Lesson: Engineering Design Process and Paper Tower Challenge

Grade Level: 6-9 – Time Required: 60 minutes.

Subject Areas:

- Science
- Physical Science

Acknowledgments

I would like to acknowledge the author(s) of Lesson: Tallest Paper Tower Challenge, found at sciencebuddies.org, which was used in an annual contest. I based the structure of my lesson on the article written by Ben Finio and found it spiring to design this lesson.

Summary

Students will have the opportunity to use the engineering design process to design and building a tall paper tower able to hold a can of vegetables or another weight on top of it. This lesson aims for students to try to maximize the height of their tower while minimizing the materials (resources) they use. They will be evaluated based on the previous conditions mentioned.

Engineering Connection

In engineering, it is important to be able to maximize the quality of result/solutions that you provide while minimizing the resources used. In order to find the best solution possible, engineers need to use the Engineering Design Process and each one of the steps (*Define the problem, identify constrains and limitations, brainstorm solutions, selection the best options, prototype your solution, test and evaluate, iterate, and communicate your solution)*.

Learning Objectives

After this lesson, students should be able to:

- Design and build a paper tower following a specific criterion.
- Differentiate different kind of materials to get the best result by determining the best choice based on test.
- Explain and list the steps of the Engineering Design Process.
- Identify and analyze possible solutions to a problem.
- Test and modify their prototypes to improve its performance.

Educational Standards

- International Technology and Engineering Educators Association – Technology
    - Students will develop an understanding of the attributes of design. (Grades K-12)

    - Illustrate how systems thinking involves considering relationships between every part, as well as how the system interacts with the environment in which it is used. (Grade 6-8)

- SC.6.P.13.2
    - Explore the Law of Gravity by recognizing that every object exerts gravitational force on every other object and that the force depends on how much mass the objects have and how far apart they are.
- MS-ETS1-4
    - Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (Grades 6 - 8)
- HS-ETS1-3
    - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Materials

- Printer Paper
- Construction Paper
- Graph Paper
- 1 roll of Invisible tape
- Scissors
- 1 Ruler
- 1 Pencil
- 1 Pen
- 1 Measuring Tape
- 1 Can of food

Lesson Background

Students and teachers should know that engineers, throughout the years, have designed a variety of towers for different uses such as observatories, factories, apartment buildings, parking lots, offices, etc.

To succeed in this lesson, students should have a notion of gravity forces and compression forces that work on objects. It is also important to make sure students remember the Engineering Design Process steps: Define the problem, identify constrains and limitations, brainstorm solutions, selection the best options, prototype your solution, test and evaluate, iterate, and communicate your solution.

Students should also have knowledge related to the scientific method.

Introduction

Before we start with this lesson, let us watch a short video of a tall building. *(show this short video that was recorded with a go pro to show the Burj Khalifa from the outside).* What is the name of the building? It is the tallest building in the world. Do you think that building this tower was easy or challenging? What would you say were the challenges that engineers had to face? *(here prompt answers and guide students by giving them hints).* We have thought about the problems and challenges they had to face while constructing this. Now, in your daily life, when you have a problem, how do you find a solution? Do you think about the best ways to fix it or do you just do the first thing that comes to your mind? Exactly, and guess what… Engineers do the same. Engineers also think about the best solution, but they do not necessarily use the classic scientific method. They use what we call "The Engineering Design process". What is the difference between the Engineering Design Process and the Scientific Method? *(Teacher explains the difference between those two terms).*

Now, let us see what the steps for the Engineering Design Process are. *(Teacher explains each one of the steps: Define the problem, identify constrains and limitations, brainstorm solutions, selection the best options, prototype your solution, test and evaluate, iterate, and communicate your solution.)*

Now that we know the steps and we know about towers, today we will take on the role of an engineer and will have to design, create, and test our own towers. For this challenge, you will have to design the tallest paper tower possible, and it must support a weight at the top. In order to minimize the cost, the tower should use as little material as possible without sacrificing safety or its stability.

Procedure

Before the activity:

- Gather materials with the students.
- Go over the rules of this challenge:
    - 1. The tower can only be built from paper and tape. Tools (scissors, ruler, and pencil) cannot be used as structural elements of the tower.
    - 2. You cannot use more than 30 pieces of paper.
    - 3. You cannot use more than one roll of tape.
    - 4. The bottom of the tower can only be taped to the horizontal surface that it rests on (floor, table, etc.). It cannot be taped to anything else (like the vertical leg of a table or a wall) or supported by a person.
    - 5. You are allowed to fold, bend, roll, cut, etc. the pieces of paper.
    - 6. Materials cost is not prorated. If you cut a piece of paper in half and only use half the sheet, it still counts as a whole sheet.

- 7. The tower must support one can of food (14–16 oz or 400–500 g) for at least 1 minute without collapsing. You cannot touch, modify, or repair the tower during this minute.
- 8. The can must rest freely on the tower and be removable. It cannot be taped to the tower.

Part 1: Design and Construction

1. Have students discuss in their groups their possible models.
2. Monitor what they are doing and help students if they have any kind of questions.
3. Have students start their construction.
4. Give students time to build their prototypes and then ask them to test it.

Part 2: Test and Evaluation

1. After building their prototypes, students will put the can on top of their towers and record how long it can stay there and measure the height of their tower. (the can should be able to stay by itself at least 30 seconds)
2. Based on the testing and observations, evaluate the designs following the criteria. Give room for students to iterate. How could they make their towers taller? Can they reduce the amount of material? Why or why not? What would they make different if hey had to do it over again?

Part 3: Reflection and Discussion

- Start asking questions as a group:
  - What structural elements seemed to work the best?
  - What challenges did groups encounter and how did they address them?
  - What things would you guys make different?
- Students could also make an oral presentation based on their prototype and procedures to finish with the last step of the Engineering Design Process (Communication).

Differentiation/Accommodations

In this activity, instead of using hot glue guns, students could use tape or the classroom teacher could help students, who need it, use the hot glue gun. As per the teacher's guidance, students will be given the choice to express their final conclusions in a range of creative formats, such as poetry, artwork, or any other suitable format they wish to choose. This approach aims to provide a more engaging and personalized learning experience to the students, where they can showcase their creative abilities in addition to displaying their understanding of the subject matter. We believe that this approach will enable students to better reflect on their learnings and convey their conclusions in a more effective and engaging manner.

We can provide students with prompts to help them start their points of view and statements. Some examples of prompts are:

- "A question I have about [concept] is..."

- "In my opinion, the most important aspect of [concept] is..."
- "I believe [concept] is relevant to our lives because..."
- “I think the best way to do this is…”
- “If I could, I would change my design by…”

Since this is a challenge that was use nationally, there are resources online available for you to show students who may have doubts.

Vocabulary/Definitions

Brainstorm *- A group discussion to generate ideas or to solve problems.*

Prototype *- A first, typical, or preliminary model of something, especially a machine, from which other forms are developed or copied.*

Design*: To form a plan.*

Assessment

You can assess this activity by using the worksheet that will be attached to this lesson plan

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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