TEACHER GUIDE
ELABORATE LESSON 24

Food and Agriculture Center for Science Education

Module Question: *How can we improve on the costs and risks of the dairy system?*

What We Figure Out:

We figure out that the best solutions we can help each other improve on our solutions by asking meaningful questions that challenge our peers to think deeply about their designs.

3D Learning Objective:

Students communicate scientific information about the redesign of the dairy system to explain how it can more responsibly manage natural resources, improve on the system's risks, and maintain its benefits.

Students ask questions to each other that challenge the suitability of their designs that aim to redesign a part of the dairy system to help it improve upon its costs and risks.

Time estimate:

100 minutes

Materials:

Lesson 24 Student Guide
Lesson 24 Student Handout Peer Feedback
Lesson 24 Presentation Look Fors
Chart Paper and/or Computers

Targeted Elements

SEP:

AQDP-H7:
Ask and/or evaluate **questions that challenge** the premise(s) of an argument, the interpretation of a data set, or **the suitability of the design.**

DCI:

ESS3.A-H2:
All forms of energy production and other **resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies**

CCC:

SYS-H1:
Systems can be designed to do specific tasks.

INFO-H5 **Communicate scientific and/or technical information or ideas (**e.g. **about** phenomena and/or **the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and** mathematically**).**	and social regulations **can change the balance of these factors.** **ESS3.C-H1:** **The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.**	

Directions

Part 1: Our Motivation

Ask students to return to the list of steps of the engineering design process that they created in Lesson 21 Part 1. Ask students what they figured out in the previous lesson and what they think the best next steps are as part of the engineering design process. In student responses, listen for the following ideas:

- We analyzed possible solutions to the problem, and we selected what we think is the best solution based on the criteria and constraints for our problem. Next, we want to propose this solution and share it with our peers and a relevant audience.

Build off student responses to share that to be able to help address the impacts that the dairy system is having on the environment, it will help us to follow the engineering design process and, next, prepare a presentation of our solutions for our peers and a relevant audience. Students can record what they want to figure out and the next step in the engineering design process in Lesson 24 Student Guide Part 1: Our Motivation. This will help students understand how this lesson connects to what they were previously trying to figure out about determining an approach to solving problems.

Part 2: Proposing Solutions

Assemble students to work in their Problem Groups to develop a Solutions Presentation showcasing the most promising solution chosen in Lesson 23. To support their choice, students should use the results of the Engineering Design Matrix and evidence gathered throughout the unit. Direct students to the Lesson 24 Student Guide Part 2: Proposing Solutions for space to develop an outline for the Solutions

Presentation. Share with students that they will develop this presentation to share with their peers, receive feedback from their peers, revise it, and then share it with an audience from their school or community (in Lesson 25). Students may develop their presentation in any format, including a physical poster or digital presentation, such as a PowerPoint or Google Slides presentation, a video, or a written narrative.

TEACHER SUPPORT

When preparing their presentations, it is important for students to take into consideration the perspectives of their audience (dairy industry stakeholders and community members). To do this, consider asking the class:

- Who is your targeted audience for this presentation? What information is most relevant and informative to them? What important ideas are you trying to communicate to them?
- What design solutions would be most important to members of the community? How would it impact them?
- How might a person in the dairy industry feel about this solution? How would it impact them?

Share with students that their presentations will be evaluated at the end of Lesson 25 according to the Presentation Look Fors. Provide students with the Presentation Look Fors, read them together, and again allow students to use the Look Fors to guide their responses.

Allow students time to create their Solutions Presentations. As students work, circulate the room to support students as they make decisions on what to present and how to present it. Ask questions such as:

- How are you showing _____?
- In what way will you communicate _____?
- What part of your solution is most important to tell others about? About your decision-making process?
- How might your proposed solution positively impact your home or community?

Sample Student Model

Problem: Fertilizers pollute nearby waterways

Potential Solution: Building farms closer to consumers and incorporating rotational grazing practices on pastures

This solution reduces the amount of synthetic fertilizer required for crops which means less fertilizer will pollute nearby waterways. This solution also increases soil fertility.

Changing farming practices to incorporate grazing cattle can somewhat negate the biodiversity impacts of growing monoculture crops; we learned this during Biodiversity and Other Environmental Impacts Module. It can sequester carbon in the soil, which eliminates it from the atmosphere. This information comes from our Greenhouse Effect and Carbon Cycling Module that shows how carbon cycles between the dairy food system and the atmosphere.

The potential downsides of the solution include:

- Requires farmers to grow specific crops that sequester nitrogen into the soil like soybeans or alfalfa
- Higher initial costs for some of these nitrogen fixing plants.
- Tradeoffs for other desirable plant traits such as drought tolerance or yield.
- Need more space to graze cattle
- More labor is needed to move cattle from pasture to pasture

How the Solution Maintains System Benefits	How the Solution Improves on System Costs and Risks
• Cattle that graze on grass from rotational grazing can still produce milk for consumers. • Farms closer to consumers can get dairy products to local consumers faster.	• Pastures require less fertilizer because cattle manure is dropped on the pasture as cattle graze, which can enhance soil fertility • This will also reduce the amount of synthetic fertilizer that is used which could reduce fertilizer pollution in waterways • Perennial grass growth sequesters more carbon in the soil root system than do annual plants like corn. • Less transportation distance means less greenhouse gases like carbon dioxide added to the atmosphere due to transit.

Solution Benefits	Explanation
Environmental	Requires less synthetic inputs, reduces runoff, sequesters carbon and nitrogen
Economic	More jobs for farmers to manage cattle, more jobs on more local farms
Social & Ethical	More people to connect with local farmers if they are closer to where the food is consumed
Scientific	Meets standards in the industry, fits what we know about the greenhouse effect

FORMATIVE ASSESSMENT OPPORTUNITY

Students communicate scientific information about the redesign of the dairy system to explain how it can more responsibly manage natural resources, improve on the system's risks, and maintain its benefits.

Assessment Artifacts:

- Students' draft solution presentations (students will have their own artifacts for this assessment).
    - Note that this should be considered a formative assessment for students prior to summatively assessing these presentations in the next lesson.

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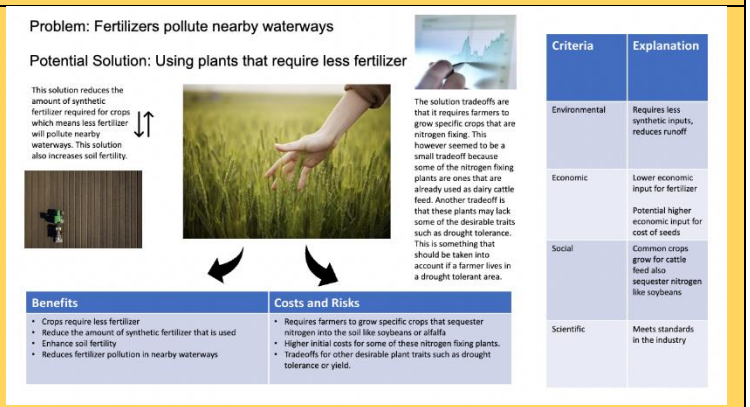
Look Fors:

- Student identifies a dairy production system cost or risk as a problem. The identification of the problem is backed up by evidence that explains the problem in full (ESS3.A-H2).
- Student names the new task that the solution is intended to accomplish and describes how the solution accomplishes it (SYS-H1).
- Student describes how the solution proposed will more responsibly manage natural resources (ESS3.C-H1).
- Student describes how the solution chosen maintains the benefits of the dairy system and helps improve on its costs and risks. Student names these as economic, social, environmental, and/or geopolitical costs / risks / benefits (ESS3.A-H2).
- Student presentation includes multiple formats of communication, including oral/verbal/speaking, graphics/media, writing/text (INFO-H5).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Problem: Cow burps contribute to GHG emissions and high levels of methane in the atmosphere. This can lead to climate change through the greenhouse effect. Solution: The solution to this is to use rotational grazing.	Problem: Cow burps contribute to GHG emissions and high levels of methane in the atmosphere. This can lead to climate change through the greenhouse effect. Solution: The solution to this is to use rotational grazing. A rotational grazing strategy for cattle can help offset the negative effects on biodiversity and may lead to more carbon sequestration in soils. This strategy can allow us to still produce milk for consumers and improve on some of the costs and risks of the current	

		system design.	
How to Achieve This Level	Student completes 0-2 out of 5 Look Fors	Student completes 3-4 out of 5 Look Fors	Student completes 5 out of 5 Look Fors

If Students Need Additional Support:

- Direct students back to their artifacts from the previous three modules and asking students to use these to inform their presentations. For example, encourage students to identify parts of those models their solution addresses and how it addresses them. Guide students to showcase those parts of the models as a part of their Solutions Presentation.
- Remind students that they will likely share this solution with a stakeholder. Ask them what a stakeholder needs to know and understand to choose their solution to the identified problem.
- Focus students' attention on an item on the Look Fors they may be overlooking.
- Remind students that this is just a draft presentation for now and that they will receive peer feedback to improve on their presentation.

CCSS SUPPORT

SL 9-10.4: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
Through their work on their Solutions Presentations, students are working to improve their work. Students should consider organization, audience, and the requirements of the task when developing their presentations.

Part 3: Providing Feedback on Proposed Solutions

Share with students that they will now share their Solutions Presentations with their peers to receive feedback on how they can improve their presentations.

Direct students to set up a Gallery Walk by displaying their group's Presentations (from Lesson 24 Student Guide Part 2: Proposing Solutions) around the classroom. If students have digital presentations, have them set up a device set to presentation mode to allow other students to move through the group's presentation slides. If students have a physical poster, hang them on the wall. To the side of each presentation, hang a blank piece of chart paper.

Share with students that they will ask questions to challenge the suitabiity of their peers' designs. Instruct students to move around the classroom, review the proposed solutions, and write their feedback on the large sheets of chart paper. Encourage students to provide feedback that:

- Includes questions to challenge their peers on their design choices and statements indicating if they agree with their design choices.
- Describes if they think the presented solution is appropriate for the problem and relative to the identified criteria and constraints.
- Addresses the specific improvements the presented solution will have on the system.

TEACHER SUPPORT

If chart paper is unavailable, students can use sticky notes or smaller sheets of paper to provide feedback.

FORMATIVE ASSESSMENT OPPORTUNITY

Students ask questions to each other that challenge the suitability of their designs that aim to redesign a part of the dairy system to help it improve upon its costs and risks.

Assessment Artifacts:

- Students' questions they ask of peers while they provide peer feedback (Lesson 24 Gallery Walk)

Look Fors:

- Student asks questions about the suitability of their peer's design (AQDP-H7).
- Student asks questions about how the new design accomplishes a new task (SYS-H1).
- Student asks questions that challenge how the design improves on the dairy system's costs and risks (ESS3.A-H2).

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	What makes your solution better than the old system? How does your design improve the system?	How does your design improve on the negative biodiversity impacts of the dairy system? How can your design help produce dairy products while also improving on biodiversity impacts?	Do you think this is the right solution choice? Could your solution better address additional costs and risks of the dairy system? How does your design improve on the negative biodiversity impacts of the dairy

			system? How can your design help produce dairy products while also improving on biodiversity impacts?
How to Achieve This Level	Student completes 0 out of 3 Look Fors	Student completes 1-2 out of 3 Look Fors	Student completes 3 out of 3 Look Fors

If Students Need Additional Support:

- Provide sentence stems to ask peers questions or press peer reasoning and evidence, such as:
  - How does your design improve on _____?
  - I'd like to challenge part of your design decision. In your explanation, you said ____, and instead, I think...
  - I disagree with _____ in your design solution because...
  - What is the evidence you have to say _____?
  - In your solution, I saw you wrote _____. Instead, did you think about...?
- Have a class conversation about what an effective question that challenges the suitability of a design would look like.
- Provide students with an example student presentation and ask students to first rate the sample work as a class and discuss what kinds of questions they would ask to challenge the suitability of the design and why.

You can also consider having students provide additional feedback based on the assessment rubric presented in Part 2. Students could rate each other's presentation and give additional feedback on how peers could improve their presentations.

Part 4: Peer Review and Finalizing Solutions

Share with students that since we have given initial feedback to different groups, each group will now focus on giving more in-depth feedback to a single group with which they are paired. Remind students that this is one of the stages of the engineering design process. They have identified the problems of the impacts of dairy on the environment, identified criteria and constraints of a potential solution, used the Engineering Design Matrix, shared the most promising solution for their dairy system problem, and now are getting feedback and defending their proposed solution for the problem they identified.

Pair up student groups and allocate time for each group to orally present their argument to their partner group. During presentations, students will use the Lesson 24 Peer Feedback to provide feedback on how well the solution presentation meets each of the Look Fors. Each section should include an evidence-based explanation to help students revise their solution. Like before, encourage students to ask the following questions that:

- Challenge your peers on their design choices, including identifying if you agree with their rationale for their design choice.
- Describe if you think the solution presented is appropriate for the problem and relative to the identified criteria and constraints.

SEP SUPPORT
AQDP-H7: Ask and/or evaluate **questions that challenge** the premise(s) of an argument, the interpretation of a data set, or **the suitability of the design.**

Though this is the first time students have used this element in this unit, students can use the proficiency they have built with ARG-H3 throughout the module so far to engage in AQDP-H7 here.

Part 5: Navigation to the Next Lesson

To conclude the lesson, share with students that they will have an opportunity to use the peer feedback to revise their presentations in the next lesson. Share with students that they will then present their final design solution proposal to stakeholders and the class.