

A Guide for Teachers to Implement an Inquiry-Based Activity Plan for Climate Change and its Impact on the Ocean

Course: Environmental Education and Climate Change

Target Group: 7th and 8th grade students

Objectives & Purposes:

1. Questions the events that cause an increase in greenhouse gases.
 - a. Students are expected to identify greenhouse gases that contribute to environmental issues.
 - b. It is explained that a certain level of greenhouse gases is necessary to maintain atmospheric temperature balance.
2. Recognizes that global warming is a result of the greenhouse effect.
3. Interprets the effects of global climate change through case studies.
 - a. Students are made aware of the impacts of climate change through case studies, such as biodiversity loss, melting glaciers, rising sea levels, changes in coastal ecosystems, drying lakes, chemical changes in aquatic environments, reduction in freshwater resources, and shifts in animal migration and breeding patterns.
 - b. The interconnections between various events caused by global climate change are emphasized.

Recommended Methods: Collaborative learning methods are encouraged to foster group work, discussions, and social interactions.

Additional Resource: Students will be given an *Activity Sheet* to complete the activities listed below.

Activity Plan

Course Stages	Objectives	Week/Lesson	Teacher Steps	Activity Sheet Matching	Duration (min)
Research Inquiry	To make students curious about the theme. Mobilizing students' prior knowledge. To introduce the basic concepts for an inquiry-based study.	Week 1/ Lesson 1 Ocean Ecosystem and Greenhouse Gases	a. Introducing the Topic: Identify students' prior knowledge about the topic. Activity1: Brainstorming on the Ocean and Greenhouse Gases: The questions in this section can be asked in a brainstorming activity. "Today we are going to investigate the diversity of living things in the oceans and why they are under threat. Why do you think the oceans might be under threat?" Activity 2: Creating a Mind Map*: Ask students to create a mind map that answers the following questions: - Which creatures live in the oceans? - What are the physical and chemical changes in the oceans? - How can greenhouse gases affect these changes? - Which living things are affected by these changes?	Research Section: Marine life in the oceans is in danger. Find out how greenhouse gases affect this situation! 1. Which words or concepts can you write about the topic? 2. Which values in the ocean do you expect to change? 3. What is your prediction about the changes in the ocean? Which variables might be affecting each other?	20
			b. Knowledge Presentation: Give basic information about the effect of greenhouse gases on the oceans: - How CO₂ mixes from the atmosphere into the oceans**. - Formation of carbonic acid and effects of pH decrease. Activity 3: Visual or Video Presentation: Visuals about the ocean ecosystem and the impact of greenhouse gases are shown and a short video is shown Example video: The impact of greenhouse gases on the changing chemistry of the oceans https://www.youtube.com/watch?v=0a2QNmKeVQ		20

			Activity 4: Questions for the learner: Reinforce the information with sample questions: • "Which marine organisms are more affected by acidification? Why?" • What makes a solution acidic? • What are some of the effects of low pH water on marine organisms?		
		Week 1/ Lesson 2 Ocean Ecosystem and Greenhouse Gases	c. Expand and Deepen Knowledge: Have students research sources and formulate premise questions. Activity 5: Creating Researchable Questions (Question Machine Activity): Students can be divided into groups to carry out this activity. • Students are asked to write a few starter questions about the ocean ecosystem and greenhouse gases. • They develop these questions and make them researchable through the question machine by following the steps and activities below. Introducing the Question Machine: Explain to the students the characteristics of a good research question: 1. It should be clear and concise. 2. It should require research for an answer. It should not be a fact question. 3. It should be linked to the theme. 4. It must be a question that he or she does not yet know the answer to and is curious about. 5. Must be singular. Multiple research questions should not be combined. Using the Question Machine: Work together on sample questions using the question machine. For example: 1. Students first write a broad question: "Why might the oceans be in danger?"	Research Section: 4. How do you ask questions about these effects?	40

			2. These questions can then be made more researchable: "What is the effect of CO₂ on the ocean pH level?" Question Development Study: 1. In groups, students discuss the changes in the ocean ecosystem and the impact of greenhouse gases. 2. They share their questions with each other and get feedback. Example: "How do greenhouse gases affect the pH of the oceans?" Creating a Question Wall: 1. Groups share their researchable questions with the class and add them to the class "Question Wall". 2. Sample questions: • "How do temperature changes in the ocean affect fish species?" • "Do greenhouse gases have the same effect on different living things?"		
Testing	Observing ocean acidification experimentally. Acquisition of scientific observation skills.	Application (Between Week 1 and 2) Changes in the Environment and the Ocean	Introducing VR Technology: Explain how VR technology can be used in scientific research: • Identification of sources of greenhouse gases and a scenario simulating their impact on climate change and the ocean. • In this scenario, it is a way to observe and collect data on measurable variables such as pH, temperature and fish diversity. Simulation and Data Collection in VR Environment: • Each group watches scenarios of the past, present and future in a VR environment. • Students are asked to measure pH, temperature and biological data appropriately in each time period.	Virtual Reality Application Process (Outside the Classroom Environment) <i>This part will be carried out by the researchers.</i>	1 Week

Analysis	Scientific analysis of the collected data. Application of hypothesis formulation and testing processes.	Week 2 / Lesson 1 The Effects of Greenhouse Gases on the Ocean and Living Life	d. Hypothesis Formulation and Testing: Ask the groups to formulate a hypothesis based on the data they have collected. - For example: "Increasing CO₂ threatens coral life by lowering pH values." - Explain that they should select evidence from the data that supports or refutes the hypothesis. Activity 6: Formulating a Hypothesis: You can use the relevant sections in the Activity sheet to support students to formulate their hypotheses. Activity 7: Questions for learners: Support this process with sample questions: "Do your data support your hypothesis? If not, why not?" "Would another group come to a different conclusion based on the same data? Why might it be different?" Activity 8: Discussion between Groups: Ask the groups to share their findings with the class.	Analysis Section: What Did You Observe? - What values did you measure in the ocean? - Which of the measured values, if changed, could affect the other values as well? - My hypotheses based on my observations; - Can the hypotheses you stated above be tested?	40
		Week 2 / Lesson 2 The Effects of Greenhouse Gases on the Ocean and Living Life	e. Creating Data Table and Graph: - Ask students to put the data they have collected into a table. This table shows CO₂ concentrations, temperature, ocean pH changes and fish numbers over the years. - Encourage them to make a graph to make the data more visual. Activity 9: Making a graph: You can use the relevant sections in the Activity sheet to support students to create their graphs. Activity 10: Questions for learners: Support this process with sample questions: "What changes did you observe when analyzing the data in your table?"	Analysis Section: What Does the Data Tell Us? - Put the values you measured in the table. - Draw a graph about the data you measured.	40

Conclusion and Interpretation	Reinforcing students' learning in the process of scientific inquiry. Sharing and interpreting the results obtained.	Week 3 / Lesson 1 Impact Analysis, Problems and Solutions	f. Summarizing the Results: - Ask the groups to report the data they analyzed and their hypotheses. - Ask each group to share their results with the class in a table, graph or short presentation. Activity 11: Creating a table of results: You can use the table of results section in the Activity sheet for students to summarize their data. Activity 12: Questions for learners: Support this process with sample questions: "Do your results answer your research questions? If not, why not?" Activity 13: Giving Feedback: - Ask other groups to give critical and constructive feedback on the results presented. - Encourage discussion: "Do you think your results are consistent with the hypotheses of the different groups?"	Conclusion Section: My Hypothesis-Evidence-Results - Do greenhouse gases increase or decrease ocean water temperature? - How does ocean temperature change impact the number and diversity of marine life? - Do greenhouse gases increase or decrease the pH of ocean water? - How does pH change affect marine life diversity and population?	40
		Week 3 / Lesson 2 Impact Analysis, Problems and Solutions	g. Interpretation of Results: Reinforce the interpretation of the results by making a general evaluation with the whole class. Activity 14: Creating a Report: You can use the report, future predictions and solutions activities in the Activity sheet for students to interpret their results. Activity 15: Discussion: Have the groups discuss their similar and different ideas and suggestions for future predictions and solutions. Activity 16: Questions for learners: Support the students' overall assessment process with sample questions: "What was the most important finding you made during the interrogation process?" "If you were to redo the research process, what would you do differently?"	Interpretation Section: My report: How would you interpret the impact of greenhouse gases on the ocean and marine biodiversity based on your research? Future predictions How will marine life be affected in the future? How will humans be impacted by this situation? Proposed Solutions: What actions can be taken to mitigate the effects of greenhouse gases?	40

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* Mind Map Application Steps

Mind maps are an effective way to visualize students' prior knowledge and their progress in the learning process. Here is how you can apply mind mapping in an inquiry-based activity:

1. Mind Map Initiation (Exploration Phase):

- Objective: ocean acidification knowledge and ocean acidification and identifying their areas of interest.
- Implementation:
 1. Start a mind map on a large piece of paper or whiteboard in the middle of the class.
 2. Write "Ocean Acidification and Greenhouse Gases" in the center and ask students the following questions:
 - "What do you know about the oceans?"
 - "What are the effects of greenhouse gases?"
 - "Could there be a connection between these issues?"
 3. Add the students' short and clear answers on different branches of the map.
 - For example: Ocean Ecosystem → Corals, Fish Species, Salinity Level
 - Greenhouse Gases → CO₂, Climate Change, pH Level

2. Expanding the Mind Map (Testing Phase):

- Objective: To add to the map the new knowledge and findings students have gained during the learning process.
- Implementation:
 1. Divide students into groups and ask them to include the data they collected in the VR simulations in the mind map.
 - For example: "What pH changes have you observed in the VR environment? How do these changes affect fish diversity?"
 2. Update the map and create subheadings:
 - Greenhouse Gases → CO₂ Concentration → pH Level → Coral Loss
 - Ocean Ecosystem → Temperature Rise → Decline in Fish Species
 3. Ask the groups to explain how each finding affects the other and visualize these relationships on the map.

3. Completion of the Mind Map (Interpretation and Deepening Stages):

- Objective: For students to review the whole learning process and bring together what they have learned in the project.
- Implementation:
 1. At the end of the project, ask students to complete the mind map individually or in groups.

- They can make additions to previous branches or reorganize links.
 - For example: Consequences → Less Coral → Reduced Fish Diversity → Impacts on the Human Food Chain
2. Ask the students the following questions:
 - "What new information can you add to the mind map?"
 - "What do you think is the most important information learned in this process and why?"
 3. Compare the project with individual mind maps alongside the class map. This allows students to see the increase in knowledge.

4. Visualization and Presentation:

- Objective: For students to share what they have learned.
- Implementation:
 1. You can ask the groups to visualize the mind map with digital tools (e.g., MindMeister, Lucidchart, or Canva).
 2. Each group contributes to the whole class learning process by presenting their mind map.
 - Question: "What conclusion does the information in the mind map point to? Which topics require further research?"

****Additional Context for Teachers**

Introduction

Many scientists around the world are concerned with global warming and climate change. Global warming is an increase in the average measured temperature of the layers of air and ocean closest to the Earth's surface. Climate change is a significant long-term change in the average weather conditions experienced by a particular region. The causes of warming remain an active area of research. However, one theory is that current global warming is partly due to increased anthropogenic greenhouse gases such as carbon dioxide (CO₂) since the beginning of the industrial revolution.

Our atmosphere, which comprises several layers, protects and keeps the Earth warm. Visible sunlight easily penetrates the atmosphere and heats the Earth's surface. The Earth's surface then emits invisible infrared radiation. As the radiation travels upwards, layer by layer, through the atmosphere, some of it is absorbed by each layer. Each layer of air sends some of the absorbed energy back to the Earth and some back to higher layers. The higher you go, the thinner and cooler the atmosphere becomes. Eventually, the energy reaches a thin layer so radiation can escape into space. Adding more carbon dioxide to a layer allows that layer to absorb more radiation or heat energy. So the layers where most heat energy is used to leave the Earth to heat up and send more of the heat energy back to the Earth. This means that the energy cannot leave the Earth until it reaches the higher, thinner, and colder layers and, therefore, cannot send as much heat back to the Earth. The planet then receives more energy than it emits, so it warms up.

One of the mechanisms that prevents some of the CO₂ from entering the atmosphere is our oceans. The oceans absorb about a third of anthropogenic CO₂. However, this comes at an ecological cost - a phenomenon called ocean acidification. As CO₂ dissolves in seawater, the pH of the water decreases. pH is a measure of the amount of hydrogen ions, or activity, in a solution. As pH decreases, water becomes more acidic.

When CO₂ dissolves in seawater it forms carbonic acid. This reaction is shown in Equation 1.

Equation 1:



Carbon dioxide and water combine to form carbonic acid.

Some of the carbonic acid dissociates in water, releasing hydrogen ions and bicarbonate. This is shown in Equation 2.

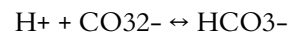
Equation 2:



Carbonic acid decomposes in seawater, resulting in hydrogen ions and bicarbonate.

Hydrogen ions have two effects. Some remain in the ocean water and increase the overall pH of the ocean. Others react with carbonate ions already in the water to make bicarbonate. This process removes carbonate ions from the water. Organisms such as corals, mussels and oysters use carbonate ions and calcium to make their shells or skeletons. If the amount of carbonate decreases, it is more difficult for these organisms to thrive. Equation 3 shows how hydrogen ions and carbonate combine to form bicarbonate.

Equation 3:



Hydrogen ions combine with carbonate ions to form bicarbonate.

Oceans naturally take up atmospheric CO₂, about 7 billion metric tons per year. The oceans absorb CO₂ at the surface and transfer it to deep waters without contact with the atmosphere over centuries. Before the industrial revolution, ocean and atmospheric CO₂ concentrations were in balance. But high atmospheric CO₂ levels caused by the

burning of fossil fuels forced excess CO₂ into the ocean's surface waters. This invasion of fossil fuel CO₂ gas into the surface waters of the ocean is now advancing at about 1 million tons of CO₂ per hour. The oceans are now more acidic than they have been for at least 650,000 years.

Acidified water can also lead to acidosis in higher marine life forms. Acidosis is an increase in carbonic acid in body fluids, resulting in lower pH values in the blood. This can lead to a range of health problems in these organisms