Sinkhole Lesson Plan

NGSS Performance Expectation
MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

NGSS Science and Engineering Practices:
- 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(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

NGSS Disciplinary Core Idea:
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)

NGSS Crosscutting Concepts:
- Connections to Nature of Science Science Addresses Questions About the Natural and Material World
  Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)
- Stability and Change
  Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Introduction:
Geologic hazards affect us all, but each region of the Earth may be affected by different natural hazards. The west coast of the United States is known to be at risk for earthquakes while the central United States is more often threatened by tornadoes. The south-east coast of the United States is plagued by a unique natural hazard; sinkholes. In September of 2018 a 40ft wide, 20ft deep sinkhole opened up suddenly between two houses in New Port Richey, Florida. One house overhangs the sinkhole and the other is near enough that officials deemed both of the houses unsafe to live in (http://www.wafb.com/2018/09/05/families-displaced-after-after-sinkhole-opens-florida/). Sinkholes occur in areas that are underlain with certain materials that are easily dissolved by groundwater. This subterranean erosion causes a landscape known as karst topography. Some areas, like the Florida panhandle, are composed of calcium carbonate limestone, the rock most readily dissolved by water. Even slightly acidic groundwater can quickly erode paths and caves through the limestone weakening the crust above it. When a
cavern roof collapses, the damage can be catastrophic if people, homes, and/or businesses are at the surface.

Other karst areas are caused by evaporite (such as gypsum and rock salt) materials being eroded away underground through similar processes as limestone. The southwestern United States is an area where evaporite sinkholes tend to occur. When water is introduced underground, evaporite minerals are dissolved back into the water and evacuated from their location leaving caverns and caves behind. When these caves collapse they can also result in devastating sinkholes.

The speed at which a sinkhole forms can vary. Cavern collapses can break without warning and people and property may not have time to evacuate the area. Some sinkholes occur more gradually, beginning with depressions in the land that eventually subside and form a hole in the earth. This sinking land serves as an early warning system to evacuate the area. The surface area affected by the sinkhole may never be safe to build on again, so any structures that are affected may be lost due to safety.

It is important for students to learn about geologic hazards so they can better understand the world around them and possibly mitigate the effects. By taking the time to research the subsurface of an area, developers can make safe choices of what areas should be developed and what areas should be left alone for the safety of the community.

Earth Science Literacy Initiative Big Ideas:
Big Idea 8: Natural Hazards Pose Risks to Humans
8.1 Natural hazards result from natural Earth processes
8.4 Natural events can be sudden or gradual
8.7 Humans cannot eliminate natural hazards, but can engage in activities that reduce their impacts.
8.8 An Earth-science-literate public is essential for reducing risks from natural hazards.

Earth Science Literacy Initiative Common Misconceptions:
- Natural disasters happen very rarely and these events are just the bad luck of the people that are affected.
- Hazards are random in both time and place and just bad luck.

Objectives:
Students will be able to
- explain what a sinkhole is
- model/simulate the development of a sinkhole.
- relate natural hazards to human safety and the necessity of human intervention in the face of a geologic hazard.

Materials Needed:
- Material list for the Sinkhole Model can be found attached to this lesson plan, along with the building and operating instructions.
- Final project packet
- A way to broadcast the model to the entire class (if applicable)
- Towels, or a way to quickly dry any water spills

Procedure:
1. Print out the proposal packets that will be delivered to each student in the class.
2. Divide class into teams, 3-4 or 4-5 students per team, depending on how many students you have in your class.
3. Hand out the proposal packets to your students.
4. Introduce your students to this lesson by assuming the role of a developer who is wanting to develop a small city with a shopping center in a portion of land on the Florida Peninsula. Display the map of the area for the class to see using a projector or similar technology.

5. Introduce students to the area and the topic through a short powerpoint presentation about Florida’s geology and natural hazards.

6. Run the model for the class to see (if possible broadcast the model on the projector for the class to see more easily). Discuss the model as it runs (roughly 5 minutes from start to finish) asking questions and answering students’ questions. The packet will have room for notes. Encourage students to draw the model’s stages (before, during, and completed).

7. Release students to their groups to decide on roles within their teams and decide on a company name. Students will need to complete research (guided by a webquest), write a short paper, and give a short presentation on whether or not the developer should build on the land. All this work should be done collaboratively, students can work remotely through google drive, and video conferencing.

8. Give students 1 full week (7 days) to complete this assignment, checking in with them each day to check progress and answer questions and concerns that may come up for the students.

**Tips, Tricks & Safety:**

The research portion of this project will probably be the most difficult for the students. Be sure to point out different options for students to use including the internet, library, and textbooks where they might find more information about karst topography. Some research websites have been included in the final paper project, individualized to each team role.

Water is the only safety concern for running the model. All water should be easily contained within the system, but be sure to empty the water bucket between classes so it does not get too heavy to lift later in the day. If water gets on the ground, it can create a slip hazard, so be sure to have towels on hand to clean up any spills.

**Extensions:**

**Assessment Plan:**

Students will have two deliverables in this lesson, both will be attached to this lesson plan for easy access.

1. Model worksheet (pg 5-6)
2. Sinkhole project packet with notes and final presentation (pg 7-12)

The following rubric should be used when considering student’s overall understanding of the unit/lesson.

<table>
<thead>
<tr>
<th>Student Name:</th>
<th>Beginning level of understanding</th>
<th>Emerging level of understanding</th>
<th>Competent level of understanding</th>
<th>Mastery of understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to explain what a sinkhole is</td>
<td>Students define a sinkhole using words OR drawing a diagram, but labels are missing.</td>
<td>Students define a sinkhole AND draw a diagram with labels, which one or two labels may be incorrect.</td>
<td>Students define a sinkhole using correct terminology AND draw a diagram with correct labels.</td>
<td>Students define a sinkhole using correct terminology AND draw a diagram with labels that explain the</td>
</tr>
</tbody>
</table>
### Students will be able to relate natural hazards to human safety and the necessity of human intervention in the face of a geologic hazard.

<table>
<thead>
<tr>
<th>Description</th>
<th>Students understand that natural hazards exist but struggle to connect with the importance.</th>
<th>Students can name sinkholes as a natural hazard and understand that they affect people but aren’t sure how.</th>
<th>Students know that sinkholes are a natural hazard and understand that humans are affected by them under certain conditions.</th>
<th>Students can identify natural hazards and understand that humans are affected by them, and where hazards are likely to occur.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to model/simulate the development of a sinkhole.</td>
<td>Students can draw a sinkhole but are missing the steps of formation and labels.</td>
<td>Students can draw a sinkhole and label the different parts</td>
<td>Students can draw the steps of sinkhole development but are missing some labels.</td>
<td>Students can draw the steps of sinkhole formation and labels are correct.</td>
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</tbody>
</table>

Created By: Kate Gibson and Dr. Natalie Bursztyn
Before we view the model, Answer these questions:

1. What is a geologic hazard?

2. How are geologic hazards important to people?

3. What is a sinkhole, and how do they form?

4. In the space below, draw what you think the sinkhole model will show when it is complete.

Answer these next questions have you have viewed the model and listened to the short lecture.

5. Explain how sinkholes can affect people.
6. Do Californians have the same sinkhole danger as those living in Florida or Tennessee? Why not?

7. Why is it important for everyone to learn about sinkholes and karst topography, even if it's not a danger for where we live right now?

8. What types of rocks are known for creating karst topography?

9. Draw the steps that we viewed in the model of the sinkhole development in the space below and add labels. What were the first indicators, at the surface, that something was happening below the surface? Feel free to use the back of this page if you need more room.
SINKHOLE FINAL PROJECT PACKET

Congratulations! Your geologic research team has been chosen to decide where and how to build a small community in Karst City, Florida. Your team needs to research the area, including the rocks below the surface, research building codes, and take into consideration the safety concerns of building and having people live on unstable grounds.

As a team you will need to decide on a team/company name, and choose a position within the team according to the position list in the next section (read each job description before deciding what would be best for you!). You will all work together as a team, within your roles, to research the area and create a presentation of your findings and your group’s decision of where to build and how to build the community. It may be possible for your team to decide it is unsafe to build at all, but you must support your decisions (whether to build, where, and how or not) with your research!

Once your team has a name and jobs have been decided, begin working on a timeline to make sure everything gets done on time. You will be given some time to work on this in class, but it may be a good idea to meet as a team outside of class if possible, (at someone’s house, the library, starbucks, etc).

Team/Company Name: ______________________________________

Job Titles:
- General Manager (1)
- Geologist (1 to 2)
- Risk Assessment Manager (1 to 2)
- Geotechnical Engineer (Building Codes) (1 to 2)
- Public Educator (1)

Individual Job Roles:

General Manager:
- The General Manager is the team leader role. The person that assumes this role helps out in all areas of the team. This person can act as a liaison between any two positions but ultimately will help out any team member that is overwhelmed with their work. The General Manager establishes a timeline with goals for students to work toward. They should be someone who is willing to motivate their team members to do their best work. You may use extra time to come up with company logo as well. This work should be done with the Public Educator, but seek input from the rest of the team as well.

Geologist:
- The Geologist of the team is the rock expert. This person will research the rocks beneath the ground’s surface in the area to be studied. Important things to know about these rocks would be the rock type, erosional properties, strength of the rocks, and what kind of topography each rock type leads to. These findings are reported to the other members of the team. They will use this information within their own research and you will also need to help supply images and information for the Public Educator to present your findings.
Risk Assessment Manager:
- The Risk Assessor assess the risks associated with building on each terrain. The rock type and general weather need to be considered and researched in order to understand the geologic hazards of the area. The risk assessor also needs to determine the ethical responsibility of building in an area, and decide whether or not the risk is worth it. The risk assessor will need to work closely with the General Manager to discuss ethics and with the Building Code Expert in order to determine the best location to build...if any! The Risk Assessor will also work with the Geologist for rock type information and the Public Educator to present your findings.

Geotechnical Engineer (Building Codes):
- The Building Code expert researches the current building codes to decide on the best suggestion as to how building can take place on the terrain and suggest the best design for building. The building code expert may find that there is no current building codes and needs to address that situation as well. The Building Code Expert will work closely with the Risk Assessor and General Manager to decide the best decision to be made. The Building Code Expert needs to present their findings to the Public Educator for the presentation.

Public Educator:
- The Public Educator will be designing, organizing, and presenting the data to the class. The Public Educator needs to work closely with each member of the team to gather all the information, decide the most important pieces to present and present it in a way that a generally educated public will understand. This student should be charismatic and confident in their material and their team to present a well organized and complete report of their findings plus the decision of where and how to build the community proposed. The Public Educator needs to work closely with everyone within the team to be sure they understand the problem and solution that is being suggested. You may also come up with a team logo, which should be done with the General Manager, but seek input from the rest of the team as well.

**IMPORTANT: All roles should help each other at any time. If you feel your role is complete, then ask each of your team members what you can do to help them. You are a team and teams work together! Do not hesitate to ask your team mates for help as well.**
Map of the proposed building site within Karst City, Florida:

*When each rock type has been identified, fill in the legend with the rock type/name next to the identifying block.

**Clues for Identifying the Underlying Rock Types:**

**Section A:** Strong clastic sedimentary rock, formed in beach-type environments.

**Section B:** Biochemical sedimentary rock, formed in a marine environment. A large cavern has been eroded into the rock below the surface.

**Section C:** Chemical sedimentary rock, formed in a shallow water environment. A few radial depressions have been noted at the surface.
Some Good Places to Start Researching:

General Manager:
Leadership skills:
https://www.skillsyouneed.com/leadership-skills.html

Geologist:
Textbook,
Karst Topography: https://www.usgs.gov/science-support/osqi/yes/resources-teachers/background-information-6-8
(find “Karst” in the “find” window (ctrl+f) and it will take you to the karst topography section)
Evaporite Karst:
Sandstone:
https://www.sandatlas.org/sandstone/

Risk Assessor:
Background/General Information:
https://www.ready.gov/risk-assessment
Sinkhole Hazards (Specific):
https://www.tandfonline.com/doi/pdf/10.1080/01944369308975871 -This article is very detailed, it’s okay to jump around to section headers that you think will be most beneficial for your ability to assess the risks!

Building Code Expert:
Karst Topography Building Information:
https://mdc.mo.gov/property/responsible-construction/building-karst-best-practices
Building Information for Sinkholes:
http://www.mgs.md.gov/geology/geohazards/engineering_problems_in_karst.html
Related Journal Paper to building on Karst Topography:
(This is a very long and detailed journal article, which specifically talks of Ireland but you may find some useful information that you can relate to Florida karst topography. You may be most interested in section labeled: Design and Construction. Specifically Earthworks and Foundations. The Conclusion is also a good place to get a summary of the entire article.)

Public Educator:
Ways to present information:
https://blog.rankreveal.com/interesting-ways-to-present-boring-information/
Effective Presentation Information:
https://www.skillsyouneed.com/present/presentation-tips.html

**These websites and suggestions are just a jumping off point, please feel free to use websites and other research material you discover on your own! You may also find that something you are reading may relate to another role within your team, please share this information! Remember to cite your sources!**
Grading:
While you will be working in teams to complete this project, your grade will be individual.
- Save your research and turn it in on the day of your final report attached to this packet. Each team member will need to turn in their own research notes with this packet.
- Each team will also turn in a copy of the final report in whatever fashion you can give that to me (powerpoint slides, video recording, etc) for grading, this is one presentation per team.
  - Be as creative as you can within the time allotted,
    - you can create a public education video
    - a powerpoint (or other presentation software) presentation,
    - write a song, etc.
    - Just be sure all necessary information is there to make a decision about where you determine the city should build, or if they should build at all. Support support support support!
- An anonymous survey will be given at the end of the project for your participation grade. You must work as part of the team, be respectful, helpful, available and timely for your teammates!
- Citing your sources is required, please be sure to have a clear way of citing your sources for your research and presentation (reference list, page numbers, reference slide, reference section on a pamphlet, etc).

Grading Rubric

<table>
<thead>
<tr>
<th>Student Name:</th>
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<th>Mastery of concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Research Notes</td>
<td>Few notes were taken and don’t fully connect to the role in the team</td>
<td>Few notes were taken, attempted to connect to the role within the team</td>
<td>An adequate amount of notes were taken with connection to the role within the team</td>
<td>An adequate amount of notes were taken which connected well to the role within the team. Took notes to share with other team roles when dis</td>
</tr>
<tr>
<td>Final report presentation</td>
<td>No clear direction for the presentation and missing citations</td>
<td>Presentation has a direction but organization for the story is lacking, some citations missing</td>
<td>Presentation is organized and tells a story. Student is confident in their role and citations are correct</td>
<td>Presentation is organized and tells an interesting story. Student is creative and captures attention of audience. Citations are correct.</td>
</tr>
<tr>
<td>Team reached a clear conclusion on whether or not to build and/or where to build the new city</td>
<td>Team did not reach clear conclusion</td>
<td>Team reached a conclusion but with little support as to the reason they made their decision</td>
<td>Team reached a conclusion and supported it with at least 2 details.</td>
<td>Team reached a conclusion and supported it with 3 or more details and made alternate suggestions</td>
</tr>
<tr>
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</tr>
<tr>
<td>Team work</td>
<td>Student was given poor remarks on the survey</td>
<td>Student was given moderate remarks on their survey</td>
<td>Student was given high remarks on their survey</td>
<td>Student was given excellent remarks on their survey</td>
</tr>
</tbody>
</table>

**Anonymous Survey**
(to be put online for students to complete at the end of the project. This can be done with any free survey website such as surveymonkey.com, surveyplanet.com, or Google forms, among many others. Answers should be similar to “Definitely yes, somewhat yes, somewhat no, definitely no”)

One survey should be filled out for each member of the team. This is anonymous so answer honestly and thoughtfully. There is space provided to clarify answers if needed.

Questions about individual team members
1. Did this member complete their own research in a timely manner?
2. Did this member communicate well with the team?
3. Did this member help other members when their own research was complete?
4. Would you work with this member again on another project?
5. Explanations: In the space provided, write down any comments about this person that will explain your previous answers, or if there is an unsolved problem or concern you feel I (the teacher) needs to be aware of.

Questions Regarding the project itself:
6. Did you enjoy this project?
7. Do you feel your learned more by doing your own research and working in a team environment?