Oregon Museum of Science and Industry

ShakeAlert™

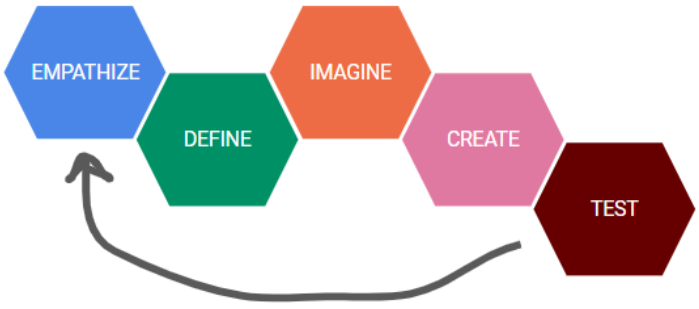
Designing for Disasters:

Learning About Earthquakes Using Design Thinking

Description: *How can we make our communities more earthquake-safe, using tools and systems designed for people?* This collection of activities engages youth in exploring earthquake science and preparedness through the lens of Design Thinking.

What is Design Thinking?

Design Thinking (DT) is an approach to problem solving focused on people; it begins with empathy, which then informs the process of imagining, creating, testing, and improving design-based solutions to real-life problems, including problems related to earthquakes. Within this frame, topics like earthquake detection, engineering, and preparedness are re-framed, not as science problems specifically, but as human problems. For this reason, Design Thinking also goes by the name "Human Centered Design."



Graphic modified from Stanford d. school

In a DT-based learning experience, learners are introduced to the problem, then invited to consider the needs and perspectives of the people affected by that problem—either imaginatively or through direct listening. With their users' specific needs in mind, learners then begin to imagine possible solutions and articulate those ideas through drawing, writing, or models. Depending on the depth of the program, students may test and

improve their ideas by building working prototypes and getting feedback from users, to see if the design serves their needs and addresses the original problem.

Program format and timeline
The program format suggested here includes five 50–60–minute activities, which may be facilitated over one or multiple days.

Each activity uses multiple steps in the DT process, with a focus on one of those steps in particular. For example, Activity 1 is focused on practicing *Empathy*, while Activity 2 is focused on *Defining the Problem*. Over the course of all five activities, students will have an opportunity to practice a range of skills related to DT applied to the topic of earthquake science and preparedness.

Recommended order of activities

1. Empathize: The Perfect Present
2. Define the Problem: Preparing for Earthquakes
3. Imagine: Design an Earthquake Alert
4. Create: Earthquake-Resistant Structures
5. Test: Shake, Don't Break

Some general recommendations for facilitating Design Thinking activities with students

- *Provide just enough scaffolding.* Some instructor-led introduction may be helpful to introduce the topic and provide helpful contextual information. Beyond that, students should be given free rein to develop their ideas. In the context of DT, "failure" is acceptable, and even encouraged as a part of the process. It might be helpful to redefine "failure" with students, framing the concept as something positive that allows us to learn what doesn't work and provides an opportunity for improvement.
- *Facilitate for process skills*. In DT, the primary emphasis is on the process skills of empathizing, defining, imagining, creating, and testing. For example, to encourage students to practice the skill of empathizing, you might invite them to pair up, then have each student talk for 5 minutes about their experience with a given problem, while their partner listens and repeats back what they hear.

Empathize: The Perfect Present

Description

In this introduction to Design Thinking, students will develop a gift for a partner based on that partner's individual needs and unique interests. The focus of this activity is developing and practicing empathy—a key component of the Design Thinking process!

This activity is adapted from Stanford Design School's "Gift Giving Project." See https://dschool-old.stanford.edu/groups/designresources/wiki/ed894/The_GiftGiving_Project.html

Supplies

Supplies	Amount	Notes
Design Thinking Graphic		See Appendix A
Objects/images representing products or systems that could be developed through Design Thinking (e.g. a public transit system, a prosthetic limb, a line of cosmetics—the options are endless!)	4–7 objects/images	Example images in Appendix A
Perfect Present booklet	1 per student	Appendix H
Object cards	3–4 cards per student	Appendix H
Pencil	1 per student	
Colored pencils	1 set per pair of students	
Building materials, e.g.: - Rubber bands - Cotton balls - Foam sheets - Wooden craft sticks - Pipe cleaners - Paper clips - Binder clips - Straws - Modeling clay	Amounts may vary; provide an abundance of different materials to allow for creative building	If building materials are not available, you may choose to let students draw their designs instead.

Advance Preparation

- Print or display examples of products or systems developed through Design Thinking
- Print one Perfect Present booklet per student. Fold and staple the booklets, ensuring the page numbers are in order.
- Print and cut out the object cards. You may also choose to write your own prompts for objects on index cards or slips of paper.

Introduction

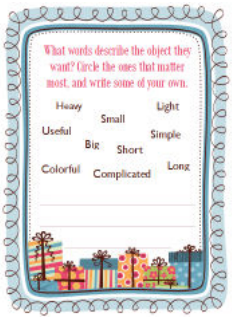
- **Invite discussion:** What problems—big or small—do you encounter in your daily life?
- **Show:** Examples of designed products and solutions that attempt to solve real-life problems. Display physical objects and/or images (as in Appendix A). For each example, invite discussion: What problem, or problems, is each of these products attempting to solve?
- **Explain:** Design Thinking is similar to engineering or inventing. The goal is to create something new that meets a need or solves a problem. The key is to consider the user—the person or group of people that you are designing for.
- **Show:** Design Thinking Graphic (Appendix A).
- **Invite discussion:** The first step in Design Thinking is e*mpathy*. What does empathy mean to you?

Partner Activity: Design and build a perfect present

- **Explain:** Today you are going to use the design thinking process to come up with the "perfect present" for your partner. The key here is to use *empathy* to listen and understand your partner's specific needs and wants—these may differ from your own needs and wants!
- Follow the instructions below as the students form pairs and work through the activity using the Object Cards (Appendix H) and the Perfect Present design booklet (Appendix H). Encourage learners to work on each step for a designated amount of time (a timer may be useful here) and to refrain from proceeding until given instructions for the next step. This is particularly important in Step 2, where rushing to complete the interview may prevent participants from adequately understanding and empathizing with their partners' needs.

Page in Book	Instructions	Suggested facilitator script

	**Step #1 – Pick Your Gift** Pass out 3–4 object cards to each pair of students. Allow one minute for each student to choose a card that represents the object they would like their partner to design for them.	Look through the cards and pick what object you'd like your friend to design for you. Maybe choose something that you think could be improved in your life, such as an object that you want to change the appearance of and make work better for you. Think about the questions on the page. What did you envision the gift to look like when you picked the object card? How can you improve an existing version of that object? Your idea doesn't have to make complete sense or even be technologically possible right now. Dream big!



Step #2 – Interview your partner

Partners take turns interviewing each other, using the booklet and the object cards as a guide. The partner who begins as the interviewer should spend the first 7–8 minutes asking questions and taking notes to better understand what their partner wants and needs from their designed gift. After 7–8 minutes, partners should switch, with the interviewer becoming the interviewee.

Time to interview your partner so you can start designing their gift! Use the questions on the back of the object card to get you started, or come up with your own.

Be sure to ask "why" often. Try to uncover stories, feelings, and emotions from your partner. Figure out what he or she will be using the object for and when. Is it for sharing, playing with, or using at home? Take notes about what your partner says

Partner #1 will start interviewing partner #2. You each get 4 minutes, and I will let you know when it's time to switch.

 	**Step #3 – Design your gift!** Both partners can work on this step at the same time, using the booklet as a guide.	Sketch at least five different ideas that could be the perfect present for your partner! Don't worry about the quality of the idea or the drawings. Just come up with as many different "wild" ideas as you can! Remember to try changing all parts of the object for each design sketch: color, shape, size, how it's used, etc. Give your partner lots of options to choose from!
 	**Step #4 – Share your ideas** Partners take turns sharing their ideas with each other. For the first 4 minutes, one partner will share their ideas and get feedback. Then, they will switch and the other partner will share their ideas and get feedback.	Show your sketches to your partner and listen to their feedback! As you give feedback, focus on what you like about each idea, and what parts you think could be improved. Try not to defend your ideas, but instead listen to what your partner likes and doesn't like as much. Take notes on his or her feedback.

	**Step #5 – Incorporate feedback** Both partners can work on this step at the same time, using the booklet as a guide.	Consider what you learned about your partner and sketch a new idea. It might be a variation of one of your first ideas, or it might be something completely new. Don't be afraid of starting over if you don't think any of your ideas are working, but keep in mind what your partner wanted from the gift in the first place, and what parts of your original ideas they liked.
	**Step #6 – Build your gift!** Both partners can work on this step at the same time. Using the hands-on materials provided (pipe cleaners, wooden craft sticks, modeling clay, etc.), each student should create a physical version of their designed gift.	Build your idea! It doesn't have to be realistic, but it will give your partner a design to interact with. You can build the whole item or just focus on one part of it.

	**Step #7 – Share and get feedback** Partners take turns presenting their perfect presents to each other. The receiving partner should interact with the designed object and provide feedback. After five minutes, switch.	Present your perfect present! Let your partner interact with the prototype, or model, you built for them. Watch how they use it or misuse it. Capture their feedback on the next page.
	**Step #7 – Share and get feedback** If time allows, students may repeat the improving, redesigning, and testing steps; this is all part of the Design Thinking process!	

Wrap Up

- If time allows, host a final showcase of all of the gifts. Encourage each participant to share with the larger group one part of the design that they developed specifically in response to their partner's needs and/or feedback.
- **Invite discussion:**
    - We began this activity by talking about empathy. Why is empathy important for the design process?
    - How did your partner practice empathy during the design process? How did you practice empathy for your partner?
    - Were there times when you realized that your partner's ideas wouldn't work with your design ideas? What did you do?
    - Can you think of any other real-life situations where practicing empathy could help solve a problem?

Define the Problem: Preparing for Earthquakes

Description

In this activity, students apply Design Thinking skills to develop two earthquake preparedness tools: 1) a short video/skit illustrating *Drop, Cover, and Hold On* in a particular setting, and 2) an emergency backpack. This activity emphasizes "defining the problem" as a key step in the Design Thinking process. Preparedness tools must consider the specific problems and hazards associated with earthquakes, and how those problems and hazards vary for different people in different spaces.

This activity is adapted from the activity "Emergency Backpack and Earthquake Preparedness Actions" available at https://www.iris.edu/hq/inclass/activities/emergency_backpack_and_earthquake_preparedness_actions

Supplies

Supplies	Amount	Notes
Whiteboard or poster board	1	
Design sheet: Preparedness Video or Skit	1/small group	Appendix B
Design sheet: Emergency Backpack	1/small group	Appendix C
Pens or pencils	1/small group	
Computer and projector to show video: *Earthquake! Steps to Take When it Strikes*	1	Video available at: https://www.iris.edu/hq/inclass/animation/earthquake_what_should_i_do_when_an_earthquake_strikes_
Video recording devices	1/small group	Phones or tablets are fine for video recording; high quality equipment is not required.
Large empty backpack or duffle bag	1	

Example items for emergency backpack (physical objects or images)	1 each	For a list of recommended items, see Appendix C

Advance Preparation

- Assemble supplies
- Set up computer and projector to display video

Introduction (7 min)

- **Explain:** Today, we are looking at the specific problems that earthquakes can create for people, and then designing solutions that address those problems.
- **Invite discussion:**
    - Has anyone here ever experienced an earthquake? Tell us about that experience!
    - Has anyone ever experienced another kind of natural disaster or emergency situation, such as a large storm, a power outage, or a flood? Tell us about that experience!
    - What kinds of problems or challenges did you face during those experiences?
- **Explain:** An earthquake can be a scary, sometimes destructive event. We can't predict or prevent earthquakes, so preparedness is essential. But in order to prepare, we have to understand what, exactly, we're preparing for. We have to *define the problem* — step two in the Design Thinking process.
- **Invite discussion:** Imagine a major earthquake happens here in [specific location].
    - What challenges, problems, or dangers do people face while the ground is shaking? (Possible responses include: people falling, objects falling on people, feelings of fear or panic).
    - What challenges, problems, or dangers do people face afterwards? (Possible responses include: injuries; lack of power, water, or internet; damage to roads or infrastructure; need for shelter, food, or first aid; stress and trauma; families being in separate locations and unable to communicate). Record student responses on a whiteboard or poster.

Small Group Activity – Design a Video or Skit (35 min)

- **Show:** The video *Earthquake! Steps to Take When it Strikes.*
- **Discuss:** The video recommends that, in most cases, people should Drop, Cover, and Hold On when they feel shaking. Why is this the recommended action? (Possible responses include: risk of falling, risk of getting hit by falling objects,

exposure to dangerous chemicals or machinery, etc. These are the *problems* we're trying to solve!).

- **Explain:** For this first activity, we are going to use Design Thinking skills to create short videos [or skits, if video recording supplies are unavailable] showing people how to protect themselves during an earthquake. The video we just watched showed examples of what to do in different kinds of places, *in general*. Your video should focus on a specific, real-life space or location. It should also be designed for the specific people who use that space.
- **Form small groups** of 2–5 students.
- **Each group chooses a location**. You may provide options for students to choose from, or let them come up with their own ideas. Encourage students to pick a location that is specific and familiar to them. If the site is presently accessible to students, they may even film their videos "on location." Examples of settings include:
    - The school cafeteria
    - A local playground
    - The parking lot
    - The library
    - On the bus
    - A local grocery store
- **Each group completes the Preparedness Video Design Sheet** (Appendix B) . Working in their small groups, students should work through the questions on the Design Sheet in order to identify a) the space they will focus on, b) the people who use that space, and c) the specific problems or hazards people might face if an earthquake occurs while they're in that space. As students are planning their videos or skits, remind them of the following:
    - Everyone participates. If filming, one person may operate the camera. Everyone else should perform in the video or skit.
    - Your video or skit should have a beginning, middle and end. It should show people using the space as usual. Then, show how people react when the ground is shaking—how do they protect themselves? Then, show what they do afterwards.
    - If you are filming, you can shake the camera to make it look like the ground is shaking.
- **Record videos** [or rehearse skits] in small groups
- **Share videos** [or perform skits] with large group
- **Discuss:**
    - Who else could we share these videos [or skits] with?
    - Will everyone protect themselves in the same way? What if a person is physically unable to Drop, Cover, and Hold On?

- What other spaces or locations could a person be in when an earthquake strikes? How would you protect yourself in that situation?

Small group activity: Design an Emergency Kit (15 min)

- **Explain:** In the last activity, we created a tool to help people keep themselves safe *during* shaking. But what about afterwards, when the earthquake is over? Our next challenge is to design an emergency kit that can help people survive and stay healthy *after* a major earthquake.
- **Form small groups** of 2–5 students.
- **Pass out** Emergency Backpack Design Sheet (Appendix C)
- **Read** the introductory paragraph on the Emergency Backpack Design Sheet
  - *Imagine there has just been a major earthquake.* You were at home when it happened. You dropped, covered and held on, so you are unhurt—phew! Unfortunately, power, water, and gas lines have all been damaged. Roads are not driveable due to fallen debris and damaged bridges. Not to mention that gas stations are out of order. Your family members are all in different places—school, work, and friends' houses. It's starting to get dark and cold. Your mission is to survive, to gather your family and help them as needed, and to help anyone else along the way, if you can.
- **Discuss:**
  - What sorts of problems do you have, now that you've survived the earthquake? (Refer back to responses generated during introductory discussion, as well as the story just read).
- **Explain**: A well-designed emergency kit will help you cope with these problems, so you can reunite with your family, survive, and stay healthy during the emergency.
- Each small group should pick (or be assigned) one or two categories under the column "Need." Then, each group should brainstorm specific items they would include in their backpack in order to address this need. For example, under "Food," they might indicate granola bars, beef jerky, etc.
- **Invite one small group at a time** to share with the larger group what items they identified and why.
  - As each small group reports, you may show physical objects or images of these and/or similar items, and place them in a physical backpack.
  - See Appendix C for a list of recommended items to include in an emergency backpack. Note that this list is not comprehensive, and students may identify additional items that would support their needs following an earthquake.
- **Discuss:**
  - What other items might be useful to include in an emergency backpack?
  - Will everyone's emergency backpack look the same?

Imagine: Design an Earthquake Alert

Description

In this activity, students learn about technology for earthquake detection and early warning, then consider how these designed systems could be used in different ways. Because the science behind earthquake detection and early warning may be new to students, this session begins with instructor-led activities to scaffold learners' understanding of these topics. Next, students will use this basic understanding, plus their knowledge of the Design Thinking process, to imagine an Earthquake Early Warning application for a specific setting such as a school, sports arena, shopping center, airport, or other location.

The "Seismic Slinky" portion of this activity is adapted from the activity "Seismic Slinky: Modeling P and S waves" available at https://www.iris.edu/hq/inclass/activities/seismic_slinky_modeling_p_and_s_waves

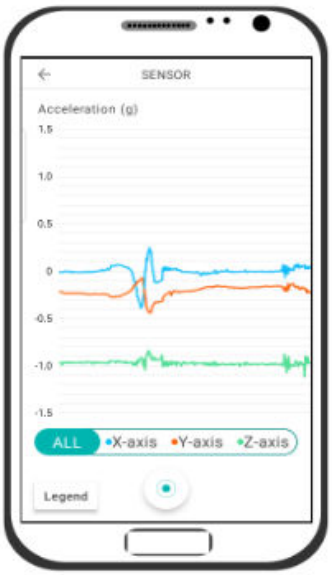
Supplies

Supplies	Amount	Notes
Computer, screen and/or projector setup to show video	1	The 4-minute video *ShakeAlert: Earthquake Early Warning System* is available in English and Spanish at https://www.iris.edu/hq/inclass/animation/722
Mobile phones and/or tablets	1/small group	For each phone/tablet download the app **MyShake** from Berkeley Labs (available for free in the app stores for Android and iOS)
Seismometer Exploration Sheet	1/small group	Appendix D
Slinky	1/small group	
Earthquake Early Warning Design Sheet	1/small group	Appendix E

Advance Preparation

- Load video *ShakeAlert: Earthquake Early Warning System* (see Supplies, above, for URL) on computer, TV, or other display.

- Load each tablet/phone with the MyShake app. Open the app, and in the options menu, select "Sensor" to open the seismometer feature. It should look like this:

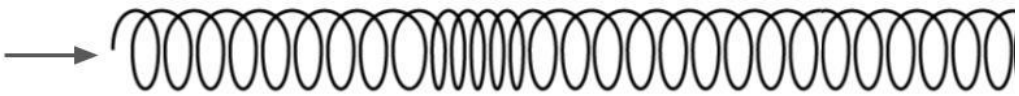


Introduction

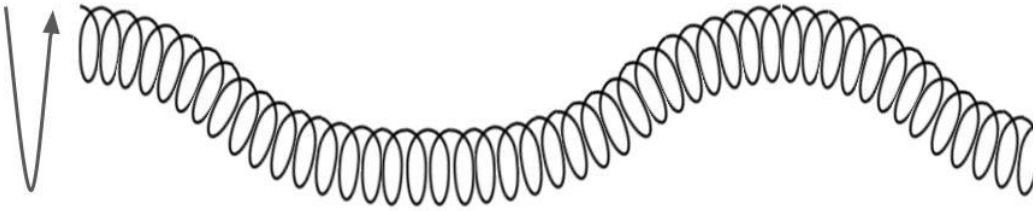
- **Explain:** Today we are focusing on the next step in the Design Thinking process: *Imagine*. So far, we have spent some time *defining the problems* around earthquakes and using *empathy* to consider how those problems affect people. Next, we are going to imagine some solutions to those problems by learning more about technology for earthquake detection and alerting.

Small group activity: Seismic Slinky (15 min)

- **Explain:** When an earthquake occurs, waves of energy, called seismic waves, travel through the earth, causing shaking. Let's imagine that this Slinky is the surface of the earth; we're going to see how seismic waves travel through it.
- **Demonstrate seismic waves using Slinky:** Lay the Slinky on a flat surface like a table or floor. Hold on to one end and have an assistant hold the other end as you stretch it long.
    - ***P* Wave** – Give one end of the Slinky a quick, sharp, forward push. A compressional wave will travel down the length of the Slinky. It should look like this, as viewed from the top:



    - ***S* Wave** – Flick one end of the Slinky left and right. A transverse wave will travel down the length of the Slinky. It should look like this, as viewed from the top:



- **Form groups of 2–3**
- **Pass out** 1 Slinky per group.
- **Explore:** Each group should use their Slinky to make both types of waves. Remind learners to be careful with Slinkies, to avoid tangles. As groups make both kinds of waves with their Slinkies (or after), you may offer some prompts and questions, such as:
    - Can you make bigger and smaller waves?
    - Can you make faster and slower waves?
    - How long can the wave go before it loses energy and dies out?
    - How long does it take for the wave to get from one end to the other? What if you stretch it longer?
    - Which earthquake wave travels faster: the *P* wave or the *S* wave? *(In this model, they are nearly the same speed, but in real life, the* P *wave is actually faster, which means that during a real earthquake, the* P *wave is typically detected first).*

    - Which earthquake wave do you think would cause more damage: the *P* wave or the *S* wave? Why? *(In general, the S wave is more damaging because of the up-and-down and side-to-side motion generated by this kind of wave).*
- **Discuss:**
    - As you were making waves with your Slinkies, what are some things that you noticed? *(Answers will vary; highlight the fact that different kinds of waves cause differing levels of damage AND that it takes time for any seismic wave to travel through the earth. This means that people close to the epicenter—where an earthquake begins—will feel shaking right away, while people farther from the epicenter will feel shaking seconds or even minutes later!*

Small group activity: Explore seismometer apps (15 min)

- **Explain:** One of the ways that people study earthquake waves is through seismometers. A seismometer is essentially a motion detector. Seismometers are used all over the world to detect earthquakes, and they come in a variety of forms. Today, we are going to be exploring a seismometer app on phones/tablet.
- **Form small groups** of 2–5 students.
- **Pass out** 1 Seismometer Exploration Sheet (Appendix D) and 1 phone/tablet per small group.
- Each small group should work through the challenges on the Exploration Sheet.
- **Discuss:**
    - As you were going through the challenges, what did you notice? *(Invite specific observations)*
    - Based on what you saw, would you say that a seismometer can predict earthquakes? *(No. Seismometers can only detect shaking from an earthquake that's already started).*
    - What kind of information *can* a seismometer give us about an earthquake? *(Seismometers can tell us about an earthquake's location, its size, the length of time that shaking lasted, and the intensity of that shaking).*
    - How could this information be useful? *(Seismographic data from past earthquakes can help us prepare for future earthquakes. This data also tells us about the structure of the earth beneath the surface. And, seismometers are a key part of earthquake early warning systems like ShakeAlert).*

Large Group Activity: Watch and Discuss ShakeAlert Video (10 min)

- **Discuss:**
    - Has anyone heard of ShakeAlert? If so, what's something you know about it?
- **Show:** On a screen or projector, show the 4–minute video *ShakeAlert*
- **Discuss:**

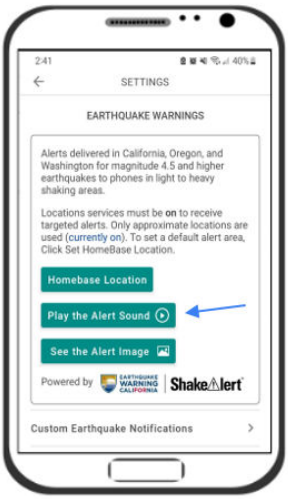
- Based on what you saw in the video, how can ShakeAlert help people? How might it help solve some of the problems and challenges related to earthquakes? *(Possible responses include: helping prevent injuries by giving people a few seconds of warning before shaking reaches them; reducing damage to infrastructure by triggering automatic actions such as slowing down a train to closing a gas valve).*

Small Group Activity: Design a Use for Earthquake Early Warning (15 min)

- **Explain:** The ShakeAlert System works because electronic data travels faster than seismic waves. When an earthquake begins, seismometers rapidly detect the seismic waves, sending that information to a computer program that can quickly estimate the location and size of the earthquake. Then, alerts can be sent out to areas that are expected to feel shaking. All of this happens very fast, which means that some people will get alerts *before* they feel shaking.
- **Form small groups** of 2–5 students.
- **Pass out** 1 Earthquake Early Warning Design Sheet (Appendix E) per group
- Each group should work through the sections of the Design Sheet, choosing a real-life setting where earthquake early warning might be beneficial, then *imagining* how it could be set up. Who will get alerts in this setting? How will they get alerted? What other automated actions (e.g. slowing down a train or automatically opening elevator doors) would help protect people and property in this setting? You may choose to let groups work at their own pace, or pause after each section to discuss and share their ideas.
- **Discuss**
  - Encourage each group to share their ideas and invite feedback. What else could you imagine for this space?

Large Group Activity: Earthquake Early Warning Drill with MyShake App (5 minutes)

- **Explain:** There are many ways to get earthquake early warning alerts. One is through the MyShake app. If you have this app on your phone or tablet in Oregon, Washington, or California, you can get ShakeAlert-powered alerts letting you know when an earthquake near you may cause shaking. This app also has a test feature, so you can hear what the alert sounds like in advance.
- Find the test feature, under “settings” in the MyShake App. There are options to “Play the Alert Sound” or “See the Alert Image”



- **Discuss:**
    - We've already discussed how we would Drop, Cover, and Hold on in different settings, if we started to feel the ground shake. (Activity 2: Define). But what if we simply received an alert, telling us that the ground was *about* to starting shaking? What would we do? (*The same thing! Answers may vary, but emphasize that, in general, the best thing to do if you receive an earthquake early warning alert is to Drop, Cover, and Hold On, then wait for shaking to begin).*
- **Practice responding to an alert** – Let students know that you are going to play the alert sound on the MyShake App. When you do, everyone should Drop, Cover, and Hold On (and/or practice any other relevant protective actions identified during Activity 2).

Create: Earthquake-Resistant Structures

Description

In this activity, students learn about techniques for bracing and strengthening structures, to make them more resistant to shaking. Students then apply these techniques—along with considerations for their building's users—as they design and create their own model structures out of toothpicks and marshmallows.

The "Structural Bracing" portion of this activity is adapted from the activity Designing Earthquake-resistant Structures—Engineering for Safety," available at https://www.iris.edu/hq/inclass/activities/designing_earthquake_resistant_structures

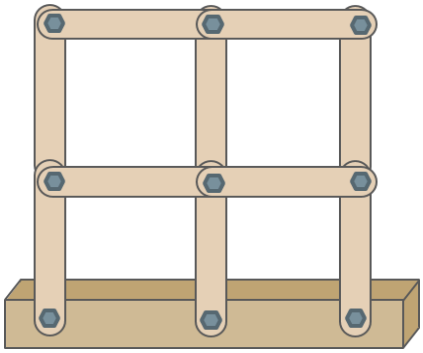
Supplies

Supplies	Amount	Notes
Model walls	1/small group *or* 1/large group	See "Advance Preparation"
Reinforcement supplies for model walls	1 set/small group	This can include binder clips, paper clips, additional craft sticks, pipe cleaners, and/or and stiff pieces of cardstock, cardboard, or other materials, along with scissors
Earthquake-Resistant Structures Design Sheet	1/small group	Appendix F
Pieces of styrofoam, to serve as bases	1/small group	Each base should be at least 4" wide x 4" long x 1" thick. Thick cardboard can also work.
Toothpicks	About 100/small group	
Mini marshmallows *Or* Plasticine, no-dry clay	Enough for about 100 pieces/small group	Marshmallows are traditional in this activity, but no-dry clay is an

		excellent alternative, if there are concerns about using food as a building material. Students can shape clay into mini-marshmallow-sized pieces.

Advance Preparation

- Prepare your model wall(s). For video instructions on how to build the model wall, see https://www.iris.edu/hq/inclass/video/253 . The finished model wall, made of craft sticks, connected into a grid with nuts and bolts, will look like this:



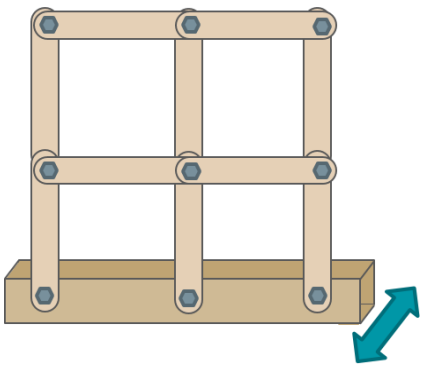
  - For each model wall, you will need:
    - A piece of wood for the base, approximately 1" x 3"
    - 10 wood tongue depressors (jumbo 6" craft sticks)
    - 3 wood screws (#8 x ½")
    - 6 bolts (8–32 x ½")
    - 18 washers (#8)
    - 6 nuts (#8–32)
  - Additionally, you will need the following tools for assembly:
    - Eye protection
    - Electric drill
    - 11/64" drill bit to accommodate the 8–32 bolts
    - Scissors
    - Phillips head screwdriver
    - Scrap wood for a protective work surface while drilling
    - Several rubber bands (to bundle tongue depressors
    - while drilling)

Introduction

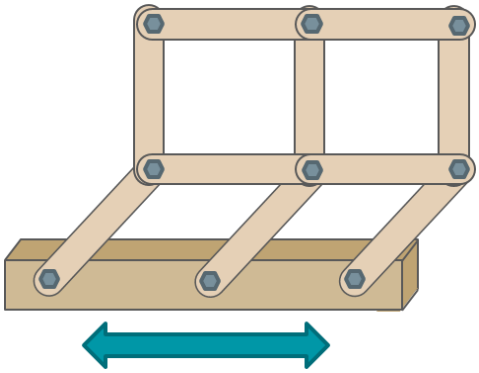
- **Explain**: In today's activity we will be working on the fourth step of the DT process: *Create*. We will focus on specific design features that can help buildings survive earthquake shaking.
- **Discuss**
    - Have you ever seen images or video of structures that collapsed during an earthquake?
    - What about those structures made them weak?
    - What are some ways that buildings, bridges, and other structures could be made stronger, and more resistant to shaking?

Small Group Activity: Structural Bracing (15 minutes)

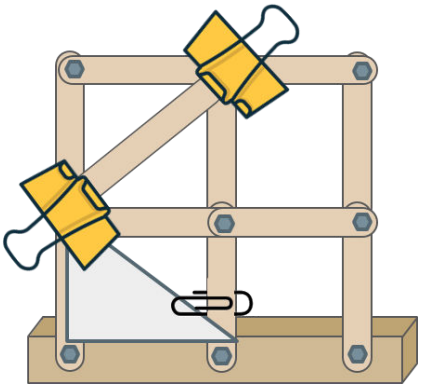
- This activity may be done as a large-group demonstration or in small groups, depending on the number of model walls you have available.
- Set up model wall so that it is standing upright. The screws connecting each of the support beams (i.e. the popsicle sticks) should be barely loose.
- **Explain:** Have you ever seen a building while it's under construction? If you take off the exterior covering, what you see is an internal structure like this, with beams made of wood, steel, or other materials.
- **Discuss:**
    - What do you think will happen to this wall if an earthquake causes it to shake?
- **Demonstrate (and/or invite students to try in their small groups):**
    - Shake the base of the model in a forward-and-back motion relative to the base. Invite predictions and/or observations. *(The wall will sway but is unlikely to collapse)*



- Shake the base of the model in a side-to-side motion relative to the base. Invite predictions and/or observations. (*The wall will sway and the bottom section will collapse).*



- Reinforce the wall using the various reinforcement supplies (binder clips, paper clips, additional craft sticks, cardstock, etc.). Continue to experiment with different materials and orientations, shaking the model to see which combination of materials yields the sturdiest wall. Students will find that triangular and diagonal shapes are typically stronger than squares.



- **Explain:** Diagonal bracing is a common strategy used to make buildings, bridges, and other structures stronger and more resistant to shaking. Keep that in mind when you create your structures in the next activity!

Small Group Activity: Create an earthquake-resistant structure

- **Explain:** We are going to take what we've learned about bracing—plus what we already know about designing for specific users—to create an earthquake-resistant structure.
- **Form small groups** of 2–5 students.
- Each group should complete the Earthquake Resistant Structures Design Sheet (Appendix F), beginning by choosing a structure type, identifying the users and

site-specific considerations for that type of structure, and sketching out their idea. Once they have completed this planning process, they may move on to the next step.

- **Pass out** styrofoam bases, toothpicks and marshmallows (or plasticine clay) to each group. Using the marshmallows as connectors, students will build models of their structures. Encourage students to periodically give their bases a shake in multiple directions, to ensure that their structures are sufficiently sturdy to withstand an earthquake. Remind them, as needed, of the value of diagonal bracing to support the structure.

Test: Shake, Don't Break

Description

In this activity, students continue to explore design strategies for building earthquake-resistant structures. Students design base isolators using model materials, then systematically test them in a homemade shake table.

This activity is adapted from the activity "Shake, Don't Break" from OMSI's Designing Our World curricula.
https://omsi.edu/wp-content/uploads/2023/07/DOW__Shake-Dont-Break.pdf

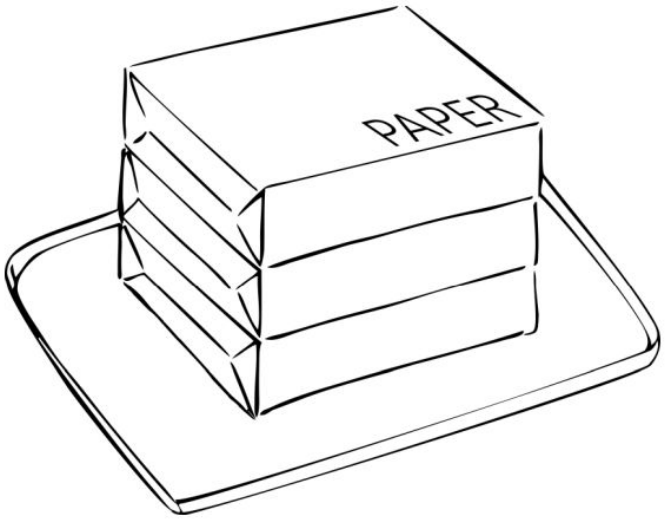
Supplies

Supplies	Amount	Notes
Sheet pans	1/small group	Cookie sheets or cafeteria trays would also work
Reams of paper, unopened	3/small group	
Base Isolation Testing Sheet	1/small group	Appendix G
Materials for testing Round 1 • Wine corks • Small round objects (e.g. bouncy balls) • Medium round objects (e.g. golf balls) • Large round objects (e.g. tennis balls) • Cotton balls • Marbles • Beads	10–50 of each, depending on size	These supplies can be replaced by similar ones. You will need at least two testing materials for every group. Make sure your chosen materials vary in shape and size (i.e., provide large round objects, small round objects, non-round objects, soft objects, and hard objects).
Add'l materials for Round 2 • Craft wax sticks (e.g. Wikki Stix) • Paper cups • Cardboard tubes • Sticky tack • Scissors	A few of each/small group	

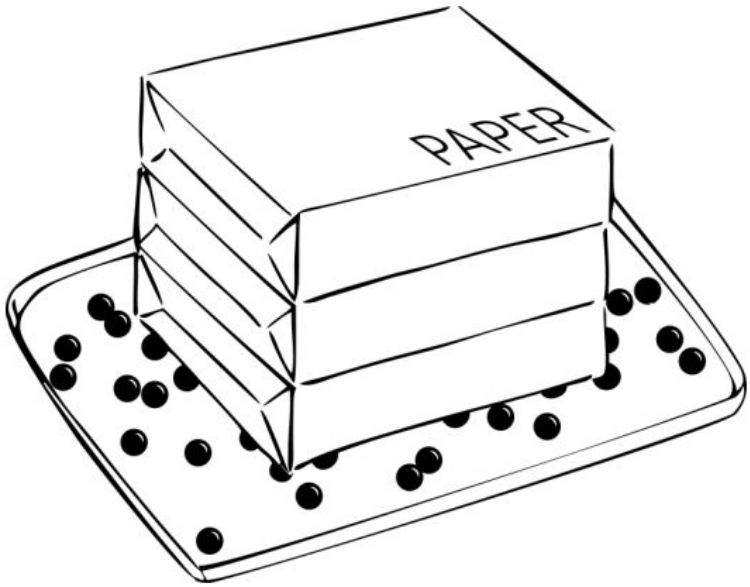
Dollhouse w/ furniture and people figurines	1	(optional) To use in final test of base isolators
Shallow, clear rectangular bin (such as a storage bin)	1	(Optional) If using the dollhouse. Should fit around the base of the dollhouse with at least 2" extra on each side.

Introduction

- **Explain:** One way that buildings can be designed to withstand shaking is through base isolation. Base isolation means separating the base of the building from the ground so that the building can remain in place while the ground moves back and forth underneath it. This helps protect the structure from major damage or collapse during an earthquake. Today we are going to design and build base isolation systems for a model building. Then we are going to use the final step of the DT process: *test* to determine whether our base isolation systems were successful.
- **Demonstrate:** Stack three reams of paper on a sheet pan as in the image below. Explain that the paper stack represents a three-storey building and the sheet pan represents the foundation of the building. Shake the sheet pan, simulating an earthquake, and ask students what they observe. (The three reams of paper quickly separate and fall off).



Next, place a handful of bouncy balls between the paper reams and the sheet pan. Shake the sheet pan again, and ask students what they observe. (The three reams of paper should stay stacked for longer).



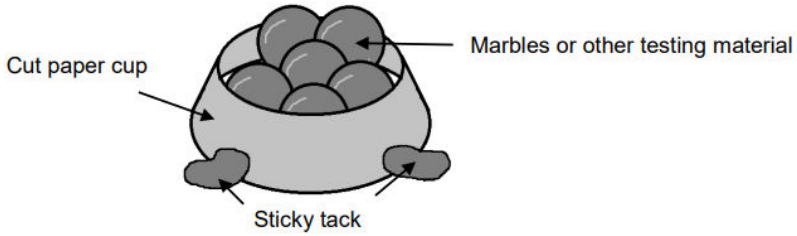
Small Group Activity: Testing, Round 1.

- **Form small groups** of 2–5 students.
- **Pass out** to each group the Base Isolation Testing Sheet, three reams of paper, a sheet pan, and *one* type of material to test as a base isolator (e.g., just tennis balls, just marbles, or just wine corks).
- Following the instructions on the Testing Sheet, each group should:
    - Indicate on the first line which base isolation material they are testing (e.g. marbles)
    - Place the material between the paper reams and the sheet pan, then shake the sheet pan for a full 10 seconds. You may want to count out loud together for the first round.
    - Rate the effectiveness of that base isolation material on the testing sheet.
    - After testing the first material, groups may swap and try a different material. Do not mix two materials together at this point.
- **Discuss:**
    - Which materials worked best and why?
    - What are some challenges you're facing?

Small Group Activity: Testing, Round 2

- **Explain:** In this next round you can take what you learned about the different materials and begin to get creative! You will be able to test combinations of each material to find the most effective way to protect the building. And you should think about how to keep the base isolators underneath the tower.

- **Pass out** the additional materials (sticky tack, paper cups, scissors, craft wax sticks, cardboard tubes, and/or magnets). Groups may have a difficult time keeping the testing materials from scattering out from underneath the paper reams while testing. The paper cups, cardboard tubes, or craft wax sticks are helpful for containing the objects so they don't roll away (see image below). Allow the students to cut their containers to whatever size they think is necessary. Sticky tack or magnets will add traction to keep the containers from moving away with the testing material.



- Following the instructions on the Testing Sheet, each group should:
    - Draw or describe their base isolation system
    - Place their base isolators between the paper reams and the sheet pan, then shake the sheet pan for a full 10 seconds.
    - Rate the effectiveness of their base isolators on the testing sheet.
- **Discuss:**
    - What strategies or designs were most successful, according to your tests?
    - How else could you imagine improving your design, to make it more effective?
    - What are some challenges you're still facing?

Large Group Activity: Dollhouse Testing (Optional)

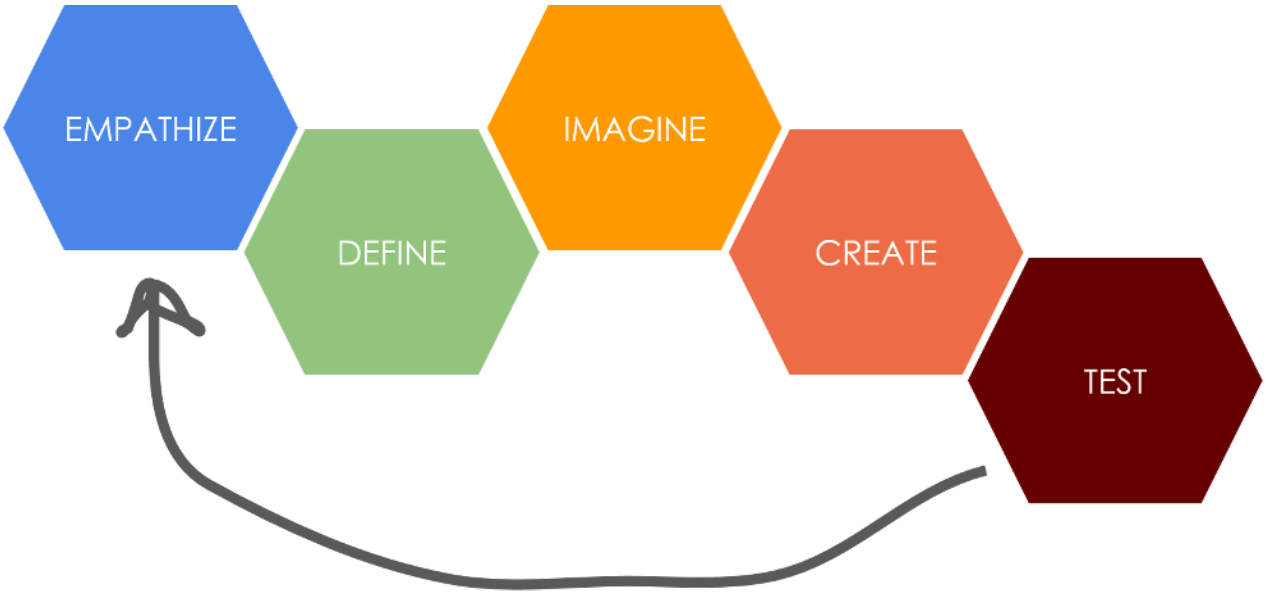
- **Explain:** A building is not just the outside structure. Think about what you see in the building you are in (other people, furniture, hanging ceiling lamps, etc.). For this round, you will work in your group to discuss what objects worked best as base isolators. We will pick our top three and see if they work in making an earthquake-safe base isolation method for this miniature house. There are objects inside, and we will take note of how much everything moves around.
- **Discuss:**
    - How is this dollhouse different from the reams of paper?
    - How will you judge whether the base isolators will successful? *(Decide on some criteria—for example, the furniture and people remain upright).*
    - Which base isolator design(s) do you think will work best? (Discuss as a large group to narrow down the options to three).

- Test each of the three base isolators the students predicted would be successful.
    - Place the base isolators in the base of the large, clear tub. Place the dollhouse on top. Make sure the furniture and people are upright to begin with.
    - Shake the tub for a minimum of 10 seconds.
    - Evaluate the effectiveness of the base isolators, using whatever criteria the group decided on.

Appendices

Appendix A

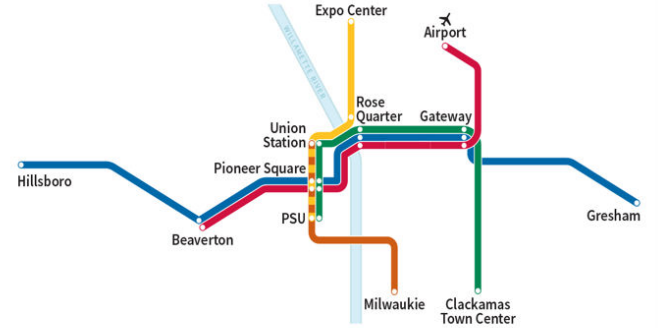
Design Thinking Process



Graphic modified from Stanford d. school

Example Images

What can you develop using Design Thinking?



… anything that solves problems for people!

Appendix B

Design Sheet – Preparedness Video or Skit

Your challenge: design a video, skit or other creative product that shows people how to stay safe during an earthquake. Your video should focus on a specific space or location. It should also be designed for the specific people who use that space.

Describe **the space**
(For example, a local park, the library, or your school cafeteria)

Who uses that space?

Imagine a major earthquake happens! **What specific problems** will people face if they are in this space when the ground starts shaking?
(For example, what things could fall over and hit people? Are there other hazards, like heavy machinery, crowds, etc.?)

How should people protect themselves in this space? (There may be multiple ways).

Plan your video or skit! Keep the following in mind:

- Everyone participates. If filming, one person may operate the camera. Everyone else should perform in the video or skit.
- Your video or skit should have a beginning, middle and end. Show people using the space as usual. Then show how they react when the ground is shaking. How do they protect themselves? Then, show what they do afterwards.
- If you are filming, you can shake the camera to make it look like the ground is shaking.

Appendix C

Design Sheet – Emergency Backpack

Imagine there has just been a major earthquake. You were at home when it happened. You dropped, covered and held on, so you are unhurt—phew! Unfortunately, power, water, and gas lines have all been damaged. Roads are not driveable due to fallen debris and damaged bridges. Not to mention that gas stations are out of order. Your family members are all in different places—school, work, and friends' houses. It's starting to get dark and cold. Your mission is to survive, to gather your family and help them as needed, and to help anyone else along the way, if you can. Good thing you have an emergency backpack!

Your challenge: Design an emergency backpack that would work for you in this fictional (but realistic) situation. An emergency backpack should be portable, accessible, and include supplies that will allow you to survive for at least 72 hours following an earthquake.

Need	Specific items to include
Water (how will you purify it?)	
Food (What kinds? How much?)	
Shelter and warmth	
Cleaning and personal hygiene	

Medical and first aid	
Communication	
Comfort and mental health	
Other supplies	

Instructor Key - Emergency Backpack

The following is a list of specific items that may be helpful in an emergency backpack. This is not a comprehensive list; learners may come up with other ideas!

Need	Items
Water (how will you purify it?)	- Water bottle(s) filled with clean water (at least 2 liters) - A water filter and/or water purification tablets
Food (What kinds? How much?)	- Any non-perishable, high-calorie foods, including energy bars, beef jerky, trail mix, etc.
Shelter and warmth	- A jacket, hat, and gloves (this is a good use for old, stained, or beat-up garments that you'd otherwise throw away). - An emergency mylar blanket
Personal hygiene	- Toothbrush and toothpaste - Hand sanitizer - Eye care (spare glasses or contacts) - Menstrual supplies - Toilet paper - Wet wipes
Medical and first aid	- Any medications you take regularly (including prescriptions as well as over-the-counter medications) - A first aid kit
Communication	- A two-way radio (battery or hand-crank) - Whistle to signal for help - Local maps - A solar-powered phone charger
Comfort and mental health	- A small book or journal - A card game - A token or object that brings you comfort
Other supplies	- Flashlight and extra batteries - Multi-tool

Appendix D

Seismometer Exploration Sheet

Try each of the following challenges with the seismometer app, with the phone/tablet resting on a table. For each challenge, record your observations using words or drawings.

Challenge	Observations
Give the table a little shake. What do you notice?	
Jump up and down on the ground. What do you notice?	
Make just the green line wiggle.	
Make just the orange line wiggle.	
Make just the blue line wiggle.	
Without touching the actual phone/tablet, make the reading go “off the charts”	
Take 3 big steps away from the seismometer. Jump on the ground. Can the seismometer still detect the motion? Move farther away and try again.	
Pair up with another group. Place your devices on tables at least 3 feet apart. Jump on the ground between them, first closer to one table, then closer to the other table.	

Appendix F

Design Sheet – Earthquake Early Warning

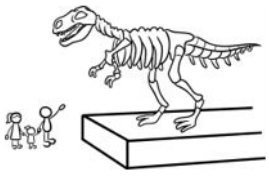
Pick a setting that could use earthquake early warning.

School

Library

Park

Construction Site



Museum

Hospital

Airport

Other ideas?

Imagine: How could earthquake early warning be used in this setting to protect people and property? Remember, you only have 10 seconds!

Who are you going to warn? *(Think about the different kinds of people in this setting)*

How are you going to warn them? *(Circle your choices or add your own ideas)*

Mobile devices

Electronic Road Signage

Digital Billboard

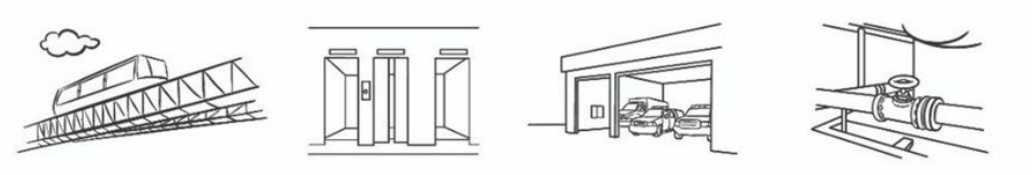
PA Speakers

TV and Radio

Other ideas?

What will your warning message look like or sound like?

What other systems does your setting have? *(Circle your choices or add your own ideas)*



Trains | Elevators | Garage doors | Gas and water pipes

Generators | Machinery | Bridges | Other ideas?

What automatic actions can your earthquake early warning system trigger? (For example, in your system, trains might automatically slow down and stop any time an earthquake is detected nearby).

Imagine some more.

What will you call your earthquake early warning system? Draw a logo if you like.

How will people know about your earthquake early warning system? How will they know how to use it?

Appendix F

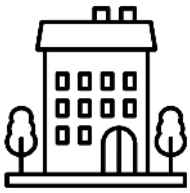
Design Sheet - Earthquake-Resistant Structures

Pick a type of structure to create

Gym

Created by Linseed Studio from the Noun Project

Multi-Storey Apartment



Created by Made from the Noun Project

Bridge

Created by Adrien Coquet from the Noun Project

Water Tower

Created by Orange Cat from Noun Project

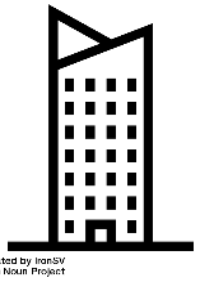
Treehouse

Created by Pixel Bazaar from Noun Project

Two-Storey House

Created by Pham Thi Dieu Linh from Noun Project

Skyscraper



Created by IronSV from Noun Project

Senior Home

Created by Nithinan Tatah from Noun Project

Who will use this structure? What do you know about them?

This structure should survive shaking from an earthquake. What else will your users want or need from this structure? Are there specific features that will make it safer or better for your users?

Appendix F

Sketch your structure, labeling any important features you plan to include.

Appendix H

Testing Sheet – Base Isolation

Instructions: How well did the materials separate, or isolate, the base from the building and prevent the paper reams from separating and falling? Fill out the chart, rating each testing material by circling a number on the scale from 1 to 5. Use the pointers below as your guidelines.

1. All three paper reams collapsed immediately
2. Most reams fell after the shaking began
3. The reams started separating and falling after a few seconds of shaking
4. The paper reams separated some, but stayed mostly in place
5. The paper reams stayed stacked neatly on top of one another

Round 1 – Testing single materials

Testing material	Effectiveness				
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

Round 2 – Testing multiple materials. It doesn't count if your base isolators roll out from underneath your building!

Draw or describe base isolator	Effectiveness				
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

Appendix H

Perfect Present Booklet and Object Cards

Note: To correctly print the Perfect Present booklet, use the following printer settings:

- Print only the pages of the booklet (not this entire PDF)
- Select “Duplex” or “Print on both sides” and “flip on SHORT edge.”
- Once printed, the entire stack of pages can be placed together, folded in half to form a booklet, and the pages will be in the correct order.

Engineer the Perfect Gift!

- Pair up
- Interview
- Design a gift for your partner

Depending on time, these steps can be done over and over and over again...

It's all part of the Engineering Design Process!

Step #8: Improve!

Improve your design even more based on the last bit of feedback your partner provided.

Step #1: Pick your gift

What object do you need? Is there an object you would like to improve?

Choose your card and give it to your partner.

Step #2:
Interview your partner

What does he/she need?

Read the questions on the back of your partner's card and take notes on their answers.

Feedback

What worked well:

What could be improved/changed:

Questions:

New ideas:

Step #7: Share and get feedback

Share your creation with your partner and get feedback about the gift you made for them.

Take notes here:

What words describe the object they want? Circle the ones that matter most, and write some of your own.

Heavy

Light

Small

Useful

Simple

Big

Short

Long

Colorful

Complicated

Building Time.

Have fun!

Step #6: Build your gift!

Use the materials at your table and make something your partner can interact with.

My partner _____ (name)

needs _____ (object)

_____

that _____ (what it does)

_____

_____

_____

because/but/and _____

_____ (reason or constraint)

_____

_____

_____

Step #3:
Design your gift!

Sketch at least 5 wild new ways to meet your partner's needs (they don't have to be good sketches!)

Sketch Here!

Step #5:

Sketch your new idea based on the feedback you received.

Sketch Here!

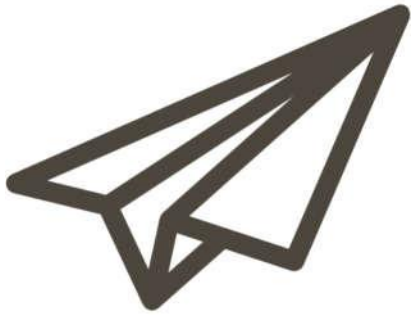
Step #4: Share your ideas

Share your ideas with your partner and capture his or her feedback on your designs.

Feedback

What parts my partner liked:

What parts they didn't like:



A Form of Transport

Something to Carry Things In

A Communi-cation Device

Something to Sit On

Shoes

Something to Wear

- Where and with whom would you need to communicate?
- How could you improve existing communication devices?
- What else would it do?
- How does it help you?
- How is it powered?

- What type of things would it carry?
- What else would it do?
- How does it help you?
- How would you carry it?

- How could you improve existing modes of transportation?
- What else would it do?
- How does it help you?
- What is your favorite and least favorite mode of transportation?
- Where would you go?
- How would it be powered?

- Why do you need it?
- What is your favorite thing to wear?
- What else would it do?
- How does it make you feel?
- How does it help you?

- Why do you need them?
- When would you wear them?
- What else would they do?
- Describe your favorite shoes.

- Where would you use it?
- Where is your favorite place to sit?
- What else would it do?
- How does it help you?