ACTIVITY 7

Reducing Scientific Uncertainty

INVESTIGATION

Sunshine, temperature, wind, and rain are some of the factors that you may consider when going outside to fly a kite. These are some of the same factors that affect outdoor air quality.

7: REDUCING SCIENTIFIC UNCERTAINTY

GUIDING QUESTION

What are ways to collect and analyze data to reduce scientific uncertainty?

INTRODUCTION

Probabilistic reasoning helps assess the chances of different outcomes. People use this kind of thinking all the time in daily life, such as deciding which line in the grocery store will be the fastest or how likely it is to rain on a particular day. Important decisions often have to be made when there is scientific uncertainty. Data may be incomplete, unclear, or different from one source to another. In this activity, you will apply probabilistic reasoning to the analysis of air quality data in a fictional community and investigate the effect of systematic error on conclusions.

Changes that occur in a community, such as construction projects, may sometimes affect local air quality.

CONCEPTUAL TOOLS

MATERIALS LIST

FOR EACH PAIR OF STUDENTS

- SET OF 6 COLORED PENCILS: green, yellow, orange, red, purple, and maroon
- RULER

FOR EACH STUDENT

- 2 STUDENT SHEETS 7.1 "Map of Kairoba"

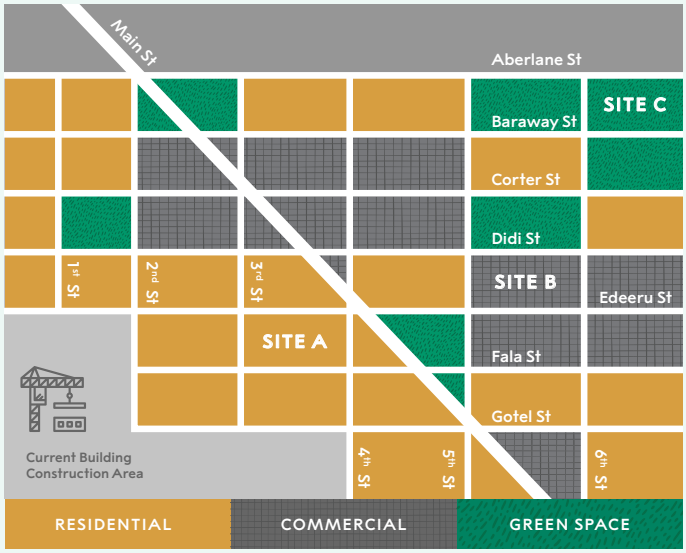
PROCEDURE

PART A: KAIROBA'S AIR QUALITY

1 Read the following fictional scenario.

THE KAIROBA JOURNAL

Local Residents Protest Against New Construction



The city of Kairoba is experiencing a population boom, and city planners are building more housing for the growing population. Many residents who live in neighborhoods near new construction have complained that the air quality has become noticeably worse since building started. They report an increase in asthma and coughs. Local officials point out that the construction work has created new jobs and will provide new housing in Kairoba. For the past 10 years, some residents who were concerned about local air quality bought and installed air quality sensors at intersections near their homes. They plan to use the data from these air quality sensors to influence where future housing construction takes place.

2 Your group of four will role-play air quality experts making a recommendation to the city about which of three locations to build another housing development: Site A, Site B, or Site C. Discuss with your group how a construction project might affect the air quality (both short-term and long-term) at each potential housing site and what type of data could support your ideas.

3 Residents have provided some initial air quality data from their sensors. Your first step is to map the sensor data found in Table 1 on a town map. Decide which half of your group will map the data for October 25 and which half will map the data for November 1 (one week after work at the construction site began).

TABLE 7.1
Kairoba's Air Quality Index (AQI) Data

SENSOR	SENSOR LOCATION	AQI ON OCT 25	AQI ON NOV 1
1	ABERLANE & 2ND	22	36
2	ABERLANE & 5TH	57	39
3	BARAWAY & MAIN	30	45
4	BARAWAY & 6TH	87	35
5	CORTER & 4TH	44	38
6	DIDI & 2ND	61	84
7	DIDI & 5TH	91	81
8	EDEERU & 6TH	91	91
9	FALA & 5TH	55	48
10	GOTEL & 6TH	101	141

4 Record your chosen date of data collection on the line provided at the top of Student Sheet 7.1, "Map of Kairoba." Work with your partner to map the data for your chosen date on your copy of Student Sheet 7.1 by writing the AQI value at the intersection of each pair of streets on the map. Note that the town of Kairoba is laid out on a grid, with numbered streets going from west to east and named streets going from north to south in alphabetical order. Main Street intersects diagonally across the town.

5 Use colored pencils to circle each AQI value on your map with the color of the AQI category it falls into, as shown in Figure 7.1.

FIGURE 7.1
Air Quality Index (AQI)

AQI CATEGORY (COLOR)	INDEX VALUE	DESCRIPTION OF AIR QUALITY
Good (green)	0–50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate (yellow)	51–100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive* to air pollution.
Unhealthy for Sensitive* Groups (orange)	101–150	Members of sensitive* groups may experience health effects. The general public is less likely to be affected.
Unhealthy (red)	151–200	Some members of the general public may experience health effects. Members of sensitive* groups may experience more serious health effects.
Very Unhealthy (purple)	201–300	Health alert: The risk of health effects is increased for everyone.
Hazardous (maroon)	301 AND HIGHER	Health warning of emergency conditions: Everyone is more likely to be affected.

* According to the American Lung Association, sensitive groups include children under 18, adults over 65, people with chronic heart or lung disease, people who are pregnant, and people with diabetes. Adults who are active outdoors, including outdoor workers and frequent outdoor exercisers, can be considered sensitive because of prolonged exposure to outside air.

6 With your partner, examine your maps and discuss the following questions.

- What is the range of AQI data on this date?
- What can you conclude about the air quality of Kairoba on this date?

7 Calculate the average AQI on your date and record it in the space provided at the top of Student Sheet 7.1. Then, discuss with your partner how the average AQI compares to the range of AQI data you both mapped.

8 Compare your mapped data and AQI average with the data from the other half of your group (who looked at data from the other date). Then discuss the following questions:

- How did the air quality compare on October 25 vs. November 1?
- Does the mapped data support the claim from the article that the air quality is not affected by construction? Why or why not?
- Explain what additional data would reduce uncertainty in this conclusion.

PART B: MAPPING ADDITIONAL DATA

9 Other local residents shared their data from three additional sensors installed close to the construction site. Record AQI data from these three sensors for the original date and times, as shown in Rows 11–13 of Table 7.2. (All previously collected data from Table 7.1 is shaded.) Plot the additional data from the 3 new sensors on your corresponding Oct. 25 and Nov. 1 maps.

10 Residents also collected data from all 13 sensors on Nov. 8 while construction on the foundation of the building was ongoing (as shown in the last column of Table 7.2). You will receive another copy of Student Sheet 7.1. On your new copy of the student sheet:

- **a** plot all the data for Nov. 8.
- **b** circle each AQI number with the color of the AQI category it falls into, as shown in Figure 7.1.
- **c** calculate and record the average AQI for Nov. 8. Then, discuss with your partner how the average AQI compares to the range of AQI data that you mapped and how it affects your conclusions.

TABLE 7.2
Kairoba's Air Quality Index (AQI) Data with Additional Sensors

SENSOR	SENSOR LOCATION	AQI ON OCT 25	AQI ON NOV 1	AQI ON NOV 8
1	ABERLANE & 2ND	22	36	32
2	ABERLANE & 5TH	57	39	42
3	BARAWAY & MAIN	30	45	40
4	BARAWAY & 6TH	87	35	42
5	CORTER & 4TH	44	38	29
6	DIDI & 2ND	61	84	14
7	DIDI & 5TH	91	81	40
8	EDEERU & 6TH	91	91	49
9	FALA & 5TH	55	48	40
10	GOTEL & 6TH	101	141	51
11*	FALA & 2ND	81	200	221
12*	GOTEL & 3RD	103	199	212
13*	GOTEL & 4TH	76	259	301

* Newly discovered air quality data.

11 Discuss with your group what you can conclude about the air quality of Kairoba on November 8.

12 With your group, place the three maps in the order of their dates. Then discuss:

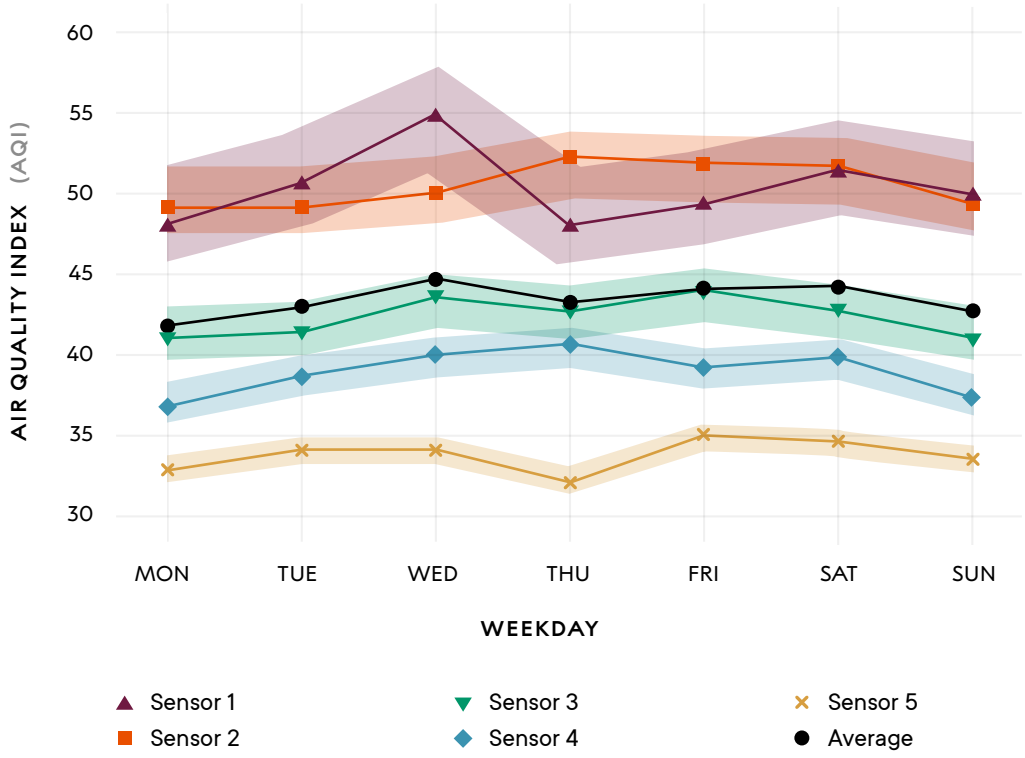
- What systematic error from the initial data set was corrected for when you found the three additional sensors?
- Does this larger data set support the article's claim that the construction has no impact on AQI? Use the data to explain your answer.
- What additional evidence would you want to collect to reduce uncertainty in your conclusion?

BUILD UNDERSTANDING

① Describe at least two possible sources of systematic error when collecting and analyzing air quality data. Then explain how you could address each of these errors to reduce your uncertainty in the data.

② The graph in Figure 7.2 shows daily average AQI at 5 sites in 1 city over the course of a week. The shaded areas indicate the 95% confidence interval of the daily averages at each site. The black line represents the average of the 5 sites for each day.

FIGURE 7.2
AQI Readings for 5 Sites in 1 City



a Based on the confidence intervals of each sensor, identify which sensor has the least uncertainty and which has the most uncertainty. Describe how this affects your conclusions about the data.

b A city official proudly claims that the city's AQI is always good (0–50). Do you agree? Support your answer with evidence.

c Would you be more concerned about your local air quality if you lived near Sensor 1 or Sensor 5? Explain.

③ It is time for the city of Kairoba to make a decision about which site to build. As part of their decision-making, they have created a table of additional considerations. Based on your work in the activity and the information in Table 7.3, where would you recommend the city build? Support your answer with evidence and identify the trade-offs of your decision.

TABLE 7.3
Additional Housing Considerations

	SITE A	SITE B	SITE C
NUMBER OF PROPOSED APARTMENTS	100	100	75
RELATIVE COST TO BUILD	$$	$	$$$

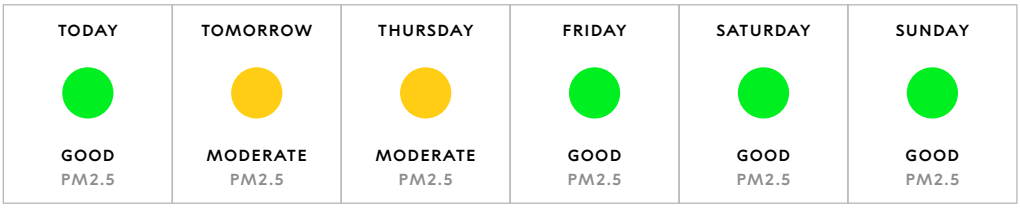
CONNECTIONS TO EVERYDAY LIFE

④ The U.S. Environmental Protection Agency (EPA) provides air quality forecasts for cities and counties around the United States. Look at the air quality forecast in Figure 7.3, which shows PM2.5 levels over a period of six days.

a What do you predict the PM2.5 levels are likely to be on Monday? Explain your answer, using probabilistic reasoning.

b What additional information could reduce uncertainty in your prediction?

FIGURE 7.3
Air Quality Forecast



⑤ Examine Figure 7.4, which shows dots when emergency room (ER) visits due to asthma are higher than average.

Suppose you want to know if wildfire smoke was a cause for this increase. Explain what conclusions you could make from the data in this graph. Be sure to include the following in your explanation:

- Describe the patterns you observe between wildfires and ER visits due to asthma.
- Describe the part of the graph that looks like a signal.
- Considering the relationship between wildfires and ER visits due to asthma, describe which day(s) appear to be noise.
- Explain what could have created this noise in the data.
- Explain what conclusions you can make about the relationship between wildfires and ER visits due to asthma.

FIGURE 7.4
Emergency Room Visits for City Region 1