Systems Education Experiences
Baliga Lab at Institute for Systems Biology

PROJECT FEED 1010

Institute for Systems Biology

CURRICULUM SERIES: MODELING SUSTAINABLE FOOD SYSTEMS

FOOD SECURITY (FS) MODULE

Students take an interdisciplinary approach to understand a global issue. The driving question: "*How can we think and act on a systems level to produce and consume food resources that will be environmentally sustainable and sufficient for global needs*?" Students learn that systems thinking is helpful in identifying influences and interactions within the food security system. After critically examining the environmental tradeoffs involved with various food production techniques, students engineer a system, such as an aquaponic system, to evaluate the potential of scaling up aquaponics to fill the future food gap. Next, students examine the origins of food and resources required to produce it. Throughout this module, student groups investigate various aspects of the food crisis in a specific country, which culminates in a UN council meeting to propose a solution.

COURSE INTEGRATION

Statistics, Human Geography, Biology, AP Biology, Environmental Systems, AP Environmental Science, Agriculture, Social Studies

LESSON 1: INTRODUCTION TO FOOD SECURITY

TIME

50 minutes - 1 class period

STANDARDS

- NGSS PE: HS-LS2-1; DCI: LS2.A; SEP: Using Mathematics and Computational Thinking; CC: Scale, Proportion, and Quantity
- NGSS PE: HS-ESS3-1; DCI: ESS3.A; SEP: Constructing Explanations and Designing Solutions (CEDS); CC: Cause and Effect (C&E)
- NGSS PE: HS- ESS3-3; DCI: ESS3.C; SEP: Using Mathematics and Computational Thinking; CC: Influence of Engineering, Technology, and Science (ETS)

OBJECTIVES

What students learn

Food security is defined by 3 pillars, and it is influenced by many factors including poverty, geography, society, climate, and politics. 11% of all people worldwide go hungry each day. This is a complex, global problem that needs addressed in *their* lifetime.

What students do

Students create their own definition of food security using knowledge from class discussions. They apply statistics to compare and contrast food security in countries around the world and collaborate with team members to investigate one country with food insecurity.

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

TIME

90 minutes - 2 class periods

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: Stability and Change (S&C)
- NGSS PE: HS-ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of ETS
- NGSS PE: HS-ESS3-4; DCI: HS-ESS2.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS- ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

OBJECTIVES

What students learn

Conventional farming methods are limited by resource dependence, while others may better adapted to our increasing population and changing climate. Determining the best solution is highly dependent upon the needs, resource availibility, and climate of each region.

What students do

Students respond to *Food for Thought* video and research four food production methods to evaluate their impact and efficiency. Students assign sustainability scores to each method, propose the "best" method in a presentation, then demonstrate understanding by justifying the most effective method for their assigned country.

APPLICATION 1: DESIGNING, CONSTRUCTING, AND RE-ENGINEERING A SYSTEM

TIME

90 minutes - 2 class periods, weekly monitoring

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-ETS1-4; DCI: ETS1.B; SEP: Using Mathematics and Computational Thinking; CC: Systems and Systems Models
- Extensions: NGSS PE HS-LS2-4 and HS-LS2-5

OBJECTIVES

What students learn

Students review the nitrogen cycle and how it can be engineered into a resilient system for growing food. This gives students context for better understanding the resilience of natural ecosystems and the importance of system stability. Students learn modeling can help inform solutions to global food insecurity.

What students do

Students apply systems biology approaches to illustrate an aquaponic network and then design a model system. They scale up an aquaponic system to apply to a food system with limited water resources. Students analyze data from ISB systems or their own model systems to build and carry out an investivation.

LESSON 3: WHO CARES? STAKEHOLDERS!

TIME
50 minutes - 1 class period

STANDARDS
- NGSS PE: HS- ESS3.1; DCI: ESS3. A; SEP: Constructing Explanations and Designing Solutions; CC: C&E
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- CCSS ELA-LITERACY.RI.11-12.1 Key ideas and details in text

OBJECTIVES
What students learn

Stakeholders are people or organizations with a vested interest in an issue. Students recognize the influence of stakeholders in decision making and the challenges of coming to a consensus. Many stakeholders are involved in the food security crisis.

What students do

Students are assigned the role of a stakeholder. After examining the stakeholder's information, students introduce themselves through presentations and generate a response to a critical question: *will an increase in food production alone solve the global food crisis?*

LESSON 4: FOOD SECURITY AS A SYSTEM

TIME
90 minutes - 2 class periods

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 PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

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 in the food security system as well as the "tipping points" that 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.

LESSON 5: WHY DON'T WE JUST GROW MORE?

TIME
50 minutes - 1 class period

STANDARDS
- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: HS-LS4C & HS-LS4D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS-ESS2-5; DCI: HS-ESS2C; SEP: Developing and Using Models; CC: Energy and Matter
- NGSS PE: HS-ESS3-1; DCI: HS-ESS3A; SEP: CEDS; CC: C&E
- NGSS PE: HS-ESS3-4; DCI: HS-ESS3C; SEP: CEDS; CC: S&C & ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

OBJECTIVES
What students learn

Students recognize that solving the global food security crisis is complex and that decisions made to address it will affect all stakeholders. Students also learn some network nodes have more influence than others.

What students do

Students work in groups to analyze "The Great Balancing Act", a working paper from the World Resources Institute. In partners, students analyze the impact each stakeholder would have in each of the suggested scenarios and connect the concepts to the network.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

TIME
60-90 minutes - 1-2 class periods

STANDARDS
- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: LS4.D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS- ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of ETS
- NGSS PE: HS-ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; ETS
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEPS

OBJECTIVES
What students learn

Students understand not only the economic, but also the environmental costs associated with production and consumption of food products and how external variables can affect them. External costs may not show up on the price tag!

What students do

Students play a game and become business people who are challenged to grow ingredients to make sustainable food products in the face of economic difficulties and changing environmental conditions. Students strategize and make decisions to build a food system that is profitable while also balancing their system's impact on the environment.

LESSON 7: UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION SUMMIT

TIME

Part I (50 min) - Defining problem and gathering evidence
Part II (50 min) - Finding solutions and building consensus
Part III (50 min OR homework option) - Testing a solution

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS- ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: CEDS; CC: Influence of ETS
- Common Core Science Standards: 1) ELA/Literacy: Integration of Knowledge and Ideas: ELA-LITERACY.RH.11-12.7; 2) Mathematics: MP.2 Reason abstractly and quantitatively (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4); 3) Using Mathematics and Computational thinking
- AP Environmental Science standards 11, 16, 17

OBJECTIVES

What students learn

Students learn that a thorough understanding of the complexity of the global food production system is necessary for designing effective solutions to food insecurity. They will learn the importance of negotiation and compromise in reaching consensus in the global community, and the role that the UN plays in addressing international issues. Students also learn how to outline an effective argument, and to support their claims with evidence and logic.

What students do

Students conduct a UN Summit, working collaboratively to come up with practical and realistic solutions to food insecurity in three different countries. They will synthesize information and apply skills learned in FS lessons 1-6, both when outlining major food security challenges as well as when designing their solutions. Finally, they will apply the claim-evidence-reasoning approach in critically evaluating the final four UN Summit Actions developed by the class.

FOOD SECURITY MODULE ICON KEY

Infer global patterns and trends in food insecurity using geography

Apply math and statistics to quantify relationships and population parameters

Examine relationships between geography, climate, and politics and food security

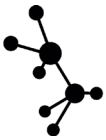
Collaborate with peers through group activities and class discussions

Synthesize information from online resources to propose solutions

Examine and analyze case studies through video clips to inspire innovation

Present and defend opinions and/or findings to an audience

Propose a plan for creating and evaluating a food production system



Use systems thinking to infer effects of perturbations within a system

Design and construct a model to demonstrate systems biology concepts

Compile information from text to make inferences and draw conclusions

Evaluate the impact of decisions and solutions on global processes and societies

Apply cost-benefit analyses and business strategies to sustainably support the economy