ENGINEERING SMART START GRANT LESSON PLAN

Date: 1/27/2026 - 1/30/2026 **Lesson:** Carbon Cycle **Grade:** 8/9

Materials and/or Resources:

- ☐ Computers or laptops with internet access (1 per student)
- ☐ Access to the Scratch platform - free (scratch.mit.edu)
- ☐ Student handout
- ☐ Carbon cycle reference materials (diagrams and class modeling notes)
- ☐ Carbon cycle glossary
- ☐ Rubric for final model and reflection
- ☐ Headphones (optional)

Standard Addressed:
ETS1B: Developing Possible Solutions

HS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Computer Science – 9-12.CT.5:
Modify a function or procedure in a program to perform its computation in a different way over the same inputs, while preserving the result of the overall program

Student-friendly "I Can" Statements:

I can…
I can explain and model how carbon moves through Earth's spheres (atmosphere, biosphere, geosphere, and hydrosphere).

I can use Scratch to simulate how carbon flows through Earth's systems.

I can identify and describe a design problem related to too much carbon in the atmosphere.

I can create or remix part of a Scratch program (such as a rule or function) to change how carbon moves through Earth's spheres.

I can reflect on how engineering and computer science can be used to help solve climate-related problems.

Vocabulary Words:

Core Ideas
Carbon – An element found in all living things.
Carbon cycle – How carbon moves through Earth's systems.
Carbon dioxide (CO_2) – A gas released by organisms and used by plants.
Oxygen (O_2) – A gas needed for cellular respiration.
Homeostasis – Balance in a system.

Earth's Systems
Atmosphere – The air around Earth.
Biosphere – All living things.
Hydrosphere – All water on Earth.
Geosphere – Rocks, soil, and land.

Key Processes
Photosynthesis – Plants use CO_2, water, and sunlight to make food.
Cellular respiration – Organisms use oxygen to release energy from food.
Decomposition – Breaking down dead organisms.
Combustion – Burning fuels that releases CO_2.
Gas exchange – Movement of CO_2 and O_2 between systems.

Living Things
Producers – Organisms that make their own food (plants, algae).
Consumers – Organisms that eat other organisms.
Decomposers – Organisms that break down dead matter.

Created by Marie Rice, EdD, University of Rochester

ENGINEERING SMART START GRANT LESSON PLAN

<table>
<tr><td></td><td>Storage & Human Impact
Carbon sink – A place that stores carbon long-term.
Fossil fuels – Coal, oil, and natural gas.
Human emissions – CO_2 released by human activities.</td></tr>
<tr><td>Cross-Curricular Link(s):
Computer Science: Programming, debugging, modeling systems, computational thinking

Earth & Environmental Science: Carbon cycle, climate change, human impacts on Earth systems

Engineering/Technology: Engineering Design Process, problem definition, criteria and constraints

Mathematics: Use of variables, counters, and quantitative changes in models

ELA (Literacy): Research skills, evaluating sources, explanatory writing, scientific communication

Digital Literacy: Creating and revising digital simulations</td><td>Approximate Time to Complete Lesson (in mins):

8 & 9th Grade Biology - 4 class periods (40 minutes each)

Day 1 (40 min):
● Introduction to phenomenon and task
● Review of carbon cycle concepts
● Begin Scratch model (Part 1)

Day 2 (40 min):
● Continue building carbon cycle model
● Add human emissions element (Part 2)
● Define the problem, criteria, and constraints (Part 3)

Day 3 (40 min):
● Choose solution and conduct quick research (Parts 4–5)
● Begin revising Scratch model

Day 4 (40 min):
● Complete model revisions (Part 6)
● Final reflection (Part 7)
● Optional sharing or peer feedback</td></tr>
</table>

ENGINEERING SMART START GRANT LESSON PLAN

EDP STEP 1: ASK

In this lesson, the problem is that human activities are adding excess carbon dioxide (CO_2) to the atmosphere, disrupting the natural balance of the carbon cycle and contributing to climate change. Students investigate how carbon normally moves among Earth's systems (atmosphere, biosphere, hydrosphere, geosphere) and how human emissions alter these flows. The goal is to clearly define the problem by identifying the source of excess carbon, the impacts on Earth systems, and the need for a solution that restores balance (homeostasis).

Students should ask questions such as:

- What human activities are increasing atmospheric CO_2?
- How does excess atmospheric carbon affect other Earth systems?
- Where could the extra carbon be stored instead?
- What would a successful solution need to accomplish?
- What limitations or constraints must be considered?

Students will use these questions to define the problem, establish criteria (what the solution must do), and identify constraints (real-world limits), preparing them for designing and modeling a carbon-reduction solution.

EDP STEP 2: IMAGINE

Students brainstorm possible ways to reduce excess atmospheric carbon by changing how carbon moves through the carbon cycle. They consider solutions that either decrease carbon entering the atmosphere or increase carbon stored in other Earth systems (carbon sinks). Students draw on prior knowledge, class resources, and initial research to generate ideas that are scientifically accurate and feasible.

Students should think about:

- Where could excess carbon be redirected or stored?
- How might human activities be changed to reduce emissions?
- Which solutions could realistically be shown in a computer model?
- What processes in the carbon cycle could be strengthened or accelerated?

Students then select ONE solution that meets the design criteria and constraints to develop further.

Created by Marie Rice, EdD, University of Rochester

ENGINEERING SMART START GRANT LESSON PLAN

EDP STEP 3: PLAN	Students develop a clear plan for how their chosen solution will work and how it will be represented in their Scratch model. This includes determining what elements must be added or changed, how carbon movement will be altered, and what variables or visual features will show the impact of the solution. Students will: ● Describe how the solution reduces atmospheric CO_2 ● Identify which Earth systems are affected ● Decide how carbon will move differently in the model ● Plan sprites, labels, counters, arrows, or variables needed ● Ensure the plan meets all criteria and constraints This step prepares students to build an intentional, scientifically grounded model rather than experimenting randomly.
EDP STEP 4: CREATE & TEST	Students build or revise their Scratch carbon cycle model to include human emissions and their chosen solution. They test the model to see whether the solution successfully reduces atmospheric CO_2 and changes carbon storage in an appropriate sink. During testing, students should check: ● Does atmospheric CO_2 decrease when the solution is active? ● Is carbon increasing in another Earth system appropriately? ● Are human emissions still present? ● Does the model behave in a scientifically reasonable way? ● Are labels, visuals, or explanations clear? Students debug coding issues, adjust variables, and refine carbon flows to improve accuracy and functionality.

Created by Marie Rice, EdD, University of Rochester

ENGINEERING SMART START GRANT LESSON PLAN

EDP STEP 5: IMPROVE & SHARE

Students analyze their test results and revise their model to better meet the design goals. Improvements may include correcting scientific inaccuracies, strengthening the effectiveness of the solution, clarifying visuals, or fixing programming errors.

Students then communicate their work by sharing their model and explaining:

- How their solution reduces atmospheric carbon
- Where the carbon goes instead
- How the model demonstrates changes in the carbon cycle
- Benefits and limitations of the solution

Sharing may occur through class presentations, demonstrations, peer feedback, or submitting the Scratch project link. Reflection on the engineering and modeling process helps students recognize how iterative design leads to better solutions.

EVALUATE: Assessment of Student Knowledge:

❑ Informal (observation, student work sample, etc..)
Observation of student engagement and problem-solving during modeling
Checkpoints for model progress
Review of criteria/constraints and research responses
Peer discussions and troubleshooting

❑ Formal (formative or summative)
Completed Scratch carbon cycle model with human emissions and solution
Written problem definition, criteria, constraints, and research responses
Final reflection paragraph
Use of rubric assessing:
Scientific accuracy
Effectiveness of solution
Quality of model revision
Understanding of carbon movement
Clarity of explanation

Homework / Notes / Reflection:

Homework (optional):

- Complete unfinished Scratch work

Created by Marie Rice, EdD, University of Rochester

- Finish research questions or written components
- Revise reflection paragraph

Teacher Notes:

- Students may work individually or in pairs
- Provide example Scratch features (sprites, variables, broadcasts) as needed
- Encourage debugging as part of the engineering process
- Allow remixing for students new to Scratch

Student Reflection (extension option):

- What was most challenging about modeling the carbon cycle?
- How did your understanding of carbon movement change?
- What would you improve if you had more time?