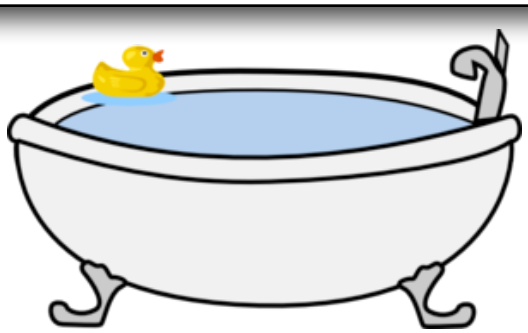
What are "stocks and flows?"

Student Worksheet

A laboratory experiment from the Little Shop of Physics at Colorado State University

Learning Objective:

Stocks are accumulations. They're storage. The stock describes the state of the system at any point in time, as if you were to take a photo of it. Stocks are usually so large compared to their flows that they only change gradually over time. It's the "flows" -- the inflows and outflows, that are responsible for effecting the change. Flows can change at any time and at any speed - slowly, quickly, or even instantaneously, but they are the only elements that can change a stock over time.



Think of a bathtub consisting of a stock (water level) and flows (inflow and outflow, or faucet and drain) helps us to understand the important parts that represent a complex system.

Activity 1: Creating a physical stock-flow model: "People on the Bus"

Using a simple scenario about people getting on and off a bus, create a physical model of the changing system, "People on the Bus." Use beans or mini-m&m's to move "people" in and out, and the table provided to keep track of the stock and flows.

You'll need the following materials:

- Small beans or candies
- Map of the bus interior (attached)
- Data table (attached)

Scenario: There are 7 people already on a bus which has 37 seats. On average, five people get on the bus and three people get off at each bus stop.

Problem Question: How many bus stops will it be before people will have to start standing?

1. What is the stock in this problem question? _____
2. What are the flows? _____

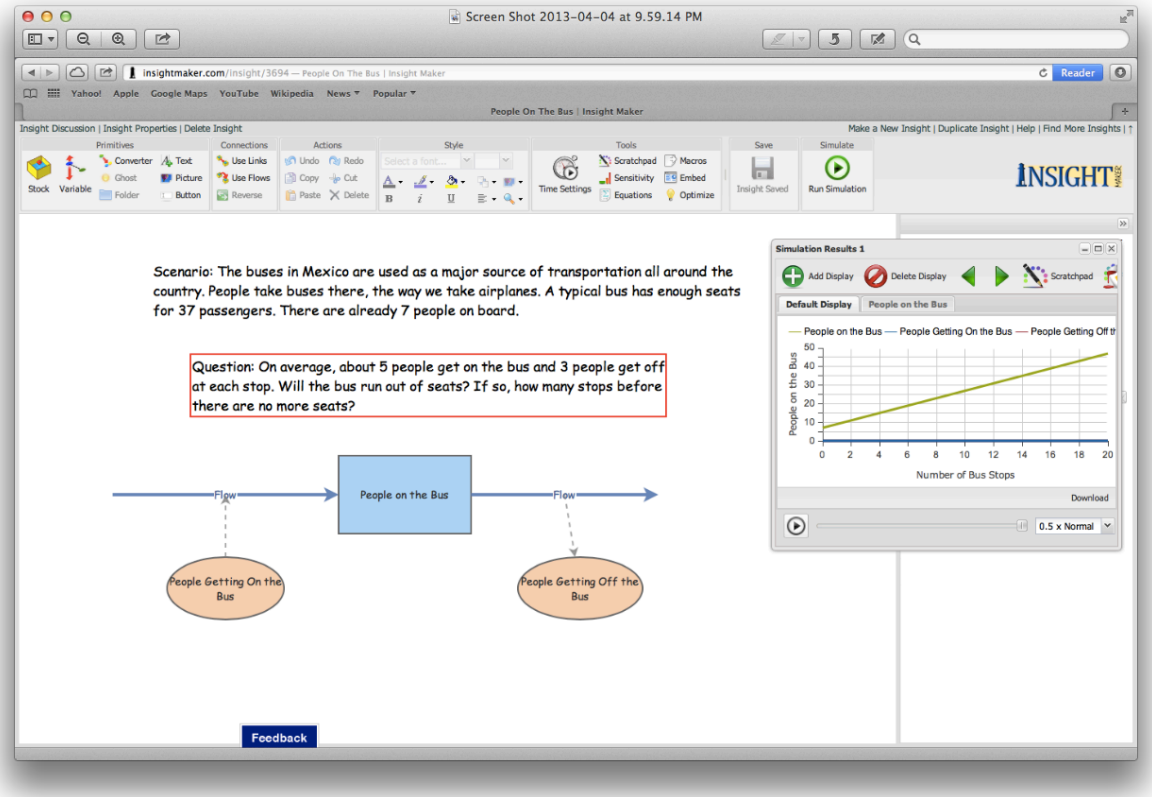
3. Use the attached bus layout, some beans or candies to represent the people on the bus, and the accompanying data table to move "people" on and off the bus at each stop. Keep track of the stock for each iteration over time (at every bus stop) on the data table. Your teacher may want you to graph your results to include the stock and flows on the same graph.
4. What is your answer to the Problem Question? ie. How many bus stops will it be before people will have to start standing? _____
5. How does the stock change if the inflow goes to zero? _____
6. How long would it take to return the the stock to its original amount if we changed the inflow to zero? Run this scenario. Document how long it took.

_____

_____

Activity 2: Use Insight Maker and see a computer stock-flow model for "People on the Bus."

1. Go to www.insightmaker.com
2. Click on "Find Insights."
3. In "Search" type: People on the Bus
4. "Run Simulation"



Answer the following questions:

1. Did your answer to the Problem Question using your physical model match the answer in the systems model?
2. What are the benefits of using a physical model?
3. What are the benefits of using a computer model?
4. Which do you prefer and why?
5. This was a relatively simple systems model, can you think of some more complex ones?

Activity 3: Review another example of a computer stock-flow model in Insight Maker. It's called Dead Skunk in the Middle of the Road. Review how it was created and replicate it yourself. Adjust the time settings and run the simulation to answer the following questions:

1. How many skunks will be alive in 10 years?
2. Adjust the time setting to out to 100 years. Will the skunk population maintain itself or not?

Activity 4: Now, create your own stock-flow systems model using Insight Maker with the following scenario.

Scenario: Presently, there is about 800 Gigatons (Gt) of carbon in the atmosphere. (One gigaton is one billion tons - so that's 800 billion tons of carbon.) Every year, we add to that about 9 Gt carbon into the atmosphere from burning coal, oil, and natural gas (fossil fuels). However, 5 Gt of that is taken out of the atmosphere naturally - by plants and oceans.

Create the stock-flow model using Insight Maker to analyze the problem:

1. Go to Insight Maker www.insightmaker.com
2. Click "Create New Insight"
3. Click "Clear Sample Model"
4. Click Stock icon and then click on the canvas of the page. Name your stock.
5. Hover over the stock and click the "equals" sign to give your stock its initial value. Click Apply.
6. Hover over the stock until you see the blue arrow. This is your flow arrow. Use it for inflows and outflows. Make sure the arrow is pointing in the right direction - you will need to select "reverse direction" for one of the arrows.
7. Hover over each flow line until you see the "equals" sign and click to it to add the flow rate for the inflow and the outflow.
8. Change the flow names to "Fossil Fuels" and "Ocean and Land Uptake" if you're using the climate scenario by clicking on the green arrow in the center of the flow line.
9. Click on "Time Settings" and set time at one-year intervals for 200 years.
10. Run the simulation.

11. **Make a print out of your simulation and attach it to this worksheet.**

12. **Answer the following Problem Questions**:

a. Over the next 100 years, at the current rates, how much carbon will accumulate in the atmosphere? _____

b. How long will it take, at current rates, for carbon in the atmosphere doubles?

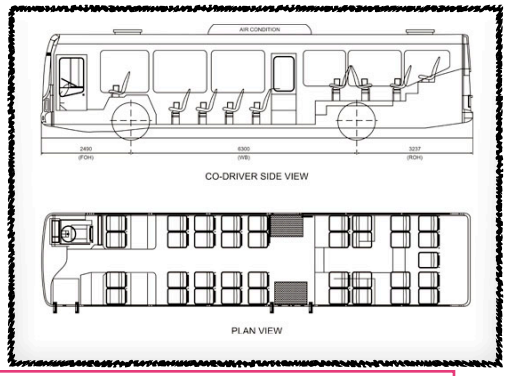
_____

Summing Up:

Understanding inflows and outflows of a system really can help us understand how things change over time. Stocks may increase at a predictable rate, but to decrease the stocks, you must either decrease the inflow or increase the outflow. Until the inflow is less than the outflow, the stock will continue to increase. It may rise at a slower rate but it will continue to rise. That is the counterintuitive part! When we say we are going to "reduce fossil fuel emissions," we need to understand that the carbon in out atmosphere will continue to increase, even if we reduce emissions, unless that reduction is below the amount that is absorbed out of the atmosphere by land and oceans.

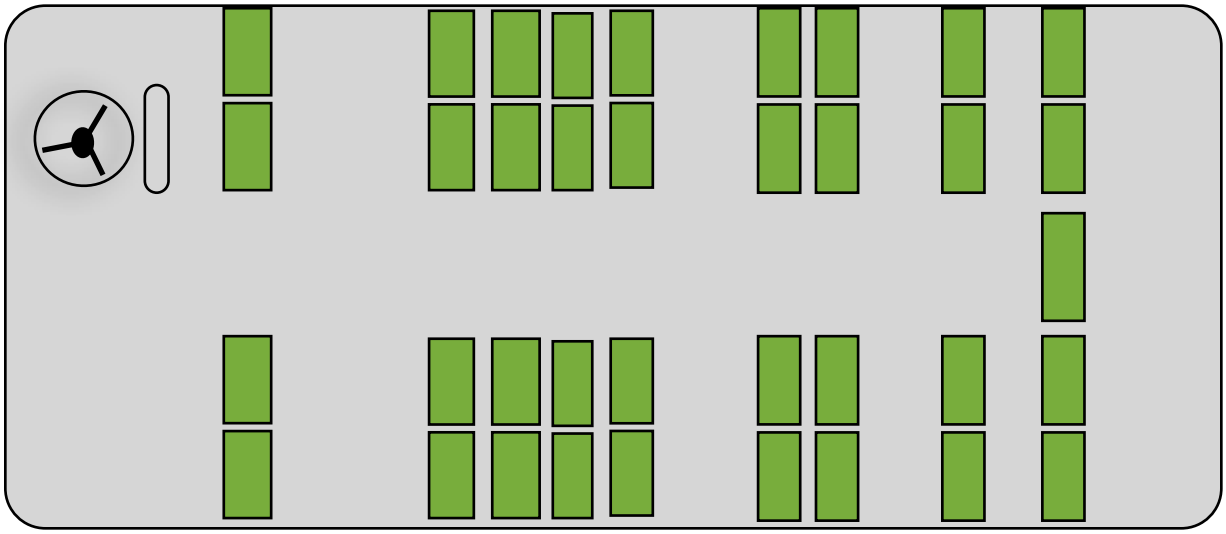
Climate change is one of the best examples of a classic systems problem. To understand global climate, we need to understand the concepts of stocks and flows.

Use the layout below as a physical model, use mini-m&m's to move your "people" in and out, and the table below to keep track of your stocks and flows.



<u>Scenario</u>: The buses in Mexico are used as a major source of transportation all around the country. People take buses the way that we take airplanes. Use the diagram below, to keep track of the people on the bus. There is room for 37 passengers to sit

Question: On average, 5 people get on the bus and 3 people get off at every stop. How many bus stops before people have to stand.



Bus Stop #	IN-flow	OUT-flow	Stock

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