Endeavor
STEM Teaching Certificate Project

Volcanic Eruptions and Food Security

Grade 5~8

Gifted and Talented Program
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BIG IDEAS

This lesson is designed for grades 5-8 in the gifted and talented program, with a focus on exploring the impact of volcanic eruptions on food security. Students will examine historical volcanic eruptions, such as Indonesia's Mount Tambora (1815), the Philippines' Mount Pinatubo (1991), and Iceland's Laki (1783-1784), which had significant effects on food security. Working in small groups, students will choose one of these eruptions for their research.

The lesson integrates STEM, history, and the economy to explore several key conceptual ideas. From a scientific perspective, students will examine *Earth and Environmental Science*, studying the causes, types, and environmental impacts of volcanic eruptions. They will also use *Mathematics and Statistics* to analyze the relationship between volcanic eruptions, climate anomalies, crop production, and economic outcomes. *Data analysis and interpretation* will play a vital role as students collect and analyze data on historic volcanic eruptions, climate anomalies, crop yields,

and economic factors.

Furthermore, the lesson will investigate the *historical context* of past volcanic eruptions, offering valuable insights into how societies have coped with crop disruptions and the subsequent famines. Based on the investigation, students will research ongoing scientific and policy endeavors aimed at mitigating the impact of volcanic eruptions on crops. Engaging in *Engineering Design and Technology*, students will be encouraged to brainstorm and craft innovative solutions to tackle the challenges posed by volcanic eruptions.

By addressing these conceptual ideas through the lenses of STEM and social studies, students will develop a comprehensive understanding of the scientific, mathematical, historical, and economic dimensions of volcanic eruptions' impact on food security.

EDUCATION STANDARDS

- 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.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

NGSS Performance Expectation(s)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. (MS-ESS3-2), (MS-ETS1-3) **Developing and Using Models** Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena. (MS-LS2-3) **Engaging in Argument from Evidence** Engaging in argument from evidence in 6–8 builds on K– 5 experiences and progresses to constructing a convincing argument	**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) **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** ▪ Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	**Patterns** ▪ Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2) **Energy and Matter** ▪ The transfer of energy can be tracked as energy flows through a natural system. (MSLS2-3) **Stability and Change** ▪ Small changes in one part of a system might cause large changes in another part. (MS-LS2-5) ---------- *Connections to Engineering, Technology, and Applications of Science* **Influence of Science, Engineering, and Technology on Society and the Natural World** ▪ The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and

that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2- 5) ,(MS-ETS1-2)	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** ▪ Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5) **LS4.D: Biodiversity and Humans** ▪ Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5) **ETS1.B: Developing Possible Solutions** ▪ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5) ▪ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) ▪ Sometimes parts of different solutions can be combined to create	economic conditions. Thus, technology use varies from region to region and over time. (MS-LS2-5) --- *Connections to Nature of Science* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ▪ Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3) **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-LS2-5)

	a solution that is better than any of its predecessors. (MS-ETS1-3)	

Common Core State Standards:

Math:

6.SP.B.5: Summarize numerical data sets in relation to their context.
7.RP.A.2: Recognize and represent proportional relationships between quantities:
8.SP.A.1: Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities.
6.SP.A.3: Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, such as the mean or median.
7.EE.B.3: Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals).
7.G.A.2: Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.
8.EE.B.5: Graph proportional relationships, interpreting the unit rate as the slope of the graph.
8.SP.A.3: Use the equation of a linear model to solve problems in the context of bivariate measurement data.

ELA:

SL.6.1: Engage effectively in a range of collaborative discussions.
W.6.7: Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

MEASURABLE STUDENT LEARNING OBJECTIVES

- ✓ Students will be able to collect and analyze historical data on volcanic eruptions, temperature anomalies, and crop production to identify patterns and relationships.
- ✓ Students will be able to interpret and evaluate the impact of volcanic eruptions on crop production based on the analysis of data and historical records.

- ✓ Students will be able to apply mathematical models and calculations to analyze the correlation between temperature changes and crop yield fluctuations.
- ✓ Students will be able to construct graphs, tables and diagrams to represent the relationship between volcanic activity, temperature anomalies, and crop production.
- ✓ Students will be able to formulate evidence-based conclusions about the fragility of the global food system to major disruptions caused by volcanic eruptions, using scientific evidence and reasoning to support their arguments.
- ✓ Students will be able to collaborate effectively in groups to brainstorm and design strategies to enhance food security in regions fragile to volcanic eruptions.
- ✓ Students will be able to effectively communicate scientific findings and recommendations regarding the impact of volcanic eruptions on crop production.

STEM INTEGRATION

- **Science:** In this integrated lesson, students will explore the impacts of volcanic eruptions on crop production, focusing on the relationship between climate anomalies and agricultural systems. They will analyze historical data on volcanic eruptions and temperature anomalies to identify patterns and understand the scientific processes behind crop disruption. Through hands-on investigations and data analysis, students will develop scientific practices such as observation, data collection and analysis.

- **Technology:** Technology will be integrated into the lesson through the use of digital tools and resources for data analysis, graphing, and research. Students will utilize technology to access historical data on volcanic eruptions and temperature anomalies, create graphs and visual representations of their findings, and conduct online research to explore the impacts of volcanic

eruptions on crop production. They will develop technological practices such as data interpretation, digital and information literacy.

- **Engineering:** Engineering will be incorporated through problem-solving activities related to enhancing food security in regions prone to volcanic eruptions. Students will work collaboratively to brainstorm and propose strategies to mitigate the impact of crop disruption caused by volcanic activity. They will apply engineering practices such as designing solutions, evaluating alternatives, and considering constraints to develop innovative strategies for food security.

- **Math:** *Math will play a crucial role in the lesson* by analyzing and interpreting data related to volcanic eruptions and crop production. Students will use mathematical models and calculations to analyze the correlation between temperature changes and crop yield fluctuations. They will create graphs and tables to represent the relationship between volcanic activity, temperature anomalies, and crop production. Mathematical practices such as data analysis, graphing, interpretation, and mathematical modeling will be introduced and developed.

- **Social Studies:** Social Studies will be integrated by exploring the social and economic implications of volcanic eruptions on global food security. Students will examine case studies and historical events to understand the impact of major disruptions in food supply caused by volcanic activity. They will analyze the economic consequences and consider the cultural and societal factors related to food security. By integrating Social Studies, students will gain a broader perspective and develop an understanding of the global implications of volcanic eruptions on society.

The integration of Science, Technology, Engineering, Math, and Social Studies in this lesson is logical and beneficial for students' understanding as it provides a *holistic approach* to learning. By integrating multiple subject areas, students can explore the

topic from various perspectives, allowing for a comprehensive understanding and the development of interdisciplinary connections.

NATURE OF STEM

Nature of Science:

- Empirical: Students will explore historical volcanic eruptions, collect and analyze data, and use scientific methods to understand the causes and impacts of volcanic eruptions on food security.
- Tentative: Students will engage in ongoing research and investigate scientific and policy efforts aimed at mitigating the impact of volcanic eruptions on crops, recognizing that scientific understanding evolves with new evidence.
- Testable: The lesson encourages students to formulate testable hypotheses and use data analysis to draw evidence-based conclusions about the relationships between volcanic eruptions and food security.
- Objective: Students will approach the investigation and analysis of data with objectivity, relying on empirical evidence to draw conclusions about the impact of volcanic eruptions on crops.
- Collaborative: Students will work in small groups to conduct research, brainstorm innovative solutions, and develop a comprehensive understanding of volcanic eruptions' impact on food security.

Nature of Mathematics:

- Abstract and Symbolic: Students will use mathematical models and statistical analysis to examine the relationship between volcanic eruptions, climate anomalies, crop production, and economic consequences, utilizing abstract concepts and symbols to represent real-world data.
- Logical and Systematic: In analyzing data, students will apply logical and systematic approaches to identify patterns and relationships, enhancing their understanding of the impact of volcanic eruptions on food security.

- Communicative: Students communicate their mathematical findings and analyses through data representations, graphs, and interpretations. Mathematical communication is an essential aspect of the lesson.

Nature of Engineering:

- Problem-Solving: Students will engage in engineering design to brainstorm and develop innovative solutions to tackle the challenges posed by volcanic eruptions on food security.
- Practical Application: By addressing real-world challenges, students will apply engineering principles to develop feasible solutions that can be practically implemented.

Nature of Technology:

- Application-Oriented: Students will utilize technology, such as digital data analysis tools and online resources, to collect and analyze data on historical volcanic eruptions and their impact on food security.
- Creative and Innovative: Encouraged to brainstorm and design solutions, students will demonstrate creativity and innovation in their engineering and technological approaches.

MATERIALS NEEDED

- Computers or laptops with internet access
- Smartboard for interactive classroom learning
- Volcanic eruption data from historical events (e.g., VEI, eruption dates, locations - NASA, NOAA)
- Temperature data from past volcanic eruptions and corresponding crop production data (from NASA, FAO, etc.)
- Graphing software or tools (e.g., Excel, Google Sheets) for data analysis and visualization
- Research materials on the impacts of volcanic eruptions on agriculture and food security

- Printed or digital worksheets for data analysis and mathematical modeling
- Reference materials on volcanic eruptions & food security
- Interactive online resources

ENGAGING CONTEXT/PHENOMENON

1. *Historical Case Study and Interesting News Articles:* Presenting a case study of a significant historical volcanic eruption, such as the eruption of *Mount Tambora in 1815,* which resulted in the "Year Without a Summer." Discussing the impacts of this eruption on global climate, agriculture, and food security can captivate students' attention and spark their curiosity about the link between volcanic activity and crop disruption.

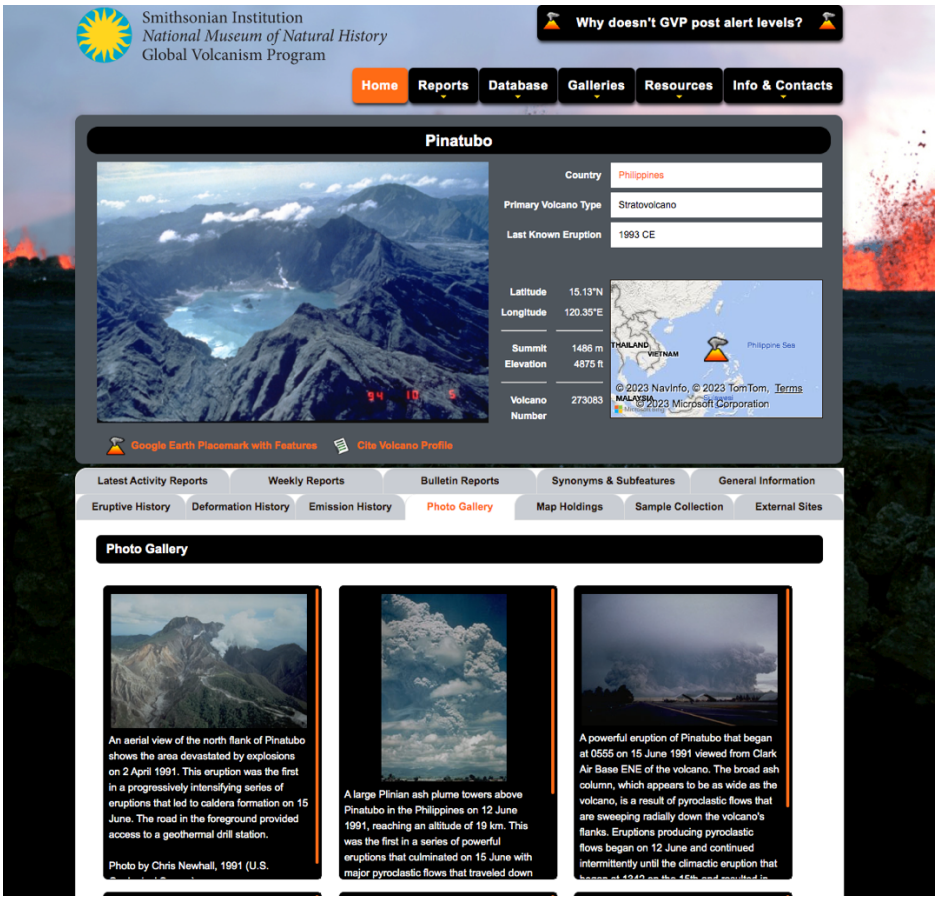
2. *Visual Documentation:* Sharing visually compelling images or videos of volcanic eruptions and their aftermath can create a sense of awe and curiosity among students. NASA's Earth Observing System Data and Information System (EOSDIS) provides access to satellite imagery and data related to volcanic activity.

3. *NASA Resource:* Integrating a NASA resource, such as satellite data or scientific research on volcanic eruptions and their impact on agriculture, adds an authentic and credible dimension to the lesson. Utilizing NASA's Earth Science resources, such as the Global Volcanism Program or the MODIS instrument data and NASA Earth Observatory data on volcanos (https://earthobservatory.nasa.gov/topic/volcanoes) can provide students with access to real-time or historical data, enhancing their understanding of the topic.

DATA INTEGRATION

1. *Volcanic Eruption Data:* Students access historical data on volcanic eruptions, including information such as eruption dates, locations, and Volcanic Explosivity Index (VEI) ratings. This data can be obtained from reliable sources, such as the

Smithsonian Institution's Global Volcanism Program or other reputable volcanic databases.

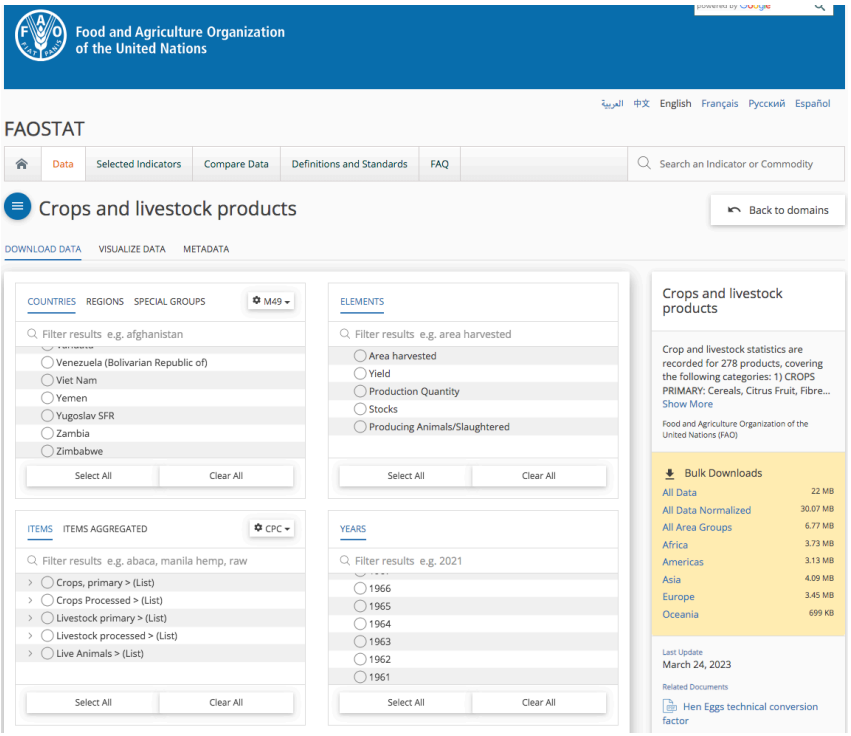


(Figure 1: Volcano Database, Sources: Smithsonian Institution's Global Volcanism Program, https://volcano.si.edu/)

2. *Temperature Data:* Students analyze temperature data associated with past volcanic eruptions, which can include data on pre-eruption, during-eruption, and post-eruption temperature anomalies. Temperature data can be sourced from meteorological organizations such as the Royal Netherlands Meteorological Institute (KNMI), climate research institutions, NASA's Earth Science Data or scientific journal review. For events that occurred earlier than 1880, students can

research scientific literature focusing on specific events such as Mount Tambora (1815).

3. *Crop Production Data:* Students examine crop production data to understand the impact of volcanic eruptions on agricultural output. This data can include historical crop yield records, regional crop production statistics, or information from agricultural organizations and databases. This information can be obtained at Food and Agriculture Organization of the United Nations (FAO) (https://www.fao.org/faostat/en/#home).



(Figure 2: Crops and Live Stock Products Statistics, Sources: FAOSTAT at https://www.fao.org/faostat/en/#home)

4. *NASA Earth Science Data:* Depending on the availability and relevance of NASA data, students can access satellite imagery, remote sensing data, or climate models that provide insights into volcanic eruptions and their effects on crop

production. This can include datasets from NASA's Earth Observing System Data and Information System (EOSDIS) or other NASA Earth Science resources.

During the lesson, students will learn how to collect relevant data from the reliable sources and analyze the collected data to identify patterns, trends, and correlations between volcanic eruptions, temperature anomalies, and crop production. They engage in data interpretation, graphing, and mathematical modeling to understand the *cause-and-effect* relationships and draw evidence-based conclusions. Students may also engage in discussions and group work to analyze and compare different datasets, identify potential limitations, and propose strategies to mitigate the impact of volcanic eruptions on food security.

TEACHER BACKGROUND KNOWLEDGE

As a co-author in the publication of the article "Exploring the potential impacts of historic volcanic eruptions on the contemporary global food system" in *Past Global Changes Magazine* in 2015 (https://pastglobalchanges.org/publications/pages-magazines/pages-magazine/7173), I had the opportunity to work alongside scientists on this important issue. Being directly involved in the research and publication process, I gained a deep understanding of the connections between volcanic eruptions and food security. I hope this firsthand experience allows me to bring valuable insights and figures from the article into the classroom, making the STEM lessons on this topic more engaging and relevant for students. By incorporating my knowledge and expertise, I plan to provide students with a comprehensive understanding of the subject matter.

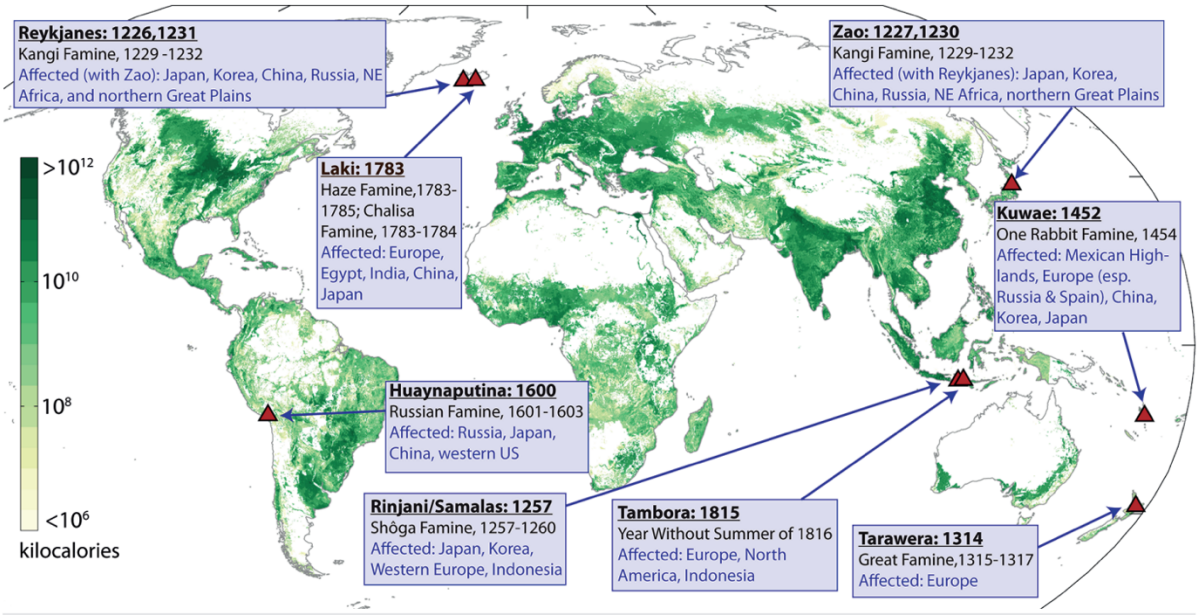


Figure 1: Crop production and select volcanic eruptions (with associated famines and crop failures) over the last millennium that had major impacts on food supplies. Global crop production for the year 2005 in kilocalories based on SPAM (You et al. 2014) and estimates of the caloric content of different crops from UN's Food and Agriculture Organization.

(Figure 3: Crop Production and Select Volcanic Eruptions, Sources: https://pastglobalchanges.org/publications/pages-magazines/pages-magazine/7173)

DIFFERENTIATION OF INSTRUCTION

Content Differentiation:

In this lesson on volcanic eruptions and their impact on food security, content differentiation is applied to accommodate the diverse levels and interests of students. Various resources, such as reading materials, videos, and interactive tools, are provided at different complexity levels, ensuring that students with varying abilities can engage with the content effectively. Additionally, tiered assignments are offered, presenting varying levels of complexity and depth, allowing students to select tasks that align with their individual capabilities and interests. By employing these content differentiation strategies, the lesson promotes inclusivity and encourages a comprehensive understanding of volcanic eruptions and food security among all students.

Process Differentiation:

To address the diverse learning needs in the lesson on volcanic eruptions, process differentiation is effectively employed. Flexible grouping allows students to collaborate in small groups based on their interests and learning preferences, enabling some to engage in hands-on experiments while others focus on data analysis or simulations. Learning stations are also implemented, offering a variety of activities related to volcanic eruptions, where students can freely rotate and select tasks aligned with their preferred learning styles. Through these process differentiation strategies, the lesson encourages a dynamic and inclusive learning environment, where students can thrive and explore volcanic eruptions in ways that resonate with their individual strengths and interests.

Product Differentiation:

To cater to the diverse abilities and interests of students in the gifted and talented program, product differentiation is carefully integrated into the lesson on volcanic eruptions. Varied presentations are embraced, giving students the freedom to choose how they showcase their findings, whether through multimedia presentations, written reports, posters, or oral presentations. Additionally, the lesson emphasizes real-world applications, prompting students to design practical solutions that mitigate the impact of volcanic eruptions on food security. Students are encouraged to take a more comprehensive and innovative approach in creating solutions. Through product differentiation, the lesson fosters individual creativity and allows students to demonstrate their understanding in ways that best align with their strengths and interests.

REAL-WORLD CONNECTIONS FOR STUDENTS

- *Real-Life Connection*: The lesson explores the real-life impact of volcanic eruptions on food security and crop production. By studying historical volcanic events and their effects on agriculture and the society, students gain an understanding of how natural disasters can have significant consequences on global food systems and the society.

- *Cultural Responsiveness*: The lesson can be made culturally responsive by incorporating examples and case studies from diverse regions (Asia, Europe, and North America) around the world. By highlighting the experiences of different communities affected by volcanic eruptions, students can develop an appreciation for the cultural and geographical diversity in how societies cope with and recover from such events.

INTEGRATION POSSIBLE MISCONCEPTIONS

I will design a diagnostic assessment to test students' prior knowledge and misconceptions of volcanic eruptions and food security. The major questions will be as follows:

1. *Do volcanic eruptions only affect the areas near the volcano?* (Students may have a limited understanding of the broader impacts of volcanic eruptions and may assume that the effects are localized to the immediate proximity of the volcano.)

2. *Are crops immediately destroyed by volcanic eruptions?* (Students may assume that crops are immediately wiped out by volcanic eruptions, without considering the indirect and long-term effects, such as changes in temperature, precipitation patterns, or air quality.)

3. *Do all volcanic eruptions have the same impact on crops?* (Students may lack awareness of the variability in the impact of different volcanic eruptions based on factors such as eruption size, location, duration, and climate conditions.)

4. *Is there no connection between volcanic eruptions and global food security?* (Students may not initially see the link between volcanic eruptions and global food systems, underestimating the potential disruptions and vulnerabilities they can cause.)

LESSON PROCEDURE

The lesson is designed for a 10-day plan, with each class lasting 45 minutes, and it aligns with the 5E instructional framework as follows:

5E	Details of 5E Lesson Implementation
Engage (Day 1: *Introduce the lesson with an intriguing question and captivating images or videos of historical volcanic eruptions. Encourage a group discussion to engage students' initial thoughts.*)	**Procedure:** ▪ Begin the lesson by asking an intriguing question to engage the gifted and talented students, such as: "*Imagine a massive volcanic eruption occurred here in NJ. How do you think it would impact the availability of food in your neighborhood*?" ▪ Show captivating images or short videos of historical volcanic eruptions and their global impact to spark curiosity and interest among the students. (e.g.: **Why the Year 1816 Was the Year Without Summer:** https://www.youtube.com/watch?v=lkv1pDmN7JY) ▪ Facilitate a group discussion by encouraging the students to share their initial thoughts and ideas about the potential connections between volcanic eruptions and food security. ▪ Introduce a real-world event such as Indonesia's Mount Tambora (1815), the Philippines' Mount Pinatubo (1991), and Iceland's Laki (1783-1784), where a volcanic eruption led to disruptions in crop production and food supply chains, prompting the students to consider the broader implications. ▪ Provide brief background information on volcanic eruptions, their causes, and how they can affect climate, agriculture and society. **Modifications:** ▪ Offer additional reading materials or online resources for more advanced students who want to explore the topic in greater depth. ▪ Allow students who show great interest in the topic to take on leadership roles during the discussion, guiding the conversation and encouraging their peers to contribute. **Standards Addressed:** ▪ 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. ▪ MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services. ▪ SL.6.1: Engage effectively in a range of collaborative discussions.

	Formative/Summative Assessments: ▪ Observe the level of engagement and active participation of students during the group discussion. ▪ Assess their ability to make connections between volcanic eruptions and food security based on their discussion contributions. **Resources:** ▪ Visually captivating images or short videos of historical volcanic eruptions and their impacts. (https://www.youtube.com/watch?v=lkv1pDmN7JY) ▪ Real-world scenarios or case studies illustrating the impact of volcanic eruptions on food security. ▪ Brief background information or a short summary on volcanic eruptions and their effects on climate and agriculture.
Explore (Day 2-4: *Students research specific historical volcanic eruptions and their impacts on food security. They analyze data using mathematical models to understand relationships between eruptions, temperature anomalies, and crop production.)*	**Procedure:** ▪ *Group Formation:* Divide the students into small groups, taking into consideration their diverse abilities and interests. Assign each group a specific historical volcanic eruption to research. Ensure that each group has access to the necessary research materials and data sources. ▪ *Research and Data Collection:* Instruct the groups to conduct in-depth research on their assigned volcanic eruption. They should gather data on eruption dates, locations, Volcanic Explosivity Index (VEI) ratings, temperature anomalies during and after the eruption, and information on crop yields in the affected regions. ▪ *Exploring Impacts:* Encourage the students to explore historical records, scientific articles, and studies to understand the broader impacts of the volcanic eruption on food security and agriculture. They should investigate how the eruption affected crop production, food availability, and livelihoods in the regions surrounding the volcano. ▪ *Mathematical Analysis:* Challenge the students to apply mathematical models and calculations to analyze the correlation between temperature changes and crop yield fluctuations for their assigned volcanic eruption. This analysis will help them identify patterns and trends in the data. ▪ *Provide guidance and support* to the students as they work on their research and analysis. Offer an assistance in understanding complex datasets, statistical techniques, and the interpretation of results. **Modifications:** ▪ For more advanced learners, offer more complex datasets and research challenges that require advanced statistical analysis. Encourage them to explore additional scientific literature and the data.

	▪ Independent Research: Allow driven students to pursue independent research on specific aspects of their assigned volcanic eruption. Provide them with the freedom to explore related topics of interest in greater depth. **Standards Addressed:** ▪ 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. ▪ MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. ▪ MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. ▪ SP.B.5: Summarize numerical data sets in relation to their context. ▪ RP.A.2: Recognize and represent proportional relationships between quantities. ▪ SP.A.1: Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. ▪ SP.A.3: Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, such as the mean or median. **Formative/Summative Assessments:** ▪ Formative: Monitor students' progress during group discussions and research activities. Assess their ability to analyze data, identify patterns, and use mathematical models effectively. ▪ Summative: Evaluate the final research presentations of each group. Assess the accuracy of their data analysis, interpretation of findings, and the depth of understanding regarding the impact of volcanic eruptions on food security. **Resources:** ▪ Computers or laptops with internet access ▪ Research materials on historical volcanic eruptions, temperature anomalies, and crop production ▪ Data analysis tools (e.g., Excel, Google Sheets) ▪ Scientific articles and studies related to the selected volcanic eruptions

Explain

(Day 5: Groups present research findings on volcanic eruptions' impact on food security. Class discussions deepen understanding and clarify cause-and-effect relationships.)

Procedure:

- *Allow each group to present* a summary of their research on their assigned historical volcanic eruption and its impact on food security and agriculture. Emphasize the importance of data analysis and scientific research in understanding the complex relationships between volcanic events, temperature anomalies, and crop production.
- *Conceptual Understanding:* Facilitate class discussions to help students develop a deeper conceptual understanding of the connections between geological events, such as volcanic eruptions, and their effects on climate, ecosystems, and agriculture. Encourage students to draw connections between the data they analyzed and broader scientific principles related to Earth's systems and natural processes.
- *Explain the cause-and-effect relationships between volcanic eruptions, temperature anomalies, and crop production,* addressing any misconceptions identified in the Engage Phase.
- *Interdisciplinary Connections:* Explore the interdisciplinary nature of the topic by integrating concepts from various subjects. Discuss how mathematics, statistics, and scientific research are essential in understanding natural hazards and their implications for society.

Modifications:

- Encourage more advanced students to delve deeper into the underlying scientific principles and theories related to volcanic eruptions and their impacts. Challenge them to present their findings in a more comprehensive and sophisticated manner.
- Deeper Analysis: Ask students to analyze the limitations of the data they collected and the potential uncertainties in their findings. Encourage critical thinking and open discussions about the complexity of natural systems and the challenges of predicting future volcanic events and their consequences.

Standards Addressed:

- 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.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Formative/Summative Assessments:

	▪ Formative: Assess students' comprehension and ability to explain the causal relationships between volcanic eruptions and food security during class discussions. Provide constructive feedback to address any misconceptions. ▪ Summative: Evaluate the quality and depth of students' explanations and presentations about their assigned volcanic eruptions and the broader implications for food security and agriculture. Assess their ability to connect data analysis to scientific concepts and standards. **Resources:** ▪ Visual aids (e.g., charts, graphs, diagrams) to illustrate the relationships between volcanic eruptions, temperature anomalies, and crop production. ▪ Scientific articles and research papers to support discussions on the topic. ▪ Previous data analysis and research conducted during the "Explore" phase.
Elaborate *(Days 6-8: New groups focus on specific regions affected by eruptions. They brainstorm strategies and propose comprehensive plans to mitigate future impacts on food security.)*	**Procedure:** ▪ *Group Brainstorming*: Divide the students into new small groups and assign each group a specific region or country that has experienced a historical volcanic eruption. Instruct the groups to brainstorm potential strategies to mitigate the impact of future volcanic eruptions on food security in their assigned region. ▪ *Research and Solutions*: Provide access to relevant research materials and data on disaster management, sustainable agriculture, and technological innovations that could aid in mitigating the effects of volcanic eruptions on crops. Encourage students to explore solutions that integrate knowledge from multiple disciplines. ▪ *Design Challenge*: Pose a design challenge to each group, asking them to create a comprehensive plan to enhance food security and agricultural resilience in their assigned region. The plan should consider the specific challenges posed by volcanic eruptions and consider the region's unique environmental, social, and economic factors. ▪ *Collaborative Work:* Foster a collaborative environment, where students can exchange ideas and expertise from their respective regions. Encourage them to evaluate each other's proposals and provide constructive feedback to enhance the quality of the plans. ▪ *Presentation and Justification:* Instruct each group to prepare a detailed presentation of their proposed plan. They should justify their choices based on scientific evidence, data analysis, and the principles of sustainable development and disaster management. **Modifications:** For more advanced and motivated students: Provide advanced research topics or additional challenges that cater to the higher abilities of students. Allow them to delve deeper into the

	subjects they are passionate about and encourage presentations or demonstrations of their findings. **Standards Addressed** ▪ 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. ▪ MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. ▪ MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. ▪ MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. **Formative/Summative Assessments** ▪ Formative assessments can include ongoing monitoring of students' progress in research, problem-solving activities, and modeling simulations. ▪ Summative assessments may involve evaluating the quality of research projects, the effectiveness of proposed solutions to real-world challenges, or the complexity and accuracy of students' modeling efforts. **Resources:** ▪ Curated research materials suitable for students in grades 5-8. ▪ Interactive modeling software appropriate for their grade level.
Extend *(Days 9-10: Advanced students engage in independent research projects. Authentic challenges encourage critical thinking and creativity in proposing*	**Procedure:** ▪ Independent Research Projects: Encourage students to pursue independent research projects related to volcanic eruptions, climate change, or food security. They can choose specific topics of interest and conduct in-depth research to become subject matter experts. ▪ Authentic Challenges: Present authentic, real-world challenges that require critical thinking, problem-solving, and creativity. These challenges should push students to use their knowledge to propose innovative solutions or design projects that address complex issues related to the topics studied. ▪ Mentorship and Expert Collaboration: Provide opportunities for students to collaborate with experts or professionals in relevant fields. This mentorship can offer valuable insights, guidance, and feedback on their projects or solutions.

innovative solutions.)	▪ STEM Competitions: Encourage students to participate in STEM (Science, Technology, Engineering, and Mathematics) competitions where they can showcase their research findings, projects, or proposed solutions. **Modifications:** ▪ Challenging Tasks: Tailor tasks and projects to match the advanced capabilities and interests of driven students. ▪ Independent Learning: Give students more freedom in their learning process, allowing them to explore areas of personal interest and passion. **Standards Addressed:** ▪ 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. ▪ MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. ▪ MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services. ▪ SP.B.5: Summarize numerical data sets in relation to their context. ▪ RP.A.2: Recognize and represent proportional relationships between quantities. ▪ SP.A.1: Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. ▪ 8.EE.B.5: Graph proportional relationships, interpreting the unit rate as the slope of the graph. **Assessment:** ▪ Assessments in this phase should focus on the depth of understanding, the originality of ideas, and the quality of solutions or projects presented by students. ▪ Provide constructive feedback and recognition for exceptional work. **Resources:** ▪ Access to research databases, scientific journals, and online resources for independent research. ▪ Support in connecting students with mentors or experts in their chosen fields. ▪ Information about relevant STEM competitions or symposiums for participation.

Evaluate

(Day 10: Assessment criteria are planned. Peer and teacher evaluations provide feedback. Student groups reflect and revise proposals for improvement.)

Procedure:

- *Peer Evaluation:* Divide students into groups and instruct them to evaluate each other's proposed plans to mitigate the impact of future volcanic eruptions on food security. Provide a structured evaluation form that includes assessment criteria such as scientific accuracy, feasibility, innovation, and consideration of regional factors.
- *Teacher Evaluation:* Conduct a comprehensive evaluation of each group's proposed plan, using the same assessment criteria established during the peer evaluation. Provide constructive feedback to student groups to help them refine their proposals.
- *Reflection and Revisions:* Allocate time for student groups to reflect on the peer and teacher evaluations. Encourage them to identify strengths and weaknesses in their proposals and make necessary revisions to improve the overall quality of their plans.

Modifications:

- Challenge more advanced students to evaluate proposals with a higher level of critical analysis, considering potential limitations and unintended consequences of the proposed solutions.

Standards Addressed:

- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Formative/Summative Assessments:

- Formative: The peer evaluation process serves as a formative assessment, providing students with timely feedback to enhance their plans before final submission.
- Summative: The teacher's evaluation and final revisions made by student groups contribute to the summative assessment of this phase.

Resources:

- Evaluation forms (e.g. Google Forms) outlining assessment criteria for the proposals.

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