**Description**
During this lesson, students will apply their knowledge of cause and effect by working in teams to design and test a device to solve a real-world problem involving product and profit loss caused by earthquakes.

| Grade Level | Objectives | Grade Levels in adaptations (Appendix A) |
|---|---|---|
| 6 | Students will:<br>• Design an optimal device that will help prevent product loss during earthquakes.<br>• Use data from their tests to create a pitch that explains the iterations the product went through, how it works and why it is the optimal design. | • 1, 5, 9-12, after school program |

| Duration | Tech Tips |
|---|---|
| Four 45-minute sessions | Our Tech Tips and their accompanying videos can be found here.<br>• Assessment<br>• Brainstorming<br>• Data Collection<br>• Framing the Challenge<br>• Material Strategies<br>• The Language of Engineering<br>• What is Engineering? |

**Standards Connections**
Note: Bolded parts of the standards are fully met by this lesson.

- **NGSS Performance Expectation**
  MS-ETS1-4. Engineering Design: **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.**
- **NGSS Disciplinary Core Ideas (DCI)**
  Developing Possible Solutions (ETS1.B)
  **A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.** (MS-ETS1-4)
- **NGSS Science and Engineering Practices (SEP)**
  2. Developing and Using Models
    - **Develop a model to generate data to test ideas about designed systems,** including these representing inputs and outputs.
- **NGSS Crosscutting Concepts (CCC)**
  6. Cause & Effect
    - **Cause and effect relationships may be used to predict phenomena in** natural or **designed systems.**

**Content Standards**

This engineering challenge can be adapted for a variety of ELA content standards over many grade levels:

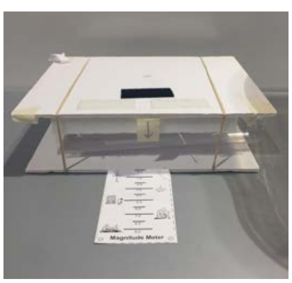
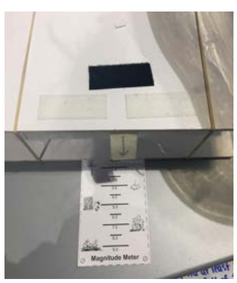
- CCSS.ELA-LITERACY.W.6.2: Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content.
  - CCSS.ELA-LITERACY.W.6.2.A: Introduce a topic; organize ideas, concepts and information such as definition, classification, comparison/contrast and cause/effect; include formatting (e.g., headings), graphics, using strategies (e.g., charts, tables) and multimedia when useful to aiding comprehension.

## Set up and Prep

- Collect building materials.
- Put learners in groups of 2-4.
- Each student will need copies of the data collection tools (see Appendix D: “Test Data Collection” and “Iterations Data Collection”) to record their prototypes and iterations as they build. See Tech Tip: Data Collection.
- Create a class chart for groups to record their data. Make columns for their group name(s), yes/no for product accessibility and percentage of products still on their shelf after the simulated earthquake.
- Prepare shake table Test Rig (you may choose to set up two rigs to allow for more testing room during build time).

**Test Rig**

- Basic shake table:
  - Construct a shake table with pull tabs and magnitude meter (as shown below. Allow teams to test (at the same magnitude) — here are some examples:
    - RAFT
    - PBS Kids
    - Engineering Adventures: Shake Things Up
  - Shoe boxes (1 per group)
  - Magnitude meter (for shake table)
  - Hook and loop tape (4 in/20 cm strips; 2 for shake table; 1 per each shoe box
  - Four “test products” that increase in difficulty (e.g., canned soup or tuna, small boxes of cereal, snack bags of chips, etc).

Each team will have a shoebox “shelf” to modify. Standing the shoebox on its long side creates the simulated shelf. The products that students will be protecting can be lined up inside the box.

Hook and loop tape (e.g., Velcro) can be used to temporarily secure the shoebox to the shake table during testing. Add one side of the hook and loop tape to the shake tables and use the complementary side of the hook and loop tape on each shoebox.

| Materials (per class of 32 students)* | | |
|---|---|---|
| **Structural pieces (~200 total)**<br>• String (lengths that are shorter than the length of a shoebox)<br>• Scraps of fabric<br>• CD cases<br>• Pipe cleaners<br>• Wooden craft sticks<br>• Cardboard squares<br>• Foam pieces<br>• Plastic lids (various sizes)<br>• Straws (various sizes)<br>• Twine<br>• Ribbon<br>• Tubes<br>• Dowels | **Connectors (~150 total)**<br>• Binder clips<br>• Clothespins<br>• Paper clips<br>• Rubber bands<br>• Alligator clips<br>• Hair clips (ex. butterfly clips)<br>• Play-Doh or modeling clay | **Other materials**<br>• Scissors<br>• Small containers to hold materials |
| Organize the materials by type so students can easily see what is available and make them accessible. Send teams to the table one at a time or have one member from each team access the materials. See Tech Tip: Materials Strategies for Engineering Design for more materials management suggestions.<br><br>*Many of these materials are suggestions based on what learners have found useful. It is not necessary to have all of the building materials listed. Feel free to use other materials you have on hand. | | |

**A. Introduction**

This lesson is designed to be used as either an inquiry based learning experience, alongside teaching of the content standard introduced and taught after the initial design challenge, or as an application of previously covered content material.

1. Lead a discussion to introduce the concept of engineering and what an engineer does. Tech Tip: What is Engineering? provides information on discussing engineering, problem solving and creative thinking with youth.
2. Explain to students that they are going to solve a problem as contracted engineers. Conduct a discussion to uncover students' prior knowledge of **earthquakes**, and their effects on people and their communities.
   - *What is an earthquake?* Possible answers include: When the ground shakes because tectonic plates are moving or volcanoes are active.
   - *What causes an earthquake?* Possible answers include: Tectonic plates moving or slipping against each other.
   - *Are earthquakes predictable?* Possible answers include: Sometimes animals seem to know, but not very far ahead.
   - *How do earthquakes impact humans, our structures, belongings, etc.?* Possible answers include: Injuries, damage to buildings and property.
3. Use a video clip such as this to engage students and start a conversation about what happens to communities during and after an earthquake. Discuss briefly that earthquake "size" is measured in **magnitude** and based on the motion of the quake; the Richter Scale helps scientists compare one quake to another.
4. Introduce the engineering challenge scenario that students will be working to solve. For modifications for grades 1, 5, high school, and after school, see Appendix A.

| |
|---|
| *On July 4, 2019, a 6.4 magnitude earthquake shook the town of Ridgecrest, California. It was followed by a 7.1 magnitude earthquake the next day. The two large earthquakes and many smaller quakes between and after them caused damage to homes, freeways and stores. Store owners cleaned up the mess of products on their floors after the first earthquake, only to be rocked again by a larger quake the very next day. Products were damaged and broken all over again, increasing the profit lost by the stores and their employees. To help prepare for the possibility of another big earthquake, the Mayor of Ridgecrest is calling on engineers like you for help. A device needs to be designed quickly and efficiently to prevent future product loss. You are one of several engineers bidding for your product to be the one that the Mayor of Ridgecrest adopts for the city. Your task is to design an optimal device to prevent items from falling off of shelves during an earthquake while still allowing for convenient everyday shopping.* |

**B. Design Challenge**

1. Introduce concepts of criteria and constraints. Tech Tip: Framing the Challenge provides guidance on the subtle differences between criteria and constraints and tips for helping youth to understand these subtleties.
2. In middle school, students should be encouraged to help define criteria and constraints by thinking critically about the problem. (SEP)
   - *How do customers access a product in a store?* Possible answers include: They pull the items off of shelves, or out of freezers, coolers etc.
   - *What are some features of shelves that you've seen in stores?* Possible answers include: Sometimes shelves are very long. (SEP)
   - *When building a device, how do you want it to function?* Possible answers include: It should keep products on the shelf during an earthquake while also being accessible to shoppers. (SEP)
   - *How might a device affect a customer's shopping experience?* Possible answers include: Difficulty in taking items off the shelf or seeing the labels. (CCC)
   - *Based on what we've shared, what additional criteria or constraints might we add?*
3. Introduce the engineering design challenge.

| |
|---|
| **Design Problem**<br>Design a device that will help prevent product loss during earthquakes. |
| **Criteria (Design Requirements/Desired Features)**<br>• Label of the products should be visible.<br>• Products can be removed in less than 5 seconds without knocking over other products.<br>• Device can withstand a 7.0 magnitude earthquake, minimum 75% of items remain on the shelf *(If not using the magnitude meter, establish a standard shaking strength for consistency).* |
| **Constraints (Design Limitations)**<br>• Budget: Use only given materials.<br>• Schedule: 20 minutes to build.<br>• When testing, the device and products may not be touched. |
| **Testing**<br>• Students will arrange the "test products" (cans, bottles etc.) on their "shelf."<br>• Students will test their device multiple times and enter their data on the class chart.<br>• Students will track their tests on their data collection handout. |

4. After students have received design challenge instructions, they can start brainstorming for their design or go right into building. See Tech Tip: Brainstorming.

5. Questions to facilitate materials choice and build time:
    - *What do you want your design to do? Which materials support that kind of movement or stability? (DCI)*
    - *How might you combine materials to create a system? (SEP)*
    - *How will the motion of the shake table affect the products on the shelf? What might you design to reduce those effects? (CCC)*
6. Questions to facilitate sharing solutions:
    - *Does your latest design solution incorporate parts from previous tries? Which parts? (DCI)*
    - *How does your design prevent damage caused by an earthquake? (CCC)*
    - *Which materials resulted in more success? Which materials resulted in less success? What caused this success/failure? (DCI)*
    - *Which solutions successfully met all or most of the criteria? What made them successful? (SEP)*
    - *Where did solutions commonly fail? Why? (SEP)*
    - *What type of data did you collect? What changes will you make to your device based on this data? (SEP)*

**C. Content Learning**

1. Revisit the original scenario and design problem with students.

    > *Now that you have designed a device to prevent items from falling off shelves and to reduce product loss during earthquakes, the Mayor of Ridgecrest has asked engineers to submit a* ***proposal*** *for their designs: a written description of the device, how it works and why it's the optimal design. Using data from your tests, you will create a proposal for the Mayor that explains the iterations your product went through to show why it's the best choice for the city.*

2. Spend time reviewing informational writing strategies (e.g., the use of cause and effect). Emphasize that technical writing is a skill that engineers must have. Writing is a tool used to make proposals, contract bids and even instruction manuals. Help students to make connections as to how their data collection and iterative process can serve as evidence in their proposal.
    - Resources that students might use to explore to write a proposal:
      https://www.wikihow.com/Write-a-Proposal OR
      https://www.hloom.com/more/sample-proposal-templates/
3. Give students a copy of the Making the Case: Final Design Proposal handout so that they can begin to think about the additional evidence they may need to build their case.
4. Questions that connect the design challenge with the content standard:
    - *Why might a store owner be interested in protecting their merchandise?* Possible answers include: To lose less money.
    - *What happens to products in stores during an earthquake?* Possible answers include: They fall and break or hit customers.
    - *How might this affect a store's profits?* Possible answers include: Less product means less profit. *(CCC)*
    - *What data do you think you'll need to support your proposal as an engineer?* Possible answers include: The number of products it protects in an earthquake. *(SEP)*
    - *How can your data help you in creating your proposal?* Possible answers include: Data will support the claim that the design protects the products successfully. *(CCC)*
    - *What information might be most important to include when communicating to the mayor about your solution?* Possible answers include: How the design works and data from test runs. *(CCC)*
5. Prepare students to iterate their design solutions by looking at their data.
    - What did you learn from your data? What does it tell you? *(SEP)*
    - How well did other groups meet the criteria and constraints? *(SEP)*
    - What were common failure points we saw during testing?
    - How can you use the above information to create an optimal design? *(DCI)*

**D. Iterate Design Solutions**

1. Introduce iteration criteria and constraints.
    - Change to criteria: Design must be based on results from a previous test, creating optimized design.
    - Change to constraint: Use no more than four total pieces of materials to build device (real-world problem reasoning: budget cuts to the project to reduce the cost of the product for the city/consumers).
2. Remind students of the Design Problem they are working to solve, as well as the criteria and constraints.

| |
|---|
| **Design Problem**<br>Design an **optimal** device that will help prevent product loss during earthquakes. |
| **Criteria (Design Requirements/Desired Features)**<br>• Product visibility: label of the products should be visible<br>• Access to products: can be removed in less than 5 seconds without knocking over other products<br>• **Optimized design is based on results from a previous test**<br>• Device can withstand a 7.0 magnitude earthquake, minimum 75% of items remain on the shelf |
| **Constraints (Design Limitations)**<br>• Budget: Only use given materials, **limit 4 items or fewer**<br>• Schedule: Build time: 20 minutes<br>• When testing your device, you may not touch the product or device with your hands or secure anything to shake table |
| **Testing**<br>• Students will arrange the "test products" (cans, bottles, etc.) on their "shelf"<br>• Students will test their device multiple times and enter their data on the class chart<br>• Students will track their tests on their data collection handout |

3. Questions to facilitate reflection on design solutions and planned iteration.
    - *Based on your data from the first test, how might you modify your design to make sure fewer products fall off the shelf? (DCI)*
    - *What was one part of your first design that worked differently than you expected? (DCI)*
    - *Which criteria did your first design meet or not meet?*
4. Questions to facilitate group sharing solutions.
    - *How did you change your design based on your data? (DCI)*
    - *What effect did your changes have on your design? (CCC)*
    - *What improvements did you notice other groups made based off their data? (DCI)*
    - *In what ways are these designs "optimized"?*

**E. Evaluation**

Formative assessments and evaluation of student learning is integrated throughout the lesson. This section summarizes suggestions for implementing summative evaluations, as well as creating authentic experiences for the students around the design challenges and their learning by making work public. Note that rubrics and assessments are developed to meet NGSS engineering standards, allowing educators to integrate additional mastery evidence in the final assessment and rubric specific to the content standard(s) each educator teaches. For additional guidance on facilitating authentic assessment, see Tech Tip: Assessment.

1. Remind learners that the Mayor of Ridgecrest has asked for a proposal from engineers to design a device to prevent items from falling off shelves and causing product loss.
2. Introduce and explain the final assessment project with students.
    - Using data from your tests, you will create a pitch for the mayor that explains the iterations your product went through, how it works and why it is the optimal design.

- Include an introduction to explain how earthquakes affect stores and cause inconveniences for shopkeepers/shoppers.
- Explain how the design solution meets the criteria and constraints of the design challenge and why your design solution is the best choice.
- Include a labeled graphic that represents the final design noting failure points (what and how materials failed).
- Using the shake table, demonstrate how and why it works.

3. Questions to connect the design challenge to the assessment project and/or project goals:
    - *How will you help the mayor understand that your design is the best choice?*
    - *What concerns might the mayor have about your design? How can you use your data to convince them?*
    - *How does your design reduce the damage from unpredictable earthquakes?*
    - *Why is your device the optimal design? How do you know?*
    - *Is your final sketch and data summary clear and complete enough that the mayor and shop owners will know exactly how and why the solution works?*

**Appendix A – Grade Level Modifications**

While this challenge was initially designed for 6th grade learners, people of all ages showed engagement in the task during our tests with guests at The Tech Interactive. To increase the difficulty, we suggest the following ideas for older students:

- Materials may not exceed more than ¼ of the shelf height
- Budget cuts! Reduce number of materials students can use to build device
- Time constraints (more time, less time)
- Assigning costs to all materials (budgeting)

Specific modifications for individual grade levels:

| |
|---|
| **First Grade**<br>Standard: CCSS.ELA-LITERACY.W.1.2<br>Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure. |
| **A – Intro and Scenario**<br>• Earthquakes happen all over California and other parts of the world. During a recent earthquake, items were knocked off shelves, causing lots of clean-up and damaged items. In libraries, books were tossed from shelves, causing extra work for local librarians. The local librarian has asked the class to design a device that she could use to help prevent a mess during an earthquake. |
| **B – Design Problem**<br>• Design a device that will help keep books on a library shelf during an earthquake.<br>• Learners could use a paper box as the shelf.<br>• To test, simply rock the box back and forth, rather than using a shake table. |
| **C – Content Connections and Adaptations**<br>• Learners identify features of their designs that are most helpful in keeping books on the shelf. |
| **D – Iterating Design Solutions**<br>• Budget cuts! Now you can only use four things to build your device. |
| **E – Assessment**<br>• Students or class will write a letter to their librarian describing their device, how it works, what it is made of and its key features. |

**Fifth Grade**
Standard: CCSS.ELA-LITERACY.W.5.2
Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
CCSS.ELA-LITERACY.W.5.2.A
Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.

**A – Intro and Scenario**
- Same as sixth grade lesson above.

**B – Design Problem**
- Design a device that will prevent product loss and injuries in stores during an earthquake.

**C – Content Connections and Adaptations**
- Students make posters or slideshows to communicate why their design should be chosen.

**D – Iterating Design Solutions**
- Budget cuts! Students must only choose four materials that are vital to the function of their optimal design.

**E – Assessment**
- Students organize their proposal presentation using their data to support their claims.

**High school**
Standard: CCSS.ELA-LITERACY.W.9.2
Write informative/explanatory texts, including career development documents (e.g., simple business letters and job applications), to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content.
CCSS.ELA-LITERACY.W.9.2.A
Introduce a topic or thesis statement clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

**A – Intro and Scenario**
- Same as sixth grade lesson above.

**B – Design Problem**
- Design a device that will prevent product loss and injuries during an earthquake.
- Must be made to fit any shelf.
- Provide boxes of different sizes to test flexibility of the designs.

**C – Content Connections and Adaptations**
- Learners will be writing a technical manual for installing and using their device.
- How will they organize their content to convey their ideas to users?

**D – Iterating Design Solutions**
- Assign supplies a cost, groups must include their total cost for their design.
  OR
- Establish a time limit for the installation of their device to a shelf.

**E – Assessment**
- Technical manuals should include words and images.
- Students can test their instructions by trading with another group and following using their manual.

| |
|---|
| **After School**<br>Standard: Quality Standards for Expanded Learning in California<br>Skill building<br>The program supports projects and activities in which participants demonstrate mastery by working toward a final product or presentation.<br>The program supports activities in which participants develop and demonstrate 21st century skills. |
| **A – Intro and Scenario**<br>• Students can partake in a gallery walk with different images from the destruction of earthquakes. |
| **B – Design Problem**<br>• Design a device that will help prevent product loss during earthquakes. |
| **C – Content Connections and Adaptations**<br>• Students will reflect on how their use of 21st century skills during the lesson helps them to create a better product:<br>  • collaboration<br>  • creativity<br>  • critical thinking |
| **D – Iterating Design Solutions**<br>• (same as sixth grade lesson plan) |
| **E – Assessment**<br>• Students can present to other groups in the program, as well as staff. One of the staff members can represent the mayor. |

**Appendix B – Vocabulary**

The following is the start of a suggested list of words to discuss as your progress through this lesson with students. For more in-depth information about engineering specific vocabulary, see Tech Tip: The Language of Engineering.

| Term | Student-friendly definition | Scientific Definition |
|---|---|---|
| earthquake | Sudden shaking of the surface of the Earth | The ground shaking caused by a sudden slip on a faultline or by volcanic or magmatic activity, or other sudden stress changes in the earth. (USGS) |
| magnitude | The size of the earthquake | A number that characterizes the relative size of an earthquake. (USGS) |
| proposal | A plan to be considered | A plan or suggestion, especially a formal or written one, put forward for consideration or discussion by others. |

**Appendix C – Resources and References**


- "32 Sample Proposal Templates in Microsoft Word: Hloom." *Hloom.com*, www.hloom.com/more/sample-proposal-templates/.
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- News, ABC. YouTube. YouTube, 5 July 2019. Web. 23 July 2019.
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- Southern California: N.p. Web. 23 July 2019.
- Vector Yellow Earthquake Art Word Natural Disaster, Vector Art. Web. 23 July 2019.
- Venezuela: N.p. Web. 24 July 2019.
- Earthquake Glossary.US Geological Society. https://earthquake.usgs.gov/learn/glossary/?term=magnitude.

**Appendix D – Lesson Handouts**

Name:________________________________

Date:________________ Class:____________

**Test Data Collection**

Draw a diagram of your **original device**. Include labels for:

1. All materials and measurements.
2. Any failure points observed during testing.

<u>Star the materials that were vital in the functioning of your device.</u>

| Test Number | How many materials did you use? | Was the product easy to access? (can remove in 5 seconds without knocking other items) | Was the product label visible? | How many products remained on the shelf? |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

| Criteria and constraints this solution DOES meet: | Criteria and constraints this solution DOES NOT meet: |
|---|---|
| | |

a. Based on your data, what will you modify to improve performance?

b. How will this modification affect how your device performs?

Name:________________________________

Date:________________ Class:____________

## Iteration Data Collection

Draw a diagram of your **original device**. Include labels for:

1. All materials and measurements.
2. Any failure points observed during testing.

| Test Number | How many materials did you use? | Was the product easy to access? (can remove in 5 seconds without knocking other items) | Was the product label visible? | How many products remained on the shelf? |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

| Criteria and constraints this solution DOES meet: | Criteria and constraints this solution DOES NOT meet: |
|---|---|
| | |

a. Why is your device the optimal design? How do you know? Explain using iteration data.

Name:____________________________________

Date:__________________ Class:______________

## Making the Case: Final Design Proposal

**Situation**

What is the issue in the community? Why are you being tasked with building this device? Who is this affecting? Why does this problem need to be solved?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**Goals and Objectives**

What criteria and constraints is your device meeting? (Be sure to include data from your iterations.) Are there any criteria and constraints it is currently not meeting? Be sure to include your failure points and the changes you made or might make.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**What materials were used?**

Explain how your materials were important to the success of your device.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

**Proposed Solution:** What data do you have to support that your device is optimal? How did you improve your device each iteration?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

# Shaky Shelves: Exploring Cause and Effect: Worksheet

**Steps Involved:**

1.

2.

3.

4.

5.

**Benefits:**
If this device is selected, how would the community be affected?

**Potential Obstacles/Problems:**

**Summary**:

## Student Rubric

### Designing and Testing to Solve Real World Problems

**NGSS PE:** 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.**

| | Below Standard | Approaching Standard | Meeting Standard | Above Standard |
|---|---|---|---|---|
| (NGSS DCI) ETS1.B: Developing Possible Solutions **A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.** (MS-ETS1-4) | *Areas that individual students may need one-on-one support with:*<br>• Trying and documenting solutions.<br>• Using data to make changes to a design.<br>• Identifying failure points.<br>• Explaining how a design solution has improved with iterations. | • 1 or 2 solutions are tried and documented<br>• Explanations of solution does not include all criteria and/or constraints or is not supported by data.<br>• Design improvements on final solutions are not based on failure points from prior tests and/or do not incorporate successful aspects.<br>• Case made for how this final design solution improves on previous iterations is unclear or incomplete. | • 3 (or more) solutions were tried and documented (in data collection).<br>• Explanation of how each solution meets the criteria and constraints are documented completely and are supported with data (in data collection).<br>• Design improvements on final solution are based on failure points from prior tests and incorporate successful aspects.<br>• A clear case is made for how this final design solution is better than previous iterations. | *Areas where students may exceed:*<br>• Thorough and detailed documentation<br>• More than 5 solutions tried/ documented<br>• Clear and detailed explanation of failure points and causes<br>• Focused improvements on failure points from prior tests and ability to persevere until optimal designs are reached<br>*Ideas for next steps for growth:*<br>• Identify aspects of each design that best met each criteria and constraints<br>• Incorporate ideas from other groups' designs into own design. |
| (NGSS SEP) Develop Solutions Using Models -(6-8) **Develop a model to generate data to test ideas about designed systems,** including these representing inputs and outputs. | *Areas that individual students may need one-on-one support with:*<br>• Creating a device and conducting multiple tests.<br>• Collecting data on a chart and explaining in detail.<br>• Explaining the original device and iteration.<br>• Documenting qualitative and quantitative data | • An unfinished device is created, or 1 or 2 tests are conducted.<br>• Most of the data is collected on a chart but may not be explained.<br>• An explanation of the original device that includes minimally labeled sketch and iteration are provided.<br>• Documented quantitative data includes the number of products that stayed on the shelf from one or two trials.<br>• Documented qualitative data linked to ease of access, visibility, withstanding the shake table from one or two trials. | • A device is created with a minimum of 3 tests conducted (in data collection).<br>• A clear explanation of the original device that includes a detailed and labeled sketch including any changes from iterations are provided. (final assessment).<br>• Documented quantitative data includes the number of products that stayed on the shelf from all three trials (in data collection and summarized in final assessment).<br>• Documented qualitative data linked to ease of access, visibility, from all three trials (in data collection and summarized in final assessment). | *Areas where students may exceed:*<br>• Thorough and detailed documentation.<br>• More than 5 solutions. tried/ documented.<br>• Clear and detailed explanation of failure points and causes with labeled drawing.<br>• Focused improvements on failure points and ability to persevere until optimal designs are reached.<br>*Ideas for next steps for growth:*<br>• Identify aspects of each design that best met each criteria and constraint. |

| | Below Standard | Approaching Standard | Meeting Standard | Above Standard |
|---|---|---|---|---|
| (NGSS CCC)<br><br>Cause & Effect -(6-8) **Cause and effect relationships may be used to predict phenomena** in natural or **designed systems** | *Areas that individual students may need one-on-one support with:*<br>• Predicting how the device will perform in an earthquake.<br>• Explaining how earthquakes affect the designed system.<br>• Using failure and/or success data in the proposal. | • Based on the collected data (# of products that remained on the shelf), an unclear prediction is provided on how the device will perform in an earthquake.<br>• Explanation of how earthquakes affect the designed system is unclear or incomplete. | • Based on the collected data (# of products that remained on the shelf), a clear prediction is provided on how the device will perform in an earthquake.<br>• Explanation of how earthquakes affect the designed system is clear and concise. | *Areas where students may exceed:*<br>• Thoroughness and detail of explanations.<br>• Clear and detailed explanation of earthquakes.<br>• Predicting how the device will perform in an earthquake of different magnitudes.<br>*Ideas for next steps for growth:*<br>• Challenge students to research earthquake retro-fitting and materials used. |