Lesson: Catapulting your Imagination

Grade Level 7-9 – Time Required: 50 minutes.

Subject Areas:

- Physical Science

Acknowledgments

I would like to acknowledge the author(s) of Lesson: The Magician's Catapult . I based the structure of my lesson on the article which was found at teachingengineering.org. Special recognition to Michael Bendewald and Malinda Zarske who were contributors for the original lesson from which I found inspiration.

Summary

In this activity, students will learn about complex machines. They will reinforce their knowledge of compound systems and The Engineering Design Process by designing, planning, and building a catapult. Throughout ages, catapults have been built for multiple reasons - from lifting materials for warfare, to entertainment. Just like in the medieval era, we are going to create our own catapult system, but instead of stones, we will use grapes this time. Students will try to build their best design to throw the grape the furthest possible.

Engineering Connection

Machines can be simple and complex. Both are the foundation of modern uses and solutions. Engineers use different machines and uses such as levers, wedges, wheels, axels, pulleys, etc. to create and develop simple tools for a use. For example, based on the previously mentioned machines, engineers could build elevators, airplanes, among other things. The world is full of complex machines. Engineers design machines for a specific purpose and use, everything having been specified by the client. Engineers also must create and make their designs based of limitations, constraints and problems including time, resources, and money.

Learning Objectives

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

- Use the Engineering Design Process to create complex solutions to a problem (in this case a catapult).
- Describe how simple and complex machines are related.
- Identify and describe the limitations of the designs created by them in the context of engineering.

Educational Standards

- International Technology and Engineering Educators Association- Technology

    - Make two-dimensional and three-dimensional representations of the designed solution. (Grade 6-8)
    - Refine design solutions to address criteria and constraints. (Grade 6-8)

- MS-ETS1-1
    - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (Grade 6-8)
- SC.6.P.12.1
    - Measure and graph distance versus time for an object moving at a constant speed. Interpret this relationship.

Materials

- Straws
- Tongue Depressors
- Popsicle Sticks
- Hot glue gun
- Hot glue sticks
- Wooden Dowel
- Rubber Band
- Grapes
- Spoons

Lesson Background

For students to understand compound machines, they should be able to understand the use of the materials they are given and a simple machine.

Introduction

Complex or compound machines are two or more simple machines that work together to meet a purpose. Examples of these machines can be found everywhere in everyday items such as a can opener, an elevator, a guitar, a pair of scissors, among other examples. The simple machines that are used to build a compound machine must work in harmony since each one of them are equally important. If we remove one part or one simple machine, the wholes system will stop working or will not function properly. In that sense, engineers must know simple machines to create complex ones.

Today we will imagine that we are structural engineers, and our firm has been contacted by a client who needs a complex machine, specifically a catapult, to use as entertainment for their kid. They need the catapult to throw grapes 2 meters. Your firm accepted the challenge and assigned you to be the one to create it.

First, since you already know the problem and what you are being asked to do as well as your audience, we can start with the process. An engineer starts by thinking about the requirements and limitations to start with their design. What are some of the requirements? The client wants it to be as inexpensive as possible, and since we have predetermined materials, that means that we need to use less of them or cannot exceed the amount that we use.

Now, an engineer must think about the information that can be useful to solve the problem. It needs to throw a grape more than 2 meters away, so we must measure the length and distance. We will have to try out our catapult several times to make sure it actually works. To make sure that it meets the purpose of its creation, we will have to measure three or more launches and get the average distance from them. Now, we are ready to start with this activity.

Procedure

Before the Activity:

- Make sure you have enough glue guns for the students (per group) and the materials can be put on a table or desk if there are not enough tools.
- Prepare a specific space for student to test their catapults. Here, you have to place the measurements so the values can be recorded. You can make marks every 10; 20; 30; 40; or 50 centimeters, so the measurements are accurate.
- You can also show the students an example of a catapult, so they know what they are supposed to build (or at least have an idea).

Part 1: Planning and Designing the Catapult (10-15 minutes)

1. Arrange the students in groups of 3 or 4 (it is up to how many students there are)
2. Have students grab (or you can provide them with) materials for this project.
3. Make sure students remember that the catapult has to be as inexpensive as possible (least number of materials).
4. Have students draw or investigate about possible models they can use for their catapults.
5. Monitor and guide students in case they are having problems with their project.

Part 2: Building the Catapult (20-25 minutes)

1. Remind students that when they build the catapult, they not only have to think about how strong it is because good engineers also care about a well-thought design that are also attractive. In that sense, if they use too much glue, it will not look good, and it is considered waste of material, which causes the price to go up.
2. Help students gluing their pieces if necessary.
3. Monitor the activity while they work on their prototypes.

Part 3: Testing the Catapults (10-15 minutes)

1. Have each group line up and gather around the space that was assigned for the project test part.
2. Make every group grab a couple of grapes that they can throw (they should be about the same size)

3. Have students measure each one of their attempts (try to have them throw the grapes 3 times so they can take a correct average calculation)
4. Have students calculate the average of their measurements. Try to have them do that without using a calculator.
5. If it is necessary, have student adjust their designs. Some modifications can be making the catapult taller, using a smaller arm, using less glue, modifying the model, etc.

Differentiation

If students are struggling to cut their materials, teachers can offer assistance. When explaining how a catapult works or addressing any doubts or questions about concepts, it may be helpful to use visual aids such as pictures or videos to ensure that the explanation is clear for all students. A video is linked below to provide visual representation of a catapult:

- https://youtu.be/xM0I6MsVmn8?si=bbkPjpAuXY4ez2PA (Catapult Examples)

A helpful tip for students who are designing prototypes is to consider highlighting and drawing out the steps rather than writing them out. This approach could be more accessible for some students. To encourage all students to participate, providing prompts to jumpstart their thinking can be beneficial.

Vocabulary/Definitions

Average: *A mathematical calculation used to predict or understand a phenomenon.*

Compound Machine: *Consists of two or more simple machines and allows for work to be done easier.*

Constraint: *A restriction or limitation.*

Consulting: *The profession of giving advice.*

Simple Machine: *The fundamental parts of any machine. Simple machines can exist on their own and are also sometimes hidden in the mechanical devices around you; a device which performs work by increasing or changing the direction of force, making work easier for people to do.*

Structural Engineering*: The branch of civil engineering that is responsible for the design of structures.*

Assessment

Pre-Lesson Assessment

As a pre-lesson assessment, you can have students brainstorm different ideas by engaging them in open discussions. Make sure students remember that when they brainstorm, no idea is considered wrong. Every person has the right to be heard and their ideas should be respected and taken into consideration. As a teacher, do not take a critical position. Instead, encourage students to share their ideas and discourage judgement or criticism. You can also write their ideas on the board. Some questions you can ask are:

- What is a catapult?
- What does a catapult look like?
- What is the use of a catapult?
- Do you have any idea of how to build a catapult?

During the Lesson

During the lesson, it is always important to use discussions as well. They can be among the whole class or for them to discuss in groups. Something important to remember is to elicit answers from them. For example, you can have students discuss what units we use to measure the distance their catapults launch the grapes. If we use SI units, do we use meters or inches?

Post Activity Assessment:

You can ask students how they ended up building their catapults, what things they would change if they had to do it again. If they want to make the grape go further, how can they adjust their catapult or what can they do to make that happen?

Another way in which you can assess what the students are doing is the presentation of their prototypes itself. Students can be asked why they think their catapults worked or did not work so well.

References

Dictionary.com. Lexico Publishing Group, LLC.. (Source of most vocabulary definitions, most of which were done in my own words) http://www.dictionary.com

CPALMS Standards and Achievement Standards Network (Source of educational standards) https://www.cpalms.org/Public/search/Standard
http://asn.jesandco.org/resources/ASNJurisdiction

Contributors

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