Natural Challenges in Hawaiian Earth Systems

ABSTRACT

Hawai‘i is truly a diverse geosphere with its active volcanoes, towering waterfalls, and sandy beaches. However, the islands are also vulnerable to certain kinds of hazards resulting from natural processes such as hurricanes, flooding, lava flows, earthquakes and tsunamis. These processes are interconnected through all of Earth’s spheres. Students will analyze these phenomena using case studies, NASA satellite images, and University of Hawai‘i School of Ocean and Earth Science and Technology data. They will explore how these phenomena are related through Earth System Science spheres. Using this knowledge, they will determine ways that humans can take steps to understand and reduce the impact of such events.

BACKGROUND INFORMATION FOR TEACHERS

Hawai‘i is an ideal location to study natural hazards. It is a remote volcanic island chain in the middle of the Pacific Ocean, making the state prone to many natural hazards such as: hurricanes, flooding, tsunamis, volcanic eruptions, and earthquakes. Most hazards are infrequent and cause minimum damage. However, when severe hazards occur preparation and early warnings are key to reducing the impact of such events.

Hurricanes are relatively rare in Hawai‘i. Since 1949, 38 hurricanes have crossed the Main Hawaiian islands, with only 5 causing major damage. A few factors decrease the strength of approaching storms formed in the eastern Pacific Ocean. The average sea surface temperature in Hawai‘i is 25°C and hurricanes need 26°C or warmer water to develop and maintain strength. Combined with the Northeastern tradewinds most storms weaken or are deflected away from the islands. However, when hurricanes do make landfall they often bring high winds, heavy rains, high waves, and large storm surges.

In Hawai‘i flooding is primarily caused by heavy rains; small rivers can quickly turn into gushing torrents of water that sweep away everything in its path. Flash floods in Hawai‘i are more frequent during the wet season between October and April, and are the leading cause of direct weather related deaths in the state. Hazards from floods include high water, moving debris caught in the flow of water, landslides, mudslides, and contaminated waters.

Tsunamis occur about once a year in Hawai‘i, and cause a greater potential for damage than any other natural hazard. Tsunamis are a series of waves in a body of water caused by the displacement of a large volume of water usually caused by an earthquakes, displacements in the ocean floor, landslides, and...
volcanic activity. Rather than looking like a breaking wave, a tsunami may first resemble a rapidly rising tide, so often they are called “tidal waves.” They usually consist of a series of waves with periods ranging from minutes to hours. In the deep ocean, their waves may be only a few inches high, but when they reach land their height increases and can become a moving wall of water several meters high.

There are several events caused by volcanic activity that can be harmful to life as the geosphere interacts with the biosphere. Along with lava flows, gases such as sulfur dioxide, causes acid rain that affects vegetation. Carbon dioxide emitted from volcanoes can also be dangerous as it tends to collect in valleys where it can accumulate into toxic proportions that harm people and animals.

Hawai’i Island experiences thousands of earthquakes a year, and many are hardly noticeable. Eruptions and magma movement within the volcanoes are often accompanied by frequent small earthquakes. Other earthquakes that can occur in Hawai’i are tectonic earthquakes. These happen in regions of structural weakness at the base of active volcanoes or deep inside the Earth’s crust below the islands. Students can examine causes of earthquakes in Hawai’i, effects that earthquakes can have on these islands and ways to be earthquake prepared.

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**PLANNING**

**Essential Questions**
- Are natural events disasters? Why or why not?
- What is the least destructive natural event in Hawai’i? Explain your choice.
- What are the most destructive forces in Hawai’i? Explain your choice.

**Instructional Objectives**
Students will:
- Collaborate in small groups to select a case study of a natural hazard in Hawai’i.
- Gather and analyze data from various sources.
- Create a presentation that demonstrates an understanding of Earth system science interactions and how they can affect them in Hawai’i.

**Key Vocabulary**
- Hurricane
- Tsunami
- Flood
- Volcano
- Volcanic eruption
- Earthquake

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**INSTRUCTION**

**Materials**
- Collection of photographs of natural events (provided in the lesson)
- Clipboards for outside exploration and recording
- Chart paper
- Science notebooks
- Selected video clips listed in resources and references

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● Class examples of “Rubric Sample One” and “Rubric Sample Two”
● Selected literature on natural hazards (suggestions included)
● Computer access and Powerpoint software

Preparation
● Organize and evaluate sources for research.
● Print student worksheets.
● Prepare enough computers for independent research and small group presentations using Powerpoint.

Resources
NASA:
● Goddard Media Studios, Multiple views of Kilauea Volcano: http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10398
● Model simulation of a double tsunami in Japan: http://www.nasa.gov/topics/earth/features/tsunami20111205.html
● When Waters Rise: NASA Improves Flood Safety: https://www.nasa.gov/content/goddard/when-waters-rise-nasa-improves-flood-safety/#.VXtEVrViko

Other:
● Incorporated Research Institutions for Seismology, Origins of Earthquakes in Hawai‘i: https://www.iris.edu/hq/programs/education_and_outreach/animations/37

Bishop Museum:
● SOS: Earth Extreme Makeover

1. Students examine these photographs of the storm surge and impact upon the biosphere after Hurricane ‘Iniki:
In pairs, have students take notes on what they see in the photos. After sharing ideas, begin a discussion with these “I Wonder…” questions:

- How are these photos related?
- What do you think caused what you see in the photos?
- What kinds of forces do you think caused the events you see in the photos?

2. Have students list various types of major natural events that they have heard of, studied, or experienced. In small groups, they discuss their lists and students record their ideas on what causes the various events they have listed. Have the groups share and discuss their ideas back with the whole group.

3. Take a walk outside the classroom. Pose questions that allow students to visualize various major natural events that could occur in your specific community. The focus of the questions will vary based on location. For example, if you are near the ocean, pose questions about the water and waves. If you are in a region that is prone to heavy rains, discuss what happens when there are quick storms with heavy rainfall. Have students record ideas about what they see in their own environment and potential hazardous events that might impact them.

4. As a whole group, chart ideas of events that might occur in Hawai‘i. These may include: floods, hurricanes, tsunamis, mudslides, earthquakes, volcanic eruptions, etc. After charting student responses, pose the questions:

- How do these events become hazards and affect living things on land?
- How do these events affect living things in the water?
- Do you think humans have a role in causing some of these events? Why or why not?

EXPLORE

1. Using their charted list from the previous section, ask students why Hawai‘i might be a special place to study major natural events and natural hazards. Have them discuss this question in small groups and report their ideas to the whole class.

2. Share selected resources with students from literature. Possible titles include:

   - 100 Most Destructive Natural Disasters by Anna Claybourne.
3. As a whole group, the class will select and view from assorted short video clips for more specific information. Topics include:
   - Hurricane 'Iniki
   - Kīlauea Volcano
   - Tsunami simulation
   - Flash floods
   - Earthquakes in Hawai’i

4. Engage in short discussions following each video clip. Discussion questions may include:
   - What did you notice about ________ event?
   - What can we add to our chart to explain the interactions between air, water, land, and life?

5. In pairs, students begin to sort and classify information using the four column graphic organizer entitled “Linking the Spheres to Natural Hazards”. Under each sphere, they will list how various natural hazards interact with the geosphere, hydrosphere, atmosphere, and biosphere. Examples might include: hydrosphere: floods, heavy rains, etc. The organizer may be started as a whole class and guided by the teacher, followed by students pairing up to brainstorm ideas and associations between the spheres and what they have learned so far about natural events.

EXPLAIN

1. The teacher introduces the idea of sharing their student learning with others. Discuss how students could inform others more about these events and offer background and ideas to help people understand more about these natural processes the affect our islands.

2. Provide an overview of the project explaining that students will be using what they have learned through their unit and conducting research in small groups on a natural event that impacts Hawai‘i. They may use case studies to learn about the causes and effects of their chosen topic and what humans can do to lessen the impact of these events. They will be presenting their project to the class as a Powerpoint slideshow. They will be evaluated on their presentations based on peer feedback with a presentation rubric.

3. Ask the class to do a quick write, stating three things each student feels would make an effective presentation for this project. Collect organize and discuss these student quick writes to create a basic four point rubric. Facilitate the students in a classroom discussion about their ideas, guiding them with the following questions:
   - What things do we need to include in our presentation? Why?
   - What will make an effective presentation? How can we group these ideas to set our class expectations for completing a quality project?

If students are unfamiliar with rubrics or creating scoring guides, the teacher may want to display the two basic rubrics samples included at the end of the lesson to familiarize students with how they are constructed.
4. Students may come up with ideas that fit into these basic categories:
   - Content: finding and using reliable sources recorded and organized information identified big ideas relating to interactions of Earth systems causes and effects identified human impact issues and importance of disaster preparedness,
   - Process: How will we work in small groups? Should we assign group roles? How will all group members contribute?
   - Presentation skills: clear voice, comfortable pacing

5. Post the rubric in development to return to it as students work further in their projects.

6. Model effective research strategies by using one example from a case study. Ask guiding questions and elicit student answers that focus on finding finding and using reliable sources. Questions might include the following:
   - What topic is of interest to me and why?
   - How will I find information that is accurate so that I may share my findings with classmates?
   - What are some sources I can use?

   Charting these questions and answers will provide students with a framework to begin their own research projects.

7. The teacher models the following by using chosen topic and graphic organizer: Using the example, the teacher does a think aloud:
   - What do I know about ____________?
   - What do I want to learn about this topic?
   - Why is it important?
   - Where can I find specific information on this topic?
   - How will I share my findings?

   The teacher then takes students to the school library and/or uses the computer to engage in discussions of how to gather sources for the project. This would include a discussion on use of appropriate databases for student research as well as how to cite sources. Several websites are available for teachers to access that show students how to properly cite sources, a suggestion is listed in Additional Resources.

8. The teacher models the use of graphic organizer “Natural Disasters Notetaking Outline” to record ideas and information. Students will use this to classify and sort research ideas into key sections and group big ideas while classifying information. An example of this could be: earthquake: cause, effect, implications on spheres and engineering designs in places to protect humans.

9. Students proceed to conduct research projects on their chosen case study references and resources such as books, magazines, and/or websites and take notes using the graphic organizer. They move on to elaborate on ideas from their graphic organizer and take notes in their science notebooks.

EXTEND

1. Revisit the student generated rubric with the class for final presentation. Collaborate together to set final expectations and finalize the rubric:
2. Students now work together to create the multimedia presentation on their case study. The teacher models how to create a basic Powerpoint presentation slideshow. The instructor may wish to use a website such as the one listed in the resource section, or their own steps depending on comfort level in using this software program. As students progress from the research phase to the production phase, the teacher shows how each title corresponds to the graphic organizer and information collected and emphasizes simple formatting and clear visuals to share information effectively. Cite the sources! Students collaborate together to create the presentation in small groups. Presentations should include data, graphics, labels and captions the cover the content discussed and given in the graphic organizer. Students contributes their understanding of the topic as they discuss what should be included on each slide and contribute to the presentation.

3. Upon completion of the presentation, small groups rehearse their presentations referencing the class-made rubric as a guide.

**EVALUATE**

1. Discuss audience expectations and behavior. In a whole group setting, generate examples from students that show appropriate feedback and questions for presenters, and refer to the rubric for reminders of what audiences will be looking for. This discussion might include setting up a general format that teachers and students have used already, or something pertaining to this lesson. For example, in some classes, after a presentation, audience members are allowed one comment about what they liked, one thing they learned, and one clarifying question, calling on various students for these responses. Then teams may be given 3-5 minutes to fill out the feedback form provided entitled “Team Feedback Form”. Self Assessment forms will be filled out by the group after presentation is completed.

2. Groups that have been working together may benefit from short student-teacher conferences to provide temperature checks as to their progress. Teams that finish early have the option to create posters, gather artifacts, and devise team names before their presentation.

3. Groups should be allowed rehearsal time before their final presentations. This may take an additional class period for conferences and rehearsals.

4. Audience is provided with feedback forms and rubric is posted. Teams present their PowerPoints to the class in the chosen format, with audience Q & A and/or feedback form sessions.

5. Audience teams provide feedback through the forms provided and forms are collected after each team’s presentation and group presenters self assess themselves.

6. Students review their feedback and complete a final individual reflection on the lesson and their learning in the unit in their science notebooks.

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Formative Assessment

- Through classroom discussions, teacher receives feedback on students’ understanding of topical information. When encountering misconceptions, the teacher reviews information and checks for understanding with individual students.
- During research, the teacher observes how students are using the graphic organizer and provides feedback and support to those students who need it.
- Student notes in their Science Notebooks may also be used as formative assessment, as well as quick writes and peer feedback on rubrics to assess their understanding of summative assessment criteria.

Summative Assessment

- The presentation based on the student-created rubrics as well as peer feedback serves as the summative assessment piece.

CULTURE CONNECTION

Image courtesy of B. Kutsunai.

ʻŌlelo Noʻeau

A collection of Hawaiian proverbs, translated and annotated by Mary Kawena Pukui, offers a unique opportunity to savor the wisdom, poetic beauty, and earthy humor of finely crafted expressions.

_Ako ʻe ka hale a paʻa, a i ke komo ana mai o ka hoʻoiro, ʻaʻole e kulu i ka ua o Hilinehu._
(Hawaiian proverb)

_Thatch the house beforehand so when winter comes it will not leak in the shower of Hilinehu._
(English translation)

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Do not procrastinate; make preparations for the future now. Hurricanes, earthquakes, tsunamis, floods, and lava flows on the Big Island make it of utmost importance to be prepared, for procrastination can lead to personal ruin. Although there are no measures that ensure complete safety at all times, it is prudent to keep our keiki informed on how to understand and handle the hazards that have taken great tolls on our islands' biosphere in the past.

**DIFFERENTIATION**

**Emerging Learners**
- Emerging learners may need help with research components and using informational text to complete graphic organizers and note taking. Small group work or one-on-one help for these students may be necessary. Having students print out their online research and use of highlighting tools and dictionaries may help these students better understand nonfiction text.

**Advanced Learners**
- These students may wish to extend their projects and contact local scientists or people who lived through the disaster of their topic and add this component to their presentations.

**English Language Learners**
- English language learners may need more visuals when exploring these topics. A dictionary and/or thesaurus may help these students as well.

**EXTENSIONS**

- To extend their understanding of how people long ago explained the phenomena associated with natural disasters in Hawai‘i, students may wish to study Hawaiian myths and legends. *Pele, ancient goddess of contemporary Hawai‘i* by H. Arlo Nimmo: [https://journals.lib.byu.edu/spc/index.php/PacificStudies/article/viewFile/9405/9054](https://journals.lib.byu.edu/spc/index.php/PacificStudies/article/viewFile/9405/9054)
- Students work in pairs or individually to study ways that researchers and scientists are using technology to help mitigate the impact of natural disasters here in Hawai‘i. Use the worksheet entitled “Technology and Disaster Preparedness”. The photographs may be used to spark students' interest and further research on this topic.

**STANDARDS**

**Next Generation Science Standards**

**Crosscutting Concepts:**
- Systems and System Models - In grades 3-5, students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.
- Cause and Effect - In grades 3-5, students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationships.
- Energy and Matter - In grades 3-5, students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.

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● Obtaining, Evaluating, and Communicating Information

Disciplinary Core Idea:
● ESS3.B: Natural Hazards: a variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

Common Core
● 4.RI.3: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

Hawaii Content & Performance Standards III
● SC.4.8.2 Describe how fast processes (e.g., volcanoes, earthquakes) sometimes shape and reshape the surface of the Earth

General Learner Outcomes
● Quality Producer
● Effective Communicator
● Effective and Ethical User of Technology

ADDITIONAL RESOURCES

● There are many online sites that show students how to properly cite sources. A good website that shows students examples of citations can be found at Houghton Mifflin Harcourt Education Place.
● A step-by-step online resource guide to creating Powerpoint presentation may be used. This website by readwritethink, entitled Creating a Powerpoint Slide provides a great starting point for teachers and students who are unfamiliar with the software program.
● Suggested Classroom Library Books:
  - 100 Most Destructive Natural Disasters by Anna Claybourne. Fourth grade students will find this engaging. They may use it for general research purposes or may be used as a good read-aloud with information on hurricanes, earthquakes and tsunamis.
  - Tsunamis and Other Natural Disasters: A Nonfiction Companion to High Tide in Hawaii (Magic Tree House Fact Tracker) by Mary Pope Osborne. This book is a great resource to use, especially if you make available the Magic Tree House fiction book or use it as a read-aloud. Fourth grade students will love to separate the fact from the fiction between these engaging books.
  - Children’s True Stories: Natural Disasters is a series of books that feature real children who have survived natural disasters. The series includes books about surviving droughts and famines, earthquakes, floods, hurricanes, tornadoes, and tsunamis. The biographies of the child survivors tell of their life after the disaster and include maps showing areas of impact, safety tips, and groups and organizations dedicated to helping victims. The book entitled Surviving Tsunamis, by Kevin Cunningham includes the 1946 Hawaii tsunami. These books are great additions to the classroom when studying natural disasters and are especially engaging for children as they speak from their perspective on difficult topics.
  - I’ll Know What to Do: a Kid’s Guide to Natural Disasters by Bonnie Mark is a good resource book for kids to have on hand when researching this topic. The book offers practical tips on disaster preparedness that students can understand and helps with some of the feelings that may come with studying these types of natural phenomenon.
# REFERENCES


### Linking Spheres to Natural Hazards

<table>
<thead>
<tr>
<th>Geosphere</th>
<th>Biosphere</th>
<th>Hydrosphere</th>
<th>Atmosphere</th>
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### Natural Hazards Notetaking Outline

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<th>Introduction to Natural Hazard</th>
<th>Causes and Effects</th>
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<tr>
<th>Connections to the 4 Spheres</th>
<th>Preparedness</th>
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Team Feedback Form

Directions: Provide friendly feedback to your peers so that they can improve their presentation skills. Remember to use constructive terms to describe how you, as an audience member, understood more about their topic through their presentation.

Powerpoint Title:_________________________________________

Presenters’ Names: ________________________________________

Team Feedback Provider’s Name: ____________________________

Here are 2 things my team learned by listening to this presentation:

Bright lights: What we liked best about the presentation:

Some suggestions we have for improvement:
Name: ___________________________ Date: _______________________

**Self-Assessment**

What did I learn by completing this lesson:

What questions I still have about the topic or other parts of the lesson:

What are some things I can do to improve?

What are some things my teacher can do to make this lesson better?

Overall, I would give myself a ________ (1-4 based on the rubric)
Because (give evidence)...

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Technology Extensions and Lava Flows at Pāhoa

Images courtesy of B. Kutsunai and Hawaii Electric Light Information.


http://khon2.com/2014/11/02/how-pahoa-students-used-science-to-find-a-way-to-protect-power-poles/
**Technology and Hazard Preparedness**

Directions: Use this outline to research and learn about how scientists design systems to help meet challenges of natural hazards.

<table>
<thead>
<tr>
<th>Tsunamis</th>
<th>Earthquakes</th>
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<th>Lava Flows</th>
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<th>Hurricanes</th>
<th>Other Hazards</th>
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## Basic Rubric Sample One

<table>
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<tr>
<th>Content - Accuracy</th>
<th>All content throughout the slides is accurate. There are no factual errors. All questions are addressed.</th>
<th>Most of the content is accurate but there is one piece of information that might be inaccurate. Most questions are addressed.</th>
<th>The content is generally accurate, but one piece of information is clearly flawed or inaccurate. Some questions are addressed.</th>
<th>Content is typically confusing or contains more than one factual error. No questions are addressed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of Graphics</td>
<td>Graphics/videos are appropriately incorporated to support the theme/content of the presentation.</td>
<td>Most graphics/videos support the theme/content of the presentation.</td>
<td>Only a few graphics/videos are used to support the theme/content of the presentation.</td>
<td>No graphics/videos are used to support the theme/content of the presentation.</td>
</tr>
<tr>
<td>Text</td>
<td>Font formats (e.g., color, bold, italic) have been carefully planned to enhance readability and content.</td>
<td>Font formats have been carefully planned to enhance readability.</td>
<td>Font formatting has been carefully planned to complement the content. It may be a little hard to read.</td>
<td>Font formatting makes it very difficult to read the material.</td>
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<tr>
<td>Cooperation</td>
<td>Group delegates tasks and shares responsibility effectively all of the time.</td>
<td>Group delegates tasks and shares responsibility effectively most of the time.</td>
<td>Group delegates tasks and shares responsibility effectively some of the time.</td>
<td>Group often is not effective in delegating tasks and/or sharing responsibility.</td>
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</table>
## Basic Rubric Sample Two

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<tr>
<td><strong>COMMUNICATION &amp; ORGANIZATION</strong></td>
<td>Presents ideas and information with insufficient effectiveness. Organization is lacking. Uses academic language with insufficient effectiveness.</td>
<td>Presents ideas and information with passable effectiveness. Organization is only partly effective and transitions are rough. Uses academic language appropriately with passable effectiveness.</td>
<td>Presents ideas and information to a specific audience with acceptable effectiveness. Presentation has generally effective introduction, organization for body, and closure. Uses academic language appropriately with acceptable effectiveness.</td>
<td>Presents ideas and information to a specific audience with competent effectiveness. Introduction is clear and effective, body is focused, and closure assists in unity. Uses academic language with competent effectiveness.</td>
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<tr>
<td><strong>CONTENT &amp; CRITICAL THINKING</strong></td>
<td>Shows an unsatisfactory degree of understanding of ideas, concepts, themes and information. Uses critical and creative thinking skills to plan and assist group presentation with insufficient effectiveness.</td>
<td>Shows a passable degree of understanding of ideas, concepts, themes and information. Uses critical and creative thinking skills to plan and assist group presentation with passable effectiveness.</td>
<td>Shows an acceptable degree of understanding of ideas, concepts, themes and information. Uses critical and creative thinking skills to plan and assist group presentation with acceptable effectiveness.</td>
<td>Shows a competent degree of understanding of ideas, concepts, themes and information. Uses critical and creative thinking skills to plan and assist group presentation with competent effectiveness.</td>
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<tr>
<td><strong>CREATIVITY</strong></td>
<td>Overall presentation shows little or no evidence of creativity, leading to a dull and prosaic presentation that is lacking in detail.</td>
<td>Overall presentation shows some evidence of creativity, leading to a passable presentation that falls somewhat short on detail.</td>
<td>Overall presentation shows an acceptable level of creativity, leading to a satisfactory and general presentation.</td>
<td>Overall presentation shows strong evidence of creativity, leading to an interesting presentation that affects the audience.</td>
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