electrical, magnetic, chemical, nuclear, sound or radiant. For purposes of this activity and its associated lesson, we are focused primarily on mechanical energy since it is the energy of motion.
- *force:* Anything that tends to change the state of rest or motion of an object. Force is represented by two quantities; its magnitude and direction in space. The magnitude of a force is represented by quantities such as pounds, tons or Newtons. Direction in space refers literally to the direction a force is applied. This means that force is a vector and requires two pieces of information to define it completely. When a number of forces act simultaneously on an object, the object moves as if acted on by a single force with a magnitude and direction that are the sum of the applied forces.
- *impact:* The striking of one object against another; collision.
- *kinetic energy:* The energy possessed by an object because of its motion.
- *mass:* A measure of how much matter an object contains, or the total number of particles in an object. Mass is not weight. Weight is the force caused on a mass by gravity. Thus, a

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person's mass would not change on different planets, but their weight would. For instance, you would weigh about 1/6th of your body weight now if you were on the moon.

- *natural disaster:* a natural event such as a flood, earthquake, or hurricane that causes great damage or loss of life.
- *potential energy:* The energy of a particle or system of particles resulting from position, or condition. Gravitational potential energy is based on how high off of the ground an object is while other forms of potential energy include springs, batteries, or fuel.
- *vector:* A quantity that has both magnitude and direction. Example vector quantities include velocity, weight, and force. Alternatively, speed and mass are NOT vector quantities and can be represented by their magnitudes.
- *velocity:* A vector quantity whose magnitude is an object's speed and whose direction is in the object's direction of motion. Velocity is different from speed because velocity describes a direction as well.

Assessment

- As a class, plot the distances away from the target that each egg lands, with the height on the x-axis and the distance away from the target on the y-axis. Use different colors to plot the different groups and discuss reasons why some designs may have been more accurate than others. How does accuracy change as the height is increased?
- *Design Explanations*: Review team designs to be sure students understand the concept of mechanical energy. One method to measure comprehension is to have students draw their designs and write short paragraphs explaining in their own words why they think their designs ensure safe, accurate drops.
- *Design Evaluations*: Listen to student descriptions of their devices and results. How well did students design their devices for different drops? Do they understand what worked and what didn't? Perhaps most importantly, do they understand why particular designs did not work?
- *Energy Questions*: Ask students to explain how energy is transferred when the egg is released until it impacts the ground. The importance of this question is to connect the material from this engineering design activity to the associated lesson on types of mechanical energy. Cover the material in the lesson either before or after the activity.

Investigating Questions

- What ideas worked the best to protect the egg? Why do you think they worked? (Ask students to think about the transfer of energy. For instance, a parachute limits acceleration

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by causing some of the energy to dissipate due to air having friction with the parachute. This friction causes an upward force that limits acceleration.)

- Which ideas worked best to improve the accuracy of the device in landing close to the target? Why did they work?
- Which ideas looked promising in the design phase, but did not work well? What went wrong? (Perhaps a parachute got caught underneath the package, etc.)
- How would you improve your designs to better protect the egg?
- How would you improve your designs for more accurate landings?

Safety Issues

- Scissors and supplies are the primary sources of danger. Be sure students use proper caution.
- If dropping from a height such as a second-story window, be sure to maintain proper supervision of students near the window. For the greatest safety on higher drops, have only the teacher, parent, or guardian drop the eggs.
- Be sure the drop location remains clear for quite a surrounding distance, especially on a windy day. Falling eggs could harm someone, and raw eggs are messy and unsanitary.

Troubleshooting Tips

Students may accidentally break their eggs when building their devices. Implement a small penalty for the first infraction, perhaps a loss of time or materials, as well as the task to clean up the mess.

Beware that broken eggs left outside of a refrigerated environment smell really bad when broken.

If this seems like too much to accomplish in one day, divide the activity into three sections: design, creation and testing.

Activity Scaling

- For more advanced students, reduce the number of supplies.
- Make the challenge harder by providing many supplies but limiting the total package weight to not much more than the weight of the egg. This requires an accurate scale, but the

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additional constraint more accurately represents the real-world problem. Since aircraft have a limited cargo weight capacity, dropped packages usually have a maximum allowable weight. This may require some testing on the part of the teacher to determine what the maximum allowable weight should be.

- Make the challenge more demanding by adding an economic aspect to the activity. Assign prices to the supplies and give each group a limited budget with which to purchase supplies.
- For more advanced students, either limit the types of materials that make good parachutes (no plastic or large sheets of paper, challenging students to devise creative ways to make parachutes) or eliminate parachutes entirely.