Data: fair or misleading?

Focus question	How do farmers use scientific data to make informed decisions about food production, resource management, and sustainability?
Vocabulary	Correlation vs. causation, variables, evidence-based argument, scatter plot, histogram, pie chart, line graph, scale, axes, yield, composition, irrigation, biotechnology, biofuels, sustainability, total mixed ration (TMR), lactating

Graphs are powerful tools that help people understand data quickly. Farmers use graphs to make important decisions about what to plant, when to water crops, and how to manage resources efficiently. However, not all graphs are fair! Sometimes, graphs are created in a way that misleads the audience, making data seem more dramatic or hiding important details. This can trick people, like farmers, into making poor decisions, costing them money and hurting their crops.

In this activity, you will learn how to sort misleading graphs and decide if a graph presents data accurately or unfairly. By the end of the lesson, you will be able to identify fair vs. misleading graphs and provide evidence for your decisions.

Objectives
- Identify fair and misleading graphs
- Explain how graphs can be manipulated to influence decision-making
- Use evidence from graphs to justify your reasoning

Misleading technique	Description	Example in agriculture
Truncated y-axis	The y-axis does not start at zero. This can exaggerate differences between data points.	A fertilizer company may show crop growth with and without their product, but the y-axis makes the increase seem more dramatic than it actually is.
Inconsistent scaling	The x-axis or y-axis intervals are uneven. This can make data appear more or less significant than it actually is.	A graph comparing drought years may space out wet years disproportionately, making it look like droughts are occurring more frequently.
Cherry-picked data	Only a select portion of the data is shown. This can lead to ignoring information that may contradict a claim or provide only one portion of evidence for an explanation.	A seed company may present crop yields from only one successful season instead of showing a multi-year average.

Misleading technique	Description	Example in agriculture
Misleading pie charts	Pie chart slices are manipulated (either by size or by excluding categories). This can make one variable seem dominant.	A market report might exclude certain competitors in a pricing comparison, making one company appear to control a larger portion of the market.
Overuse of 3D effects	3D graphs distort proportions. This makes some bars or slices appear larger than they actually are.	A dairy industry report might use 3D bars to make milk production increases seem larger than they are.
Cumulative graphs without clarification	A line graph showing cumulative data instead of yearly changes. This can create the illusion of constant increases.	A report on pesticide usage might show a growing line over several years, but it does not indicate if usage is leveling off or declining in recent years because of the cumulative effect of addition.

Materials
- Device to access the internet

Procedure

Activity 1
You will rotate through different graph stations around the classroom. Each graph shows different data, but some graphs are fair while others are misleading. At each station, analyze the graph and complete the chart below by deciding:
- Is the graph fair or misleading?
- What makes it fair or misleading?

Gallery walk data table

Graph	Circle one	Evidence (Why do you think this?)
1	fair misleading	
2	fair misleading	
3	fair misleading	
4	fair misleading	
5	fair misleading	
6	fair misleading	
7	fair misleading	
8	fair misleading	
9	fair misleading	
10	fair misleading	

Post-lab questions

1. What were some of the most common ways that graphs were misleading?

2. Why do you think people might create misleading graphs?

3. How could misleading graphs affect a farmer's decision?

4. What strategies can you use to determine if a graph is trustworthy?

Activity 2

Complete a scenario as assigned by your instructor. After completing the task and answering the reflection questions, complete the self assessment rubric below.

Rubric for self-assessment

Skill	Yes	No	Unsure
I can identify differences between fair and misleading graphs and explain why a graph may be misleading.			
I accurately created a graph that best represents the data from my scenario.			
I used evidence to support my claim and recommendation to the farmer.			
I communicated my findings clearly in my group presentation.			
I worked effectively with my group to analyze data and prepare our presentation.			
I can explain how misleading data could negatively impact real-world agricultural decisions.			

Scenario 1: Finding the right fertilizer rate

Background

Farmer Jackson has been growing corn for the past 10 years, but each season, he struggles to find the right amount of fertilizer to use. He knows that adding too little fertilizer might cause his plants to lack nutrients, leading to lower crop yields. On the other hand, using too much fertilizer could be wasteful, expensive, and harmful to the environment.

Recently, Farmer Jackson has come across conflicting advice - one fertilizer company claims that more fertilizer always leads to higher crop yield, while environmental groups warn that excessive fertilizer use pollutes waterways and damages soil over time. Now, he's looking at real data to help him make the best decision.

Farmer Jackson needs your help! He wants to know: ***"What is the best amount of fertilizer to use to get the highest crop yield without wasting money or harming the environment?"***

Your task

1. Research this phenomenon to gain background knowledge
2. Create a graph of the fertilizer rates and crop yield to identify trends in the data
3. Analyze the data to determine the most effective amount of fertilizer for growing the highest yield
4. Take a stance!
   a. If you were a fertilizer salesperson, how would you present this data to convince Farmer Jackson to buy more fertilizer?
   b. If you were an environmentalist, how would you present this data to persuade Farmer Jackson to use the least amount of fertilizer?
5. Present your findings to Farmer Jackson. Be sure to include both the fertilizer's and environmentalist's point of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend a fertilizer rate based on your findings. Remember to use evidence-based decision-making.

Data set for analysis

Fertilizer rate (lbs/acre)	Crop yield (tons/acre)
0	1
50	3
100	5
150	6
200	6.25
250	6
300	5.5
350	5
400	4.5

Reflection

1. What patterns do you notice in the relationships between fertilizer and crop yield?

2. Does adding more fertilizer always result in a higher yield? Why or why not?

3. What fertilizer amount gives the best balance between yield and efficiency?

4. Suppose that each pound of fertilizer costs approximately $0.53 and an average acre of land yields about 5 tons of corn. What would be the best fertilizer rate for Farmer Jackson to use based on the cost of fertilizer?

Scenario 2: Seeding rates: Finding the best spacing for soybeans

Background

Farmer Emily has been growing soybeans for years, but she's always debating the best seeding rate and row spacing to maximize her crop yield while keeping costs low. Some farmers plant soybeans closer together (15-inch rows) to increase the number of plants per acre, while others believe wider spacing (30-inch rows) helps the plants grow stronger and healthier.

Recently, seed companies have been encouraging farmers to plant at higher rates, claiming that it will result in more soybeans and higher profits. However, some agronomists argue that planting too densely can cause overcrowding, competition for nutrients and waste seed.

Farmer Emily needs your help! She wants to know: ***"What is the best seeding rate and row spacing to produce the most soybeans while keeping costs low?"***

Your task

1. Research this phenomenon to gain background knowledge.
2. Create a graph comparing seeding rate and final soybean population for both 15-inch and 30-inch row spacing.
3. Analyze the data to determine how different row spacings impact the final number of plants.
4. Calculate how much seed is needed per acre and the cost per acre. A 50-lb bag of soybean seed contains 140,000 seeds and costs $90. How many bags will it take to plant each seeding rate and how much will it cost?
5. Take a stance!
   a. If you were a soybean salesperson, how would you present this data to convince Farmer Emily to buy the most seeds?
   b. If you were a cost-conscious farmer, how would you present this data to recommend the most cost-effective planting method?
6. Present your findings to Farmer Emily. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend the best seeding rate and spacing based on your findings.

Data set for analysis

Planted seeds per acre	Final population (15-inch row spacing)	Final population (30-inch row spacing)
75,000	71,500	62,700
125,000	107,800	95,900
175,000	146,500	122,000
225,000	174,400	153,900

Reflection

1. What pattern do you notice between seeding rate and final plant population?

2. How does row spacing impact the number of surviving soybean plants?

3. How many bags of seed would be needed for each seeding rate? How much would this cost?

4. What additional costs should Farmer Emily consider?

5. How could misleading graphs be used to influence Farmer Emily's decisions?

Scenario 3: Choosing the best farm animal to raise

Background

Your friend, Alex, has a large backyard and wants to start raising farm animals. However, Alex isn't sure which animal is the best choice. He loves them all! He wants something that is affordable to feed, provides good nutrition, and is realistic to care for in a backyard setting.

Different animals require different amounts and types of feed, and the cost of feeding them varies widely. Some animals eat a large amount of food per day, while others require less food but still provide valuable products like meat, eggs, or wool.

Alex has asked for your help to analyze the data and recommend which animal(s) would be the best choice for his backyard! He wants to know: ***"Which farm animal should I raise in my back yard? What is the most cost-effective choice based on feed input and material output?"***

Your task

1. Research each animal to gain background knowledge.
2. Create a graph that compares animal size to the amount of feed they consume.
3. Analyze the differences in feed requirements among the animals.
4. Identify the most cost-effective choice by considering feed costs, weight, and annual expenses.
5. Take a stance!
    a. If you were an advocate for backyard farming, how would you present this data to convince someone to raise smaller, more efficient animals?
    b. If you were promoting large livestock farming, how would you present this data differently to argue for raising large animals like cows?
6. Present your findings to your friend Alex. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend the best farm animal(s) based on your findings.

Data set for analysis

Animal	Animal size	Gross daily feed intake	Feed input per animal per year	Annual cost of feed per animal
Chicken	5 lbs	0.25 lb	68.4 lbs	$68.40
Pork (pigs)	300 lbs	6 lbs	2190 lbs	$1138
Beef (cows)	1200 lbs	24 lbs	(Grass/forage only)	114 lbs other than grass
Sheep (lamb/wool)	150 lbs	3 lbs (grass/forage only)	5.5 lbs other than grass	$3

Reflection

1. How does animal size relate to feed intake and cost?

2. Why do different animals require different amounts of protein?

3. Which animal provides the best balance of cost vs. benefit?

4. If your goal is to spend as little money as possible, which animal should you recommend?

5. How could misleading graphs be used to influence a farmer's decision about which animal to raise?

Scenario 4: Maximizing ice cream sales for Sunny Acres Dairy Farm

Background

Sunny Acres Dairy Farm has been producing fresh milk and delicious ice cream for generations. Recently, they've been looking for ways to boost their ice cream sales, but they aren't sure which times of the year are best for selling the most ice cream.

They know that people tend to buy more ice cream in the summer when it's hot outside, but they also suspect that special events, holidays, and promotions might influence sales. However, there's another challenge: milk production from dairy cows can vary with the seasons!

While cows may produce more milk from winter to spring because of an increase in daylight, heat stress can affect dairy cattle from spring to winter. A cow's normal body temperature range is between 100.4 °F and 102.8 °F. Milk production and fertility decrease when a cow's body temperature reaches 102.2 °F.

Commonly known in the farming industry as "heat stress", there are strategies to increase milk production in warmer months. Techniques like air conditioning in barns, providing shade, and ensuring adequate hydration can help maintain milk production even when temperatures rise.

Sunny Acres Dairy Farm needs your help! ***"When is the best time of year to maximize ice cream sales and what steps can we take to ensure consistent milk production for making ice cream?"***

Your task

1. Research this phenomenon to gain background knowledge.
2. Create two graphs:
    a. One that shows ice cream sales by month
    b. One that shows milk production by month
3. Analyze the data to determine the best and worst times of the year for selling ice cream.
4. Identify any trends that could help the dairy farm maximize profits and maintain a steady milk supply, even in warmer months.
5. Take a stance!
    a. If you were a marketing expert, how could you present this data to convince the farm to focus on strategic marketing?
    b. If you were a farm operations manager, how would you present this data to recommend strategies for maintaining milk production in the summer?
6. Present your findings to Sunny Acres Dairy Farm. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend the best strategy for managing ice cream sales and milk production based on your findings.

Data set for analysis

Month	Avg. monthly temperature	Ice cream sales (gallons sold)	Avg. milk production per cow (gallons/month)
January	37 °F	1500	190
February	32 °F	1800	185
March	55 °F	2500	175
April	63 °F	3200	160
May	72 °F	4500	140
June	87 °F	7200	130
July	93 °F	9000	125
August	98 °F	8500	130
September	95 °F	6000	150
October	66 °F	4000	155
November	58 °F	2800	175
December	47 °F	2000	185

Reflection

1. How does temperature affect ice cream sales?

2. How does temperature impact milk production, and what trends do you notice?

3. What strategies could Sunny Acres Dairy Farm use in the summer months to maintain milk production?

4. How can the farm market ice cream in cooler months increase sales?

5. How could misleading graphs be used to persuade the farm to focus only on summer ice cream sales?

Scenario 5: Water quality and a sustainable fishery

Background

Clearwater Fisheries is a family-owned fish farm that raises trout and catfish to sell to local markets and restaurants. Over the years, the owners have learned that keeping the water clean is essential for raising healthy fish. If the water quality declines, fish grow more slowly, get sick more often, or even die, which affects the entire business.

Recently, the owners have noticed changes in the water quality. Some fish are not growing as quickly as expected, and a few disease outbreaks have occurred. A new paper mill opened last January upstream from the fishery, and some workers at the fishery are concerned that runoff from the paper mill may be polluting the watershed. Paper mills use chemicals like chlorine and sulfur dioxide in the paper-making process, and if these chemicals enter the water supply, they can lower oxygen levels, change pH balance, and introduce harmful pollutants.

The owners of Clearwater Fisheries are worried that the declining water quality could be linked to the factory's operations, but they need data to confirm their suspicions. They want to understand how different water quality factors - such as oxygen levels, pH balance, and pollution levels - affect the fish population and what steps they should take to keep their fish healthy.

Help the owners answer the following question: ***"How does water quality impact the fish population in our fishery, and what steps should we take to keep the water healthy and sustainably?"***

Your task

1. Research this phenomenon to gain background knowledge.
2. Use the data table below to create multiple graphs to compare how each factor relates to the number of healthy fish.
3. Analyze the data to identify patterns in how water quality affects fish growth and survival.
4. Investigate whether the nearby paper mill might be affecting the water quality at the fishery.
5. Recommend solutions to improve the water quality and maintain a sustainable fish population.
6. Take a stance!
    a. If you were the fishery owner, how would you present this data to support the idea that water quality investments (like filtration systems) are necessary for long-term success?
    b. If you were a local government official, how would you present this data to argue for stronger environmental regulations to protect the fishery from pollution?
7. Present your findings to Clearwater Fishery. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend the best strategy for maintaining a sustainable fishery based on your findings.

Data set for analysis

Month	Dissolved oxygen (mg/L)	pH	Pollution index (scale 1–10, 1 = cleanest)	Number of healthy fish in sample
January	8.5	7.2	2	950
February	8.0	7.1	3	920
March	7.5	6.9	4	870
April	6.8	6.8	5	800
May	6.5	6.6	6	720
June	6.0	6.5	7	650
July	5.5	6.3	8	580
August	5.2	6.2	9	500
September	5.8	6.4	7	620
October	5.7	6.4	7	615
November	5.6	6.4	8	600
December	5.3	6.3	9	590

Reflection

1. How does dissolved oxygen impact the number of healthy fish?

2. What happens to the fish population when pollution levels increase?

3. How are each of these variables related?

4. How might the new paper mill be contributing to water pollution?

5. What actions could Clearwater Fisheries take to improve water quality?

6. How could misleading graphs be used to argue that the fishery is not at risk when the data suggests otherwise?

Public perception vs. adoption of genetically modified food

Background

Golden Harvest Farms is considering expanding its crop production to include genetically modified (GM) crops. GMOs offer benefits like higher yields, pest resistance and lower pesticide use, but they also face public skepticism and negative consumer perception.

While many GM crops are used in processed foods, only a few can be found in the fresh produce section of grocery stores. If consumers are unwilling to buy genetically modified produce, farmers like Golden Harvest may struggle to find a market for their crops, affecting their business decisions.

Recently, Golden Harvest Farms read a study analyzing public perceptions toward GMOs based on two million online mentions on social media. The findings of this study suggested that 54% of the mentions were categorized as having a neutral sentiment, 32% as having a negative sentiment, and 14% as having a positive sentiment. (Study link: **pmc.ncbi.nlm.nih.gov/articles/ PMC10038016/**)

Because of this recent information, Golden Harvest Farms wants to determine whether it's worth investing in GM crops for their farm, or if consumer perception is too much of a barrier to make it a profitable decision. Help them answer the following question: ***"Should we invest in growing genetically modified crops, or will negative consumer perception limit our ability to sell them?"***

Your task

1. Research this phenomenon to gain background knowledge.
2. Create a few graphs:
    a. One that shows public sentiment toward GMOs through the social media study
    b. One that shows consumer sentiment toward GMOs from Natural Grocers
    c. One that shows GMO projected sales
    d. One that shows Non-GMO projected sales
3. Analyze the data to determine whether GM crops have consumer support or resistance.
4. Take a stance!
    a. If you were a biotech company, how would you present this data to convince farmers that GM crops are the future of agriculture?
    b. If you were a consumer advocacy group, how would you present this data to argue against GMOs in fresh produce?
5. Present your findings to Golden Harvest Farms. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend if they should invest in GM crops based on the data.

Data set for analysis

Social media study

Sentiment toward GMOs	Percentage of mentions
Negative	32%
Neutral	54%
Positive	14%

Consumer study

Sentiment toward GMOs	Percentage of mentions
Avoid	46%
Neutral	40%
Prefer GMOs	14%

Source: **naturalgrocers.com/health-hotline-article/are-you-savvy-non-gmo-shopper**

Visit these two websites to make sense of the Non-GMO food market and the GMO food market:
- Non-GMO: **fortunebusinessinsights.com/non-gmo-food-market-106359**
- GMO: **researchnester.com/reports/genetically-modified-gmo-food-market/117**

Reflection

1. What patterns do you notice in public sentiment toward GMOs from social media vs consumer sentiment?

2. How does consumer sentiment compare to the projected sales growth of GMO and non-GMO products? What does this suggest about future market trends?

3. If you were a farmer, would you choose to invest in GM crops based on this data? Why or why not?

4. What role does social media play in shaping consumer attitudes towards GMOs?

5. How could misleading graphs be created using this data to either support of oppose GMOs?

Scenario 7: Should a farmer transition to biofuels?

Background

Farmer Sandy owns a large corn and soybean farm in the midwest, where she also operates several large trucks and tractors that run on gasoline and diesel. Recently, she has been considering switching some or all of her farm equipment to biofuels, specifically ethanol (E85) and biodiesel (B20).

Many farmers have started using biofuels as a cost-saving and environmentally friendly alternative to petroleum-based fuels. However, there are concerns about fuel efficiency, long-term costs, and performance in farm equipment.

Farmer Sandy wants to analyze the data before making a final decision. She needs to understand:

1. How do biofuels compare to gasoline and diesel in terms of fuel efficiency and cost?
2. How much could I reduce greenhouse gas emissions by switching to biofuels?
3. Would switching to biofuels benefit my farm financially in the long run?

Essentially, Farmer Sandy needs you to answer: ***"Should I transition my farm equipment to biofuels, or will conventional gasoline and diesel remain the better option?"***

Your task

1. Research this phenomenon to gain background knowledge.
2. Create comparative graphs to illustrate:
    a. The energy content per gallon of each fuel type
    b. The percentage reduction in greenhouse gas emissions when using biofuels compared to their petroleum counterparts
    c. The average cost per gallon of each fuel type
3. Analyze the data to determine answers to each of her questions.
4. Take a stance!
    a. If you were a biofuel industry representative, how would you present this data to Farmer Sandy?
    b. If you were a conventional fuel supplier, how would you present this data to Farmer Sandy?
5. Present your findings to Farmer Sandy. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data so that you can recommend if she should swap to biofuel equipment.

Data sets for analysis

Energy content per gallon and fuel efficiency

Fuel type	Energy content (BTU per gallon)	Estimate miles per gallon
Gasoline	114,000	12 mpg
Diesel	129,500	15 mpg
Ethanol (E85)	81,800	9 mpg
Biodiesel (B20)	126,700	14 mpg

Source: `afdc.energy.gov`

Greenhouse gas emission reduction

Fuel type	Percentage reduction in greenhouse gas emissions compared to petroleum fuels	Estimate miles per gallon
Ethanol (E85)	12% lower than gasoline	12 mpg
Biodiesel (B20)	16% lower than diesel	15 mpg
Ethanol (E85)	81,800	9 mpg
Biodiesel (B20)	126,700	14 mpg

Source:

Average fuel prices

Fuel type	Average price per gallon
Gasoline	$3.25
Diesel	$3.64
Ethanol (E85)	$2.74
Biodiesel (B20)	$3.53

Source:

Reflection

1. What patterns do you notice when comparing traditional fuels to biofuels?

2. Based on the data, should Farmer Sandy transition her farm equipment to biofuels?

3. What other considerations should Farmer Sandy consider in the short term if she were to switch to biofuels?

4. What other considerations should Farmer Sandy consider in the long term if she were to switch to biofuels?

5. How could misleading graphs be used to support or oppose the adoption of biofuels in agriculture?

Scenario 8: Cow nutrition and milk production

Background

At Farmer Shane's dairy, dairy herds are split into different pens/groups based on the animal's age, stage of lactation, level of milk production, and/or stage of pregnancy. A lactating cow (one that is producing milk) requires increased levels of energy (carbohydrates and fats), in the form of an energy concentrate, and protein in order to sustain their body weight, level of milk production, and pregnancy/calf development. Lactating dairy cows also need to eat more than dry cows, consuming 3.5–4.5% of their body weight daily, while dry cows will consume only 2–3% of their body weight. Sometimes, the energy concentrate is made up of non-edible by-products such as citrus pulp, cottonseed hulls and sugarcane fibers.

Farmer Shane is interested in investigating these by-products for her lactating dairy cows. By-products are generally cheaper or even free as they are waste products from other industries. Help her answer this question: "***Is it worth it to add by-products to her cow's diet?***"

Your task

1. Research this phenomenon to gain background knowledge. (i.e. how many days does a cow produce milk across a year?)
2. Create two graphs:
   a. One that shows the diet's and milk production.
   b. One that shows milk production and feed costs
3. Analyze the difference between milk production of the two diets and the cost of feed vs the loss of production.
4. Take a stance!
   a. How might you show the difference if you sold the non-human edible byproducts?
   b. How might you show the difference if you were a dairy cattle feed producer?
5. Present your findings to Farmer Shane. Be sure to include both points of view in your presentation as well as a "fair" graph that correctly depicts the data. What would you recommend she do: Feed the by-products or not.

Data set for analysis

Diet	Milk production (kg/day)	Cost of TMR
Conventional TMR (total mixed ration)	41	$7
Non-human edible TMR (total mixed ration)	39	$4.50

Reflection

1. How does feeding a diet with non-human edible TMR impact milk production?

2. If Farmer Shane has a milking herd of 100 cows, and they decreased milk production by 2 kg/day, how many kg would that add up to across the cow's total milk?

3. 1 kg equals 0.02 hundredweight, which is the unit in which dairy farmers are paid. If Farmer Shane gets $12.31/hundredweight, how much might she lose in revenue across a year at this price?

4. What do you recommend Farmer Shane feed her milking cows? Give evidence for your answer.