STUDENT GUIDE
EXPLAIN LESSON 23

Food and Agriculture Center for Science Education

Part 1: Our Motivation

Record the next steps you want to take in the engineering design process.

With criteria and constraints in mind, we can now start generating solutions to the problem. We should have multiple possible solutions to choose from. We need to develop and think about those solutions.

Part 2: Investigating Solutions for Dairy Production Practices

Read each proposed solution and summarize the central idea in 2-3 sentences. Be sure to answer:

- What solution is being proposed by the text?
- How will this solution change the design of the dairy system?
- What impact will that change have on the outputs of the dairy system or on its externalized costs?
- How will this solution improve the responsible management of natural resources by the dairy system?

Summarize (Text 1) The suggested solution to combat biodiversity loss from dairy system infrastructure or monoculture involves adopting agroecological practices like no-till farming, cover crops, and crop rotations. Dairy infrastructure and monoculture practices contribute to habitat degradation, prompting the need for sustainable alternatives. No-till farming minimizes soil disturbance, preserving soil structure and supporting biodiversity. Cover crops, planted during fallow periods, prevent erosion, enhance nutrient cycling, and offer wildlife habitat. Crop rotations disrupt pest and disease cycles, improve soil health, and promote plant diversity. Despite potential challenges, such as the need for specialized equipment and added expenses, these practices provide ecological benefits, emphasizing the importance of careful implementation.
Summarize (Text 2) The solution being proposed for biodiversity loss from dairy farm infrastructure or monoculture is the adoption of agroforestry and intercropping. These approaches integrate trees with farming, mimicking natural ecosystems and providing diverse landscapes that support wildlife, enhance soil health, and conserve water. Intercropping, growing different crops together, further promotes biodiversity. Despite potential drawbacks like the loss of farmable land, these strategies offer ecological and economic benefits. Successful implementation requires careful planning and consideration of factors such as site suitability and tree/crop selection. Knowledge and resources are crucial for adopting these sustainable practices.

Summarize (Text 3)
The solution proposed by the text is to utilize rotational grazing as a strategy to reduce biodiversity loss from building dairy infrastructure or from using monoculture for raising crops. The solution would require farmers to systematically move cattle from one grazing area to the next. This would be in place of confining animals to one location to eat. The approach of rotational grazing would promote biodiversity, soil health, and reduce the need for inputs such as fertilizer.

Analyze the solution by listing the social, economic, environmental, and scientific benefits and potential costs and risks of the solution itself.

Benefits (Text 1)	**Costs and Risks (Text 1)**
Dairy cattle can be bred for low CH_4 production by looking at the genetic traits of sires and relying on artificial insemination to ensure those traits are more likely to be expressed in offspring. We can also expand the trait selection index as new genetic technologies become available.	While genetics are predictable, they are not always completely accurate. Traits can be expressed in unique ways, mutations can lead to unexpected genotypes / phenotypes, and expression may not include the desired trait of low CH_4 production. Additionally, other traits that are expressed may counter-balance low CH_4 production if they are not accounted for.
Benefits (Text 2)	**Costs and Risks (Text 2)**
Crops require less fertilizer. You can reduce the amount of synthetic fertilizer that is used. You can enhance soil fertility.	It requires farmers to grow specific crops that sequester nitrogen into the soil, such as soybeans or alfalfa. There are higher initial costs for some of these nitrogen fixing plants. There are tradeoffs for other desirable plant traits, such as drought tolerance or yield.

Benefits (Text 3)	**Costs and Risks (Text 3)**
It promotes biodiversity by creating diverse habitats. There are more opportunities for native plant species to thrive. It improves soil health. It reduces the need for inputs such as synthetic fertilizer. Animals have access to fresh pastures, allowing land and vegetation in previously grazed areas to recover.	It requires farmers to systematically move cattle from one grazing area to the next. Ample land to graze is needed.

Overall, how do you think these solutions increase or maintain the benefits of the dairy system, while decreasing its costs and/or risks of the problem your group is focusing on?

This solution allows us to still have many dairy cattle producing a significant volume of milk, maintaining the benefit of dairy production. Simultaneously, it improves the costs of the system by decreasing the amount of greenhouse gases produced by the cattle.

Part 3: Evaluating Possible Solutions

Using the Engineering Design Matrix, evaluate your solutions. Follow these steps to use the Engineering Design Matrix:

1. Identify the specific criteria you will be using from your list in Lesson 21. Write those criteria in the first column on the left side.
2. Next, write the three proposed solutions you analyzed from Lesson 22. Write those solutions in the top row.
3. Now, assign a weight for each criterion from 1 to 5 (with 5 as the highest value). This should reflect how important your think the criterion is.
4. Rate each proposed solution using a scale of 1-5, where 5 is the best, based on how well that solution meets the given criteria. Multiple criteria may have the same ranking of importance.
5. For each solution, score each option on a scale of 1-5 (5 being best) based on how well that option meets the criteria.
6. Multiply the weight for each solution by the score you gave the option to get the weighted score. Now, compare the overall scores of your potential solutions.

		Solution Option 1	Solution Option 2	Solution Option 3
Selection Criterion	Weight	Score: Weighted Score:	Score: Weighted Score:	Score: Weighted Score:

Which criterion did you rank as “most important?” Why did you prioritize it over the others?

The criteria I ranked as most important was safety because food products that are produced need to be safe for consumption. If they are not safe for consumption, the product cannot be used, and the other criteria do not matter.

Choose one solution that you think performed best in one criterion and explain why you think it performed better than the others. Be sure to describe the social, economic, environmental, and scientific considerations of how this solution performs.

Creating recyclable or compostable packaging for the products performed better than the other solutions in the environmental sustainability criterion. I believe it is because it minimizes waste while promoting environmental sustainability. The use of these products can also contribute to the circular economy, which is a benefit.

Based on the results of the Engineering Design Matrix, which solution is most promising? Why? Be sure to describe how this solution performed in selected criteria and what tradeoffs you are making by choosing this solution.

According to the matrix, the solution that is the most promising is rotational grazing. The reason it did so well is because it met many criteria including reducing a variety of greenhouse gas emissions, improving biodiversity loss, and protecting waterways. Some tradeoffs are that favors managing cattle to help the environment and produce milk, but it can be labor intensive and require land to graze. This would impact the economics of a dairy system and the ability for a farm to be large scale.

Which solution will you choose? Why? Be sure to describe the environmental, social, ethical, and/or economic considerations involved in your choice.

I would like to implement rotational grazing. I think this is the solution that addresses the most of my criteria. It helps the environment because it reduces pollution from fertilizers in monocropping that comes from runoff. It also addresses an ethical consideration because it helps the cattle live a happier life by allowing them to use their natural behavior of grazing instead of being in a barn all day. I think it also provides a social benefit because the milk from grazed cows is healthier for people. And finally I think it also addresses an economic consideration because the cattle can still produce milk for the farmer.

What new tasks will the dairy system accomplish if the solution you choose is implemented?

I think the dairy system will now not only be able to produce dairy products, but the parts of the system that feed the cattle will function to protect biodiversity rather than reduce it when monocultured crops are produced. It will also function to make animals have a more happy life.