

Two-Way Tables & Bivariate Categorical Data

Complete Unit Resource — Grade 8

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Full Worked Solutions for Every Problem

Aligned to CCSS.MATH.CONTENT.8.SP.A.4

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GUIDED NOTES • TOPIC 1: TWO-WAY TABLES FOUNDATIONS

Topic 1: Two-Way Tables Foundations

CCSS.MATH.CONTENT.8.SP.A.4: Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table.

What is Bivariate Categorical Data?

In previous grades, you analyzed single variables (like the heights of students in your class). Now, we look at **bivariate** data, which involves **two** variables at the same time. When both of these variables are categorical (describing qualities or categories rather than numbers), we call it **bivariate categorical data**.

Examples of Bivariate Categorical Variables:

- Favorite School Subject vs. Grade Level
- Having a Curfew vs. Doing Daily Chores
- Type of Pet Owned vs. Preferred Outdoor Activity

Teacher Tip: Bivariate vs. Univariate

Before launching into two-way tables, ask students to brainstorm a list of survey questions. Sort the questions as **univariate** (one variable, e.g., "What is your favorite subject?") or **bivariate** (two variables, e.g., "What is your favorite subject AND what grade are you in?"). This concrete distinction prevents confusion later when students must decide whether a question is asking about joint, marginal, or conditional frequencies.

Anatomy of a Two-Way Frequency Table

A two-way table organizes bivariate categorical data. It shows how the categories of one variable intersect with the categories of the other variable.

Variable B (Cols) ↓ / Variable A (Rows) →	Category B1	Category B2	Total
Category A1	a (Joint)	b (Joint)	a+b (Marginal)
Category A2	c (Joint)	d (Joint)	c+d (Marginal)
Total	a+c (Marginal)	b+d (Marginal)	n (Grand Total)

Joint Frequency: The values in the inner cells of the table (labeled 'Joint' above). These represent the count of subjects that fall into both a specific row category and a specific column category simultaneously.

Marginal Frequency: The values in the margins (the 'Total' row and 'Total' column). These represent the total count of subjects in a single category for just one variable, ignoring the other.

Grand Total: The value in the bottom-right corner. This is the total number of subjects surveyed.

Memory Aid: Joint = the Junction of a row and column (inside the table). Marginal = the Margin (edges). Grand Total = the Greatest single number (bottom-right).

Common Misconception: Marginal vs. Joint

Students often confuse the marginal frequency of a category with a joint frequency. The marginal frequency "15 students have a curfew" includes **everyone** with a curfew, regardless of chores. A joint frequency like "15 students have a curfew AND chores" is only those satisfying both conditions. Always ask: "Does this number describe one variable or both?"

13. Teen Rock + Adult Rock = $25 + 20 = 45$ (Rock Total missing; column equation)
14. Teen Total + Adult Total = $40 + 30 = 70$ (Grand Total via row sums)
15. $40 + 30 = 70$ (Matches Problem 14) (Verification - column-sum check agrees)
16. Winter Total - Soccer Winter = $50 - 35 = 15$. (Baseball Winter = 15)
(Use Winter column equation)
17. Baseball Spring + Baseball Winter = $40 + 15 = 55$ (Baseball row total)
18. Soccer Spring + Baseball Spring = $25 + 40 = 65$ (Spring column total)
19. Spring Total + Winter Total = $65 + 50 = 115$ (Grand Total)
20. Soccer Total - Baseball Total = $60 - 55 = 5$ (Soccer has 5 more players than Baseball)

Section C Solutions

Strategy: Joint frequencies live inside the table at the intersection of a row and column. Marginal frequencies live in the "Total" row or column. Locate the row label and column label you need, then read the cell where they meet.

21. 45 (Joint: intersection of Math row and 8th column)
22. 75 (Marginal: Total row for Science - all Science preferers regardless of grade)
23. 85 (Marginal: Total column for 7th - all 7th graders regardless of subject)
24. 150 (Grand Total: bottom-right cell = total students surveyed)
25. Math (8th Math = 45 vs. 8th Science = 20; $45 > 20$ so more prefer Math)
26. 22 (Joint: intersection of Bus row and Short column)
27. 20 (Marginal: Total column for Long distance)
28. 12 (Joint: intersection of Car row and Long column)
29. Short Total - Long Total = $40 - 20 = 20$ (20 more people travel Short than Long)
30. Yes, both are 30 (Car Total = 30, Bus Total = 30; equal splits)

Solutions: Relative Frequency Calculations

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Three-Step Recipe for Every Relative Frequency

Step 1: Read the question and identify the 'of ___' phrase — that group is your denominator. **Step 2:** Identify what is being counted — that joint frequency is your numerator. **Step 3:** Divide and convert to a decimal or percentage. Round only the final answer to the precision requested (here: thousandths for decimals, tenths for percentages).

Section A Solutions: Overall Relative Frequencies

Strategy: Denominator = Grand Total (100). Numerator = the joint frequency. These answer 'What fraction of all subjects...' questions.

1. $15 / 100 = 0.15$ (15%) (7th & Math)
2. $20 / 100 = 0.20$ (20%) (7th & Science)
3. $10 / 100 = 0.10$ (10%) (7th & History)
4. $25 / 100 = 0.25$ (25%) (8th & Math)
5. $20 / 100 = 0.20$ (20%) (8th & Science)
6. $10 / 100 = 0.10$ (10%) (8th & History)
7. $45 / 100 = 0.45 = 45.0\%$ (All 7th graders — marginal)
8. $40 / 100 = 0.40 = 40.0\%$ (All Math preferrers — marginal)

Section B Solutions: Row Relative Frequencies

Strategy: Denominator = Row Total (the 7th grade total is 45; the 8th grade total is 55). These answer 'What percent of [grade] prefer [subject]?' questions.

9. $15 / 45 \approx 0.333 = 33.3\%$ (Of 7th graders, % preferring Math)
10. $20 / 45 \approx 0.444 = 44.4\%$ (Of 7th graders, % preferring Science)
11. $10 / 45 \approx 0.222 = 22.2\%$ (Of 7th graders, % preferring History;
check: $33.3 + 44.4 + 22.2 = 99.9 \approx 100\%$)
12. $25 / 55 \approx 0.455 = 45.5\%$ (Of 8th graders, % preferring Math)
13. $20 / 55 \approx 0.364 = 36.4\%$ (Of 8th graders, % preferring Science)
14. $10 / 55 \approx 0.182 = 18.2\%$ (Of 8th graders, % preferring History;
check: $45.5 + 36.4 + 18.2 = 100.1 \approx 100\%$)
15. 8th graders (45.5%) have a higher percentage preferring Math than 7th graders (33.3%). (Compare #9 and #12)
16. No, 44.4% of 7th graders prefer Science, while 36.4% of 8th graders prefer Science. (7th graders are more likely to prefer Science)

GUIDED NOTES • TOPIC 4: REAL-WORLD INVESTIGATIONS

Topic 4: Real-World Data Investigations

CCSS.MATH.CONTENT.8.SP.A.4: Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects.

From Raw Survey to Full Conclusion

In the real world, data does not come pre-sorted into neat tables. It comes as raw survey responses. To investigate bivariate categorical data, you must follow a systematic process:

1. Define the two categorical variables and their categories.
2. Tally the raw data to fill in the joint frequencies of a two-way table.
3. Calculate the marginal frequencies and grand total.
4. Calculate the appropriate conditional relative frequencies (usually row percentages).
5. Write a complete contextual conclusion naming both variables, citing your relative frequency evidence.

Teacher Tip: Scaffolding the Investigation

For students new to two-way tables, provide a blank table template with row and column labels already filled in. This lets them focus on tallying and calculating rather than table design. As they gain confidence, remove the labels and require them to identify the variables themselves. By the unit test, students should be able to design the table from scratch.

Worked Example 8: Sport Preference vs. Grade Level

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Scenario: A physical education teacher surveyed 100 middle school students to see if there is an association between their grade level (6th vs. 8th) and their preferred type of sport (Team vs. Individual). Here is the raw data:

- 35 6th graders prefer Team sports.
- 15 6th graders prefer Individual sports.
- 20 8th graders prefer Team sports.
- 30 8th graders prefer Individual sports.

Comprehensive Unit Test: Two-Way Tables & Bivariate Categorical Data

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Part 1: Multiple Choice & Short Answer

1. Which of the following is an example of bivariate categorical data?
 - A) The heights and weights of students
 - B) The number of hours studied and test scores
 - C) A student's grade level and their favorite elective
 - D) The temperature and the amount of ice cream sold
2. In a two-way table, the values in the interior of the table (where a row and column intersect) are called:
 - A) Marginal frequencies
 - B) Joint frequencies
 - C) Relative frequencies
 - D) Conditional frequencies
3. A survey of 100 people asked about their gender and whether they own a dog. 40 males own a dog; 10 males do not own a dog; 20 females own a dog; 30 females do not own a dog. What is the marginal frequency of people who own a dog?
4. To answer the question, "What percentage of left-handed students play an instrument?", which total should be used as the denominator?
 - A) The grand total
 - B) The total number of students who play an instrument
 - C) The total number of left-handed students
 - D) The total number of right-handed students

Part 2: Completing Tables & Calculating Frequencies

Use the partial two-way table below to answer Questions 5–8.

Gender \ Elective	Art	Music	Total
Male	15	??	40
Female	??	30	??
Total	45	??	100

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