Hands-on Activity: **Mint-Mobiles**

Contributed by: Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

Quick Look

Grade Level:	4 (3-5)
Time Required:	50 minutes
Expendable Cost/Grp :	US $1.00
Group Size:	2
Activity Dependency :	None
Subject Areas:	Measurement Physical Science

Example mint-mobiles.

Summary

Students design, build and test model race cars made from simple materials (lifesaver-shaped candies, plastic drinking straws, Popsicle sticks, index cards, tape) as a way to explore independent, dependent and control variables. They measure the changes in distance travelled with the addition of mass to the vehicles. Students also practice the steps of the engineering design process by brainstorming, planning, building, testing, and improving their "mint-mobiles."

Engineering Connection

When developing a new product or device, engineers go through many iterations of the engineering design process. First, they imagine lots of ideas and share them with their teammates. Then, the team decides on one best design and plans its final materials, specifications, functionality and aesthetics. Before building a full-scale prototype, they create a small model on which they perform many tests with different independent variables to optimize performance and cost. Once a model has been perfected, they build at full scale.

Educational Standards

- Next Generation Science Standards: Science
- Common Core State Standards: Math
- International Technology and Engineering Educators Association: Technology
- Colorado: Math

Pre-Req Knowledge

Ability to make measurements using a meter stick.

Learning Objectives

After this activity, students should be able to:

- Explain the steps of the engineering design process.
- Identify dependent and independent variables.
- Identify control variables.

Materials List

Each group needs:

- Note: for mint-mobile construction supplies, the exact amounts required depend on the team's vehicle design; rough estimates are provided
- plastic drinking straws (estimated 4-6; make sure the straw diameter is smaller than the mint candy's hole diameter)
- Popsicle sticks (estimated 2-4)
- lifesaver-shaped candies, such as Lifesaver® mints (estimated 3-6)
- index cards (estimated 1-2; or thin cardboard or poster board scraps)
- tape, any type; duct or masking preferred
- scissors
- paper and pencil

For the entire class to share:

- ramp, for testing, made from sturdy poster board, rigid cardboard or thin wood
- meter stick, for measuring the distance traveled
- pennies, for added mass during testing (estimated 10-30 pennies; depending on robustness of mint-mobiles, individually tape pennies on vehicles, or tape a little baggie or film canister of pennies
- tape, for securing the ramp, meter stick and pennies
- (optional) hot glue gun and glue sticks (requires adult supervision)

Introduction/Motivation

(Write Figure 1 on the board as each step is discussed. Start by drawing a big circle with an arrow at the end.)

Figure 1. The steps of the engineering design

What do you think engineers do first when they begin to create a new product, say a new type of race car, a new style of backpack, or a new type of skis? That's right, the first thing engineers do is *ask*; that is, they ask what the product will do, what need they are addressing and what others have done. Then, an engineer *imagines* all the possible features and qualities of the product. This takes a lot of creative brainstorming! After an engineer has made a list and some sketches of her/his ideas, all of the engineers in a team get together and share what they have come up with. As a team, they *plan* on one design by working with the best ideas. Once the details of the design have been decided, the team *builds* the product; then they get to *test* it out!

Tests are made on models of the product or device, which are often at a smaller than full-scale size. In the testing phase, the team pays attention to what needs to be changed to the model to make the product work better. The last step of the engineering design process is to *improve* the design.

While the engineering team tests the product, they pay close attention to all the *variables* associated with their design. Two important types of variables are: independent and dependent variables. An independent variable is something that an engineer *decides to change* during each test to see how the results differ. A dependent variable is something that changes *as a result of* varying the independent variable. In testing, we also have what is called a *control*. A control is the part of the experiment that is neither changed by the engineer nor is affected by the independent variable. To help explain these new terms let's apply them to an example.

Say I am an engineer testing a roller coaster. I want the cart to go as fast as possible on a track that I have already built. I can change some things to make the cart go as fast as possible — such as its mass, its length, or the type of wheels I use. Can anyone tell me what the independent and dependent variables are in this example? (The *independent variables* are the mass, length, and types of wheels that the engineer chooses. The *dependent variable* is the speed of the cart.) *Control variables* are independent variables that are held constant in an experiment. If you were testing variables that that influence a *dependent variable*, like speed, you would not test all the variables at the same time because then you would not know which variable(s) influenced the results. So, for example, if you were testing the influence of mass, you would hold the other variables (like length and type of wheels) constant, and test varying masses. So, length and type of wheels would be the *control variables*. On the contrary, if you were testing length, then you would hold mass constant and it would be a control variable. Thus, control variables are the variables you do not change in an experiment.

Today, working as engineers, we are going to follow the engineering design process and design and build mint-mobiles! To practice identifying variables, we will investigate how adding mass to these race cars changes the distance they travel. We will add mass by securing pennies to the cars, representing a driver and passenger. We'll send them down a ramp and measure the distance they travel, using a meter stick. Think in your heads for a moment: what are the independent and dependent variables in this activity and what is the control? (Allow about 10 seconds for students to individually think about this.) Now, share what you think is the correct answer with the person next to you. (Allow three minutes for a group discussion.) Now — are you ready to brainstorm? Great! Let's get started!

Vocabulary/Definitions

brainstorming: A technique of solving specific problems, stimulating creative thinking and developing new ideas by unrestrained and spontaneous discussion.

control variable : A variable that is neither changed by the engineer/tester nor affected by the independent variable.

dependent variable: A variable that changes as a result of changing the independent variable.

engineering design process: The cycle engineers go through while creating a new device: Ask; Imagine; Plan; Build; Test; Improve.

independent variable : A variable that is intentionally changed by the engineer or tester.

variable : Something that changes while testing an idea, device or system.

Procedure

Background

As this activity is written, student teams design their cars on paper first, working from a list of possible materials and then make a list of their needed supplies (including exactly how many wheels, straws, etc.) to request from the teacher. Activity variations are many. For example, limit the number of each type of material, require that each team use the exact same number and type of construction materials, or define a competitive objective to determine the best materials based on vehicle stability or speed with a certain mass.

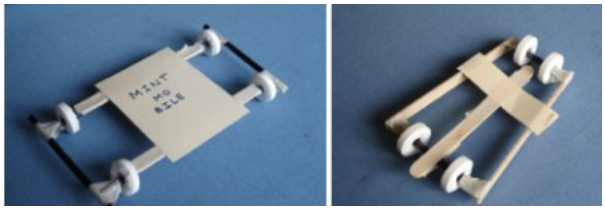
Engineers use the **engineering design process** when they are creating new devices. The main six steps of the engineering design process are: ask, imagine, plan, build, test, and improve. The improving step involves starting over again at the beginning of the design process with "ask," that is, "Where does this device need improvement? How can it be made to perform better?" Once a device has been built the first time, it is never complete! Engineers are always improving what they design. Imagine if the cellular phone had never been improved. Or cars, or computers.

Before the Activity

- Gather materials and list them on the board: plastic drinking straws, Popsicle sticks, lifesaver-shaped mint candies, index cards (or your own modified list of what's available).
- Set up a testing ramp by placing sturdy poster board or a thin wooden board at an angle over a smooth surface (such as a tabletop). Use tape to secure the ramp. Tape a meter stick from the bottom of the ramp along the table, so students can measure the distances traveled.
- Divide the class into teams of two students each.

With the Students

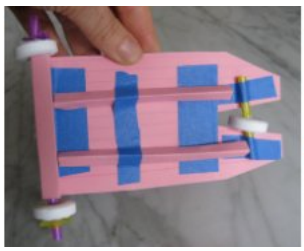
1. To begin planning their mint-mobile designs, give the class three minutes for students to individually **brainstorm** what their designs might look like. Point out the list of available materials listed on the board.



Example student-created mint-mobiles of different structural designs.

2. Next, working with their partners, direct students to share their ideas and make drawings of their final, agreed-upon designs. Require the drawings to list the materials and amounts needed to build their mint-mobiles. Remind them that their designs must be able to carry the added mass of a driver and passenger (represented by amounts of pennies) during testing.

3. Once teams have finished their designs, distribute materials and give them time to build.




More example student-designed mint-mobiles. How can they be improved?

4. Test the mint-mobiles by sending them down the ramp. Have students record their measurements of distance traveled. This is a good time for students to make modifications to their designs to ensure quality results. What can be improved? Does it roll smoothly? Does it roll straight? Can it carry some added weight?

5. Now, have the students add pennies to their mint-mobiles, representing the mass of a driver and a passenger. Secure the pennies with tape. Have each group test their design with two different amounts of pennies (same for all groups).

6. Take a moment as a class to have students identify (and list) the independent, dependent and control variables in the activity. (The independent variable is the added mass of the cart, the dependent variable is the distance the cart travels, and the controls are the length and angle of the ramp.)

7. Before they test their cars with the additional pennies, ask each group to predict which trial will travel the furthest and why they believe this. Have groups write their predictions and justifications on paper.

8. Retest the mint-mobiles and record the new distances traveled with the two amounts of pennies.

9. On the board, have each group record their initial distance, distance with first amount of pennies and distance with a larger amount of pennies.

10. As a class, review the collection of results on the board. Conclude with a class discussion (using questions provided in the Assessment section) about the experiment variables, how increased mass impacted the distance traveled by the cars, and the design process. During this discussion, address any misconceptions the students identified during their predictions.

Troubleshooting Tips

If students use the straws as axles and find that the straws are bigger than the candy hole diameter, they can use scissors to slit the straws lengthwise, then curl and tape them tighter (so they are narrower) to make straws that spin better in the candy holes.

The mint-mobiles roll best on smooth surfaces rather than the textured surfaces of carpets, so build the testing ramp on a tabletop and place a thin poster board at the bottom of the ramp.

If students' mint-mobiles are quite small, they may not be able to hold many pennies. If so, tape on a few pennies at a time to determine a reasonable maximum amount.

Investigating Questions

What other independent variables affect the distance traveled by the mint-mobiles? (Possible answers: The material used on the ramp, the type of materials used to build the cart, the slope and length of the ramp, the number of wheels, the stability of the cart.)

What other independent variables could we have tested in this activity? (Possible answers: The dimensions of the cart, the length, height, and slope of the ramp, the number of wheels

What is another dependent variable in this activity that might be of interest to an engineer designing a real race car or roller coaster cart? (Possible answers: Speed, stability.)

What other independent variables could we have tested in this activity? (Possible answers: The type of ramp, the type of materials used to build the cart, the slope and length of the ramp, the number of wheels on the mobile.)

What are the dependent variables that would be affected by these changes? (Possible answers: Speed, distance traveled, and stability.)

Assessment

Pre-Activity Assessment

Identifying Variables: Have students categorize variables from different examples as independent, dependent or control variables. For example (as thoroughly explained in the Intro/Motivation section), the variables associated with roller coaster design. Then, have students talk in groups to identify the different variables involved with this activity.

Activity Embedded Assessment

Brainstorming Design Work: Have students follow the engineering design process by brainstorming different designs on paper; then have them share these ideas with their teammate(s). Have them draw their final group design, listing the exact materials they plan to use.

Theory to Practice: At the point of testing, have students identify (and list) the independent variables they will be testing, as well as the dependent, and control variables. (Note: The independent variable is the added mass of the cart, the dependent variable is the distance the cart travels, and the controls are the length and angle of the ramp.)

Prediction: Before testing the cars with the additional pennies, ask each group to predict which trial will travel the furthest and why they believe this. Have groups write their predictions and justifications on paper.

Graphing: Have students plot the distances the cars go for the three different masses; one without pennies, and the two with different numbers of pennies. Allow students to interpret results graphically and relate mass to distance traveled.

Post-Activity Assessment

Class Discussion: Ask the students the following questions and discuss as a class.

- What were the independent, dependent and control variables in this test? (Answer: The independent variable was the added mass, the dependent variable was the distance the cart travels, and the controls were the length and angle/tilt of the ramp.)
- Looking at everyone's results, how did mass affect the distance traveled by the mint-mobile? Did it travel a shorter or greater distance? (Answer: Adding mass caused the cars to travel greater distances; the greater the mass, the further the cars travel.)
- How could you get your mint-mobile to travel a longer distance while carrying the same number of pennies? (Possible answers: Increase the mass of the mint-mobile by using heavier materials or improve the design to reduce drag and friction.)

- What other independent variables could you change to test the model car's distance? (Possible answers: The angle of the ramp, the length of the ramp, the number of wheels used for the car, the width and height of the mint-mobile.)
- What sorts of things did you do at each step of the design process? (Have students share their own experiences, in their own words, that describe the repeating six-step-loop of the engineering design process: ask, imagine, plan, build, test, improve.)

Activity Extensions

Team Test Your Instructions: In addition to each team designing a mint-mobile with a sketch and list of materials, have them write instructions on how to build the mint-mobile and exchange designs with another group. Tell the students to build the other team's mint-mobile following the instructions using only the supplies listed. This exercise sharpens students' awareness of the importance of accuracy and clear communication in their engineering plans. Or similarly, conduct The Universal Language of Engineering Drawings activity, in which students practice the ability to produce clear, complete, accurate and detailed design drawings for a mint-mobile-type model car, using only specified materials. Teams trade drawings and attempt to construct the model cars in order to determine how successfully the original design intentions were communicated through sketches, dimensions and instructions.

Activity Scaling

- For lower grades, conduct the activity as a class demonstration, asking students to predict whether the mint-mobile will travel a shorter or greater distance with the added mass.
- For upper grades, have students decide on their own which independent variables they want to test. Have them list the independent variable, the dependent variable, and all of the controls in the test they perform. Ideas for other independent variables: the angle of the ramp, the length of the ramp, the number of wheels, the width and height of the mint-mobile. Discuss with students which independent variables require the easiest modification to their mint mobiles.

Contributors

Lesley Herrmann; Stephanie Rivale; Denise W. Carlson

Copyright

Supporting Program

Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

Acknowledgements

The contents of this digital library curriculum were developed under a grant from the Fund for the Improvement of Postsecondary Education (FIPSE), U.S. Department of Education, and National Science Foundation GK-12 grant no 0338326. However, these contents do not necessarily represent the policies of the Department of Education or National Science Foundation, and you should not assume endorsement by the federal government.