Systems Education Experiences

PROJECT FEED 1010

Institute for Systems Biology

LESSON 4: FOOD SECURITY AS A SYSTEM

THE BIGGER PICTURE

The goal of this lesson is to encourage students to look at the topic of food security using a systems approach, and to evaluate the stability of our global food production by assessing the interactions within the system. Students will review the definition of a system and discuss how approaching a problem or issue by modeling it as a system can lead to both improved understanding and more effective problem-solving. The lesson includes an overview of different methods used to visually represent systems-level problems, and students practice using these models to illustrate food security. Students will ultimately apply their knowledge of the concept of food security and the stakeholders involved to create a large causal loop diagram that helps them visualize interactions within the system, feedback loops, and tipping points. This activity will help students evaluate the sustainability of our food supply and the vulnerability of particular groups to food insecurity.

OBJECTIVES

What students learn

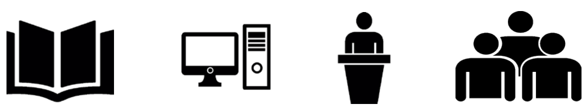
Students learn the 14 habits of a systems thinker and the 6 steps used to analyze systems, along with strategies for illustrating systems. They identify interactions between food security system parts as well as the "tipping points" which lead to irreversible change.

What students do

Students relate systems thinking habits to everyday situations, use a variety of diagrams to visualize systems, work collaboratively to create a large causal loop diagram of food security, and evaluate the stability of our food production system by assessing interactions, feedback loops, and tipping points.

TIME

50 minutes - 1 class period



STANDARDS

- NGSS PE HS-LS1-3; DCI: LS1.A; SEP: Planning and Carrying Out Investigations; CC: S&C
- NGSS PE HS-LS2-7; DCI: LS2.C & LS4.D; SEP: CEDS; CC: S&C
- NGSS PE HS-LS2-8; DCI: LS2.D; SEP: Engaging in Argument from Evidence; CC: Cause and Effect
- NGSS PE HS-ESS3-1; DCI: ESSE.A; SEP: CEDS; CC: C&E
- NGSS HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

PREREQUISITES

Students should have completed the cell phone network activity (Introduction to Systems) and have a working definition of a network. Students should have also participated in Lessons FS1 and FS3, therefore they should be familiar with both the concept of food security and the different stakeholders involved in the food production system.

BEFORE CLASS

Gather materials (see "Resources" section): Food Security Vocabulary PowerPoint, "Is It a System?" worksheet (one copy per student) and teacher notes, "Habits of a Systems Thinker" worksheet (teacher copy and one copy cut up to distribute pictures to students), "S.T.O.P." handout (one copy per student), and the "Example Food Security Network Diagram" image. You will also need a large piece of butcher paper or poster board for the class causal loop diagram, along with multi-colored markers. Read through the "Teacher Notes" of the "Is It a System?" activity. The students will also need their "Building Your Case" worksheet.All of the *Modeling Sustainable Food Systems* resources are on the SEE website: see.systemsbiology.net.

TEACHER INSTRUCTIONS

1. **Warm-Up:** Students come up with a definition for a nutrient cycle, which will get them thinking about cycles and interconnections between different parts of an ecosystem. This serves as a transition between the optional "Creating an Efficient System" lab and the idea of food security as a system.
   - Food Security Vocabulary PowerPoint: Show the Food Security Vocabulary PowerPoint for Lesson 4. Have students brainstorm what a "nutrient cycle" is, and list examples of different nutrient cycles. Tell the students that they will revisit the idea of nutrient cycles at the end of the lesson, but will be able to look at them with a new perspective.

     Nutrient cycle definition: "the cyclic conversion of nutrients from one form to another within biological communities"

     Nutrient cycle examples: carbon cycle, nitrogen cycle, phosphorus cycle
   - Tell the students that the purpose of this lesson is to evaluate the issue of food security using a systems approach. So far they have learned about the global food crisis, the different agricultural production systems, and the stakeholders involved. In this lesson, they will be thinking about how the differents nodes of the food security system interact with and influence each other.
2. **Formative Assessment - Defining a System:** Students identify different types of systems on a worksheet, and discuss the meaning of and dynamics within a system.
   - Hand out the student worksheet, "Is It A System?", and have students work in partners to determine which items are systems and which ones are not. Ask the students to justify their answers on the worksheet.
   - Worksheet answer: any answer is potentially correct, as long as students can provide a valid justification for how it represents a system. For example, most students would not think a pile of sand is a system because it's composed of one component. However, other students might argue that if you remove one grain, it impacts the overall structure and properties of the rest of the pile.

TEACHER INSTRUCTIONS CONTINUED

- Read out or write the following on the board: system definition: "a collection of things (including processes) that have some influence on one another and the whole...To be considered a system, the components must interact with or influence each other in some way...Systems have boundaries, components, resources, flow (input and output), and feedback" ("Is it a System?", NSTA 2009. Different types of systems include manufactured objects, life-forms, combinations of living and nonliving things, physical bodies, processes, or quantitative relationships. **Discuss the following with the students:**
  1. What is the goal of modeling a system rather than studying its individual parts?
  - The overall system has properties that are different from its individual parts. Understanding the system can help to explain why things happen, and can help predict future changes.
  2. Why is feedback important in systems relationships? Can you think of examples of feedback loops in nature?
  - The stability of a system can be greater when it includes appropriate feedback mechanisms. Feedback can encourage a certain pathway in a system, discourage it, or help maintain stability.
  - Examples: blood sugar levels in the human body (negative), body temperature regulation (negative), glacial melt and climate change (positive), gene regulatory mechanisms (positive or negative)
  3. Can you come up with examples of systems that have the word "system" in them? How about examples of systems that don't include the word "system"?
  - Examples: ecosystem, solar system, circulatory system, nitrogen cycle, global climate, a car
  4. How can the idea of systems be applied to the our food production?
  - The food production system has many different interacting parts and relationships between them (e.g. the farm, transport systems, fertilizer production, grocery stores, consumer households), the overall goal of which is to produce food for the consumer to eat. For the food to be produced, all nodes in the system need to be functioning well.

3. **Activity 1 - How to think about and model systems-level problems:** Students learn and discuss the habits of a systems thinker and five different approaches for visually modeling systems.
   - Tell students that different thinking strategies or habits foster problem-solving, questioning, and understanding when approaching a complex issue such as food insecurity.
   - Hand out a "Habits of a Systems Thinker" worksheet picture to each student, and ask the students to take a minute to think about how the picture represents an effective "habit of a systems thinker". The student should also come up with an example of how to apply the habit from their picture to a situation in daily life. Have the students share their thoughts with the rest of the class. Students could also work in pairs on one card, depending on the class size.
   - Hand out a copy of the "S.T.O.P Coffee Crutch Story" handout ("Habits of a Systems Thinker" pictures on the back) to each student. Tell the students that when we are analyzing a systems-level problem/issue, it is helpful to follow the 6 steps of systems analysis, as described on the worksheet.
   - Tell the students that there are different visual representations that we can use to model systems problems, and these include: Iceberg Model, Stock/Flow Diagram, Behavior Over Time Graph, Connection Circle, and Causal Loop Diagram (these models are demonstrated on the "S.T.O.P Coffee Crutch Story" handout).
   - Have the students read through "The Coffee Crutch" story on the "S.T.O.P Coffee Crutch Story" handout. Then, have them study the Iceberg Model. Discuss the following questions with the students:
     1. What does the tip of the iceberg represent?
     - Joe's fatigue - this event is the result of several interacting processes.
     2. What does the part of the iceberg underneath the sea surface represent?
     - The interacting causes of the ultimate result (fatigue) - these include Joe's assumptions and worldview ("Mental Models"), the structure of his day and his workplace ("Structure"), and his patterns of behavior ("Patterns").
     3. How is this problem like a treadmill? (refer to the graphic on the S.T.O.P. worksheet)
     - Joe's patterns of behavior and the structure of the system in which he works accentuate his fatigue. It is a positive feedback loop whereby the more caffeine he drinks, the more tired he will feel, which will ultimately lead to him drinking more coffee.
     4. Can you think of any other potential factors that might play into Joe's caffeine habit, i.e. that we could list under the sea surface?
     5. How could we design an investigation to test one aspect of this Iceberg model using the Coffee Crutch story?
   - **Transition to Activity 2** by asking the students, "Can food security be viewed/modeled as a system? Why or why not?" Definitely! The different nodes of the system are highly interconnected, and the actions of one stakeholder or a disruption in the availability of a resource could greatly impact other nodes in the system.

4. **Activity 2 - Modeling Food Security as a System:** In small groups, students diagram the issue of food security using either the Stock/Flow Diagram or Connection Circle, and then create a large Causal Loop Diagram of food security as a class.
   - Break students up into small groups of 2-3, and have them choose either a Stock/Flow Diagram or a Connection Circle to model the issue of food security. The idea is for them to figure out the components of these two models on their own, and apply them to the issue of food security.
   - As a class, or in large groups of 8-10, students now come together to build a large Causal Loop Diagram of the issue of food security using butcher paper and multi-colored markers (an example is provided in the Resources section, "Example Food Security Network Diagram" image). The student groups or class can choose one representative to build the diagram as they brainstorm ideas, or everyone can be drawing the diagram together. Help students along by delivering the following prompts:
     1. What do you think the nodes of the causal loop diagram are?
     - These could include the different stakeholders, environmental factors (water, disease, soil, biodiversity), large-scale patterns (e.g. climate change) and a variety of other concepts and phenomena (e.g. technology).

TEACHER INSTRUCTIONS CONTINUED

2. How are the different nodes connected to one another?
3. Are there any interactions between nodes that are one-directional? Or is there feedback? Is this feedback part of a "Balancing Loop" (negative feedback loop), or a "Reinforcing Loop" (positive feedback loop)?
- For example, poverty might lead to low-investment/high immediate return agricultural techniques such as slash and burn, which contribute to land degradation in the long-term. Land degradation in turn creates more poverty as people are unable to produce food. The interaction between poverty and land degradation is a "Reinforcing Loop".

- Once students have created a complex food security Causal Loop Diagram, **conclude the activity** by asking the students:
  1. Are there any nodes that are more influential than other nodes? Which ones, and why?
  2. Can you identify any "tipping point" nodes within the system? These are nodes that if removed, irreversible change will occur.
  3. Which nodes, if any, can be removed without impacting the system at all?
  4. Which stakeholders in the system are most vulnerable to changes in the system? Can you identify them from your diagram?
  5. Do you think food security is a stable system? Why or why not? What would contribute to greater stability?

5. **Building Your Case:** have the students complete the questions for this FS Lesson 4 on the "Building Your Case" worksheet. Here, they will apply the systems analysis tools that they have learned about in this lesson to modeling food security in their country.
6. **Exit Ticket:** Tell the students that to wrap up the lesson, we are revisiting the concept of nutrients cycles. However, this time, the goal is for them to think about a nutrient cycle using a systems approach, within an aquaponics system. Students should take 4-5 minutes to respond to the following prompt in their notebooks: "Draw and label a systems diagram that shows one of the nutrient cycles within an aquaponic system".

RESOURCES

- SEE website: see.systemsbiology.net
  - Food Security Vocabulary PowerPoint
  - Example food security network diagram
  - "Is It a System?" worksheet and teacher notes (Science Formative Assessment, Keeley 2009)
- "Habits of a Systems Thinker" handout (Waters Foundation 2017)
- "S.T.O.P. Coffee Crutch Story" handout
- "Building Your Case" worksheet