Carbon Cycle Game

Overview

The Carbon Cycle Game is an interactive tool which allows students to simulate the movement of carbon molecules within the carbon cycle. The students are going to experience the carbon cycle as carbon molecules or as stored carbon which travel the path of various carbon sources (atmosphere, plants, animals, soil, ocean and fossil fuels) in their journey over time. The game aims to help students understand the different carbon transfer processes and their relational impacts along the carbon cycle as well as explore the concept of feedback processes in the cycle through further discussion and teamwork.

The first part of the game is demonstrating the cycle in "pre-history" before human interaction, however in the second part, students are challenged to explore how human interaction impacts the carbon cycle.

Age:

High School

Time:

Introduction, 15-20 minutes

Simulation one class session per game expected around 50 minutes

Materials:

- One computer per student for the first game
- Teachers supervisjon
- One computer per 2 students for second game
- Simulation online:

Game 1:
https://exchange.iseesystems.com/public/vir011/carbon-cycle-game

Game 2:
https://exchange.iseesystems.com/public/vir011/carbon-cycle-and-human-interaction.

Learning objectives

Carbon Cycle game 1- without human interaction

1. Introducing the main elements of the system.
2. Familiarizing students with graphs and reading graphical data.
3. Learning about how increasing and/or decreasing different carbon source/sinks affects the system's behavior.
4. For students to be able to predict the general direction and magnitude of changes in the system due to specific changes to the system.

Carbon cycle game 2- with human interaction

1. Introducing human-interaction to the carbon cycle.
2. Learning about climate feedbacks and comparing climate feedbacks with and without human impact
3. Responsible decision-making roles and follow-up discussions about them.
4. Expanding system-oriented learning concept to their day-to- day life.

Carbon Cycle Game 1- without human interaction

Students will be given a video briefing about different steps of the game as well as how to interact with simulation along the game.

Carbon Reservoirs (stocks)

In this page, the short animation introducing the main carbon reservoirs (stocks) to students. They can also review the baseline graph for all the reservoirs by click on the "Graphical Data" button.

Figure 1. Carbon Reservoirs

Learning outcome of the page:

- Recognition of different stocks in the carbon cycle
- Learning the baseline graphs for those sticks

Carbon Cards (flows)

As they already got introduced to the carbon stocks, the next page is illustrating all the flows. We call them carbon cards due to their function in the system each flow is represented as card which needs to be played in order to create change in the cycle. The carbon cards are categorized and assigned to different colors. The colors are based on the direction and destination of carbon particle movement. Such as, direct carbon removal from the atmosphere, direct carbon emission to the atmosphere

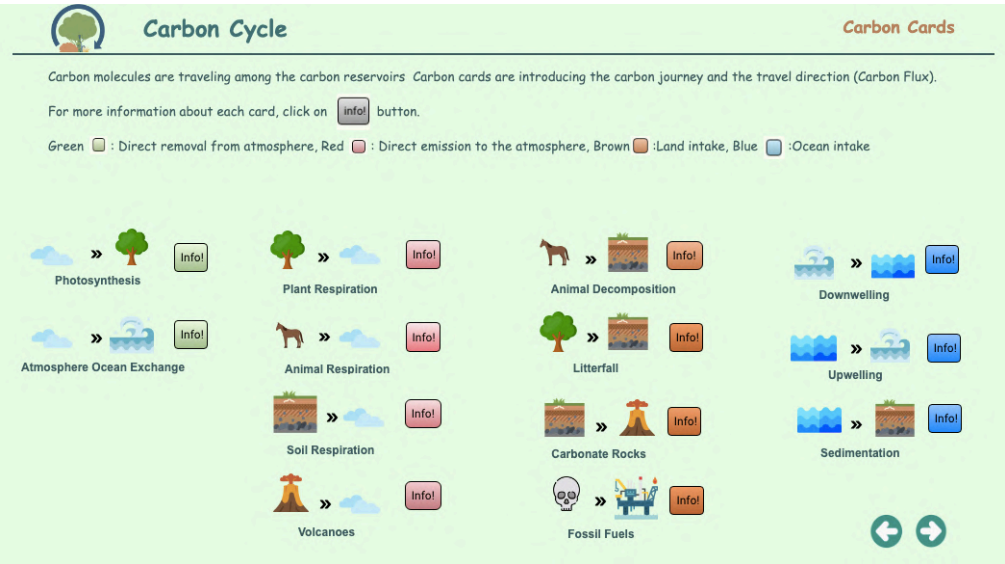

Figure2. Carbon Cards

Learning outcome of the page:

- Recognition of the carbon cards and their functions
- Learning about the concept of emission, removal, land sink and ocean sink

Main Simulator

This page is the interactive animated simulator, which allows student to explore the cycle by control different follows and observe the impact of those changes primarily on atmospheric carbon and later by list of given challenges in their journal, they can learn about which follows are more dominate and so on. Also, the expand graph button is opening the window of the graphical data of different stocks and flows of carbon.

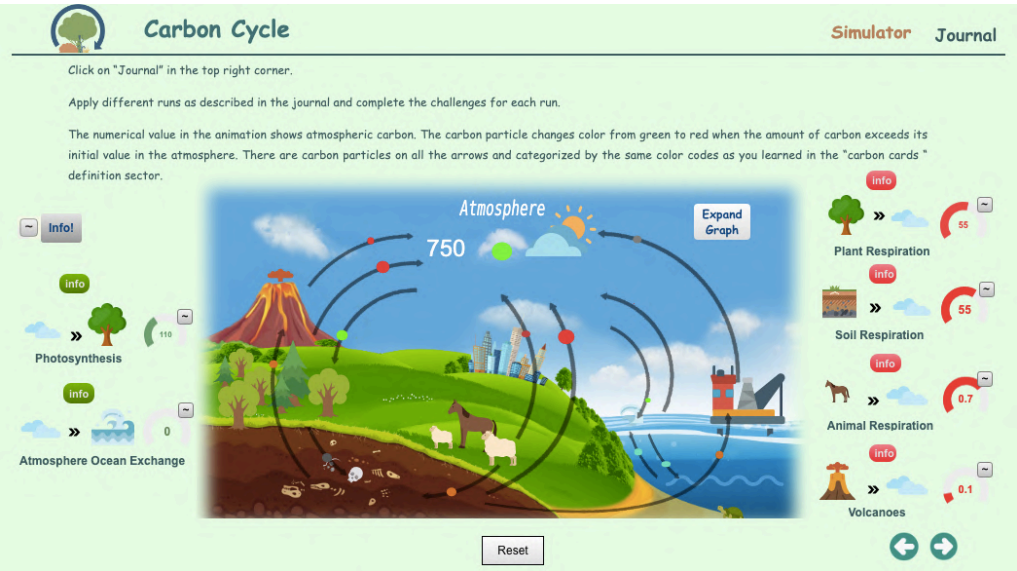

Figure3. Main Simulator

Learning outcome of the page:

- Learning the systematic relations between different variables
- Reading graphical data
- Ability to describe why different changes impact the system the way they do
- Learn about the most and least dominate carbon cards (flows)

Experiments

In this section students will be challenged to make changes in certain variables and to predict graphically the impact of the change on atmospheric carbon, after they are going to apply the change and simulate. They will have access to the comparison data from their prediction and the simulation result. They can evaluate their prediction and describe why it was easy or difficult to predict.

After second experiment they will be introduced to climate feedback concept before they move on to the 3rd experiment.

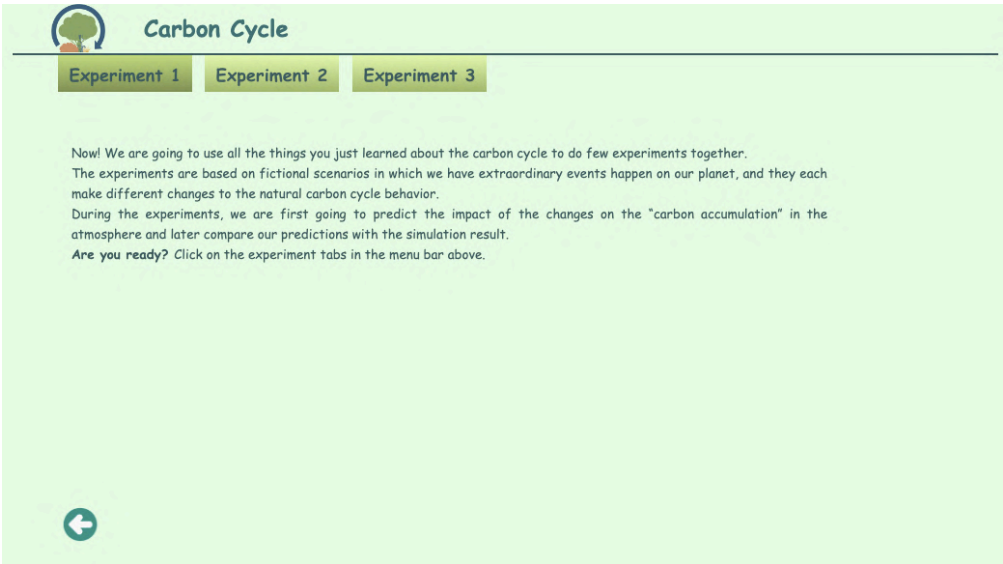

Figure4. Experiment

Learning outcome of the page:

- To prepare them to learn feedback loop concept in the next step
- To emphasize the power of different flows in the cycle

Feedback Process

This section is trying to teach feedback loop concept through a step change in the photosynthesis process and see the impact of that change in a long run.

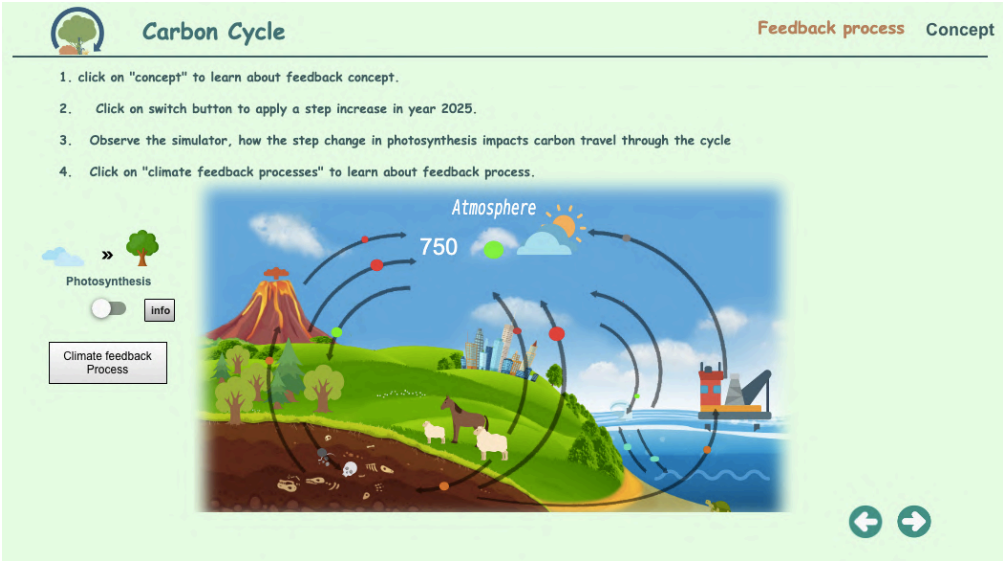

Figure5. Feedback Process

Learning outcome of the page:

- Climate feedback
- Feedback concept
- Behavior over longer period of time

Experiment3

The last experiment is a final challenge for the first carbon cycle game! Students are asked to create a scenario that will happen some changes in carbon flows. They are going to identify the relation between changes and relevant carbon flows. Also, propose solutions to stabilized atmospheric carbon afterwards.
This task allows students to apply everything they learned during the game.

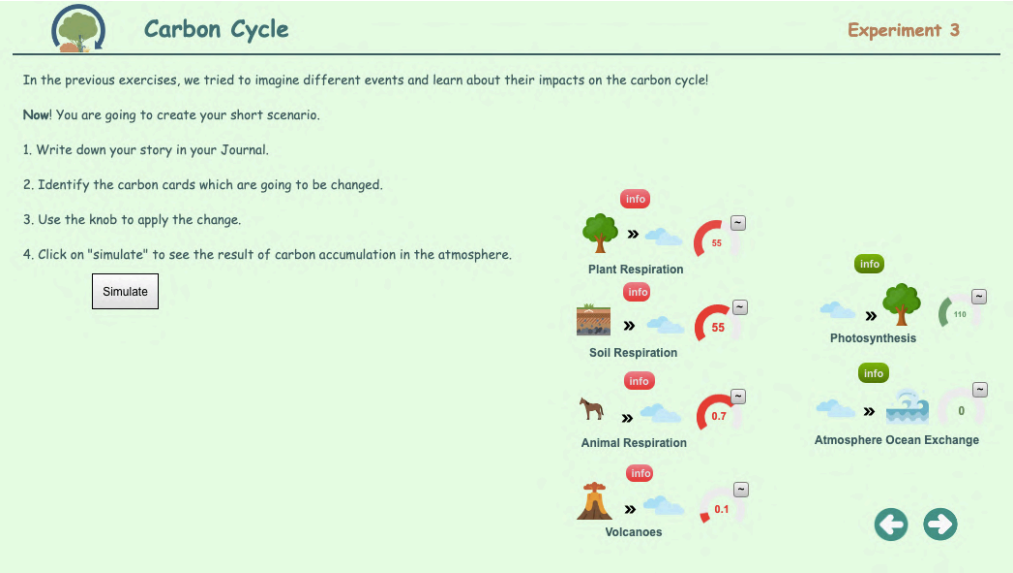

Figure6. Experiment 3

Carbon Cycle Game 2- with human interaction

The second carbon cycle game is building on the lesson from the first game. Students learn about human interaction and impact on the cycle. Students control the human impact by taking different decision-making roles. They explore and compare the carbon cycle without and with human interaction. Discussion and teamwork are important during the second game. For this purpose, students will be assigned in teams.

Briefing

Describe the objectives of the game and introduce the list of human impact which is within the boundary of this carbon cycle simulation, also the main simulator. If possible, the briefing recommended being done together with the teacher as a class.

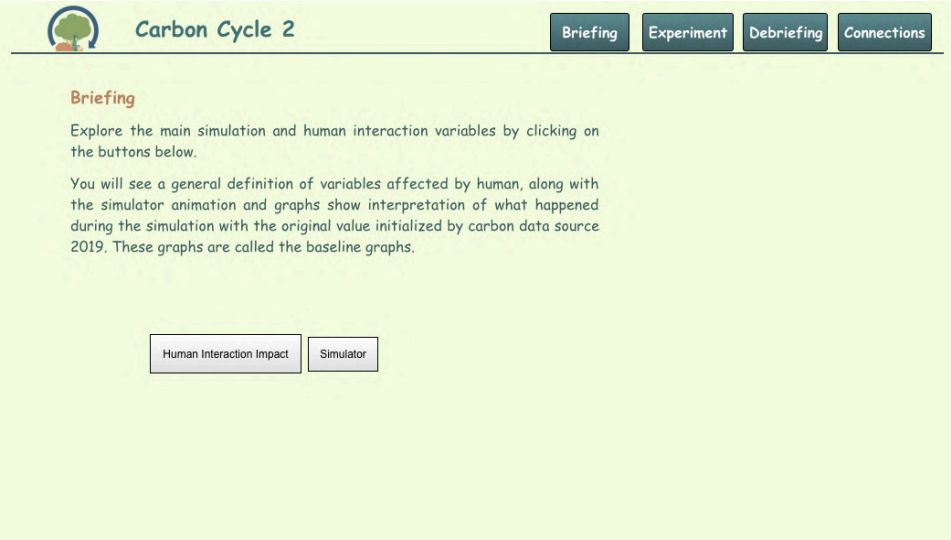

Figure7. Briefing

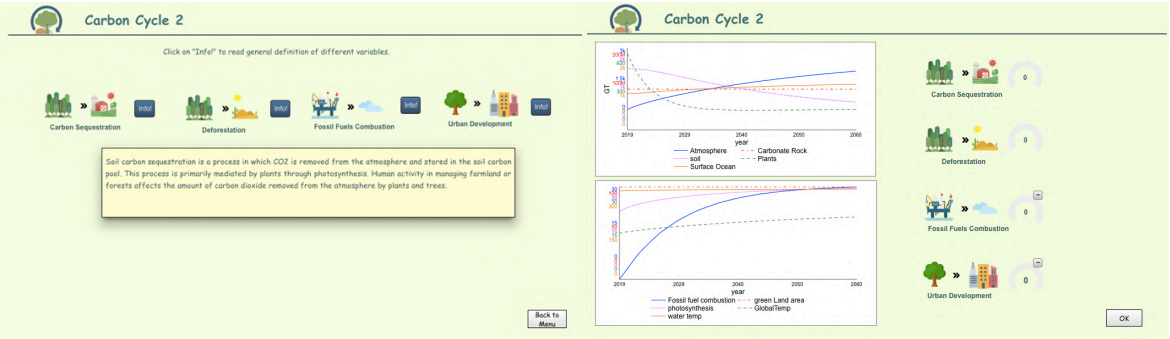

Figure8. Briefing detail

Learning outcomes of the page:

- Familiarizing with human interaction variables
- Learning about the definition and the impact
- Human interaction impact on atmospheric carbon and global temperature

Experiment

In this section students are given different scenarios about human interaction and they are challenged to make decision every 5 years in a manner to avoid dramatic atmospheric carbon increasing. The students are playing the role of the minister of industry and the mayor and they should finalize their decision in a dialog before they apply to the system, based on the system outcome they should decide for the next 5 year.

They should be asked for realistic decision, for example: if they decide to stop oil and gas combustion, they should propose the alternative energy source in their journal.

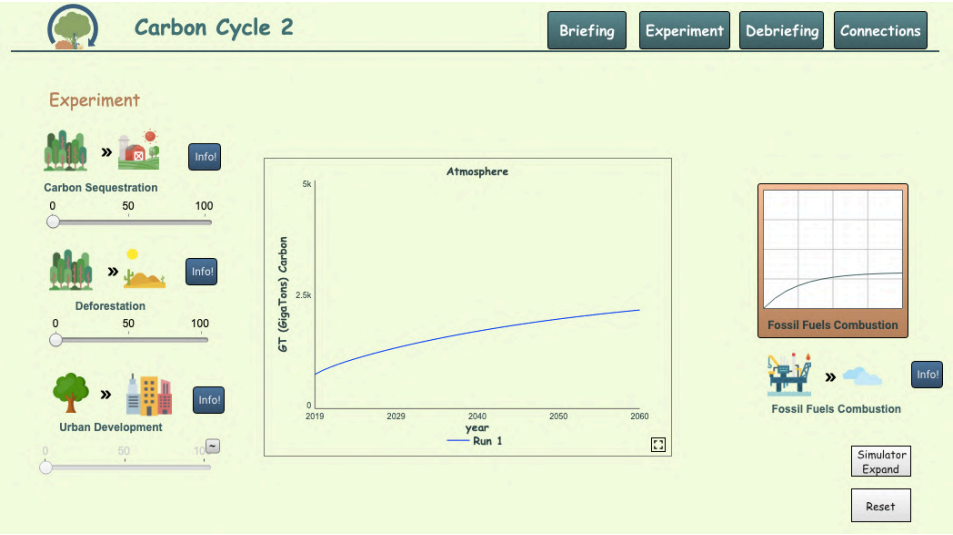

Figure9. Experiment

Learning outcomes of the page:

- Responsible decision-making and follow-up discussion
- Climate feedback and human impact

Debriefing

This section is dedicated to more general definition of system and summarized the concept in relation with carbon cycle system.
Debriefing also includes an example of photosynthesis feedback loop with and without fossil fuel combustion.

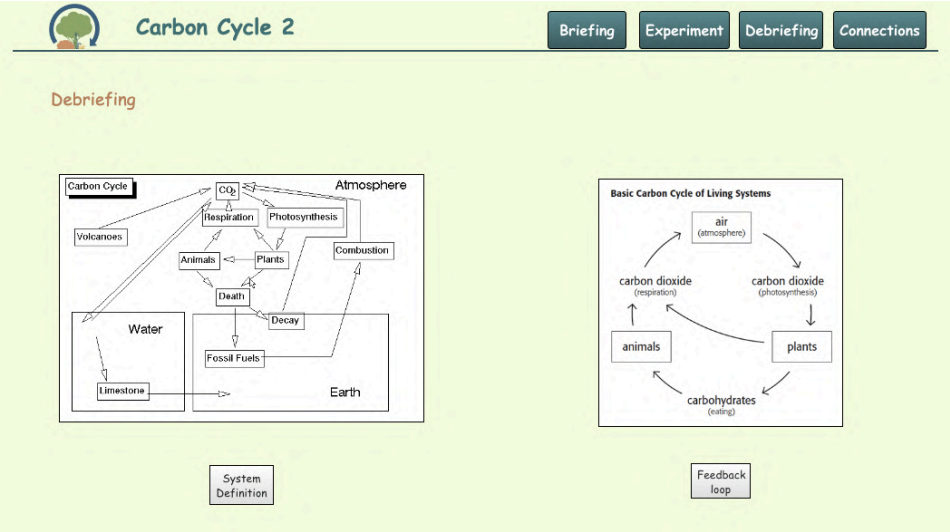

Figure10. Debriefing

Learning outcomes of the page:

- Impact of human interaction on the feedback loops
- General definition of system, understanding feedback loops as a system principle

Connections

Students are asked to relate their learning outcomes about system thinking and feedback loop processes to the day-to-day life. They are given couple of examples of feedback loops which made based on personal experience, challenged to modify them to their own real-life experience. The purpose is to let the student connect their system understanding to their daily life and practice system thinking.
It's also important for us to be able to evaluate, if the game serve to the purpose of teaching a generic concept through a narrative subject.

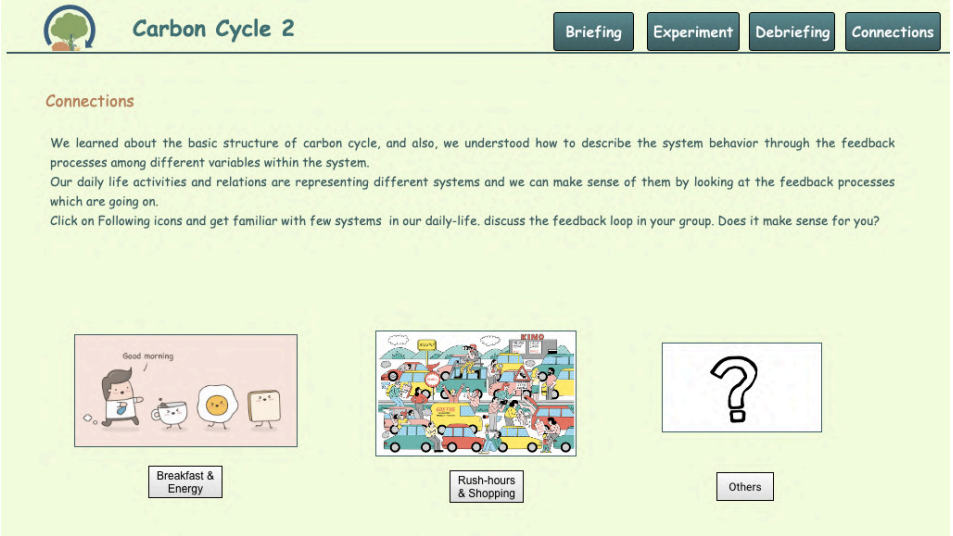

Figure11. connections

Learning outcomes of the page:

- Practicing system thinking
- Develop system understanding
- To be able zoom out from the subject and scale their understanding of feedback loops