Earthquake Resistant Buildings

6

Middle School Science
J. Bowlby, Eastampton, NJ

BIG IDEAS

Students will understand that earthquakes are a regular geologic process; the damages of this process can be mitigated with specific and unique building choices.

The ability for individuals to safely exist in a world with natural, destructive forces often occurs as a balance of luck, access to money, and individual location.

EDUCATION STANDARDS

NGSS Standards:

MS-ESS2-1.	**Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.**
MS-ESS2-2.	**Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.**
MS-ETS1-1.	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
MS-ETS1-2.	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
MS-ETS1-3.	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
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.**

NGSS Performance Expectation(s)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the	**ESS2.A: Earth's Materials and Systems** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2) **ESS2.C: The Roles of Water in Earth's Surface Processes**	**Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS2-2) **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences,

assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS2-2) **Asking Questions and Defining Problems** Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1) **Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4) **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and	• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2) **ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) 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) • There are systematic processes for	positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1) • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

differences in findings. (MS-ETS1-3) **Engaging in Argument from Evidence** Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)	evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)	

Common Core State Standards:
ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-2)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS2-2)
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-ESS2-2)*
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2), (MS-ETS1-3)
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-ETS1-3)*
Mathematics -	
MP.2	Reason abstractly and quantitatively. (MS-ESS2-2)

MEASURABLE STUDENT LEARNING OBJECTIVES

Students will analyze the strength of earthquakes based on their proximity to fault lines.

Students will test modern building techniques to demonstrate how modern society can prevent the widespread destruction caused by earthquakes.

Students will design and build a skyscraper model that survives a simulated earthquake.

STEM INTEGRATION

Science:

Science standards and concepts are required not only in the topical concepts covered, but in the background knowledge required of students at this phase of the school year. This project requires students to have a base knowledge of heat transfer, convection, and the layers of the Earth. This instruction would have occurred primarily in the previous unit regarding heat transfer, but also had been covered in previous years. Additionally, as is seen in the nature of science, students will gather data and run multiple tests for the ideal result of an earthquake resistant home and skyscraper. Regular class discussions are a norm at this point in the year, as are specific reflections based on presented phenomena, data, and class claims. Regularly students will make claims, provide evidence, and reasoning for their chosen claim.

ELA:

Utilizing writing and reasoning skills demonstrates ELA standards, and mathematics is represented in the data students analyze from the force generated in the Gizmos simulation.

Engineering:

While science, math, and language arts are present throughout this unit, engineering is the focus of this lesson series. Students run multiple tests, both iterative and physical, to gather data for a best possible solution for a home built upon a fault line. Students reflect upon their design choices and re-evaluate their choices to achieve the best possible result. A fusion of each of these skills is essential for conceptual understanding of the topics, but also to support additional content knowledge.

In addition to the science content in the lessons, engineering is covered through multiple days of comparing, analyzing, and evaluating quantitative data. Initial lessons cover the ideas behind earthquake resistant buildings, especially buildings in areas near fault lines. Prior to a physical build students utilize the Gizmos simulation to quantify a cost benefit analysis for homes that undergo Earthquakes. These decisions, and iterative data that students receive per test, inform their final decisions for their build of a mock tower on an earthquake. The concepts that are reviewed in these activities inform on the final build that students generate.

NATURE OF STEM

Science:

The initial lesson addresses overall geologic concepts with a review on how resilient buildings withstand earthquakes. The majority of the first lesson is built upon science observations, and comparing thoughts with teammates regarding how they withstand strong earthquakes, utilizing CER skills. Concepts addressed also include how earthquakes form and the nature of tectonic plate movement.

Engineering:

Students must question what they are observing, and extend these questions into their build of earthquake resistant homes and skyscrapers. As students observe what allows homes to survive earthquakes (through video evidence) they apply this to their engineering designs of a Gizmos simulation and ultimately a physical build. These evaluations heavily address the nature of engineering.

Math:

Students analyze quantitative data (cost to build and repair homes post earthquake) to inform their decision making and support overall problem solving.
Overall:

This integration makes sense due to the multiple ways the information is presented and the ultimate product, a design of an earthquake resistant skyscraper. Many iterative tests occur in students initial plans of an earthquake resistant home and finally culminate in a physical build of a skyscraper design.

MATERIALS NEEDED

Working computer	Transparent tape
Fillable data sheet	Toothpicks
Wooden blocks	Pre-cut 2x4 wood
Straws	Tennis balls
Sticky tac	Rubber hook ties
Cafeteria trays	

https://gizmos.explorelearning.com/find-gizmos/lesson-info?resourceId=1099
https://www.nextgenscience.org/dci-arrangement/ms-ess2-earths-systems
https://www.nextgenscience.org/dci-arrangement/ms-ess2-earths-systems

https://sealevel.nasa.gov/understanding-sea-level/regional-sea-level/overview/

ENGAGING CONTEXT/PHENOMENON

Students initially view the effects earthquakes have upon areas not prepared for them, showing several buildings collapsing upon themselves. Following this, students watch and reflect on additional videos from earthquake prone regions, and view how skyscrapers waver back and forth rather than collapse. Students are asked “how do some buildings survive earthquakes, while other buildings collapse?”

DATA INTEGRATION

Students observe a simulation with basic quantitative and qualitative data from a Gizmos simulation. Following, students test several rounds of earthquakes upon a building they then create in the same simulation. This attaches a price tag to necessary parts of a home and specific “destruction,” that occurs in the home itself following an earthquake. Students analyze cost of building materials, placement of a home on bedrock vs. landfill, and the percentage of effectiveness (or destruction) following a test. This information is sourced from the interactive simulation: Gizmos Earthquake Based Homes. Multiple interactive tests are run with students recording and analyzing their data.

These tests provide specific data for student choice. In addition, students are presented with data from NASA regarding the rising of sea levels. Map comparisons (in addition to specific numbers students receive) draw the connection to rising sea levels leading to greater geologic disasters.

TEACHER BACKGROUND KNOWLEDGE

Fault and Earthquake Basic Information:

- Need to know: types of faults, where these faults occur, what faults lead to specific geologic disasters

https://www.usgs.gov/faqs/what-a-fault-and-what-are-different-types

Sea Level Rise Data and Contextual Information:

- Provides contextual information for sea level rise; data here is connected to higher levels of earthquake destruction

https://sealevel.nasa.gov/understanding-sea-level/regional-sea-level/overview/

Earthquake Types: Advanced

- Reviews specific types of earthquakes

https://www.un-spider.org/category/disaster-type/earthquake

Types of Faults:

- Reviews the different types of faults and what each fault type can ultimately lead to (earthquake, volcano, etc.)

https://www.crmp.org/resources/blog/what-is-a-fault-different-types-of-faults

DIFFERENTIATION OF INSTRUCTION

- Provide scaffolded instructions for students.
- Model appropriate explanations with sentence starters and timed activities.
- Utilize specific groups for students throughout the lesson for teamwork.
- Extended time

REAL-WORLD CONNECTIONS FOR STUDENTS

The initial explore of this lesson addresses the costs of building a home, and how there are concerns for those without funds to properly protect their home from and earthquake. Gizmos access to funds, stability of land, and design knowledge can impact survival and property loss. In class discussions students learn about the ethical and logistical challenges civil engineers face.

INTEGRATION POSSIBLE MISCONCEPTIONS

Living in New Jersey doesn't lend itself to regular earthquakes. Middle school students may question why it's important for them to cover these topics; however, the aftershocks of an earthquake can absolutely us, as it has occurred before. Data of recent earthquakes and their relative strength supports this, and lends itself to discussion. Stronger and more flexible materials typically lead to better performance.

LESSON PROCEDURE

5E	Details of 5E Lesson Implementation
Engage Day 1 **Approx:** 1 class period	**Procedure:** **-**Review tectonic plate interactions with students utilizing practiced hand motions (collision, grinding against one another, and separation) **-** Utilize questioning and student share out to generate ideas about "which," interaction will generate the strongest response, with guidance towards transform faults and their "grinding," action **-**Show Youtube videos of Earthquake interactions in rural areas vs. cities **-**Pose guiding "What is different about buildings that survive vs. those that collapse?" **-**Students review and build upon each others answers, with repeated share outs **-**Teacher push towards CER responses (Claim, evidence, reasoning) within digital notebook **-**As a group of 2 (or more) students write initial claims on post it note for hanging and later review at the end of the lesson, addressing why "some buildings survive Earthquakes, vs. others." **Modifications:** Provide students with questions verbally, printed, and visually on Promethean board; Provide students with specific

	reflections within class digital notebook with sentence starters; **Standards Addressed:** MS-ESS2-1; MS-ETS1-1 **Formative/Summative Assessments:** Informal observation of student conversations; students share out **Resources:** Videos detailing earthquakes on individual skyscrapers, generating tsunamis, and destroying less fortified buildings; online notebook for note-taking on computer; https://www.youtube.com/watch?v=7Zw-BvKo0pI https://www.youtube.com/watch?v=zxm050h0k2I https://www.youtube.com/watch?v=buLMbZhp5rI
Explore Days 2 - 4 **Approx:** 3 - 4 class periods	**Procedure:** -Revisit statements from previous day (seen on the wall) encourage students to note other statements students in their (or other) class sections have stated; -Introduce Plicker's questions for students, addressing potential reasons for earthquake destruction of buildings vs. survival -Introduce Gizmos simulation and guide students through initial entry point; (model correct parts for designing Earthquake resistant buildings) - Allow students time to explore the simulation and generate results prior to data collection - Monitor students to maintain cohesion - Introduce, distribute and explain data collection sheet **Modifications** Provide students with questions verbally, printed, and visually on Promethean board; Read aloud and on the spot review of Plickers answers; Scaffold specific questions with guided questions and initial examples; Extended time to complete

<table>
<tr><td></td><td>iterative tests/reflection;

Standards Addressed MS-ESS2-1; MS-ETS1-; MS-ETS1-2; MS-ETS1-3; MS-ETS1-4

Formative/Summative Assessments: Plickers assessment and iterative testing/reflection sheet;

Resources: Gizmos earthquake simulation access; Electronic device (Chromebook); printed reflection sheet (as needed) Data sheet (See appendix A)</td></tr>
<tr><td><u>Explain</u>

Days 3 - 5

<u>Approx:</u> 2 - 3 class periods</td><td>Procedure:

This section is a continuation of the previous day, working on providing rationale to student decisions in their iterative testing

- Reflection questions regarding students optimal build are answered within the provided document

- Teacher continues to monitor student progress, altering student answers as needed through modeling and example sharing;

- Students observe other classmates optimal design and procedure for creating a similar build (utilization of GoGuardian to project student work) and students explain their reasoning for their choices;

Modifications: Provide students with questions verbally, printed, and visually on Promethean board; Scaffold specific questions with guided questions and initial examples; Extended time to complete iterative tests/reflection; Sentence stems allow for students to generate correct CER responses;

Standards Addressed MS-ESS2-1; MS-ETS1-; MS-ETS1-2; MS-ETS1-3; MS-ETS1-4

Formative/Summative Assessments : Group share out of specific information;</td></tr>
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	Resources Gizmos earthquake simulation access; Electronic device (Chromebook); printed reflection sheet (as needed)
Elaborate Days 5 - 7 **Approx:** 2 - 3 class periods	**Procedure:** - Review of previous days activities and overall conclusions derived by class (guide students towards how flexible materials distribute Earthquake force - Introduce physical modeling of a "skyscraper," design for students to create and overall challenge with materials, building process, design, and ultimate goal of survival on an Earthquake simulator - Review processes for students to participate, and provide students with a design paper for their sketch and initial thoughts regarding -As groups plan and continue in the assignment, begin testing the materials on trays placed on Earthquake wood simulator **Modifications:** Provide students with questions verbally, printed, and visually on Promethean board; Read aloud and on the spot review of Plickers answers; Scaffold specific questions with guided questions and initial examples; Extended time to complete iterative tests/reflection; Sentence stems allow for students to generate correct CER responses; **Standards Addressed** MS-ESS2-1; MS-ETS1-; MS-ETS1-2; MS-ETS1-3; MS-ETS1-4 **Formative/Summative Assessments:** Plickers round 2; reflection sheet regarding **Resources:** Plickers assessment tool; reflection papers / online access to Google document; See Appendix B for wood model

Evaluate Days 8 - 10 **Approx:** 2 - 3 class periods	**Procedure:** -Complete testing of student designs -Review students build designs overall and guide students towards reflection on their specific builds; Students share out build reflections amongst each other/class wise, providing rationale for their given and specific choices; **Modifications** Provide students with questions verbally, printed, and visually on Promethean board; Scaffold specific questions with guided questions and initial examples; Extended time to complete iterative tests/reflection; Sentence stems allow for students to generate correct CER responses; **Standards Addressed** MS-ESS2-1; MS-ETS1-; MS-ETS1-2; MS-ETS1-3; MS-ETS1-4 **Formative/Summative Assessments:** Class reflection **Resources** Reflection papers/online access to Google document; See appendix C

REFERENCES

Peters-Burton, E. E. (2014). Is There a "Nature of STEM"? *School Science & Mathematics, 114*(3), 99–101. https://doi-org.ezproxy.montclair.edu/10.1111/ssm.12063

Reiser, B. J., Berland, L. K., & Kenyon, L. (2012). Engaging Students in the Scientific Practices of Explanation and Argumentation. Science Scope, 35(8), 6-11.

APPENDIX:

A: Gizmos Guided Questions

Name	Date

Answer the questions regarding the Earthquake Proofing Home Gizmos. Follow the directions in order to complete the Gizmos correctly and answer the questions as needed.

1. Open Gizmos.
2. Open the “Earthquake - Proof Homes Gizmo.”
3. Click “Earthquake.”

4. San Francisco is located near many faults…which is why there are so many Earthquakes there.

5. When the tectonic plates slide against one another…what happens?

6. Click next. Pick a location to start.
7. Build a house using the materials provided. Make sure to go through all the variables you can choose from for each one. Build each one one at a time.
8. Test your house for Earthquakes.
9. Take a snapshot of your house for before and after. Include the “damage,” using the right button.
   a. For each additional , make sure to try different things. Different foundations, frames, etc.

Location	Foundatio n	Fram e	Walls	Roof Type	Roof Material	Extras
Bedrock						

Take screenshots and place them in each box below.

Before Earthquake snapshot	After Earthquake snapshot

Review questions: Answer each in 1 -2 sentences minimum.

1. Which house (1, 2, or 3) sustained the least damage?

2. Why do you think (of the variables you chose) your best house sustained the least damage? Explain in 1-2 sentences.

3. Extrapolate: Do you think that a house with a basement OR springs would best survive an Earthquake? Why?

4. Extrapolate: Do you think that a house with steel, or wood would survive an Earthquake? Why?

B: Wooden Earthquake Simulation Tool

C: Guided reflection

Name	Date

Using the below supplies and proposed budget you will design a skyscraper to survive several levels of simulated earthquakes. The materials are below:

For all:

50 wooden blocks (for everyone)

Determined by budget:

Sticky Tac - $10 per sample
Straws - $1 per straw
Transparent Tape - $20 for 4 inch piece
Toothpicks - $10 for 20 toothpicks

For your budget of $200 build a skyscraper as tall as possible with the **underlying** goal to survive a simulated earthquake.

Rules:

1. Your final build must be a minimum of 5 inches tall
2. Your build must use **all** blocks
3. Once purchased, materials **cannot** be returned or switched out
4. All builds must be completed on a lunch/cafeteria tray

Planning:

In the space below describe how you plan on building your skyscraper. Why are you building it this way?

Sketch on the page how your group will complete your build.

Name:

Sketch below and label your building design.

Reflect:

1. Describe your build. Why was it structured the way you chose? Use explicit reasoning. Why did you choose this specific shape?

2. What level of testing did your structure survive? Why did it reach this level?

3. What could you have done differently to improve your design? List three separate things with supporting reasons.