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Engineering Design Challenge

Phase 1

1. The "Big" concept to be covered by the engineering design challenge is to use the engineering design process to design an earthquake proof building that can be built by fault lines to keep all citizens and animals safe from a natural disaster. The earthquake itself usually doesn't kill a person, but a collapsing building suffering the effects of the seismic waves will put people at high risk of death.

2. Learning standards associated with this topic can be used from the NJSLS 2020 Grades K-12.

https://www.nj.gov/education/standards/science/Docs/NJSLS-Science_6-8.pdf

MS-ESS3: Earth and Human Activity

Students who demonstrate understanding can:

Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

Science and Engineering Practices

Analyzing and Interpreting Data Analyzing data 6-8 builds on grades K-5 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 differences in findings. (MS-ESS3-2)

Disciplinary Core Ideas

ESS3.B: Natural Hazards Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)

Crosscutting Concepts

Patterns

Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

MS-ETS1: Engineering Design Students who demonstrate understanding can:

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.

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6-8 builds on 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)

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)

Disciplinary Core Ideas

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

There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2)

Crosscutting Concepts

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, 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)

3. The most critical part of problem solving is having both declarative knowledge and procedural knowledge. Declarative knowledge in the Earthquake Engineering Spaghetti Structures STEM Challenge includes facts about structural engineering such as diaphragms, trusses, cross-bracing, shear walls, moment-resisting frames, and light roofs. <https://www.viatechnik.com/science-behind-earthquake-proof-buildings/>

Concepts such as "Earthquake-resistant designs typically incorporate ductility (the ability of a building to bend, sway, and deform without collapsing) within the structure and its structural members. A ductile building is able to bend and flex when exposed to the horizontal or vertical shear forces of an earthquake. Concrete buildings, which are normally brittle (relatively easy to break), can be made ductile by adding steel reinforcement." need to be taken into consideration when creating the building design.

<https://www.britannica.com/technology/earthquake-resistant-construction>

Design principles such as simple, sturdy, shapes, symmetry, and a low center of gravity can help a building withstand an earthquake.

<https://architecturerevived.com/design-principles-for-earthquakes/>

The Earthquake Engineering Spaghetti Structures STEM Challenge in my opinion is an ill-structured type of procedural knowledge problem because there are many correct designs and not only one answer to solve this challenge. There are multiple solutions to get the building to withstand the earthquake shake table. Information on the structural building design of an earthquake proof building must be researched and

declarative knowledge information gathered to be successful in the challenge.

4. The main objective of these design challenges is to use the engineering design process to create a structure that can withstand a natural disaster, particularly an earthquake. Some ancillary concepts and content covered by building earthquake resistant buildings include seismology, measuring primary and secondary waves. Understanding tectonic plate shifting, energy sending seismic waves to create a stress on buildings. Types of engineering, specifically civil engineering, the profession itself, and how it pertains to creating earthquake resistant buildings. How to make the building itself safer and reduce damage by reinforcing concrete with steel for flexibility and including rubber for shock absorption. The possibility of taking the base off the ground through a process called base isolation. Even having a large ball suspended at the top of the structure to swing in the opposite direction to help minimize the structure from falling to the ground could save lives. Using a shield surrounding the base of the building to deflect seismic waves and have the force dissipate is also being taken into consideration. Watching Youtube videos on other school's designs for best shapes, heights, building materials, and what constitutes a level are very helpful in the engineering design process and should be shared with students to help with brainstorming and researching for the best design to withstand an earthquake shaking table.

5. Possible Activities

Teach Engineering- Jell-O Earthquake in the Classroom-

https://www.teachengineering.org/activities/view/cub_natdis_lesson03_activity1

Science Buddies- Build an Earthquake Resistant House

<https://www.sciencebuddies.org/teacher-resources/lesson-plans/earthquake-resistant-buildings#>

Earthquake Engineering Spaghetti Structures STEM Challenge

<https://www.teacherspayteachers.com/Product/Earthquake-Engineering-Spaghetti-Structures-STEM-Challenge-2882771>

6. I think the best activity for my classroom is the Earthquake Engineering Spaghetti Structures STEM Challenge. I already own an earthquake shake apparatus foundation and C-clamps to hold it down to a table. I have a unit on Earthquakes and this is a great way to follow the engineering design process, learn about the structure/shape of an earthquake proof building, and reiterate cooperative learning and healthy competition. This lesson is a great way to end the unit on Earthquakes. The supplies of spaghetti, large marshmallows, and mini marshmallows are easy to obtain from a grocery store and don't break the bank. Masking tape, scissors, cardboard, and meter sticks are already a part of my science classroom. "Paying" for supplies three times with a check, having a budget of \$3,000 dollars, having certain needs and constraints on the building are all age appropriate for seventh graders. I appreciate how groups of students are given certain jobs or responsibilities to ensure all group members participate in the engineering design process. There is an accountant, architect, materials director, and project director to hold every student accountable in the design challenge. The steps are very similar to NASA's engineering design process. I also enjoy that there is a planning page and proposal sheet to help keep students on track and progressing through the challenge in a timely fashion. Students are also required to create a company name and logo to present to their teacher during their testing. I am excited to perform this engineering design challenge with my students and my own children.