

Using co-operative gameplay in outreach to change students' perceptions of geoscience

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Recent studies have found that for students entering college, altruism is a desired aspect of a future career. Problematically, few students perceived geoscience careers as altruistic or even expressed an understanding of the potential career paths in geoscience. This dissonance in incoming student perceptions of geoscience may be linked to declining major enrollment. Classically, geoscientists have often cited job benefits such as high income, working outdoors, and travel as reasons to pursue a career in geoscience, but these may not be as appealing to the next generation of scientists. This research seeks to test if alternative forms of outreach and recruitment that highlight geoscientists' roles in renewable energy, remediation and environmental fields, and studying climate change alter students' perceptions of geoscientists. To accomplish this, a co-operative game was developed, originally based on SERC activity 49774, a carbon cycle dice game by Callan Bentley, and a similar exercise created by Jennifer Ceven. The activity was first modified (*cont'd -->*)

by Ryan Hollister for the 2018 Earth Educators' Rendezvous, where card sheets for reservoirs were introduced and edited to have students more explicitly calculate relative reservoir sizes, fluxes between reservoirs, and the duration carbon may spend in each reservoir. The game was further altered at North Dakota State University to make carbon reservoir cards more specific to the North Dakota-Minnesota region. The most recent iteration adds co-operative gameplay where students actively intervene in the carbon cycle through roles, including geoscientist, that can actively impact the climate. Our goal is to demonstrate the influence geoscience careers can have on modern challenges, such as climate change, in an engaging format. This most recent version of the game will be used as an alternative outreach tool. This research is currently underway, and data will be collected at middle school, high school, early college, and community events through 2022.



To download a printable copy of the game, scan this code or visit <http://annakaclement.rocks>

Introduction

Recent studies have found that for students entering college, altruism is a desired aspect of a future career. Problematically, **few students perceived geoscience careers as altruistic** when compared to biology or engineering, and even **fewer expressed an understanding of the potential career paths in geoscience** (Carter et al., 2021). This dissonance in incoming student perceptions of geoscience may be linked to declining major enrollment. Classically, geoscientists have often cited job benefits such as high income, working outdoors, and travel as reasons to pursue a career in geoscience, but these may not be as appealing to the next generation of scientists. This research seeks to **test if alternative forms of outreach** and recruitment that **highlight geoscientists' roles in renewable energy, remediation and environmental fields, and studying climate change** alter students' perceptions of geoscientists.

To accomplish this, a **co-operative game was developed**, to enhance an existing carbon cycle simulation. A co-operative game was chosen for its learning potential and increasing popularity in table-top and video games (Sedano et al., 2013). The original simulations activities, SERC activity 49774 and a similar exercise by Jennifer Ceven, was a carbon cycle dice game by Callan Bentley. The activity was first modified by Ryan Hollister for the 2018 Earth Educators' Rendezvous, where card sheets for reservoirs were introduced and edited to have students more explicitly calculate relative reservoir sizes, fluxes between reservoirs, and the duration carbon may spend in each reservoir. The game was further altered at North Dakota State University to make carbon reservoir cards more specific to the North Dakota-Minnesota region. The most recent iteration adds **co-operative gameplay where students actively intervene in the carbon cycle through roles, including geoscientist, that can actively impact the climate**.

Learning during co-operative and collaborative gameplay functions similarly to learning during any co-operative learning exercise. Co-operative and collaborative gameplay has players, often with individual abilities, strengths, and weaknesses, work together to accomplish a common goal pursuant to winning the game (boardgamegeek.com; Sedano et al., 2013). The players then win or lose together. In practice, **co-operative gameplay often functions similar to a "jigsaw" technique lesson**, with each player becoming an expert in the abilities of their in-game role and working with other players to decide on a limited number of actions per round (Aronson and Bridgeman, 1979). This research seeks to test if an alternative outreach approach using well-known learning methods and focusing on the role of geoscientists in current global challenges, such as climate change, can potentially alter student perspectives on geoscience careers.



Gameplay Methods and Learning Objectives

The original simulation activity: Carbon Moves

Gameplay method: simulation

Open simulation activities act as an intermediate stage between the theoretical and "real life", allowing students to gain insight into the relationships and complexities of a system and prepare them to study said system in the real world (Leigh & Spindler, 2004).

Learning objectives:

In the original Carbon Moves simulation, students take on the passive role of a carbon atom moving through reservoirs in the carbon cycle by rolling a die and following card prompts. Using a record of their results (see below), students are able to create a diagram of the carbon cycle reservoirs and fluxes.

Usage in the co-operative game:

The version pictured here (developed by Ryan Hollister and modified by Jessie Rock), is used to simulate background carbon cycling during gameplay. The original learning objective can still be achieved after playing the co-operative version.

Round	Starting Reservoir (after #1, starting reservoir will be the same as the previous ending reservoir)	Time in Reservoir (years)	Process causing change in form of carbon (if any)	Ending Reservoir	Carbon cycle climate point per round	Event Cards climate points per round
Ex.	Atmosphere	65 years	Photosynthesis	Biosphere - Soils		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

An abstracted *Climate Points* system was added to each card and reflects an over all sink or source of background carbon for the round. *Climate Points* are summed for each round from the background carbon cycle simulation and the *Event Cards* plus the player actions.

The total *Climate Points*, + or -, each round is then recorded on the *Climate points* counter.

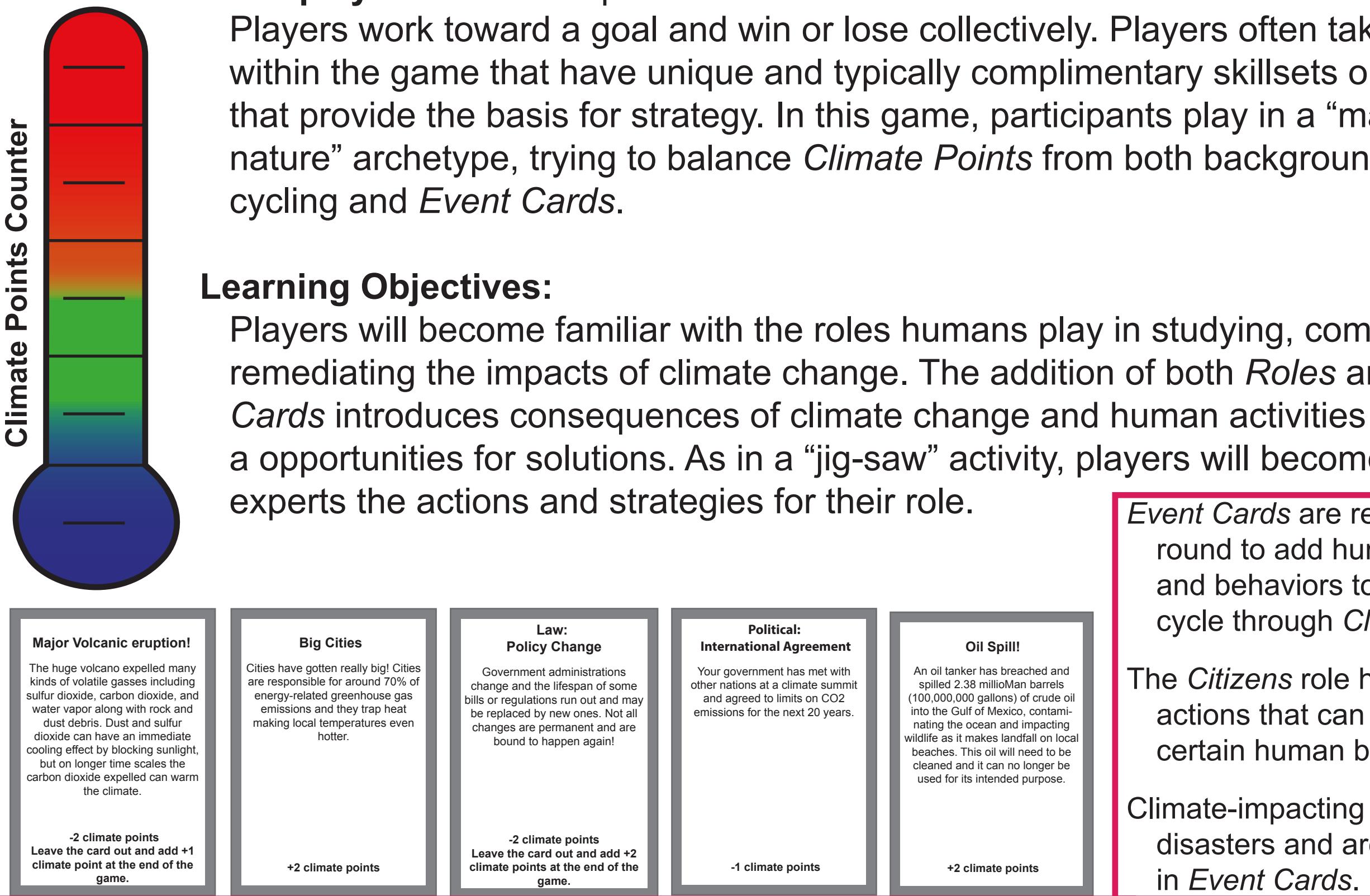
Co-operative Gameplay

Gameplay method: co-operative

Players work toward a goal and win or lose collectively. Players often take on roles within the game that have unique and typically complimentary skillsets or actions that provide the basis for strategy. In this game, participants play in a "man vs. nature" archetype, trying to balance *Climate Points* from both background carbon cycling and *Event Cards*.

Learning Objectives:

Players will become familiar with the roles humans play in studying, combating, and remediating the impacts of climate change. The addition of both *Roles* and *Event Cards* introduces consequences of climate change and human activities as well as opportunities for solutions. As in a "jig-saw" activity, players will become the experts the actions and strategies for their role.

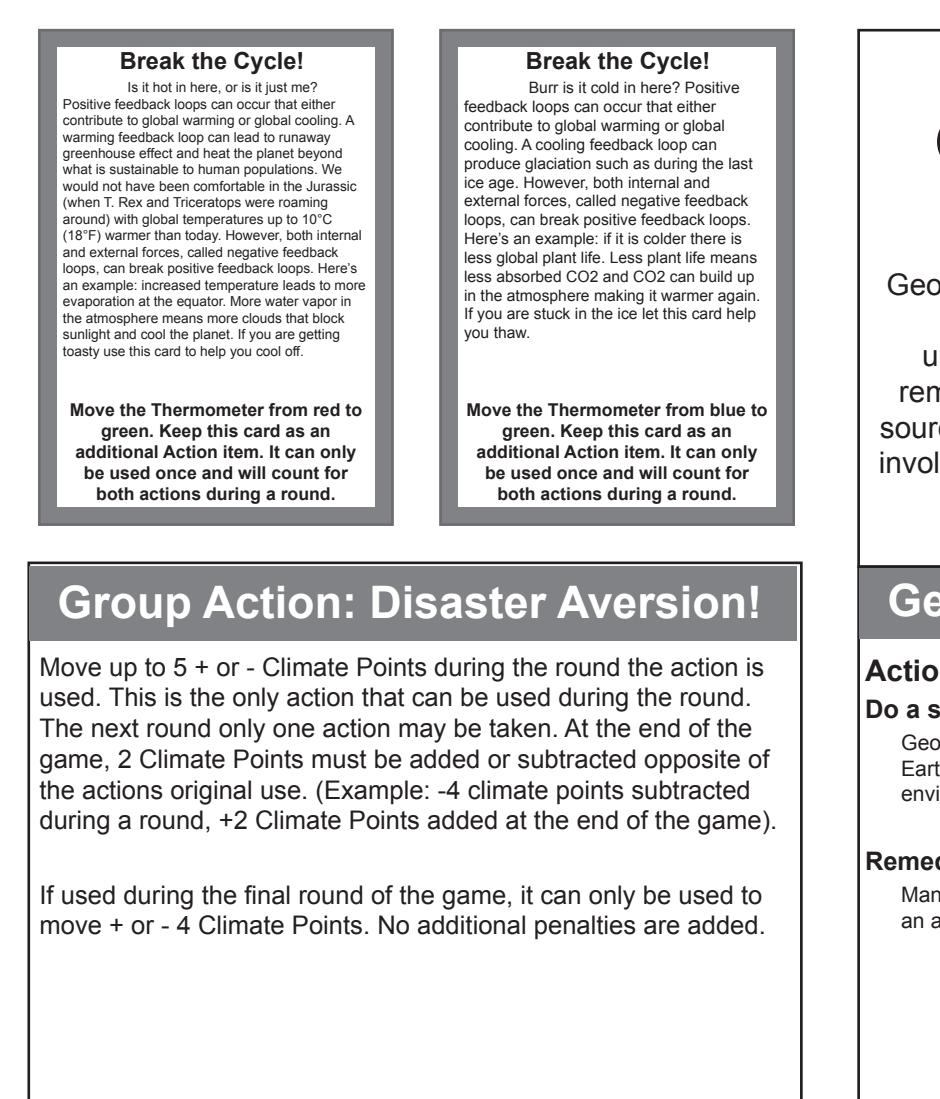


Event Cards are revealed each round to add human activities and behaviors to the carbon cycle through *Climate Points*.

The **Citizens** role has special actions that can interact with certain human behavior cards. Climate-impacting natural disasters are also found in *Event Cards*.

Roles, Actions, and Event Cards in Gameplay

- Roles were selected to represent groups with influence in combating climate change and to center geoscientists as crucial providers of information and remediation solutions.
- The actions players can take each round are dictated by their Roles. Collectively, players may select up to two actions per round providing the necessity for discussion, strategy, and teamwork.
- In each round, players must take actions to mitigate climate change and end the game with *Climate Points Counter* in the green zone on the counter. *Climate Points* from the carbon cycle simulation and *Event Cards* encountered each round prompt the players actions.



Geoscientists

Geoscientists work to study and battle climate change in a number of ways. They conduct studies to understand changes in the carbon cycle, work to remediate natural environments, strive to ethically source materials to produce new technologies, and are involved in research for developing carbon capture and storage to name just a few.

Geoscientist

Actions:
Move the Thermometer from blue to green. Keep this card as an additional action. It can only be used once and will count for the round once during a round.

Citizens

Average people have the power to change their own habits and reduce their carbon footprint. Citizens are also able to influence lawmakers and government policies through voting and collective action.

Citizens

Actions:
Move the Thermometer from blue to green. Keep this card as an additional action. It can only be used once and will count for the round once during a round.

Technology Industry

Actions:
Develop a new Technology (with help). -3 climate points (1 use, counts as both actions for a round)
Scientists and engineers who work in the public sector are involved in research and development of new technologies, and monitor the activities and clean-up of private industries.

Public Sector

Actions:
Research and Development: add 1 to another action (unlimited uses)
Money from taxes often goes into basic research and development of new technologies, and funds to improve damaged environments.

Public Sector

Actions:
Develop a new Technology (with help): -3 climate points (1 use, counts as both actions for a round)
Scientists and engineers who work in the public sector often work in research and development of new technologies and are compensated by the public. Did you know that memory foam (like in your mattress) was developed for space travel?

Why a co-operative game?

- Active and collaborative roles within the gameplay make students active participants and stakeholders in handling climate crises rather than monitors of a simulation, providing an opportunity for longer-lasting learning and sense of agency
- Game mechanics are self-contained. Teachers and students do not need to have in-depth knowledge of the climate or geoscience to have the game function. It can therefore be deployed in many classroom and activity settings without the need of an expert in the field.
- Game mechanics run on a well-known system utilized by many table-top games, such as **The Forbidden Island™**, and are considered easy to learn for older children through adults
- With a jigsaw-like learning framework built-in, the game can easily be expanded for deeper learning or longer classroom lessons
- The game addition is easily printable and dispersible with few required special pieces making it more accessible than long, expensive, and complex table-top climate games like **CO2™**

Implementation and Future Goals

Data Collection Goals

- Deploy the game in classroom, workshop, and other outreach settings through the summer and 2022-2023 school year targeting 5th grade through college freshman
- Use before and after surveys on perceptions of geoscience to evaluate any changes when outreach is done with the game vs. without
- Share results collected during the 2022-2023 school year and use these data to develop better outreach and recruitment methods for the NDSU Earth, Environment, and Geospatial Sciences program as well as other college geoscience programs

Game Modification Goals

- Tailor vocabulary and language to make middle school and high school/college versions of the game
- Rigorously test game mechanics and adjust gameplay functionality as needed to make the game challenging, but frequently winnable
- Make the current version of the game available to educators as a self-printable document
- Post a final version of the game and activity on SERC with additional classroom supportive materials for understanding the carbon cycle and related geoscience careers