Instructor Story: Molly Redmond, UNC Charlotte
Ecology, Biology 3144
The Carbon Cycle, Climate Change, and Feedback Loops in Introductory Ecology

Course Information: meets 2 x 75 minutes each week

Course Description: Processes influencing the distribution and abundance of organisms, the interactions among organisms, and the interactions between organisms and the transformation and flux of energy and matter.

Course Context: A required core class for biology majors

Course Topics: The Physical Environment, The Biosphere, Coping with Environmental Variation, Life History, Behavioral Ecology, Population Growth and Dynamics, Competition, Predation and Herbivory, Parasitism, Mutualism and Commensalism, Nature of Communities, Changes in Communities, Biogeography, Species Diversity, Production, Energy and Food Webs, Nutrient Supply and Cycling, Global Ecology, Conservation Biology, Microbial Ecology

Materials Used: Carbon, Climate and Energy Resources Module, The Changing Biosphere Module

Introductory Statement:
Teaching the Carbon Cycle, Climate Change, and Feedback Loops in Introductory Ecology
I used material from the Carbon, Climate and Energy Resources Module and the Changing Biosphere Module, along with some inspiration from the Systems Thinking Module, in my intro Ecology class. This a required core class for Biology majors at UNCC and consists largely of juniors and seniors, but most students have little to no background in environmental science or ecology.

I taught two sections of this class, each section had 76 students and met twice a week for 75 minutes. I did the activities in both sections. Our classroom was designed for active learning, with 76 desks on wheels. These desks can face forward during the lecture portion of the class or be moved into groups for activities. This flexible arrangement works very well for my class, which is mix of traditional lecture, frequent clicker questions, and longer group activities. The room has five projectors, so students can see slides on all walls of the room. The one downside is that the room is so full of desks, it's challenging for me to move around the classroom and nearly impossible for the students to move around out of their desks. I modified the InTeGrate materials to suit the physical structure of the classroom and my relatively large (but not huge) classes.

Inspirational Quote
Doing an activity where students had to think about the increase in atmospheric carbon dioxide on different time scales left a much stronger impression about the human effects on climate than just showing an image of the Keeling Curve.

My Experience Teaching with InTeGrate Materials
I combined activities from several different modules to help students understand climate change, the carbon cycle, and feedback loops.

Relationship of InTeGrate Materials to my Course
I've integrated material on climate change throughout the course, but we only have a few class periods at the end of the semester to explicitly focus on the carbon cycle and climate change. I had to be selective about the activities that were most relevant and didn't duplicate material covered earlier in the semester or in activities I'd already developed myself.

A Unit-by-Unit Breakdown of How I Taught these Modules

Unit 5 (Modern CO_2 Accumulation) from the Carbon, Climate and Energy Resources Module
https://serc.carleton.edu/integrate/teaching_materials/change_inthe_air/activity5.html

I mostly followed this activity as written, but our classroom space wasn't conducive to a gallery walk. Instead of printing them, I showed the diagrams and questions on PowerPoint slides for 2 minutes each while I circulated through the room and answered questions as needed. We then reviewed the slides together as a group, making sure students understood the answers. At the end, I showed Video 2, Year in the Earth's Carbon Dioxide and we discussed the patterns we could observe in the video. I didn't show the other videos. I also didn't do the optional activities, but I already do a somewhat similar activity with the same carbon footprint calculator. Next time I teach the class, I plan to incorporate some of the questions included here.

Unit 3 (Interconnected Nature of the Atmosphere, Hydrosphere, and Biosphere) from the Changing Biosphere Module
https://serc.carleton.edu/integrate/teaching_materials/biosphere/activity3.html

I followed most of this module as written, but rather than doing the last part about a perturbation to the system, we focused specifically on the effects of increased temperature and drawing feedback loop diagrams. Students had been introduced to the concept of feedback loops on the first day of class, but we talked more specifically about positive and negative correlations between temperature, permafrost carbon, and atmospheric carbon. They were then able to draw the positive feedback loop between these three components. This was followed by additional discussion of feedback loops related to climate, including other feedback loops that could occur as the Arctic warms and plant growth changes. I didn't explicitly use activities from the Systems Thinking module here, other than a brief discussion of the bathtub system, but material from that module and links within it inspired the way I teach about systems and feedback loops.

An additional note on teaching about feedback loops: in the past, I've found that some students are confused about the "loop" part and will give examples of feedback loops like "we'll burn

more fossil fuels and there will be more warming." This year, I focused more on drawing diagrams as a way of emphasizing that they have to be able to connect all the components of their feedback loop together. I gave them the example above and asked what other factors they could add to make a feedback loop. Some possible answers include burning of fossil fuels for air conditioning (creating a positive/destabilizing feedback loop) or burning of fossil fuels for heating (negative/stabilizing feedback loop), which then leads to a discussion of which we think is likely to be more significant. Based on their answers to an exam question about feedback loops, this was extremely effective.

Assessment:
Due to time limitations and the size of my classes, I didn't use any of the assessments provided. We reviewed the material together in class and then I had each group submit a copy of the answers to their questions for a small amount of participation credit. I used clicker questions in these and subsequent lectures to review and test understanding of important points from this material. My exams also contained questions on the carbon cycle related to these units.

Outcomes
Overall, I found it somewhat challenging to find good InTeGrate modules to use in my class. Mostly this was due to time limitations in a broad survey class with a lot of topics to cover, especially as we were running out of time at the end of the semester, but there were also relatively few activities well suited for large classes. I liked the activities I chose because they were easy to do as stand alones, rather than part of an entire module, and were straight forward enough that they could be done with relatively little one-on-one input from me, just a full class summary discussion at the end and later review through clicker questions.

In course evaluations, many students commented that group activities were their favorite part of the class and especially highlighted the Modern CO_2 Accumulation activity as one of the most effective activities. When asked about the most interesting thing they learned, many students mentioned their carbon footprints, climate change, feedback loops, and the increase in atmospheric carbon dioxide, so these activities left a strong impression. As I continue to revise this class, I hope to find the time to incorporate more InTeGrate modules.