**Unit Essential Question:** *How do humans impact organisms around the world and what can we do about it?*

**Introduction**

In the Lift-Off task, students learned that the bee population is declining. In the last unit, students also learned that algal blooms have been on the rise in recent years. While the effects are different, the same root cause is at play in both cases. In this task, students explore the rise in global temperatures over the past century, including why they are on the rise and predicting how this affects Earth. By introducing one piece of data at a time, students have an opportunity to process the evidence and use it to generate their own questions that drive further learning. By the end of this task, students will be able to explain global warming and use this new knowledge to define the problem facing their chosen organism for their culminating project.

**Alignment Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.] | **Asking Questions and Defining Problems**   * Ask questions to identify and clarify evidence of an argument. | **ESS3.D: Global Climate Change**  Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. | **Stability and Change**   * Stability might be disturbed either by sudden events or gradual changes that accumulate over time. |
| **MS-ETS1-1***.* **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.** | **Asking Questions and Defining Problems**   * Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. | **ETS1.A: Defining and Delimiting Engineering Problems**   * The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. | **No CCC listed** |
| **Supplementary Science and Engineering Practices**   * Analyzing and Interpreting Data   + Analyze and interpret data to provide evidence for phenomena. | | | |
| **Supplementary Crosscutting Concepts**   * Patterns   + Patterns can be used to identify cause and effect relationships. | | | |
| **Equity and Groupwork**   * Participate in group roles to analyze evidence and generate questions related to global temperature change. * Share ideas with a partner. * Come to consensus on selecting an organism for your culminating project. | | | |
| **Language**   * Use mathematical language in written analysis of graphs. * Represent cause and effect relationships in a flowchart. | | | |

**Learning Goals**

This learning task asks students to ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. More specifically, the purpose is to:

* Engage prior knowledge of global warming in order to make predictions.
* Explore data related to global warming and generate questions to guide further inquiry.
* Explain the cause and effect relationships to describe global warming.
* Emphasize the crosscutting concept of Stability and Change in analysis of carbon emissions data.
* Apply knowledge of global warming to define the problem a specific organism is facing.

**Content Background for Teachers**

In this task, students explore the rise in global temperatures over the past century, also known as global warming. Though this warming trend has been occurring for a long time, its pace has significantly increased in the last century due to human activities—mainly the burning of fossil fuels. Fossil fuels include coal, oil, and natural gas, which are burned for various industrial and residential purposes, such as heating and cooking. Because the human population has also drastically increased, this has further increased the burning of fossil fuels.

Burning fossil fuels creates “Greenhouse Gases” in our atmosphere, which causes what is known as the “Greenhouse Effect”. The Greenhouse Effect is when the sun’s light is absorbed by the Earth and radiated back out towards the atmosphere as thermal energy. The Greenhouse Gases (ie. carbon dioxide and methane from burning fossil fuels) then trap the heat in the atmosphere, causing an increase in the average global temperature.

Global warming causes another issue, known as climate change, which refers to the changes in weather patterns caused by global warming (for example, extreme storms, flooding, etc.). While these terms are often used interchangeably, they are actually different phenomena. In this task, students will be focused on global warming.

You can find all relevant data related to global warming in the *Explore* Station Cards, including graphs and a video of a carbon dioxide and temperature experiment.

**Academic Vocabulary**

* Global Temperature
* Carbon Dioxide
* Carbon Emissions
* Fossil Fuels
* Volcanic Eruptions
* Problem
* Criteria
* Constraints

**Time Needed (Based on 45-Minute Periods)**

4 Days

* Engage: 0.5 period
* Explore: 1.5 periods
* Explain: 0.5 period
* Elaborate: 0.5 period
* Evaluate and Reflection: 1 period

**Materials**

* Unit 4, Task 1 Student Version

Engage

* Projector and Speakers

Explore (Per group)

* Evidence Cards #1-5
* Computer or Tablet (for video)

Evaluate

* Project Organizer Handout
* Culminating Project Document (for list of organism options)
* Computers or Tablets for Research

**Instructions**

**Engage**

1. Introduce Task 1: In the Lift-Off task, you saw that the bee population is declining. Think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their student guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 1: In the last unit, you learned that algal blooms have been on the rise in recent years. But why are these things happening? Why are we seeing changes like these in many different organisms around the world? To answer these questions, we first need to investigate how environments are changing around the world and why.
   * Now pass out their Task 1 student guide.
3. Show the first minute of the following video to introduce students to global temperature rise: <https://climate.nasa.gov/climate_resources/42/video-temperature-puzzle/>.
   * Optional - For more recent news coverage on global warming, show the first 30 seconds of either of the following clips: <https://www.youtube.com/watch?v=RvaCM1TNBBk> or <https://www.youtube.com/watch?v=F-IgOWwzIL4>
4. Then have students individually make hypotheses to the following questions: What do you think is causing these rising temperatures? Why do you think rising temperatures might affect organisms?
   * Students will be exploring the first question throughout this task. The second question will remain a hypothesis throughout this task, but students will get more information on impact to organisms through their own project research and in Task 3. Therefore, it is not essential that students generate or are given a definitive answer for the second question during this task. We include this question here to help students understand the storyline of the overall unit.
   * Because these are hypotheses, any responses are valid.
5. Once students have their hypotheses, they record any questions they would want to ask in order to find out more about rising global temperatures. This begins their practice of **Asking Questions**, which is the SEP focused on in this task.
6. We highly recommend students share both their hypotheses and questions in pairs. It is also helpful to share some of these out in a class-wide discussion so both you and your students can get an idea of where students’ thinking is.

* We encourage using equity sticks to foster more equitable participation in class-wide discussions like these (See “How To Use This Curriculum” for more details).

**Explore**

1. Now that students have made hypotheses, they are ready to gather evidence to see whether global temperatures are actually rising, and if so, why.

* In alignment with the SEP for this task, **Asking Questions**, students will be given one piece of evidence at a time, so that they may generate their own questions to further their learning.
* As students analyze each piece of evidence, they are also engaging in the supplementary SEP of **Analyzing and Interpreting Data** to provide evidence of the phenomenon of global warming.

1. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Facilitator, Materials Manager, Harmonizer, and Recorder.
   * Ask the Facilitator to read the directions and to make sure everyone understands the task.
   * Ask the Materials Manager to gather and read the materials needed to complete the task.
   * Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
   * Ask the Recorder to make sure the group is recording their analysis and questions in their Student Guide.
2. Distribute one piece of evidence to each group at a time, in sequential order. They are placed in a particular order to encourage students to ask certain questions that might guide them towards the next piece of evidence. A sample evidence chart is provided below:

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| --- | --- | --- |
| **Evidence** | **What does the evidence tell you?** | **What additional questions do you have?** |
| Graph:  Global Temperature Change | *It shows me that global temperature change is caused by both natural and human causes, not just natural causes.* | *What counts as a natural cause? What counts as a human cause?* |
| Graph: Temperature and Carbon Dioxide | *This graph shows me that temperature and carbon dioxide are related. When carbon dioxide goes up, so does temperature. It also shows me that there has been a lot more carbon dioxide and a sharper increase in temperature recently.* | *Why are carbon dioxide and temperature related? What is actually making carbon dioxide increase so much recently?* |
| Experiment: Temperature and Carbon Dioxide | *Methane and carbon dioxide are both causes of temperature increases in greenhouses. This means that they are also causes of global warming.* | *What causes more methane and carbon dioxide in the atmosphere? Does methane or carbon dioxide contribute more to global warming?* |
| Graph:  Carbon Emissions From Fossil Fuels | *It shows me that carbon dioxide caused by the burning of fossil fuels has increased a lot in the last 70 years. Fossil fuels are fuels made from natural resources like coal, natural gas, and oil.* | *When do humans use fossil fuels? Does all carbon dioxide come from fossil fuels or other places?* |
| Graph:  Carbon Emissions From Volcanic Eruptions | *It shows that carbon dioxide levels in the atmosphere don’t actually change much when different volcanic eruptions happen. They have been increasing steadily regardless of a few different eruptions.* | *What else could carbon dioxide come from besides fossil fuels and volcanic eruptions? But what if it’s like a REALLY big volcano, like mass extinction big?*  Note: Student may have no additional questions for this graph. |

* Optional: Do a quick check of students’ evidence charts and ask a few facilitating questions as a check for understanding before distributing the next evidence card to a group.
* Note: The last column of this evidence chart can be used to summatively assess the SEP of Asking Questions. See the end of this Teacher Guide for a rubric.

**Explain**

1. Now that students have seen all the evidence, they can return to the original questions from the Engage: What do they think is causing these rising temperatures? Why do they think rising temperatures might affect organisms? To illustrate their answers to these questions, they individually fill out a cause and effect flowchart, using as many or as few of the boxes they would like to.

* This activity emphasizes the supplementary CCC of **Patterns**, as students use the patterns from the *Explore* data to identify cause and effect relationships in their flowchart.
* As stated in the *Engage*, the second question (Why do they think rising temperatures might affect organisms?), and thus the last few boxes of their flowchart will still be hypotheses at this time. Students will learn more about impacts to organisms in their own project research and within Task 3. We recommend you make this explicit to students.

1. Possible Student Sample:
2. Once students complete their flowchart, have them annotate the arrows of their cause-and-effect flowchart with the source of evidence that led them to make the connection.

* Because the last few boxes will still just be hypotheses based on prior knowledge, encourage students to think about what information they will still need to confidently fill out this flowchart. This continues the same kind of thinking associated with the SEP of **Asking Questions**.

1. The completed flowchart is a good option for formative assessment. Collect student work to identify trends in students’ ability to accurately describe global warming. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

**Elaborate**

1. To emphasize the CCC for this task, **Stability and Change**, students will return to two pieces of evidence from the *Explore*—both graphs about the causes of carbon dioxide emissions.
2. In partners, students discuss the following questions:
   * 1) Which one represents a sudden change? Which one represents gradual changes that have accumulated over time? Explain how you know.
     1. This question explicitly addresses **Stability and Change** as students consider how stability can be disturbed either by sudden events (volcanic eruptions) or gradual changes that accumulate over time (burning of fossil fuels).
   * 2) Which cause seems to have more of an impact over time?
     1. This second question aims to emphasize that it is the gradual accumulation of carbon dioxide associated with burning fossil fuels that has the most effect. Thus, human impact, not natural causes, is to blame for global warming.
3. This section can also serve as a good option for formative assessment. Collect student work to identify trends in students’ ability to accurately describe the main cause of global warming, using the concept of **Stability and Change**. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

* You may also want to share out a few student responses in a class-wide discussion to get a sense of students’ understanding at this point in the task.

1. Return to the whole-class concept map from the Lift-Off Task.
   * In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
     + Some facilitating questions to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
     + Draw circles around each question and boxes around each concept.
     + Write connector words to describe connections between the concept boxes.
     + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: rising global temperatures, the cause of these rising temperatures, and potential impacts to organisms.
   * Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
     + **Stability and Change**: These could be phrases such as, “remains the same”, “is changed by”, “is disrupted by”, “changes”, “disrupts,” etc.

* Once again, the purpose of this concept map is to facilitate generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Students independently complete the Task 1 section of the Unit 4 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. You have been asked to create an advocacy video that describes the human impact on an organism and gives a potential solution. Their prompt is as follows: You have been provided with a list of organisms that are affected by rising temperatures. As a group, select an organism from the list to focus on for your culminating project and research your organism. Then individually,

* Define the **problem**: What is happening to global temperature and why might it be a problem?
* Identify the **criteria** for a successful solution: How will you know if a solution addresses the problem?
* Identify the **constraints** of solving this problem: What might make it hard to solve this problem?

1. Based on prior knowledge and research, students should be able to describe that global warming changes environments in a way that might affect organisms (their traits, behavior, population size, etc.). One essential criterion for success is for their solution to ensure that no further harm impacts their chosen organism. Constraints might include: time, money, resources, buy-in from communities, natural constraints, etc.

* This Evaluate emphasizes the PE, MS-ETS1-1, as students define criteria and constraints.

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to hypothesize why temperatures are rising. Look at your hypotheses in the *Engage* and your flowchart in the *Explain*. How has your understanding changed over the course of the task?
* In this task, we focused on the crosscutting concept of **Stability and Change**: Stability might be disturbed by sudden events or the accumulation of gradual changes. Where did you see examples of **Stability and Change** in this task?
* Now that you have learned more about the rise of global temperatures and its cause, what questions do you still have?

1. There are no right answers, but encourage students to look back at their student guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. Collect students’ Task 1 Student Versions and assess the *Explore* using the 3-Dimensional Task 1 Rubric below. To maintain the authenticity of the Culminating Project, the SEP of Asking Questions will be assessed through this task rather than within the Culminating Project. The other dimensions of MS-ESS3-5 will be assessed within the Culminating Project.
2. You may collect students’ Project Organizer and assess using:

* *Criteria of your choice.* We recommend using the 3-Dimensional Assessment matrix at the beginning of this document to inform your criteria.
* This can be a formative tool to periodically look for trends in student understanding after the completion of a task. You can then use this formative data to inform any re-teaching as necessary.

1. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

**Task 1 Rubric**: Student asks questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

* Dimensions Assessed: SEP – Asking Questions, DCI – ESS3-D: Global Climate Change

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| --- | --- | --- | --- |
| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student asks **irrelevant** questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. | Student asks **some relevant** questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. | Student asks **mostly relevant** questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. | Student asks **all relevant** questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. |
| **Look Fors:**   * For all pieces of evidence (#1-4), student asks questions that are irrelevant to the piece of evidence they correspond with and/or that don’t drive further inquiry into the cause of rising global temperatures. | **Look Fors:**   * For at least one out of four pieces of evidence, student asks questions that are relevant to the piece of evidence they correspond with and that also drive further inquiry into the cause of rising global temperatures. * See last column of student sample in *Explore* for examples of relevant questions. | **Look Fors:**   * For three out of four pieces of evidence, student asks questions that are relevant to the piece of evidence they correspond with and that also drive further inquiry into the cause of rising global temperatures. * See last column of student sample in *Explore* for examples of relevant questions. | **Look Fors:**   * For each piece of evidence (#1-4), student asks questions that are all relevant to the piece of evidence they correspond with and that also drive further inquiry into the cause of rising global temperatures. * See last column of student sample in *Explore* for examples of relevant questions. |