Name _____ Class _____ Date _____

8.1 Two-Way Frequency Tables

Essential Question: How can categorical data for two categories be summarized?

Resource Locker

Explore Categorical Data and Frequencies

Data that can be expressed with numerical measurements are **quantitative data**. In this lesson you will examine qualitative data, or **categorical data**, which cannot be expressed using numbers. Data describing animal type, model of car, or favorite song are examples of categorical data.

A Circle the categorical data variable. Justify your choice.

temperature weight height color

B Identify whether the given data is categorical or quantitative.

large, medium, small _____

120 ft^2, 130 ft^2, 140 ft^2 _____

C A **frequency** table shows how often each item occurs in a set of categorical data. Use the categorical data listed on the left to complete the frequency table.

Ways Students Get to School
bus car walk car car car bus walk walk walk bus bus car bus bus walk bus car bus car

Way	Frequency
bus	8
car	
_____	

Reflect

1. How did you determine the numbers for each category in the frequency column?

2. What must be true about the sum of the frequencies in a frequency table?

Explain 1 Constructing Two-Way Frequency Tables

If a data set has two categorical variables, you can list the frequencies of the paired values in a **two-way frequency table**.

Example 1 **Complete the two-way frequency table.**

(A) A high school's administration asked 100 randomly selected students in the 9th and 10th grades about what fruit they like best. Complete the table.

	Preferred Fruit			
Grade	**Apple**	**Orange**	**Banana**	**Total**
9th	19	12	23	
10th	22	9	15	
Total				

Row totals:

9th: $19 + 12 + 23 = 54$

10th: $22 + 9 + 15 = 46$

Column totals:

Apple: $19 + 22 = 41$

Orange: $12 + 9 = 21$

Banana: $23 + 15 = 38$

Grand total:

Sum of row totals: $54 + 46 = 100$

Sum of column totals: $41 + 21 + 38 = 100$

Both sums should equal the grand total.

	Preferred Fruit			
Grade	**Apple**	**Orange**	**Banana**	**Total**
9th	19	12	23	54
10th	22	9	15	46
Total	41	21	38	100

(B) Jenna asked some randomly selected students whether they preferred dogs, cats, or other pets. She also recorded the gender of each student. The results are shown in the two-way frequency table below. Each entry is the frequency of students who prefer a certain pet and are a certain gender. For instance, 8 girls prefer dogs as pets. Complete the table.

	Preferred Pet			
Gender	**Dog**	**Cat**	**Other**	**Total**
Girl	8	7	1	
Boy	10	5	9	
Total				

Row totals:

Girl: $8 + 7 + 1 =$ ☐

Boy: $10 + 5 + 9 =$ ☐

Column totals:

Dog: $8 + 10 =$ ☐

Cat: $7 + 5 =$ ☐

Other: $1 + 9 =$ ☐

Grand total:

Sum of row totals: $16 +$ ☐ $=$ ☐

Sum of column totals: $18 +$ ☐ $+$ ☐ $=$ ☐

Both sums should equal the grand total.

Reflect

3. Look at the totals for each row. Was Jenna's survey evenly distributed among boys and girls? Explain.

_____

4. Look at the totals for each column. Which pet is preferred by the most students? Justify your answer.

_____

Your Turn

Complete the two-way frequency table.

5. Antonio surveyed 60 of his classmates about their participation in school activities and whether they have a part-time job. The results are shown in the two-way frequency table below. Complete the table.

	Activities				
Job	**Clubs Only**	**Sports Only**	**Both**	**Neither**	**Total**
Yes	12	13	16	4	
No	3	5	5	2	
Total					

6. Jen surveyed 100 students about whether they like baseball or basketball. Complete the table.

	Like Basketball		
Like Baseball	**Yes**	**No**	**Total**
Yes	61	13	
No	16	10	
Total			

Explain 2 Reading Two-Way Frequency Tables

You can extract information about paired categorical variables by reading a two-way frequency table.

Example 2 **Read and complete the two-way frequency table.**

(A) Suppose you are given the circled information in the table and instructed to complete the table.

	Eat Cereal for Breakfast		
Gender	**Yes**	**No**	**Total**
Girl	(42)	(12)	(54)
Boy	36	(10)	46
Total	78	22	100

Find the total number of boys by subtracting: $100 - 54 = 46$

Find the number of boys who do eat cereal by subtracting: $46 - 10 = 36$

Add to find the total number of students who eat cereal and the total number of students who do not eat cereal.

Ⓑ One hundred students were surveyed about which beverage they chose at lunch. Some of the results are shown in the two-way frequency table below. Complete the table.

	Lunch Beverage			
Gender	**Juice**	**Milk**	**Water**	**Total**
Girl	10		17	
Boy	15	24	21	60
Total				

Find the total number of girls by subtracting: $100 - 60 =$ ☐

So, the total number of girls is ☐. The number of girls who do not choose milk is ☐ + ☐ = ☐.

Find the number of girls who chose milk by subtracting: ☐ − ☐ = ☐

Reflect

7. Which lunch beverage is the least preferred? How do you know?

Your Turn

Read and complete the two-way frequency table.

8. 100 students were asked what fruit they chose at lunch. The two-way frequency table shows some of the results of the survey. Complete the table.

	Lunch Fruit			
Gender	**Apple**	**Pear**	**Banana**	**Total**
Girl		17	11	49
Boy		10	16	
Total				

9. 200 high school teachers were asked whether they prefer to use the chalkboard or projector in class. The two-way frequency table shows some of the results of the survey. Complete the table.

	Preferred Teaching Aid		
Gender	**Chalkboard**	**Projector**	**Total**
Female		56	99
Male	44		
Total	87	113	200

Elaborate

10. You are making a two-way frequency table of 5 fruit preferences among a survey sample of girls and boys. What are the dimensions of the table you would make? How many entries would you need to fill the table with frequencies and totals?

11. A 3 categories-by-3 categories two-way frequency table has a row with 2 numbers, and no row or column totals. Can you fill the row?

12. **Essential Question Check-In** How can you summarize categorical data for 2 categories?

Evaluate: Homework and Practice

- Online Homework
- Hints and Help
- Extra Practice

1. Identify whether the given data is categorical or quantitative.

gold medal, silver medal, bronze medal _____

100 m, 200 m, 400 m _____

2. A theater company asked its members to bring in canned food for a food drive. Use the categorical data to complete the frequency table.

Cans Donated to Food Drive
peas corn peas soup corn
corn soup soup corn peas
peas corn soup peas corn
peas corn peas corn soup
corn peas soup corn corn

Cans	Frequency
soup	
peas	

Complete the two-way frequency table.

3. James surveyed some of his classmates about what vegetable they like best. Complete the table.

	Preferred Vegetable			
Grade	**Carrots**	**Green Beans**	**Celery**	**Total**
9th	30	15	24	
10th	32	9	20	
Total				

4. A high school's extracurricular committee surveyed a randomly selected group of students about whether they like tennis and soccer. Complete the table.

	Like Tennis		
Like Soccer	**Yes**	**No**	**Total**
Yes	37	20	
No	16	15	
Total			

5. After a school field trip, Ben surveyed some students about which animals they liked from the zoo. Complete the table.

	Preferred Animal at a Zoo			
Grade	**Lion**	**Zebra**	**Monkey**	**Total**
11th	9	15	14	
12th	4	17	15	
Total				

6. Jill asked some randomly selected students whether they preferred blue, green, or other colors. She also recorded the gender of each student. The results are shown in the two-way frequency table below. Complete the table.

	Preferred Color			
Gender	**Green**	**Blue**	**Other**	**Total**
Girl	15	3	10	
Boy	3	16	6	
Total				

7. Kevin surveyed some students about whether they preferred soccer, baseball, or another sport. He also recorded their gender. Complete the table.

	Preferred Sport			
Gender	**Soccer**	**Baseball**	**Other**	**Total**
Girl	33	7	10	
Boy	15	27	7	
Total				

8. A school surveyed a group of students about whether they like backgammon and chess. They will use this data to determine whether there is enough interest for the school to compete in these games. Complete the table.

	Like Backgammon		
Like Chess	**Yes**	**No**	**Total**
Yes	10	61	
No	5	3	
Total			

9. Hugo surveyed some 9th and 10th graders in regard to whether they preferred math, English, or another subject. The results of the survey are in the following table. Complete the table.

	Preferred Subject			
Grade	**Math**	**English**	**Other**	**Total**
9th	40	35	20	
10th	41	32	17	
Total				

10. Luis surveyed some middle school and high school students about the type of music they prefer. Complete the table.

	Preferred Music			
School Level	**Country**	**Pop**	**Other**	**Total**
Middle School	18	13	23	
High School	7	32	15	
Total				

11. Natalie surveyed some teenagers and adults on whether they prefer standard cars, vans, or convertibles. Her results are in the following table. Complete the table.

	Preferred Car Type			
Age	**Standard**	**Van**	**Convertible**	**Total**
Adults	10	25	9	
Teenagers	11	7	24	
Total				

12. Eli surveyed some teenagers and adults on whether they prefer apples, oranges, or bananas. His results are in the following table. Complete the table.

	Preferred Fruit			
Age	**Apple**	**Orange**	**Banana**	**Total**
Adults	22	12	10	
Teenagers	24	9	9	
Total				

200 students were asked to name their favorite science class. The results are shown in the two-way frequency table. Use the table for the following questions.

	Favorite Science Class			
Gender	**Biology**	**Chemistry**	**Physics**	**Total**
Girl	42	39	23	104
Boy		45	32	
Total				

13. How many boys were surveyed? Explain how you found your answer.

14. Complete the table. How many more girls than boys chose biology as their favorite science class? Explain how you found your answer.

The results of a survey of 150 students about whether they own an electronic tablet or a laptop are shown in the two-way frequency table.

	Device				
Gender	**Electronic tablet**	**Laptop**	**Both**	**Neither**	**Total**
Girl	15	54		9	88
Boy		35	8	5	
Total					

15. Complete the table. Do the surveyed students own more laptops or more electronic tablets?

16. Which group had more people answer the survey, boys or students who own an electronic tablet only? Explain.

17. The table shows the results of a survey about students' preferred frozen yogurt flavor. Complete the table, and state the flavors that students preferred the most and the least.

	Preferred Flavor			
Gender	**Vanilla**	**Mint**	**Strawberry**	**Total**
Girl		15	18	45
Boy	17	25		
Total				100

18. Teresa surveyed 100 students about whether they like pop music or country music. Out of the 100 students surveyed, 42 like only pop, 34 like only country, 15 like both pop and country, and 9 do not like either pop or country. Complete the two-way frequency table.

	Like Pop		
Like Country	**Yes**	**No**	**Total**
Yes			
No			
Total			

19. Forty students in a class at an international high school were surveyed about which non-English language they can speak. Complete the table.

	Foreign Language			
Gender	**Chinese**	**Spanish**	**French**	**Total**
Girl	7	8		
Boy		6	7	18
Total				

Luis surveyed 100 students about whether they like soccer. The number of girls and the number of boys completing the survey are equal.

20. Complete the table.

	Likes Soccer		
Gender	**Yes**	**No**	**Total**
Girl		20	
Boy		35	
Total			100

21. Twice as many girls like soccer as the number that like tennis. The same number of students like soccer as like tennis. Construct a table containing the tennis data.

22. A group of 200 high school students were asked about their use of email and text messages. The results are shown in the two-way frequency table. Complete the table.

	Text Messages		
Email	**Yes**	**No**	**Total**
Yes	72		90
No		45	
Total			

23. Circle the letter of each data set that is categorical. Select all that apply.

A. 75°, 79°, 77°, 85°

B. apples, oranges, pears

C. male, female

D. blue, green, red

E. 2 feet, 5 feet, 12 feet

F. classical music, country music

G. 1 centimeter, 3 centimeters, 9 centimeters

24. **Explain the Error** Find the mistake in completing the two-way frequency table for a survey involving 50 students. Then complete the table correctly.

	Favorite Foreign Language Class			
Gender	**Russian**	**German**	**Italian**	**Total**
Girl	8	8	8	24
Boy	42	9	7	58
Total	50			

Correct table:

	Favorite Foreign Language Class			
Gender	**Russian**	**German**	**Italian**	**Total**
Girl	8	8	8	24
Boy		9	7	
Total				

H.O.T. Focus on Higher Order Thinking

25. Justify Reasoning Charles surveyed 100 boys about their favorite color. Of the 100 boys surveyed, 44 preferred blue, 25 preferred green, and 31 preferred red.

a. Explain why it is not possible to make a two-way frequency table from the given data.

b. Suppose Charles also surveyed some girls. Of the girls surveyed, 30 preferred blue and 43 preferred green. Can Charles make a two-way frequency table now? Can he complete it?

26. Persevere in Problem Solving Shown are two different tables about a survey involving students. Each survey had a few questions about musical preferences. All students answered all questions. Complete the tables. What type of music do the students prefer?

	Likes Classical Music		
Gender	**Yes**	**No**	**Total**
Girl	21		
Boy		22	
Total			100

	Likes Blues Music		
Gender	**Yes**	**No**	**Total**
Girl		15	49
Boy		15	
Total			

Lesson Performance Task

Two hundred students were asked about their favorite sport. Of the 200 students surveyed, 98 were female. Some of the results are shown in the following two-way frequency table.

	Favorite Sport				
Gender	**Football**	**Baseball**	**Basketball**	**Soccer**	**Total**
Female			36	12	
Male	38	19			
Total	64			36	

a. Complete the table.

b. Which sport is the most popular among the students? Which is the least popular? Explain.

c. Which sport is most popular among the females? Which sport is most popular among the males? Explain.

Name _____ Class _____ Date _____

8.2 Relative Frequency

Essential Question: How can you recognize possible associations and trends between two categories of categorical data?

Resource Locker

Explore Relative Frequencies

To show what portion of a data set each category in a frequency table makes up, you can convert the data to *relative frequencies*. The **relative frequency** of a category is the frequency of the category divided by the total of all frequencies.

The frequency table below shows the results of a survey Kenesha conducted at school. She asked 80 randomly selected students whether they preferred basketball, football, or soccer.

Favorite Sport	Basketball	Football	Soccer	Total
Frequency	20	32	28	80

(A) Use the frequencies to make a relative frequency table expressed with decimals.

Favorite Sport	Basketball	Football	Soccer	Total
Relative Frequency	$\frac{20}{80} = 0.25$			$\frac{80}{80} =$ ☐

(B) Rewrite the relative frequency table using percents instead of decimals.

Favorite Sport	Basketball	Football	Soccer	Total
Relative Frequency	25%			

Reflect

1. Explain what the numerator and denominator of the ratio $\frac{20}{80}$ refer to in part A.

_____

_____

2. What types of numbers can you use to write relative frequencies?

_____

_____

Explain 1 Two-Way Relative Frequency Tables

Two types of relative frequencies are found in a relative frequency table:

1. A **joint relative frequency** is found by dividing a frequency that is not in the Total row or the Total column by the grand total. It tells what portion of the total has both of the two specified characteristics.

2. A **marginal relative frequency** is found by dividing a row total or a column total by the grand total. It tells what portion of the total has a specified characteristic.

Example 1 **Complete a two-way relative frequency table from the data in a two-way frequency table. Identify the joint relative frequencies and the marginal relative frequencies.**

(A) For her survey about sports preferences, Kenesha also recorded the gender of each student. The results are shown in the two-way frequency table for Kenesha's data.

	Preferred Sport			
Gender	**Basketball**	**Football**	**Soccer**	**Total**
Girl	6	12	18	36
Boy	14	20	10	44
Total	20	32	28	80

To find the relative frequencies, divide each frequency by the grand total.

	Preferred Sport			
Gender	**Basketball**	**Football**	**Soccer**	**Total**
Girl	$\frac{6}{80} = 0.075$	$\frac{12}{80} = 0.15$	$\frac{18}{80} = 0.225$	$\frac{36}{80} = 0.45$
Boy	$\frac{14}{80} = 0.175$	$\frac{20}{80} = 0.25$	$\frac{10}{80} = 0.125$	$\frac{44}{80} = 0.55$
Total	$\frac{20}{80} = 0.25$	$\frac{32}{80} = 0.4$	$\frac{28}{80} = 0.35$	$\frac{80}{80} = 1$

The joint relative frequencies tell what percent of all those surveyed are in each category:

- 7.5% are girls who prefer basketball.
- 15% are girls who prefer football.
- 22.5% are girls who prefer soccer.
- 17.5% are boys who prefer basketball.
- 25% are boys who prefer football.
- 12.5% are boys who prefer soccer.

The marginal relative frequencies tell what percent of totals has a given single characteristic:

- 25% prefer basketball.
- 40% prefer football.
- 35% prefer soccer.
- 45% are girls.
- 55% are boys.

Ⓑ Millie performed a survey of students in the lunch line and recorded which type of fruit each student selected along with the gender of each student. The two-variable frequency data she collected is shown in the table.

	Fruit			
	Apple	**Banana**	**Orange**	**Total**
Girl	16	10	14	40
Boy	25	13	14	52
Total	41	23	28	92

	Fruit			
	Apple	**Banana**	**Orange**	**Total**
Girl	17.4%			
Boy	27.2%			
Total	44.6%			

The joint relative frequencies:

- ☐ are girls who selected an apple.
- ☐ are girls who selected a banana.
- ☐ are girls who selected an orange.
- ☐ are boys who selected an apple.
- ☐ are boys who selected a banana.
- ☐ are boys who selected an orange.

The marginal relative frequencies:

- ☐ selected an apple.
- ☐ selected a banana.
- ☐ selected an orange.
- ☐ are girls.
- ☐ are boys.

Reflect

3. **Discussion** Explain how you can use joint and marginal relative frequencies to check your relative frequency table.

Your Turn

Use the two-way table of data from another student survey to answer the following questions.

	Like Aerobic Exercise		
Like Weight Lifting	**Yes**	**No**	**Total**
Yes	7	14	21
No	12	7	19
Total	19	21	40

4. Find the joint relative frequency of students surveyed who like aerobics exercise but dislike weight lifting.

5. What is the marginal relative frequency of students surveyed who like weight lifting?

Explain 2 Conditional Relative Frequencies

A **conditional relative frequency** describes what portion of a group with a given characteristic also has another characteristic. A conditional relative frequency is found by dividing a frequency that is not in the Total row or the Total column by the total for that row or column.

Example 2 **Use the joint relative frequencies to calculate the associated conditional relative frequencies and describe what each one means.**

(A) Use the data from Example 1A. Find the conditional relative frequency that a a person in Kenesha's survey prefers soccer, given that the person is a girl.

Divide the number of girls who prefer soccer by the total number of girls.

$$\frac{\text{Number of girls who prefer soccer}}{\text{Total number of girls}} = \frac{18}{36} = 0.5 = 50\%$$

Half of the girls in the sample prefer soccer.

(B) Use the data from Example 1B. Find the conditional relative frequency that a student in Millie's survey chose an orange, given that the student is a boy.

$$\frac{\text{Number of } \square \text{ who chose an orange}}{\text{Total number of } \square} = \frac{\square}{\square} \approx 0.269 = \square\,\%$$

Your Turn

Use the data from Your Turn Exercises 4 and 5 after Example 1.

6. What is the conditional relative frequency that a student likes to lift weights, given that the student does not like aerobics?

7. Find the conditional relative frequency that a student likes to lift weights, given that the student likes aerobics.

Explain 3 Finding Possible Associations

You can analyze two-way frequency tables to locate possible associations or patterns in the data.

Example 3 **Analyze the results of the surveys to determine preferences by gender.**

Kenesha is interested in the question, "Does gender influence what type of sport students prefer?" If there is no influence, then the distribution of gender within each sport preference will roughly equal the distribution of gender within the whole group. Analyze the results of Kenesha's survey from Example 1. Determine which sport each gender is more likely to prefer.

(A) Analyze the data about girls that were surveyed.

Step 1: Identify the percent of all students surveyed who are girls.

$$\frac{36}{80} = 0.45 = 45\%$$

Step 2: Determine each conditional relative frequency.

Basketball	Football	Soccer
Of the 20 students who prefer basketball, 6 are girls. $\frac{6}{20} = 0.3 = 30\%$	Of the 32 students who prefer football, 12 are girls. $\frac{12}{32} = 0.375 = 37.5\%$	Of the 28 students who prefer soccer, 18 are girls. $\frac{18}{28} \approx 0.643 = 64.3\%$

Step 3: Interpret the results by comparing each conditional relative frequency to the percent of all students surveyed who are girls, 45%.

Basketball	Football	Soccer
$30\% < 45\%$ Girls are less likely to prefer basketball.	$37.5\% < 45\%$ Girls are less likely to prefer football.	$64.3\% > 45\%$ Girls are more likely to prefer soccer.

(B) Analyze the data about boys that were surveyed.

Step 1: Identify the percent of all students surveyed who are boys.

$$\frac{\square}{80} = 0.\square = \square\%$$

Step 2: Determine each conditional relative frequency.

Basketball	Football	Soccer
Of the 20 students who prefer basketball, ☐ are boys. $\frac{\square}{20} = 0.\square = \square\%$	Of the ☐ students who prefer football, ☐ are boys. $\frac{\square}{\square} = 0.\square = \square\%$	Of the ☐ students who prefer soccer, ☐ are boys. $\frac{\square}{\square} = 0.\square = \square\%$

Step 3: Interpret the results by comparing each conditional relative frequency to the percent of all students surveyed who are boys, ____%.

Basketball	Football	Soccer
$70\% > 55\%$	$62.5\% > 55\%$	$35.7\% < 55\%$
Boys are more likely to prefer basketball.	Boys are more likely to prefer football.	Boys are less likely to prefer soccer.

Reflect

8. **Making Connections** How can the statement "6 out of the 20 students who prefer basketball are girls" be stated as a conditional relative frequency?

Your Turn

9. Analyze the data given in the Your Turn after Example 1 to determine if liking aerobic exercise influences whether a person also likes weight lifting. Explain.

Elaborate

10. What does it mean to say there is an association between characteristics in a two-way frequency table?

11. **Essential Question Check-In** How can you use two-way frequency data to recognize possible associations between the two categories of categorical data?

Evaluate: Homework and Practice

- Online Homework
- Hints and Help
- Extra Practice

Use the table of frequency data for Exercises 1–4.

Class Survey of Favorite Colors

Favorite Color	Red	Orange	Yellow	Green	Blue	Purple	Total
Frequency	2	5	1	6	8	2	24

1. Complete the relative frequency table for this data using decimals rounded to the nearest thousandth.

Class Survey of Favorite Colors

Favorite Color	Red	Orange	Yellow	Green	Blue	Purple	Total
Relative Frequency							

2. Complete the relative frequency table for this data using percents rounded to the nearest tenth.

Class Survey of Favorite Colors

Favorite Color	Red	Orange	Yellow	Green	Blue	Purple	Total
Relative Frequency							

3. What is the relative frequency of having blue as a favorite color, expressed as a decimal?

4. Which color is a favorite color with a relative frequency of 25%?

The following frequency data shows the number of states, including the District of Columbia, that favored each party in the presidential popular vote in 1976 and in 2012.

	2012 Election		
1976 Election	Democrat	Republican	Total
Democrat	12 =	12 =	24 =
Republican	15 =	12 =	27 =
Total	27 =	24 =	51 =

5. Complete the table above with relative frequencies using percents.

6. What percent switched from Democrat in 1976 to Republican in 2012? What type of frequency is this?

7. What percent voted Republican in 1976? What type of frequency is this?

The results of a survey of 45 students and the foreign language they are studying are shown in the two-way frequency table.

	Language			
Gender	**Chinese**	**French**	**Spanish**	**Total**
Girl	2	8	15	25
Boy	4	4	12	20
Total	6	12	27	45

8. Fill in the table of two-way relative frequencies using decimals, rounded to the nearest thousandth.

	Language			
Gender	**Chinese**	**French**	**Spanish**	**Total**
Girl				
Boy				
Total				

9. What fraction of the surveyed students are boys taking Spanish?

10. What fraction of the surveyed students are taking Chinese?

In some states, a driver of a vehicle may not use a handheld cell phone while driving. In one state with this law, 250 randomly selected drivers were surveyed to determine the association between drivers who know the law and drivers who obey the law. The results are shown in the table below.

11. Complete the table of two-way relative frequencies using percents.

	Knows the Law		
Obeys the Law	**Yes**	**No**	**Total**
Yes	160 =	45 =	
No	25 =	20 =	
Total			

12. What is the relative frequency of drivers who know and obey the law?

13. What is the relative frequency of drivers who know the law?

Refer to the election data from Exercises 5–7. Answer using percents rounded to the nearest tenth.

14. What is the conditional relative frequency of a state's popular vote being won by the Democrat in 2012, given that it was won by the Democrat in 1976?

15. What is the conditional relative frequency of a state's popular vote being won by the Democrat in 1976, given that it was won by the Democrat in 2012?

Refer to the language data from Exercises 8–10. Answer using decimals rounded to the nearest thousandth.

16. What fraction of girls are studying French?

17. What fraction of Spanish students are boys?

Refer to the cell phone law data from Exercises 11–13. Answer using percents rounded to the nearest tenth.

18. What percent of drivers obey the law despite not knowing the law?

19. What is the conditional relative frequency of drivers who obey the law, given that they know the law?

Use the previously described data to determine whether there are associations between the categories surveyed.

20. Refer to the election data from Exercises 5–7. Is there an association between the party that won the popular vote in a state in 1976 and in 2012?

21. Refer to the language data from Exercises 8–10. Can you use gender to predict a preference for taking Spanish?

22. Refer to the language data from Exercises 8–10. Is there an association between gender and a preference for French?

23. Refer to the cell phone law data from Exercises 11–13. Most drivers who don't know that it is illegal to operate a cell phone while driving obey the law anyway, presumably out of a general concern for safe driving. Does this mean there is no association between knowledge of the cell phone law and obeying the cell phone law?

24. **Multipart Classification** Classify each statement as describing a *joint*, *marginal*, or *conditional* relative frequency.

a. In a study on age and driving safety, 33% of drivers were considered younger and a high accident risk.

b. In a study on age and driving safety, 45% of older drivers were considered a high accident risk.

c. In a study on age and driving safety, 67% of drivers were classified as younger.

d. In a pre-election poll, 67% of the respondents who preferred the incumbent were men.

e. In a pre-election poll, 33% of women preferred the challenger.

f. In a pre-election poll, 16% of respondents were men who preferred the challenger.

H.O.T. Focus on Higher Order Thinking

25. **Explain the Error** In the survey on gender and fruit selection (Example 1B), Millicent notices that given a preference for oranges, the conditional relative frequencies of a student being a boy or a girl are the same. She concludes that there is no association between gender and orange preference. Explain her error.

26. **Communicate Mathematical Ideas** Can a joint relative frequency be greater than either of the conditional relative frequencies associated with it? Explain your reasoning.

27. **Explain the Error** Refer to the cell phone data from Exercises 11–13. Cole found the conditional relative frequency that a driver surveyed does not know the law, given that the driver obeys the law, by dividing 45 by 250. Explain Cole's error.

Lesson Performance Task

Eighty students were surveyed about playing an instrument. The results are shown in the two-way frequency table.

	Play an Instrument		
Gender	**Yes**	**No**	**Total**
Female	28	17	45
Male	20	15	35
Total	48	32	80

a. Complete the two-way relative frequency table for the data.

	Play an Instrument		
Gender	**Yes**	**No**	**Total**
Female			
Male			
Total			

b. What percent of the students surveyed play an instrument? What percent of the males surveyed do not play an instrument? Identify what type of frequency each percent is.

c. Is there an association between the sex of a student and whether the student plays an instrument? Explain.