TEACHER GUIDE
EXPLORE LESSON 22

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 different kinds of criteria and constraints can be used for successful solutions to different problems in the dairy system.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students define criteria and constraints to help redesign the dairy system to accomplish new tasks, taking into consideration risk management, cost, safety, reliability, and social, cultural, and environmental impacts.	50 minutes	Lesson 22 Student Guide

Targeted Elements

SEP:

AQDP-H8:
Define a design problem that involves the development of a process or system with interacting components and **criteria and constraints** that **may include social, technical and/or environmental considerations.**

AQDP-H9:
Analyze complex real-world problems by specifying criteria and constraints for successful solutions.

DCI:

ETS1.A-H1:
Design criteria and constraints, which typically reflect the needs of the end-user of a technology or process, address such things as the product's or **system's function (what job it will perform and how), its durability, and limits on its size and cost. Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a**

CCC:

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

	way that one can tell if a given design meets them. **ETS1.B-H1:** When evaluating solutions **it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural, and environmental impacts.**	

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 identified the costs, risks, and benefits of the dairy system to select a problem in the dairy system to design a solution for.
- The best next step would be to define the criteria and constraints for successful solutions to the problem.

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, select criteria and constraints for successful solutions. Students can record what they want to figure out and the next step in the engineering design process in Lesson 22 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: Determining Criteria and Constraints

Ask students to recall their prior knowledge of engineering criteria and constraints. Allow students time to share a few ideas and build on other student ideas to confirm that criteria are the ways in which solutions will be judged to determine if they are successful and constraints are limits on the design.

STUDENT SUPPORT

If you get the sense that students need additional support in understanding these two definitions or that they did not encounter them in prior grade bands, consider:

- Providing a real-life example of a problem and ask students ways they would judge how successful a solution would be to this problem and what restrictions there would be on solutions to this problem. For example, ask students what ways they could judge possible solutions for the problem of choosing what to eat for breakfast and what constraints there might be on their choice.

Have students rejoin their problem groups of three from the previous lesson. Allow students time to generate a list of criteria that successful designs for their specific problem should meet and constraints that limit the solutions. Direct students to work with their group to record their list in the space provided in the Lesson 22 Student Guide. Encourage students to consider criteria and constraints that will best meet the needs of multiple stakeholders, such as dairy farmers, consumers of dairy products, and the environment.

As students work, circulate the room and ask students questions to press their thinking. Questions may include:

- What should we measure to see if the solution is successful?
- What would stakeholders find most important about a solution?
- What would stakeholders need in a solution?
- What limitations are there on a solution?

Once students have recorded a list of criteria and constraints, engage in the Think-Talk-Exchange Routine:

1. Have students form new groups of three.
2. Each group includes one speaker and two listeners. Assign one student in each group to speak first, then the student who will speak second, and third.
3. Each student talks for 1 minute to share the criteria and constraints that they came up with in their problem group.
4. After all triad members have shared, the group will together try to find similarities in their responses for 2 minutes.

Hold a whole-class discussion for students to share the criteria and constraints they shared in their mixed groups. Some examples of criteria and constraints the class could agree on are:

Criteria

- Functionality-Product or service should meet/serve a need.
- User-Friendliness-easy for the consumer to use.
- Safety-meets various safety requirements.

- Durability-withstands use.
- Aesthetics-looks good/visually pleasing.
- Accessibility-easy for consumer buy and use.
- Sustainability-sustainable practices are in place for production, use and disposal of product; may also maintain effective use over time.
- Cost-effectiveness- meets budget requirements.
- Innovation-new and fresh idea.
- Adaptability-can be used in various ways.
- Environmental impact – reduces a specific environmental impact, such as pollution, biodiversity loss, or greenhouse gas emissions or all of these.

Constraints

- Time-solutions should be implemented in the next 10 years.
- Budget-solutions should be cost effective.
- Resources-solutions should include resource that can be found/obtained easily.
- Regulations and Standards-meets standards for impacted industries.
- Environmental Factors-greenhouse gas emissions should be reduced.
- User Needs and Expectations-solution still meets the needs of the producers and consumers.
- Existing Infrastructure or Systems-solution considers current infrastructure and systems.
- Ethical and Social Considerations-animals should be treated humanely.

Part 3: Refining Criteria and Constraints

Explain to the students that there are various types of criteria and constraints. They can be categorized as scientific, social, cultural, economic, or environmental. Using the table in the Lesson 22 Student Guide, ask students to classify their updated list of brainstormed criteria and constraints into the appropriate categories.

As students work, circulate the room, and ask them pressing questions to develop their reasoning. Questions may include:

- Why are you placing this criterion/constraint in this category?
- Can you say more about what we mean when we say a criterion/constraint is a [scientific, social, cultural, economic, or environmental] criterion/constraint?

SEP SUPPORT

AQDP-H8: Define a design problem that involves the development of a process or **system with interacting components** and **criteria and constraints that may include social, technical and/or environmental considerations.**

In this lesson, students focus on generating a list of criteria and constraints and then determining what category they fall under: social, environmental, economic, cultural, or scientific. This lesson builds on how students engaged with this SEP in the previous lesson. As a result, students fully use this element across both Lessons 21 and 22.

FORMATIVE ASSESSMENT OPPORTUNITY

Students define criteria and constraints to help redesign the dairy system to accomplish new tasks, taking into consideration risk management, cost, safety, reliability, and social, cultural, and environmental impacts.

Assessment Artifacts:

- Students' identification of criteria and constraints (Lesson 22 Student Guide Part 3 Developing Specific Criteria and Constraints).
- Students' reflection on the new tasks the solutions would accomplish (Lesson 22 Student Guide Part 3 Developing Specific Criteria and Constraints).

Look Fors:

- Students generate a list of criteria and constraints (AQDP-H9)
- Students classify their list of criteria and constraints into the corresponding categories: scientific, social, cultural, economic, and environmental needs. (AQDP-H8) (ETS1.A-H1)
- Students explain their criteria/ constraint choices based on the new tasks they want the dairy system to accomplish (ETS1.A-H1) (SYS-H1)

	Emerging	Developing	Proficient
Sample Student Response	Criteria: • Safety • People have to like it. • It needs to be	Criteria: • Scientific: Safety-needs to meet food-safety requirements. • Social: User-Friendliness-solution is easy for producer to implement and/or easy for consumer to use.	Criteria: • Scientific: Safety-needs to meet food-safety requirements. • Social: User-Friendliness-solution is easy for producer to implement and/or easy for consumer to use.

	cheap. Constraints: • It can't cost too much. • It doesn't produce too much waste. New Tasks the Solution Would Accomplish: New packaging would help reduce waste and help the environment.	• Cultural: Accessibility-the ability for groups of people to access the food products at stores. • Economic: Cost-effective packaging. • Environmental: Environmentally friendly, compostable, recycled products. Constraints: • Scientific: Regulations and Standards-meets standards for impacted industries. • Social: Social Considerations-animals should be treated humanely. Time-solution being implemented within the next 10 years. • Cultural: How food is processed and packaged for various cultural/religious requirements. • Economic: Materials fit within the budget. • Environmental: Needs to meet temperature and food-safety requirements. New Tasks the Solution Would Accomplish: New packaging would help reduce waste and help the environment.	• Cultural: Accessibility-the ability for groups of people to access the food products at stores. • Economic: Cost-effective packaging. • Environmental: Environmentally friendly, compostable, recycled products. Constraints: • Scientific: Regulations and Standards-meets standards for impacted industries. • Social: Social Considerations-animals should be treated humanely. Time-solution being implemented within the next 10 years. • Cultural: How food is processed and packaged for various cultural/religious requirements. • Economic: Materials fit within the budget. • Environmental: Needs to meet temperature and food-safety requirements. New Tasks the Solution Would Accomplish: Environmentally friendly packaging would help reduce waste from the dairy system by reducing the amount of materials used in packaging and reducing the amount of waste that gets thrown away. This redesign of the system can help the dairy system produce dairy products for customers while reducing packaging pollution in the environment. We could measure how much less material is used in new packaging compared

			to old packaging, and we could analyze if the new packaging breaks down in the landfill.
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

To Provide Additional Support for Students:
If students need additional support, consider:

- Choosing one of their criteria/constraints and asking them to verbally share how they would classify it and why.
- Encouraging them to look at models or other artifacts from previous lessons to see where criteria and constraints might show up.

Have students rejoin their problem groups. Students will work with those groups to choose from the class list the three most important criteria and three most important constraints for their problem and record their selections in Lesson 22 Student. Students can then come up with a plan for how they can measure how they would meet the criteria they chose if their design were to accomplish a new task for the dairy system.

CCSS SUPPORT
SL 9-10.1(d): Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.
The goal of this standard is to challenge students to respond to diverse perspectives. At this point in the lesson, students may disagree with their peers in their problem groups. Encourage them to rely on evidence they collected in the reading from the previous lesson to demonstrate their understanding and share their thoughts respectfully with their group.

CCC SUPPORT
SYS-H1: Systems can be designed to do specific tasks.
Students engage in this element by reflecting on how a new design for the dairy system that meets the criteria they chose would accomplish new tasks.

Part 4: Navigation to the Next Lesson

Ask students to return to the list of steps of the engineering design process recorded in the Lesson 22 Student Guide Part 1: Our Motivation. Ask students which step they think is best to take next to move forward in designing solutions to the problems they chose. Confirm that students will next investigate possible solutions to the problem.