STEM ED CURRICULUM

BUILDING STRONG® STEM STUDENTS

Natural Hazards and Disasters

U.S. Army Corps of Engineers STEM ED Program

In coordination with the Department of Defense Education Activity

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Purpose and Background

In May 2013, U.S. Army Corps of Engineers (USACE) decided to take a more direct approach to STEM outreach by establishing a one-of-a-kind partnership with the Department of Defense Education Activity (DoDEA). The partnership resulted in a USACE-specific STEM outreach program, STEM ED, which advances STEM education in communities where DoDEA and USACE activities are co-located.

STEM ED is a unique program of rigor that adds engineering design concepts to the curriculum, and provides integrated conceptual understanding and long-term interaction with students. Students work with a minimum of two USACE STEM professionals—military and civilian engineers and scientists—to explore a STEM project with the concept to build strong structures that withstand forces of nature.

The USACE professionals will work in middle school classrooms one to two hours per week for approximately six weeks, addressing challenges that relate to the USACE mission and align with the DoDEA curriculum. STEM ED is USACE' s second collaboration with DoDEA, the first being the development of several new, 21st-century schools built with an infrastructure that can adapt and respond to emerging requirements.

The STEM ED initiative goes hand in-hand with the 21st-century school concept. When developing the plans for a school, you start with the question, "How do I teach in the 21st century?" Then you address the question, "How do I build the school?" USACE is providing expertise in both areas.

The USACE STEM Professionals will:

- Demonstrate the real-world relevance of science, technology, engineering and mathematics (STEM) topics that are being taught in the classroom;
- Make specific connections between what students are doing in class and what they will be doing in the world of work and higher education;
- Discuss the STEM field they represent, including different jobs within the USACE, levels of required education, expected compensation, and DoD's short- and long-term needs for civilian workers;
- Describe the importance of perseverance and hard work in STEM-related fields, the process of working as part of a team, and the importance of critical thinking, knowledge application, and communication skills to solve problems collaboratively.

Getting Started

We chose the topic of natural hazards and disasters because it affects everyone throughout the world, in some way. One never knows when or where a natural disaster will occur. USACE, the Nation's leading public engineering agency, works with other federal agencies to provide support to domestic and international disasters including the Midwest flood fights, Gulf Coast oil spill, the earthquake in Haiti and the recent Tsunami in Japan. The Corps provides auxiliary power, drinking water and ice, cleans up debris, inspects and assesses damaged areas, and provides engineering expertise to state and federal officials.

Working with USACE STEM professionals, the students will learn why natural disasters, such as tornadoes, earthquakes, and volcanoes occur. In addition, they will guide students in using data and mathematical models to explain or predict actions and events in the natural world. The natural hazards and disaster unit is planned for a middle grade classroom. The goal is for students to understand that 1) natural hazards present high risk to human lives and infrastructure 2) a key aspect of natural hazard mitigation is the implementation of adequate strategies for data collection, processing, and sharing, and 3) multiple federal agencies work together as a team to provide support when a disaster occurs.

Initiatives such as STEM ED are good, but both DoDEA and USACE need to further our efforts to inspire talented individuals who can keep up with the swift advancement of technology and the unpredictability of military needs. Ideally, the goal is to provide opportunities for students to develop the creativity and innovation necessary to support our military and our nation to remain competitive in a rapidly changing environment.

The following curriculum framework and web links introduce students to the Earth's structure and its dynamic system of natural forces through an examination of natural hazards. Students will learn how natural events become disasters when they impact people, and how engineers help to prevent and minimize harmful effects on people and property.

Standards-Driven Lessons

The lessons in this document are standards-driven and include DoDEA science standards, Next Generation Science Standards (NGSS) and Common Core Standards for English language arts and mathematics. The rigor in these lessons requires focus on problem-based learning and integration of STEM curriculum into mathematics and science classrooms.

DoDEA Science Inquiry Standards

6-8 Sa: The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled Investigative design and analysis, and problem solving.

Science and Engineering Practices in the NGSS

The eight practices of science and engineering that the *Framework* identifies as essential for all students to learn and describes in detail are listed below:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Integrate Common Core Standards for Mathematical Practices

MP1-Make sense of problems and persevere in solving them.
MP2-Reason abstractly and quantitatively.
MP3-Construct viable arguments and critique the reasoning of others.
MP4-Model with mathematics.
MP5-Use appropriate tools strategically.
MP6-Attend to precision.
MP7-Look for and make use of structure.
MP8-Look for and express regularity in repeated reasoning.

Integrate Common Core Literacy Anchor Standards*

Reading

CCSS.ELA-Literacy.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-Literacy.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).

Writing

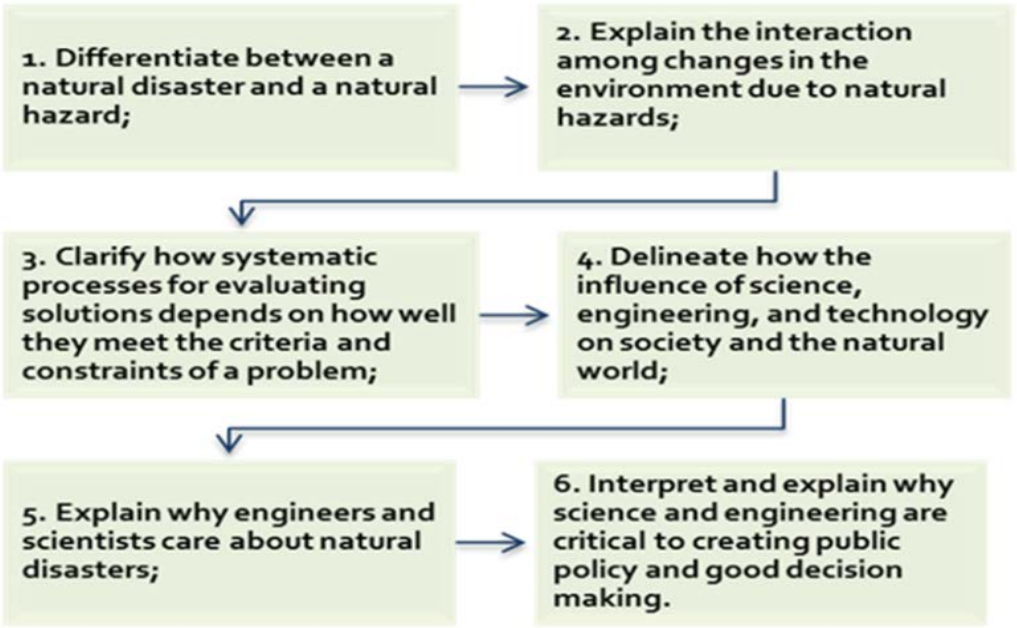
CCSS.ELA-Literacy.WHST.6-8.1
Write arguments focused on discipline-specific content.
CCSS.ELA-Literacy.WHST.6-8.1.b
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Comprehension and Collaboration

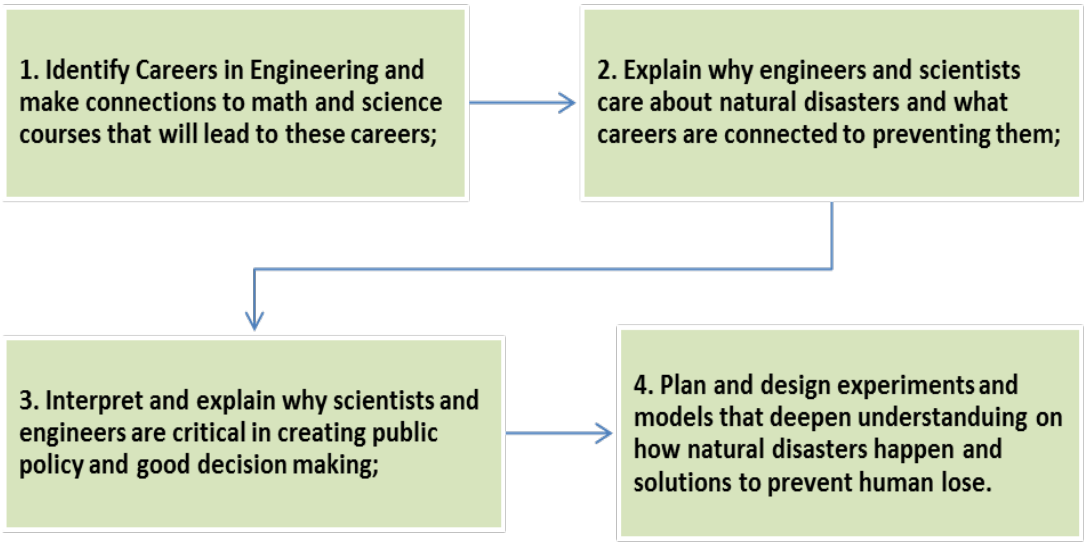
CCSS.ELA-Literacy.SL.7.1
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

*The list above is not a complete. Find a complete list of the standards at the following links: reading http://www.corestandards.org/ELA-Literacy/RST/6-8/ and writing: http://www.corestandards.org/ELA-Literacy/WHST/6-8/

Learning Objectives



College and Career Objectives



Technology and Applications of Science

Every year in the United States and throughout the world, natural hazard events threaten lives and livelihoods, resulting in deaths and billions of dollars in destruction. Science, technology and engineering play an important role in reducing risks and building the resilience of nations and communities to disasters. Science along with new technologies has increased the understanding of hazards and risks, and has helped to create new insights and methods for reducing risks. The **U.S. Geological Survey** (USGS) works with USACE and the National Oceanic and Atmospheric Administration (NOAA) to monitor, assess, and conduct targeted research on a wide range of natural hazards. The collaborative work of these agencies helps policymakers and the public understand what is needed to enhance preparedness, response and resilience. Reducing disaster risks requires increasing knowledge about the likelihood and consequences of natural and technological hazards, and empowering individuals, communities, and public agencies with that knowledge to respond effectively before and after they occur. Research has solidly established the important role that science, technology and engineering investments play in improving disaster resiliency at all stages of disaster management.

Enduring Understandings

There are many factors that can change the environment. These factors, which include natural hazards, changes in populations, and limiting factors, all have similar effects on the environment, and can also affect each other. Changes in environmental factors can have an effect on the amount of resources available in an environment. This can lead to competition for food, water, space, or shelter. It is essential for students to know that 1) there are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem, 2) the influence of science, engineering, and technology on society and the natural world, 3) the use of technologies and any limitations on their use are driven by:

1. individual or societal needs, desires, and values
2. scientific research and findings
3. differences in factors such as climate, natural resources, and economic conditions, and
4. diverse use of technology from region to region and over time

STEM LESSONS

Natural Hazards

A natural hazard is any naturally occurring event that poses a danger to human life or property. Types of natural hazards include: avalanche, earthquake, flood, forest fire, hurricane or typhoon/cyclone, landslide, thunderstorm, blizzard/ice storm, tornado, tsunami and volcanic eruptions. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

STEM Connection

Engineers and scientists learn about our planet so that humans can exist with and survive its powerful natural forces. They must be aware of natural hazards in order to prevent or mitigate their harmful effects on people and property. While most natural hazards cannot be prevented, engineers and scientists use their science and math skills to build instruments and computer simulations to better understand problems and formulate solutions. They must know where natural hazards are likely to occur, so they can contribute to the design of communities to help people survive and minimize the impact of natural hazards. Therefore, scientists collect data by using cameras, seismometers, Global Positioning System (GPS), pressure sensors, radar and satellites. 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. For that reason, engineers design test facilities to simulate and study hazard characteristics and scale model scenarios through human-made or computer generated simulations. Using knowledge gained from the data and model scenarios, engineers work with scientists to determine locations at which dangers exist and how to minimize risks.

Prior Knowledge

- Changes in the habitats of plants and animals affect their survival
- How limiting factors (food, water, space, and shelter) affect populations in ecosystems
- Demonstrate an understanding of weather patterns and phenomena

Guiding Questions

1. **What is a natural hazard?** How do natural hazards impact the environment? *(A natural event that has the power to damage or destroy property as well as injure or take lives).*
2. **What is the difference between a natural disaster and a natural hazard?** *(Natural hazards are natural occurrences that pose danger to human settlements and lives, while natural disasters are specific happenings that harm people. Volcanoes, earthquakes, tsunamis, floods, hurricanes, tornadoes and landslides are examples of natural hazards).*
3. **What types of natural hazards occur in the region where we live, and why?**
4. **Why is it important for engineers to study and understand the natural events of our planet?** *(Engineers must understand hazards and disasters in order to create devices that can monitor, predict, prevent and/or minimize the impact of natural forces.*
5. **Explain why engineers and scientists care about natural hazards and natural disasters. (***They must know where natural hazards are likely to occur, so they can contribute to the design of communities to help people survive and minimize the impact of natural hazards causing a natural disaster).*

Educational Resourses

1. U.S. Department of the Interior | U.S. Geological Survey web site contains educational resources, lessons and demonstration activities. http://www.usgs.gov/natural_hazards/
2. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder http://www.teachengineering.org/view_curricularunit.php?url=collection/cub_/curricular_units/cub_natdis/cub_natdis_curricularunit.xml and http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson01.xml
3. Federal Emergency Management Agency identifies actions that should be taken before, during and after an event that are unique to each hazard http://www.fema.gov/plan-prepare-mitigate

Landslides

A landslide is the collapse of part of a mountainside or cliff that descends suddenly, disintegrating masses of rock and earth. Similar to avalanches in that landslides involve gravity pulling material down slopes. Landslides can be deadly and destructive to people and property.

STEM Connection

Engineers create monitoring devices to help scientists predict landslides. They work with scientists to determine locations at which landslides might occur, how to minimize the damage, and how to prevent the actions of people from contributing to landslides. Engineers design test facilities to simulate and study landslide characteristics, develop measuring devices to study real-world landslides, model landslides with computer simulations, and design structures to channel existing landslides around/under existing human-made structures such as buildings and highways. They also design nets, anchors and walls that support slopes and hold back landslides.

Prior Knowledge

- A basic understanding of gravity and friction is critical to understanding landslides
- Familiarity with geological events (volcanic eruptions, earthquakes and tsunamis) is helpful to understanding landslide causes and effects

Guiding Questions

1. **What are landslides and how do they occur? (***Landslides are large areas of ground movement of rock, earth, or debris that fall, slide, or flow on slopes due to gravity).* **(***They can occur in any environment given the right conditions of soil, moisture, and the angle of slope). (Landslides can be caused by rains, floods, earthquakes, and other natural causes, as well as human-made causes such as excessive development or clear-cutting for lumber).*
2. **What impact do landslides have on the environment?** (*Some examples of how landslides can change or effect the environment are blocking roads, damaging or destroying homes, destroying habitats, or disrupting power lines).*
3. **What is geological engineering? Why is geological engineering important?** *(Geological engineering is an interdisciplinary field, in which the principles of geoscience (geological structures, materials and processes) are used to solve engineering and environmental problems. They are responsible for environmental assessments and carry out site investigations for dams, plants, roads, railways, housing projects, mines and quarries, pipelines, petroleum, and forestry operations. They interact with civil engineers to design essential project components. In addition, they carry out hazard and risk assessments such as mapping for landslides and earthquakes or clean-up activities where pollution has occurred).*

Educational Resources

1. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder
   http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson05.xml
2. U.S. Department of the Interior | U.S. Geological Survey web site contains educational resources about Landslides http://landslides.usgs.gov/learn/ls101.php
   http://education.usgs.gov/secondary.html#landslides
3. U.S. Department of the Interior | U.S. Geological Survey Landslide Handbook
   http://pubs.usgs.gov/circ/1325/
4. U.S. Department of the Interior | U.S. Geological Survey Landslide Types and Processes
   http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html
5. U.S. Department of the Interior | U.S. Geological Survey Landslide Fact Sheet
   http://pubs.usgs.gov/fs/fs-0071-00/fs-0071-00.pdf

Floods

Floods are natural hazards that involve an overflow of water that submerges typically dry land. There are different types and causes of floods; the most common are periodic river flooding and flash flooding. Periodic river-flooding is caused by melting snow and spring rain increasing a river's water level. Even though this type of flooding is easy to predict since the water level rises at a slow rate, these floods can still be disastrous if the amount of water is more than is expected. Flood water comes primarily from rain as the result of a process called the hydrological cycle (see the National Oceanic and Atmosphere Administration web link, **http://www.nwrfc.noaa.gov/info/water_cycle/hydrology.cgi**). Different types of floods occur from different water sources, but primarily from heavy rainfall. Although floods occur naturally and have benefits such as creating fertile farmland, with the increase in human population in flood-prone areas, floods are becoming increasingly more problematic. Both natural and manmade factors contribute to floods.

Flood Destruction

Floods can be far more dangerous than just washing away soil and saturating everything with water and silt. Floods can destroy drainage and sewage systems in urban areas, causing raw sewage to be released into waterways. Severe floods can actually destroy buildings and other facilities, releasing all kinds of toxic materials into the water including oil and gasoline, pesticides and other chemicals. This can cause hazardous chemicals to make their way through the water cycle into rivers, lakes and oceans. As a result, people are left without sanitation systems, drinking water, electricity, phone lines, homes and work places. The costs of floods can be in the billions of dollars and completely change life in some areas. In non-urbanized areas, flooding regenerates the natural environment, creating beautiful meadows, wetlands and riparian zones. In natural areas, floods spread nutrient-rich top soil, remove silt, and plant debris from floodplains. The preservation of natural floodplains can accommodate flood waters and reduce flood damage.

Reducing Flooding

USACE builds and maintains dams so that when a storm hits the reservoirs can hold excess water upstream, releasing the water gradually to prevent or reduce downstream flooding. These structures provide fun as well as safety. Boating, swimming, fishing and camping come courtesy of USACE reservoirs, which have more than 40 million visitors each year. Reservoirs also provide farming irrigation, water supply storage for communities and protected ecosystems for fish and wildlife. In cities near waterways, floodwalls, levees and diversion-

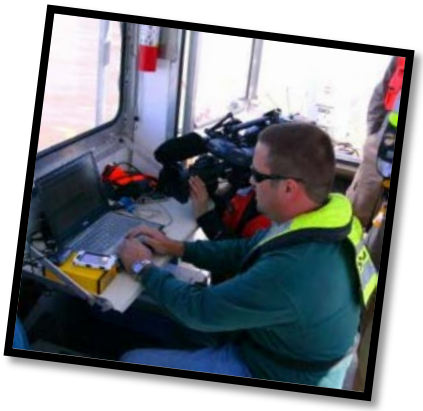
channels all work to keep storm water out of homes, schools and businesses. USACE also helps reduce flood damage by preventing additional construction in areas most prone to floods. All told, USACE flood reduction projects save taxpayers about $3 billion in damages each year.

Sustaining the Environment

As the nation's environmental engineer, USACE protects and restores the nation's environment including critical efforts in the Everglades, the Gulf Coast and along many of the major waterways. USACE cleans sites contaminated with hazardous, toxic or radioactive waste and ordnance in an effort to sustain the environment.

STEM Connection

Floods can be deadly and destructive to people and property. Engineers design river gauges and weather monitoring devices that take measurements to help predict and monitor floods. To aid in prediction and planning, engineers and scientists also develop instruments and computer programs to monitor weather (precipitation, temperature, snow pack, etc.), and develop complex models to estimate worst-case-scenario storm surges and flood risks. They work with geologists and meteorologists to devise ways to control flooding with a range of human-made structures: dams, dikes, levees, flood gates, seawalls, drainage canals, sewer/water/storm drainage systems, pumping stations, and bridges. They also design dams and levees to prevent and minimize flooding, which sometimes includes building reservoirs to serve multiple purposes of impoundments that meet several types of water resources needs such as flood control, hydroelectric power generation, navigation, irrigation, municipal and industrial water supply, water quality, fisheries, and recreation.



Prior Knowledge

- Demonstrate an understanding of weather patterns and phenomena
- A basic understanding of gravity and familiarity with geography
- An understanding of the water (hydrological) cycle

Guiding Questions:

1. **What are floods and how do they occur? (***A flood is an unusually high water stage in which water overflows its natural or artificial banks onto normally dry land). (There are two basic types of floods 1) in a regular river flood, water slowly climbs over the edges of a river and, 2) the more dangerous type, a flash flood, occurs when a wall of water quickly sweeps over an area. Some examples of factors that contribute to flooding are heavy, intense rainfall, over-saturated soil (when the ground cannot hold any more water), pre-existing high river, stream or reservoir levels caused by unusually large amounts of rain and urbanization, or lots of buildings and parking lots).*
2. **What impact do floods have on the environment? (***Some examples of the effects of floods*

on the environment may include damaging property, endangering humans and animals, or causing soil erosion and deposition of sediment and nutrients and creation of fertile soil. Property can be damaged and people can get injured. It may be impossible to control all flooding, but through the continued effort of engineers and scientists, we can figure out ways to live with flooding so that damage and injury can be reduced).

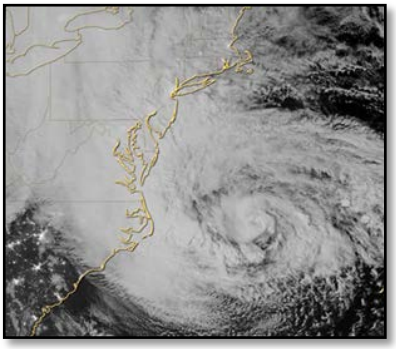
3. **How do civil engineers assist in managing flood risks?** *(Some civil engineers specialize in flood and coastal risk management. The work includes managing and controlling flood water movement, such as redirecting flood run-off through the use of floodwalls and flood gates, rather than trying to prevent floods altogether. In addition, they design the construction of flood protection systems through various federal mandates).*

Educational Resources

1. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder
   http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson07.xml
2. U.S. Department of the Interior | U.S. Geological Survey Flood Information
   http://water.usgs.gov/floods/
3. U.S. Department of the Interior | U.S. Geological Survey Floods and Flood Plains
   http://pubs.usgs.gov/of/1993/ofr93-641/
4. U.S. Department of the Interior | U.S. Geological Survey Large Floods in the United States
   http://pubs.usgs.gov/circ/2003/circ1245/
5. U.S. Department of the Interior | U.S. Geological Survey Fact Sheet
   http://pubs.usgs.gov/fs/FS-229-96/
6. National Oceanic and Atmosphere Administration (NOAA)
   http://www.nwrfc.noaa.gov/info/water_cycle/hydrology.cgi
7. U.S. Army Corps of Engineers
   http://www.iwr.usace.army.mil/Missions/FloodRiskManagement/FloodRiskManagementProgram.aspx

Hurricanes

Hurricanes are powerful tropical storms with wind speeds in excess of 74 mph (119 kph). Powerful winds and storm surge can put millions of people at risk. Even after landfall, hurricanes and tropical storms can produce tornadoes and deadly inland flooding. The National Oceanic and Atmospheric Administration (NOAA) is the federal agency charged with forecasting these potentially deadly storms to help protect lives and livelihoods. Hurricanes form in the warm ocean waters near the equator. A hurricane has an organized rotation with a central "eye" where the winds are calm. The eye is typically between 20 and 40 miles (32-64 km) in diameter. Surrounding the eye is the eye wall — where the winds are usually the strongest and are accompanied by heavy rain. Beyond the eye wall are rain bands, which are long thunderstorms that curve out away from the center of the storm. Damage from hurricanes is caused by the high winds, a powerful storm surge as the storm makes land fall, and inland flooding as an area is saturated with heavy rain. Hurricanes are known as typhoons in the Pacific Ocean and as cyclones in the Indian Ocean.



USACE Role in Hurricane Response

Every year, the U.S. Army Corps of Engineers, part of the federal government's unified national response to disasters and emergencies, sends hundreds of people to respond to disasters around the world.

- USACE has more than 40 specially trained response teams ready to perform a wide range of public works and engineering-related support missions.
- USACE uses pre-awarded contracts that can be quickly activated for missions such as debris removal, temporary roofing, water and commodities distribution, and generator installation.
- When disasters occur, USACE teams and other resources are mobilized from across the country to assist our local districts and offices to deliver our response missions.

STEM Connection

Engineers address the dangers of hurricanes by designing weather instruments and satellites that detect these storms and predict their paths. Engineers also design structures and sea walls to help people and property survive storms and minimize destruction. Scientists and engineers create mathematical models that help predict when and where hurricanes might hit coastal regions. This information helps save lives by providing warning to citizens so that they can evacuate the area well in advance. Civil engineers further protect residents by building infrastructure, such as levees, to prevent flooding during hurricanes. Furthermore, when civil engineers design roads, buildings and bridges in coastal regions, they must take into account the potential for hurricanes so that their structures can withstand high-force winds.

Prior Knowledge

- Demonstrate an understanding of the relationship between earth's atmospheric properties and processes and its weather and climate
- Compare the composition and structure of earth's atmospheric layers (including the gases and differences in temperature and pressure within the layers)
- Demonstrate an understanding of the law of conservation of energy and the properties of energy and work
- Demonstrate an understanding of weather patterns and phenomena
- Use mathematical models to represent and understand quantitative relationships

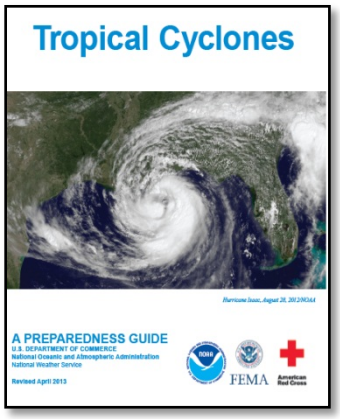
Guiding Questions

1. **What are hurricanes and how do they develop? (***Known as tropical cyclones and typhoons, these fierce storms can churn the seas into a violent topography of 50-foot (15-meter) peaks and valleys, redefine coastlines and reduce whole cities to watery ruin).* **(***During hurricane season, hundreds of storm systems spiral out from the tropical regions surrounding the equator and between 40 and 50 of these storms intensify to hurricane levels). (In the Northern Hemisphere, the season runs from June 1 to Nov. 30, while the Southern Hemisphere generally experiences hurricane activity from January to March). A hurricane builds energy as it moves across the ocean, sucking up warm, moist tropical air from the surface and dispensing cooler air upward. When a storm makes landfall it quickly loses its momentum and power, but not without unleashing wind speeds as high as 185 mph (300 kp/h) on coastal areas).*
2. **How do forecasters predict the path of a hurricane***? (Forecasters analyze various numerical models to predict the path of a hurricane. Four times a day, forecasters sift through new model runs from NOAA, the Defense Department, European weather centers, universities, and private companies. Based on their experience with each model and the particular dynamics of a storm, NOAA forecasters weigh the output of the models).*

3. **What are some of the tools that forecasters use to make their predictions? (***Geostationary east and west satellites first see the convective factors of a storm brewing, sometimes as early as a small cluster of showers and thunderstorms soon after they form off the west coast of Africa. "Satellite" observation of the hurricane is maintained from beginning to end. NOAA's polar orbiting satellite (POES) flies over the storm twice a day at a lower altitude, loaded with microwave instruments that provide massive amounts of data, all the way to the ocean's surface. Data to analyze a land falling hurricane is collected by the U.S. Air Force and NOAA hurricane hunter aircraft by flying through the eye of the storm and by NOAA's G-IV jet flying around it. The planes have Doppler radar and microwave technology to dissect the storm, and the dropsondes (tubes of weather instruments attached to a parachute) released from the aircraft send back critical data as they float down to the ocean).*

4. **How do hurricanes impact the environment? (***Heavy rains can cause significant flooding inland, and storm surges can produce extensive coastal flooding up to 25mi (40 km) from the coastline). (Though their effects on human populations are often devastating, tropical cyclones can relieve drought conditions). (They also carry heat energy away from the tropics and transport it toward temperate latitudes, which may play an important role in modulating regional and global climate).*
5. **How important are evacuation procedures? (***Emergency evacuation procedures are important for ensuring the immediate and urgent movement of people away from the threat or actual occurrence of a hazard. Two keys to weather safety are to prepare for the risks and to act on those preparations when alerted by emergency officials). http://www.nhc.noaa.gov/prepare/ready.php.*
6. **Why do engineers and meteorologists care about hurricanes?** (*Hurricanes are natural hazards that bring destruction ashore in many different ways.* The *best defense against a hurricane is an accurate forecast that gives people time to get out of its way. Engineers design a variety of extensive equipment for meteorologists to use in detecting and tracking a hurricane and predicting its path and direction).*

Educational Resources



Hurricane season begins June 1 and ends November 30. During hurricane season, it is important to have a hurricane preparedness plan in place. As the climate changes and the strength and paths of hurricanes also change, it is all the more important to understand hurricanes. The following provide educators and students with resources to explore how hurricanes form, their potential effects to humans and ecosystems, ways to prepare for hurricanes, and even a citizen science project to classify hurricanes from satellite imagery.

1. National Oceanic and Atmosphere Administration (NOAA) http://www.nhc.noaa.gov/
2. National Oceanic and Atmosphere Administration (NOAA) http://www.education.noaa.gov/Weather_and_Atmosphere/Hurricanes.html
3. National Oceanic and Atmosphere Administration (NOAA) A poster featuring the water cycle http://www.srh.noaa.gov/srh/jetstream/atmos/hydro_cycle.htm
4. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_weather/cub_weather_lesson05.xml
5. U.S. Army Corps of Engineers http://www.usace.army.mil/Missions/EmergencyOperations/HurricaneSeason.aspx
6. Federal Emergency Management Agency http://www.ready.gov/hurricanes

Tornadoes

Tornadoes are nature's most violent storms. Spawned from powerful thunderstorms, tornadoes can cause fatalities and devastate a neighborhood in seconds. A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach *300 mph (483km/h)*. Damage paths can be in excess of one mile wide and 50 miles long. Every state is at some risk from this hazard. Some tornadoes are clearly visible, while rain or nearby low-hanging clouds obscure others. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible. Before a tornado hits, the wind may die down and the air may become very still. A cloud of debris can mark the location of a tornado even if a funnel is not visible. Tornadoes generally occur near the trailing edge of a thunderstorm. It is not uncommon to see clear, sunlit skies behind a tornado.

STEM Connection

Scientists and engineers employ the process of gathering and analyzing data to better understand problems and formulate solutions to save lives and reduce damage caused by tornadoes. They utilize their understanding of science and natural phenomena to design and build strong structures to withstand natural disasters such as tornadoes. Scientists work with engineers to analyze and learn from past failures, this allows engineers to improve structural designs, advance warning systems and emergency procedures for human safety.

Prior Knowledge

- Demonstrate an understanding of the relationship between Earth's atmospheric properties and processes and its weather and climate
- Compare the composition and structure of Earth's atmospheric layers (including the gases and differences in temperature and pressure within the layers)
- Demonstrate an understanding of the law of conservation of energy and the properties of energy and work
- Demonstrate an understanding of weather patterns and phenomena

Guiding Questions

- **What is a tornado?** *A fast rotating column of air that reaches from a thunderstorm to the ground. They appear almost transparent until they pick up dust and debris or a cloud forms within the funnel — the main, center portion of the tornado.*
- **What places are considered a safe place to be during a tornado?** *Basements, storm cellars, interior rooms without windows.*
- **How fast do tornadoes rotate?** *They can rotate up to 300 mph (483km/h).*

- **Where do tornadoes frequently occur?** *Tornado Alley, east of the Rocky Mountains.*
- **How long do most tornadoes last?** *Most tornadoes only last 1-10 minutes.*
- **What scale is used to describe tornadoes?** *One scale for rating tornadoes is the Fujita Tornado Damage Scale, or F-Scale.*
- **What time of year do most tornadoes occur?** *Tornadoes are normally associated with severe thunderstorms, therefore most often; they occur in the spring and summer and in the afternoon and evening hours because the air is hottest in the afternoon and has the greatest tendency to rise.*
- **Why are engineers concerned about tornadoes?** *Engineers use their resourcefulness to save lives and reduce damage caused by tornadoes. They are working to build safer rooms in homes or safer underground basements. They are developing new buildings constructed with a concrete foundation, concrete walls, a special door and no windows.*

Educational Resources

1. Federal Emergency Management Agency
   http://www.ready.gov/tornadoes
   http://www.ready.gov/kids
2. Centers for Disease Control and Prevention
   http://emergency.cdc.gov/disasters/tornadoes/
3. U.S. Army Corps of Engineers
   http://floridadisaster.org/CIEM/2011/documents/02_State_Briefing_Alabama_Tornadoes_L_essons_Learned.pdf
4. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder
   http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson08.xml

Earthquakes

Earthquakes are potentially devastating natural hazards. Earthquakes are formed as the tectonic plates that make up the crust of the earth rub against each other. While approximately 8,000 earthquakes occur every day worldwide, nearly all are too small to feel. Occasionally one is large and close enough to a populated area to create significant damage. Scientists believe that *convection currents* in the molten rock under the crust account for the movement of the continents. Convection currents are currents, or movements, of liquid that occur because of differences in temperature. As the hot molten rock closest to the outer core of the Earth rises toward the crust, it cools slightly. The cooler molten rock is denser, so it sinks, creating a circular current similar to a pot of boiling soup. The boundaries where the tectonic plates meet are the areas of the world with the most violent natural earthquake activity. When the plates grind against each other along plate boundaries, the rocks are under so much pressure that sometimes they heat up and fold, creating mountain ranges, hills and valleys. The intense pressure at plate boundaries can also cause rocks to snap and break — forming cracks in the Earth, or *faults*. When faults are formed, a tremendous amount of energy is released, which shakes the Earth and causes *earthquakes*. There are three main types of faults: *transcurrent*, *normal* and *reverse faults*. Transcurrent faults move sideways creating earthquakes. The San Andreas Fault in California is an example of a transcurrent fault. In normal faults, the tectonic plates either move apart from one another or towards each other causing a block of Earth to fall between the two plates. With a reverse fault, a block of Earth is pushed upwards and sometimes over the tectonic plate. Through their historical assessment of earthquake activity, they are able to predict which areas of the U.S. are likely to experience high, medium, low or little to no earthquake activity. Such a map assists engineers in developing the best structure to withstand these naturally occurring events.

STEM Connection

Earthquakes cannot be prevented; however, engineers and scientist work together to design equipment to help monitor and gather data for early detection. They work collaboratively to support better and more consistent earthquake awareness and mitigation efforts among communities at risk. Engineers use their inventiveness to decrease the destruction caused by earthquakes; and mostly importantly, to save lives. They design devices such as seismometers and lasers that can help predict earthquakes through the data they collect; and they take into consideration the powerful forces of earthquakes when designing structures and bridges. The National Earthquake Information Center

(NEIC), a part of the Department of the Interior, U.S. Geological Survey, has three main missions. First, the NEIC determines, as rapidly and as accurately as possible, the location and size of all significant earthquakes that occur worldwide. They disseminate this information immediately to concerned national and international agencies, scientists, engineers, critical facilities, and the general public. Second, the NEIC collects and provides to scientists and to the public an extensive seismic database that serves as a solid foundation for scientific research. The NEIC is *the* national data center and archive for earthquake information. Third, the NEIC pursues an active research program to improve its ability to locate earthquakes and to understand the earthquake mechanism. These efforts are all aimed at mitigating the risks of earthquakes to mankind.

Prior Knowledge

- Basic understanding of processes that shape the earth
- Familiarity with constancy and change
- Demonstrate an understanding of the nature of force and motion

Guiding Questions

1. **What's the outermost layer of the Earth, and how the does this layer impact the shaping and reshaping of earth?** *(The crust is the outermost layer of the Earth). (The crust is divided into two types: oceanic crust and continental crust. Oceanic crust is about 7 kilometers (4 miles) thick and is under the ocean floor). Oceanic Crust is made of dense rocks such as basalt). (Continental crust thickness varies between 10 and 75 kilometers (6 to 47 mile) and is found under land masses). The continental crust is made of less dense rocks such as granite and is almost always much older than oceanic crust). (Unlike continental crust, oceanic crust is still being formed in places called mid-ocean ridges). Where magma from the mantle erupts through cracks in the ocean floor, creating crust as it cools).*
2. **What is the theory of plate tectonics***? (The Earth's outer shell is made of plates called the lithosphere, which includes the crust and uppermost part of the mantle). (The lithosphere is broken up into tectonic plates). (*The shifting of tectonic plates is called *Continental drift). Where plates meet, their relative motion of the plates determines the type of boundary- convergent, where plates move into one another; divergent, where plates move apart; and transform, where plates move sideways in relation to each other).*
3. **What happens at the boundaries of tectonic plates**? (*Earthquakes, the most violent natural events, the formation of mountain ranges or faults).*
4. **Explain the difference between the three main types of faults, and how all may cause an earthquake?** *(Normal, reverse (thrust) and strike-slip). (Normal and reverse faulting are examples of dip-slip, where the displacement along the fault is in the direction of dip and movement on them involves a vertical component). (Normal faults occur mainly in areas where the crust is being extended such as a divergent boundary). (Reverse faults occur in areas where the crust is being shortened such as at a convergent boundary). (Strike-slip faults are steep structures where the two sides of the fault slip horizontally*

past each other; transform boundaries are a particular type of strike-slip fault). (Many earthquakes are caused by movement on faults that have components of both dip-slip and strike-slip; this is known as oblique slip).

5. **What causes earthquakes?** (*The result of tectonic plates meeting and sliding together to create friction, which then causes tremendous Earth shaking).*
6. **Why do engineers care about earthquakes?** (*Engineers are very concerned with processes that shape the Earth, because they need to be able to design structures — buildings, schools, bridges, for example — to protect humans against natural events such as earthquakes, volcanoes and hurricanes).*

Educational Resources

1. U.S. Department of the Interior | U.S. Geological Survey
   http://earthquake.usgs.gov/learn/topics/
   http://pubs.usgs.gov/gip/2006/21/gip-21.pdf
   http://earthquake.usgs.gov/earthquakes/map/
2. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder
   http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson03.xml
3. U.S. Army Corps of Engineers
   http://www.usace.army.mil/Media/NewsArchive/tabid/204/Article/1077/earthquakes-should-have-a-season.aspx

Tsunami

A tsunami is a series of ocean waves generated by sudden displacements in the sea floor, landslides, or volcanic activity. In the deep ocean, the tsunami wave may only be a few inches high. The tsunami wave may come gently ashore or may increase in height to become a fast moving wall of turbulent water several meters high. A very large disturbance can cause local devastation and disseminate tsunami destruction thousands of miles away. The word tsunami is a Japanese word, represented by two characters: tsu, meaning, "harbor", and nami meaning, "wave". Tsunamis rank high on the scale of natural disasters. They are most commonly generated by earthquakes in marine and coastal regions. They frequently occur in the Pacific, where dense oceanic plates slide under the lighter continental plates. Since 1850, tsunamis have been responsible for the loss of over 420,000 lives and billions of dollars of damage to coastal structures and habitats. Most of these casualties were caused by local tsunamis that occur about once per year somewhere in the world. For example, the December 26, 2004, tsunami killed about 130,000 people. Predicting when and where the next tsunami will strike is currently impossible. Once the tsunami is generated, forecasting tsunami arrival and impact is possible through modeling and measurement technologies. Although a tsunami cannot be prevented, the impact of a tsunami can be mitigated through community preparedness, timely warnings, and effective response. NOAA has primary responsibility for providing tsunami warnings to the Nation, and a leadership role in tsunami observations and research.

STEM Connection

A National Weather Service (NWS) initiative promotes tsunami hazard preparedness as an active collaboration among Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system. The Tsunami Ready program is based on the NWS StormReady model. The main goal is improvement of public safety during tsunami emergencies. Since tsunamis cannot be prevented; engineers and scientists work together to design equipment to help monitor and gather data for early detection. They work collaboratively to develop more consistent tsunami awareness and mitigation efforts among communities at risk. Engineers use their inventiveness to decrease the destruction caused by tsunamis; and mostly importantly, to save lives. Early detection is important because people can be warned and evacuated to safety. Therefore, equipment from-cameras to continually watch volcanoes, to seismometers to measure tremors, GPS receivers, pressure sensors monitors, and radar and satellites are used in tandem to gather data for early detection. In addition, engineers design structures that can survive tsunamis and design warning systems such as harbor disaster sirens, automated news media bulletins and emergency communication centers.

Prior Knowledge

- Basic understanding of processes that shape the earth
- Demonstrate an understanding of the nature of force and motion
- Knowledge of constancy and change

Guiding Questions

1. **What is a tsunami and what causes a tsunami to occur?** *Undersea earthquakes or landslides, volcanic eruptions, or the impact of a large meteorite in the sea (Tsunami is a set of ocean waves caused by any large, abrupt disturbance of the sea-surface. Tsunamis are most commonly generated by earthquakes in marine and coastal regions).*
2. ***Why do engineers care about tsunamis? (****Engineers study the processes that shape the Earth, because they need to be able to design structures to prevent the loss of lives and billions of dollars in damage to coastal structures and habitats).*

Educational Resources

1. National Oceanic and Atmosphere Administration (NOAA) animation model of a tsunami http://www.tsunami.noaa.gov/
2. U.S. Department of the Interior | U.S. Geological Survey http://walrus.wr.usgs.gov/tsunami/
3. Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_natdis/cub_natdis_lesson06.xml

Wildfires

Wildfire means any unwanted, unplanned, damaging fire burning in the forest. Wildfires occur in heavily forested areas during the dry season and have the potential to destroy houses and towns in or near forested areas. Therefore, wildfires are natural hazards that can be massively destructive. While sometimes caused by lightning, nine out of ten wildfires are human-caused by campfires or a burning cigarette. Periodic wildfires are good for the forest because it helps to thin the forest and allow for new growth. Over the last few years, various factors have contributed to the high number of wildfires. These factors include 1) changing weather patterns across the U.S. 2) increasingly dry, hot weather 3) excessive plant overgrowth in forest and wild land areas 4) increased residential development in the wild land/urban interface, and 5) past fire suppression policies which allows for the accumulation of fuel in the form of fallen leaves, branches.

STEM Connection

Scientists and engineers work collaboratively to support better and more consistent wildfire awareness and mitigation efforts among communities at risk. Their main efforts focus on decreasing the destruction caused by wildfires by designing safeguards that aid in preventing, controlling, and mitigating the effects of fires. Engineers assist architects in developing safer buildings and structures that can better with stand the effects of fire to allow occupants time to evacuate safely. They also work with materials scientists to design materials that are flame retardant. The materials are used in clothing, buildings, airplanes, cars and furniture.

Prior Knowledge

- Demonstrate an understanding of relationships among biotic and abiotic factors within terrestrial and aquatic ecosystems
- Demonstrate an understanding of features, processes, and changes in Earth's land

Guiding Questions

1. **What are wildfires and how do they occur?** (*Fire is a natural event in most grassland and forest ecosystems. Generally, fires are neither good nor bad. Wildfires occur naturally and through lightning strikes or when humans start them accidentally or intentionally)*.
2. **What impact do wildfires have on the environment?** (*Fires can be beneficial to the ecosystem and are an essential component in the life cycle of some trees. Environmental impact of wildfires includes -the inability of some seeds to break open and germinate, and an increase in air pollution, habitat destruction, and destroying homes or property).*
3. **Compare and contrast the differences between a forest fire caused by human accident and a prescribed burn.**

Educational Resources

1. The US Forest Service provides wildfire prevention materials and a real time map that depicts wildfires burning today http://www.smokeybear.com/wildfire-science.asp.
2. The USGS web site contains additional educational resources about wildfires http://education.usgs.gov/secondary.html#wildfires

Summary Assessment

1. Have students make and label drawings that illustrate different natural hazards, then have them create a drawings that depicts natural disasters affecting people and communities that could result from each of the natural hazards.
2. Have students discuss how an engineer or scientist might help track or predict the pictured events. Extension, have students design devices or structures with the purpose of protecting people, warning people or predicting the timing or location of natural hazards.
3. Have students explain the interactions among changes in the environment by constructing a cause-and-effect model for the various ways that natural hazards affect the environment.

Post-Introduction Assessment

Have students vote true/false on the following questions and then explain the answers.

1. **True or False**: Natural hazards and natural disasters are exactly the same thing. (False: Natural hazards are natural occurrences on our planet that have destructive powers, while natural disasters are what we call specific natural hazards that caused the destruction of human settlements and lives).
2. **True or False**: A nuclear power plant meltdown is a natural hazard. (False: A nuclear power plant is created by humans and is therefore not a natural event.)
3. **True or False**: A fire that started by a burning candle and destroyed the personal belongings of all the people who live in an apartment building is a natural disaster. (False: This fire sounds like a disaster, but it is caused by humans and is therefore not considered a natural disaster.)

Summary Questions

1. **What is a natural hazard? (***A natural event that has the power to damage or destroy property as well as injure or take lives).*
2. **What is an example of a natural hazard? (***Avalanche, erupting volcano, earthquake, hurricane, tornado, landslide, thunderstorm, flood, forest fire).*
3. **What is a natural disaster? (***A specific event in which a natural hazard did damage to a human population).*
4. **What is an example of a natural disaster? (***See vocabulary table*).
5. **Why do engineers care about natural hazards and natural disasters?** *(Engineers must first understand hazards before they can create devices that monitor, predict,*

   prevent or minimize the impact of natural hazards, as well as design structures that can survive natural hazards and protect people).
6. **What type of Scientist or Engineer would you long to be?** *(Demonstrate how you would like to see yourself contributing to the future of your community in support of preparing and safeguarding from natural hazards or disasters.)*

Lesson Extension Activities

Have the students:

- research specific natural disasters, make posters that describes how they are caused
- give a speech about how natural hazards cause disasters as well as the effects and what might be done to prevent or minimize the impact
- work in engineering design teams, students must design their devices with constraints such as limited materials. Think about the types of natural disasters that might occur in the region in which they live. Then, imagining that a natural disaster occurs in their community, have them role play as engineers to mitigate the dangerous situations. For example, if you are safe during a blizzard, what could keep you safe? *Engineer-designed examples might include: Strong roof, insulated walls, heating system, lighting, communication devices (radio, television, phones), indoor plumbing and electricity, stoves and refrigerators, warm clothing made with modern fabrics, weather predicting and warning devices, safe vehicles, etc.) Have them explain their inventions to the class and summarize in a paper*

Competition: Building Strong

Explore Building Designs Ideally Suited to Natural Disaster Prone Areas- Many buildings were not engineered to withstand natural disasters. As natural disasters increase in frequency, the Army Corps of Engineers are designing buildings designed to keep those inside safe during a catastrophic event. Working under the supervision of the engineer and teacher, students design, build, test, redesign, and rebuild models that meets specified design criteria, to construct a model structure that withstands natural disasters. Students will employ the same analytical process as engineers as they improve and refine their designs. The design challenge culminates in the classroom with each student team preparing and presenting the process they used and the results of their work. Simple engineering mathematical formulas should be introduced to the student to aid them in understanding the forces that can withstand the forces of nature / or the natural disaster. Simplify the formulas so the students are not overwhelmed by complexity, and make it fun so they can easily comprehend the concept and appreciate the results.

Careers In STEM

1. This site http://www.science.gov/internships/ is intended for use by students, teachers, and professors who are looking for internships or fellowships in science, technology, engineering, or mathematics (STEM).
2. Career booklet that engages students in thinking about and planning for careers in science. http://pubs.er.usgs.gov/publication/70039535

Vocabulary and Definitions

avalanche- a large slide of snow, ice and/or earth down a slope.

earthquake -shaking of the ground caused by friction between the tectonic plates.

flood -when normally dry land is submerged with water.

wildfires -an uncontrolled fire in a forested area.

hurricane -an organized rotating storm that forms in or near the tropics.

landslide- large movements of earth down a slope.

natural disaster- a disaster affecting humans that is caused by a natural hazard.

natural hazard -a natural event that has the ability to cause destruction.

thunderstorm- a powerful storm that includes lightning and thunder.

tsunami -a large ocean wave caused by the displacement of the sea floor.

volcano- An opening in the earth's crust through which molten lava, ash and gases are ejected.

engineer -applies his/her understanding of science and mathematics to create things for the benefit of humanity and our planet.

Meteorologist- Scientist- studies the atmosphere and its phenomena, including weather and climate and also, predicts reports and forecasts weather conditions.

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