Lesson: Complex Ways to Solve Simple Problems

Grade Level: 6-9 – Time Required: 70 minutes.

Subject Areas:

- Science
- Technology
- Physical Science

Acknowledgments

I would like to acknowledge the author(s) of Lesson: Design and Build a Rube Goldberg which was found on Teachengineering.org and provided me with inspiration to design this lesson. I based the structure of my lesson on the article created by Michael Bendewald and Janet Yowell.

Summary

Students will learn about the use, idea, and structure of Rube Goldberg machines. In this activity, students will design and build one. This is a challenging project that uses the theory of the engineering design process to analyze and find the best ways to create this mechanism. Students will also decide the use they will give to their machines (maybe they want to make a marble go into a cup from a particular place or something different). Students will be free to determine what the purpose of their machine will be.

Engineering Connection

As we know, every single building or construction we see nowadays has a purpose and a reason to exist. Designing and building is one of the most important parts of engineering. Engineers build and construct based on the theory of the engineering design process, and they follow each of the steps to determine the best possible solution to a specific problem (engineers focus on real-life problems). These problems can be simple to solve, but others can be complex with many solutions (which may have various levels of complexity and require various levels of effort). The idea of a Rube Goldberg machine is to expose machines' unnecessary complications and complexity.

Learning Objectives

After this lesson, students should be able to:

- Explain and list the steps of the Engineering Design Process by having students plan, brainstorm, prototype, iterate and communicate their machines.
- Identify and analyze viable solutions to a problem.
- Think about the importance, use and complexity of machines we have in real life.
- Use what they know about simple tools and materials (as well as their knowledge of simple machines) to design and construct a small Rube Goldberg Machine.

Educational Standards

- International Technology and Engineering Educators Association – Technology
    - Students will develop an understanding of the attributes of design. (Grades k-12)
    - Make two-dimensional and three-dimensional representations of the designed solution. (Grades 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.

Attachments

- EOW Lesson Rube Goldberg Worksheet.pdf
- Rube Goldberg Task Ideas

Materials (per group)

- 1 Hot Glue
- Hot Glue Sticks
- One set of Construction Paper
- 5 Marbles
- 5 Paper Cups
- 2 Paper Towel tubes
- One roll of String
- 10 Paper Clip
- 10 Rubber band
- 2 PVC pipe (or paper towel/toilet paper tubes)
- 2 Lego truck toy
- 2 Scissors
- 4 Coins
- 10 Pens/Pencils
- 10 straws
- Extra materials that students want to use (previous teacher's approval)

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

Throughout our lives, we encounter various machines. Some appear complex, while others are simple. But what is a simple machine? It is a tool that makes work easier. As budding engineers, you will use your understanding of these simple machines to design complex ones. You will step into the shoes of engineers, using simple machines and movements to create a system that solves problems. Remember, a Rube Goldberg machine is a unique creation that solves a simple problem in an incredibly complex way.

When we design, we use the Engineering Design Process which has a few steps. Who know the first one? It is to define the problem, the audience, and the purpose. You must collaborate with your partners and decide what you will create. Ask yourselves, what problem are we trying to solve and for whom?

Then, an engineer thinks about all their background knowledge and can help them figure out a solution for the problem. This information includes the limitations and constraints. For example, what materials can we use? How long do we have? How safe is the place where we will be working? Where is it located? In this case, we have a list of materials available, and we have limited time as well. We will have 70 minutes to do this activity.

Once you clearly understand the problem and its constraints, it is time to brainstorm. This is a team effort. Together, you will generate a variety of design ideas and solutions. After considering all possibilities, your team will decide on the best approach and begin designing, drawing, and planning.

Remember, it is important to, first, draw it or plan it. Why do you think we do that instead of just start building? (Answer: because we do not want to waste material, time, resources).

Then, after your teacher has approved your design, start constructing. Remember to use only what you need and think about the aesthetic. When you are done, we will assess your machine and reflect on what is successful or not.

Procedure

Before the Activity:

- You can provide students with the Rube Goldberg task ideas document (check attachments).
- For this first part, get pencils and paper for students to draw their designs and write down what materials they will use.
- Grab the materials, including all the extra stuff students would want to use.

Part 1: Design The Rube Goldberg Machine (30 minutes)

1. In groups (can be 3 or 4), have students decide what simple tasks their machines are going to be for, their audience and discuss what information they have that can help them solve the problem.
2. Have students brainstorm ideas on how to find the best solution for the simple task in an overly complex way.
3. Have students draw their machine prototypes and have them include dimensions.
4. Students show their proposal to the teacher for it to be approved.

5. If needed, propose modifications, or approve the design, so the students can make the design more specific and add more details as they need.

Part 2: Build the Rube Goldberg (40 minutes)

1. Have students spend some minutes checking and reviewing their drawings so they can plan and organize their parts.
2. Make students gather materials and start building.
    - Make sure they understand that everybody must contribute to this activity.
    - Guide the students so that they can follow their design to the best of their abilities.
3. When the teams are done building, have them test their machine and have them see each other's models. (They know if it is successful if it can solve the simple problem it was created to solve)
4. You can allow students to iterate (to make adjustments and modifications to their designs).
5. Have them show their final design to the whole class during the last minutes of the class.

Differentiation/Accommodations

If students are having trouble cutting their materials, teachers can offer assistance. To better explain the concept of a Rube Goldberg machine and clarify any doubts or questions, teachers can use pictures or videos. There are many online videos available that showcase various systems used in Rube Goldberg machines, which can help students better understand the lesson. Below are links to access the videos:

- https://youtube.com/shorts/RTcB-baC8GY?si=aX3iUPDui4w_NOmk (Pop a balloon)
- https://youtu.be/vn-g1Mn2_3g?si=ztliJD-BQF9DvwHe (Place a marble in a cup)
- https://youtu.be/OHwDf8njVfo?si=6CzwJndXrYaV9F6a (Feed a dog)

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…"

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.*

Rube Goldberg: *Cartoonist and engineer who poked fun at overly complicated machines; a machine that operates in a complicated way in which the procedure could have been much simpler.*

Specification: *An exact and detailed statement of something to be built.*

Assessment

Pre-Lesson Assessment

As a pre-lesson assessment we can do a discussion question. This way we can integrate and engage most of the class and elicit prior knowledge throughout students' responses. Some of the possible questions to start a discussion could be "who was Rube Goldberg?" "What is a Rube Goldberg?" "Do complex machines that solve simple problems exist?"

During the Lesson:

Here we can also use activity discussions. We could start by reviewing the activity with the class using guiding questions to elicit answers from them and help them master definitions and ideas related to the topic. Do not forget to make sure they understand basic concepts and definitions.

Make sure students understand the steps for the Engineering Design Process as they are being mentioned and used in this activity. One straightforward way to refer to them is to display the steps on the board. You can use images or just writing it down on the board. Remember that the steps are: Define, identify, brainstorm, select, prototype, test, iterate, communicate.

Post-Lesson Assessment

We can use the worksheet attached to this document to be more familiar with the topic and to analyze and solve questions/problems.

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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