Project ASSESS (2016-18) – sponsored by
KY Dept. of Education (KDE) MSP Program

NOTE: All materials are those of the project team and do not represent KDE endorsement.

UNIVERSITY OF LOUISVILLE
CENTER FOR RESEARCH IN MATHEMATICS & SCIENCE TEACHER DEVELOPMENT

PIMSER
Partnership Institute for Math & Science Education Reform

Classroom Embedded Assessment [CEA] Title: Earthquake-resistant Buildings

a. Targeted Performance Expectation(s)

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions]

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

b. Learning Goal(s)

CEA designed to elicit student's:

1. Use of evidence from design tests to determine factors that improve a building's resistance to earthquakes (e.g., cross-bracing, large "footprints," and tapered geometry).
2. Make explicit cause-effect statements about evidence and outcomes, demonstrating ability to process experiences

DCI: Humans cannot eliminate natural hazards but can take steps to reduce their impacts. Testing a solution involves investigating how well it performs under a range of likely conditions.
SEP: Use evidence (e.g., measurements, observations, patterns) to design a solution to a problem.
CCC: Cause-and-effect relationships are routinely identified, tested, and used to explain change.

c. Instructional Context

- Students will have had prior experiences:
  a. using maps and data to describe patterns of where earthquakes occur on earth's surface.
  b. examining data about depths and magnitudes of earthquakes and effect on natural and man-made structures.
- This CEA will be administered on the first day of a two day engineering activity entitled, "Testing Model Structures: Jell-O Earthquake in the Classroom," at:

Author: Holly Veucasovic, Graves County Schools, Kentucky

https://www.teachengineering.org/activities/view/cub_natdis_lesson03_activity1 (The source of this material is the *TeachEngineering* digital library collection at *www.TeachEngineering.org*. All rights reserved.)

- Before beginning the design task, students will view a video of an earthquake engineer demonstrating a shake table and sharing tips for earthquake-resistant buildings. (https://www.eie.org/engineering-adventures/curriculum-units/shake-things)

d. Student Task/Prompt

Experience prior to CEA task:

To engage students begin by showing video footage during historic earthquakes and the damages caused. http://video.nationalgeographic.com/video/earthquake-montage?source=relatedvideo Have students make observations about the structures shown and any features that seem to help the structure be more resistant to earthquakes.

Afterwards, use a table round robin to share observable things from the video. Even though we can't stop earthquakes from happening we can plan and prepare for them as well as construct buildings better able to withstand earthquakes.

We will begin the lesson by leading a class discussion about why we practice earthquake drills in school. Timed Pair Share Question #1 Thinking about our school where we go during earthquakes and why?? Remind students that because earthquakes can cause walls to crack, foundations to move and even entire buildings to crumble, engineers incorporate into their structural design techniques that withstand damage from earthquake forces. Timed Pair Share Question #2 share ideas of characteristics of earthquake shelters with classmates gleaned from the videos (for example, cross bracing, large bases, and bend and sway with the motion of earthquakes, or are isolated from the movement by sliders).

- See student handout at end -

Tell students that today they are acting as earthquake engineers. They will use the engineering design process to construct earthquake-resistant structures. Just like engineers, students will construct models to test cause-and-effect

Author: Holly Veucasovic, Graves County Schools, Kentucky

interactions concerning the functioning of various structural designs, and then re-engineer their model based on data to better meet the criteria for success.

CONSTRAINTS: at least 2 stories high, 30 marshmallows, and 30 round or flat toothpicks (cannot mix types of toothpicks), shake test must be 10 seconds. Ask for ideas for other constraints that engineers might face.

BRAINSTORM DESIGN SOLUTIONS: Students will brainstorm design solutions with their partner and draw a diagram of their proposed structure indicating their structural considerations for withstanding an earthquake.

BUILD IT: Students build their structures based on their proposed design.

TEST IT: Students will test how well their building withstood the earthquake. They will place their structure on a pan of Jell-O, shake the pan for 10 seconds, and record their observations for a minimum of 2 trials.

NOTE: Students may want to shake the pan too hard, or perhaps too gently so that their structure resists damage. To control this variable, the teacher can set the range of motion by putting soft 'bumpers' like small pillows on either side approximately 10 cm from the back of each hand to bump into, and to control frequency of vibration use a metronome (free download for computer at https://www.nch.com.au/metronome/index.html) and set it (try something like 90 beat per minute to start, and try it out). Students then should be bumping the backs of their hands into the pillow bumpers at each 'click' of the metronome.

CRITERIA FOR SUCCESS: 1. Shear – how close are the angles to 90° after the shake test? 2. Tip or Fall – did the structure tip over or fall? 3. Slide – how close is the building to its starting place? 4. Construction – how many joints of the building stay attached? SHARE OUT: Each design team will display their data with their model structure and summarize how well their design met the criteria for success and what factors seemed to account for your model's success.

Students will examine each model/data display and record notes about structural features that seemed to better meet the criteria for success and the evidence that supports your thinking.

CEA task: (Individually)

A. Compare data collected by different teams with your team's data. Use evidence from the design tests to determine factors that caused improvement in a structure's resistance to earthquakes.

Author: Holly Veucasovic, Graves County Schools, Kentucky

B. Draw a new diagram of a proposed structure, incorporating the factors that caused improvement in the structure's resistance to an earthquake. Label these factors on your new diagram, explaining the evidence you used that led you to choose this factor.

e. Success Criteria

	2	**1**	**0**
Determine factors that caused improvement to a structure's resistance to earthquakes using evidence from design tests	Identifies several (2-3) factors that caused improved resistance to an earthquake AND cited specific evidence from design tests for each factor.	Identifies 1 factor that caused improved resistance to an earthquake AND cited specific evidence from design tests	Identifies factor(s) without using evidence (without specifics) from design tests OR Uses evidence incorrectly to identify factor(s) that caused improved resistance to an earthquake
Draw an new diagram of a proposed structure and label factors that caused improved resistance to an earthquake	New diagram incorporates 2-3 of the identified factors. Factors are labeled. Explanations of supporting evidence for each factor.	New diagram incorporates one of the identified factors. Factors may or may not be labeled. Evidence for at least one factor is explained.	New diagram does not incorporate any identified factors. If labeled, labels are not of factors (i.e., labels marshmallows, toothpicks)

Factors could be cross-bracing, large base, tapered geometry.
Evidence could be things like: 8 of 10 buildings with large bases did not fall over, had more 90° angles, and fewer joints disconnected.

f. Next Instructional Steps

<u>For students with 1s or 0s:</u>
Regroup students into small groups based on score for each criterion.

Groups may be:

Author: Holly Veucasovic, Graves County Schools, Kentucky

Students who could identify 1 or 2 factors but did not justify with evidence from tests - provide students with organizer and sentence frame to use to summarize data.
Students who could not identify any factors – provide diagram of different buildings with factors labeled. Have students compare labeled pictures to designs of all teams (take photographs of each design for reference).
Students who incorporated 1 or no factors in redesign – have students point out factors in design if present; ask students to point to data that supports a design factor, share a good and not so good example of a redesign and ask students to identify what made the good example good?

<u>Extension for students with 2s</u>:
Provide additional resources (e.g., readings, videos, simulations) about engineering designs for earthquake-resistant buildings and ask students to identify additional design considerations. One specific factor they might consider for design are "dampers" (explained in the video as like shock absorbers). They could use rubber bands as possible dampers on their structures and retest after adding this design element.

Allow students to 'test to failure' the factors they identified to determine limitations. Relate to earthquake magnitudes.

g. Student Work Samples

No student work samples are available.

h. Reflection and Revision

This CEA incorporates a revision to more explicitly ask students to cite specific evidence from model tests to make design decisions; initially with the original version students were typically vague or omitted citing any evidence at all.

Author: Holly Veucasovic, Graves County Schools, Kentucky

Project ASSESS (2016-18) – sponsored by KY Dept. of Education (KDE) MSP Program

NOTE: All materials are those of the project team and do not represent KDE endorsement.

UNIVERSITY OF LOUISVILLE
CENTER FOR RESEARCH IN MATHEMATICS & SCIENCE TEACHER DEVELOPMENT

PIMSER
Partnership Institute for Math & Science Education Reform

Shake It Up!

Engineering Earthquake-Resistant Structures

Today, you are acting as earthquake engineers. You will use the engineering design process to construct earthquake-resistant structures. Just like engineers, you will construct models to test cause-and-effect interactions concerning the functioning of various structural designs, and then re-engineer your model based on data to better meet the criteria for success.

CONSTRAINTS: at least 2 stories high, 30 marshmallows, and 30 round or flat toothpicks (cannot mix types of toothpicks), shake test must be 10 seconds.

BRAINSTORM DESIGN SOLUTIONS with your partner and draw a diagram of your proposed structure indicating your structural considerations for withstanding an earthquake.

BUILD YOUR structure based on your proposed design.

TEST IT: Test how well your building withstands the earthquake by placing your structure on a pan of Jell-O, shaking the pan for 10 seconds, and recording your observations for a minimum of 2 trials.

CRITERIA FOR SUCCESS: 1. Shear – how close are the angles to 90° after the shake test? 2. Tip or Fall – did the structure tip over or fall? 3. Slide – how close is the building to its starting place? 4. Construction – how many joints of the building stay attached?

SHARE OUT: Each design team will display their data with their model structure and summarize how well their design met the criteria for success and what factors seemed to account for your model's success.

Examine each model/data display and record notes about structural features that seemed to better meet the criteria for success and the evidence that supports your thinking.

<u>Proposed Revisions to Model Based on Data from Shake Tests</u> (Do this individually)

A. Compare data collected by different teams to your team's data. Use evidence from the design tests to determine factors that caused improvement in a structure's resistance to earthquakes.

B. Draw a new diagram of a proposed structure, incorporating the factors that caused improvement in the structure's resistance to an earthquake. Label these factors on your new diagram, explaining the evidence you used that led you to choose this factor.

Author: Holly Veucasovic, Graves County Schools, Kentucky