Investigation 4.4
Can You Roll Your Tongue?

Overview

This investigation focuses on students examining an **association** between two **categorical variables**. Specifically, they will investigate whether there is an association between gender and whether a person can roll their tongue. As part of this investigation, students will collect, organize, and analyze data in a **two-way table**; construct and analyze **segmented bar graphs**; and calculate the **percentages** of boys and girls who can roll their tongue. This investigation is based on an activity in *Probability Through Data*, a module in the Data-Driven Mathematics series (1999).

Association

Two categorical variables are associated if certain values of one variable are more likely to occur with certain values of the other variable.

GAISE Components

This investigation follows the four components of statistical problem solving put forth in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report.* The four components are formulate a statistical question that can be answered with data, design and implement a plan to collect appropriate data, analyze the collected data by graphical and numerical methods, and interpret the results of the analysis in the context of the original question. This is a GAISE Level B activity.

Learning Goals

Students will be able to do the following after completing this investigation:

- Organize data collected into a two-way table
- Analyze data in a two-way table

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.

Common Core State Standards Grade Level Content

6RP3c Find a percent of a quantity as a rate per 100; solve problems involving finding the whole, given a part and the percent.

6SP3 Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

8.SP.4 Understand that patterns of association also can 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. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.

Principles and Standards for School Mathematics

Data Analysis and Probability

Grades 6-8 Students should understand and use ratios and percentages to represent quantitative relationships and formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population.

Materials

- Data collection sheet (available on the CD)
- Data recording sheet (available on the CD)
- Grid paper
- Color markers

Estimated Time

One day

Instructional Plan

Formulate a Statistical Question

Ask your students to look around their classroom. Pose the question, "Is anyone in the room exactly like you?" "Are identical twins exactly the same?" Discuss that there are many traits or characteristics that make us different

from each other. Have students list some of these traits. Examples are hair color, eye color, skin color, blood type, having double-jointed elbows, having "free" earlobes or "attached" earlobes, and whether they can roll their tongue. Discuss with your students that many of these traits are genetic (i.e., inherited or passed on from their parents). Ask which of the traits might have been inherited from their parents.

Tell students there are many traits they could investigate. Indicate that, for this activity, they will be investigating rolling one's tongue (even though it isn't genetic). The statistical question is, "Is gender associated with ability to roll one's tongue?"



Can't roll tongue



Can roll tongue

Collect Appropriate Data

1. Have one student demonstrate how he/she is able to roll his/her tongue and another demonstrate that he/she is unable to roll his/her tongue.

2. Hand out a data collection sheet to each student. Your students should check whether they are a boy or girl and whether they can roll their tongue. Collect each of the data collection sheets. Figure 4.4.1 is an example of a data collection sheet.

Boy _____

Girl _____

Can roll tongue _____

Can't roll tongue _____

Figure 4.4.1 Data Collection Sheet

3. Hand out a recording sheet (available on the CD) to each student. Take each of the data collection sheets and read whether the sheet is checked boy or girl and whether the student can roll their tongue. As you read each data collection sheet, students should record the data on the recording sheet as shown in Table 4.4.1. Suggest that they write B for boy, G for girl, Y for yes they can roll their tongue, and N for no they cannot roll their tongue.

Table 4.4.1 Example of Class Recording Sheet

Student	Boy or Girl	Roll Your Tongue Yes or No?
1	B	N
2	B	Y
3	G	Y
…	…	…

Analyze the Data

1. Discuss with your students that one way to help analyze the data is to organize the data into a table. Ask them what answers they could record when they were reading the data collection sheets. On the board, display Table 4.4.2. Ask your students to fill in the frequencies (counts) for the four possibilities based on their recording sheet.

Table 4.4.2 Frequency Table

Possibilities	Count/Frequency
Boy – Yes	
Boy – No	
Girl – Yes	
Girl – No	
Total	

2. Explain to your students that their frequency table can be displayed in a different way, called a two-way table. A two-way table organizes data about two categorical variables with rows labeled with the categories of one variable and the columns labeled with the categories of the other variable. In this investigation, the rows of the table are labeled with gender—boys and girls—and the columns are labeled with whether a person can roll their tongue. Demonstrate drawing and labeling the two-way table. The general form is shown in Table 4.4.3. Note that the two-way format is useful when investigating whether there is an association between two categorical variables.

Table 4.4.3 Two-Way Table

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy			
Girl			
Total			

3. Label each cell in Table 4.4.3 with letters representing frequencies, as shown in Table 4.4.4.

Table 4.4.4 Example of Completed Two-Way Table

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	a	b	
Girl	c	d	
Total			

4. Explain to your students that the cell labeled "a" will contain the number of students who are both a boy and who said they could roll their tongue. Ask your students what the cell labeled "b" represents. Cell "c"? Cell "d"?

5. Ask your students how many boys are in the sample, using the letters in Table 4.4.4. **Note:** There are "a+b" boys. How many girls? There are "c+d." How many students can roll their tongues? "a+c" can roll their tongues. How many can't? "b+d" can't.

6. Have your students fill in the two-way table based on their class data as recorded in their frequency table, Table 4.4.2. An example of what their table may look like is given in Table 4.4.5.

Table 4.4.5 Row of the Boys' Data from the Two- Way Table

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	8	7	**15**
Girl	6	4	**10**
Total	**14**	**11**	**25**

7. Ask your students to use Table 4.4.5 to answer the following questions. As students answer each question, have them point to the appropriate cell.

   a. How many students were in the class?

   b. How many students could roll their tongue?

   c. How many students were girls?

   d. How many students were boys?

   e. How many girls could roll their tongue?

   f. How many boys could roll their tongue?

   g. How many boys could not roll their tongue?

8. Remind your students of the question they are investigating: "Is gender associated with ability to roll one's tongue?" Ask them if they are ready to answer the question. Note that many of your students will say more boys can roll their tongues than girls. Keep asking until someone suggests they should be looking at percentages, not raw counts, as there are more boys than girls in the class.

9. Ask your students to find the percentage of boys who could roll their tongue. To help them answer this question, show them only the row with the boys' data. See Table 4.4.6. Have them find the fraction that answers the question, convert it to a decimal, and then convert it to a percentage. For example, for the boys who can roll their tongue, 8/15 = .53 = 53%.

Table 4.4.6 Row of the Boys' Data from the Two-Way Table

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	8	7	15

10. Using Table 4.4.7, ask your students to find the percentage of girls who can and cannot roll their tongue.

Table 4.4.7 Row of the Girls' Data from the Two-Way Table

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Girl	6	4	10

11. Ask your students to put their percentages in a two-way table. See Table 4.4.8. Note that the Total row percentages are each 100%.

Table 4.4.8 Example of Row Percentages

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	8/15 = .53 = 53%	7/15 = .47 = 47%	15/15 = 1.00 = 100%
Girl	6/10 = .60 = 60%	4/10 = .40 = 40%	10/10 = 1.00 = 100%
Total			

12. To help your students visualize the different percentages of boys and girls who can and cannot roll their tongue, demonstrate the construction of a segmented bar graph. Using Table 4.4.8, a segmented bar graph is shown in Figure 4.4.2. Note that the percentages could also be visualized in side-by-side bar graphs.

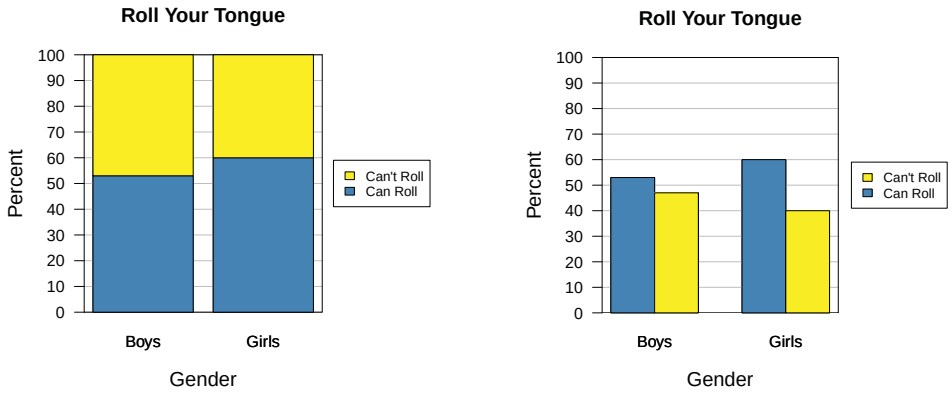


Figure 4.4.2 Segmented bar graph and side-by-side bar graph of example class data

Interpret the Results in the Context of the Original Question

1. Have your students recall the original statistical question, "Is gender associated with ability to roll one's tongue?" Have each group of students write an answer to the question and then justify it using the two-way table, appropriate calculations involving percentages, and the segmented bar graph. Suggest to your students that they should focus on the difference in the percentages and the heights of the bars in the segmented bar graph. Remind your students that an association exists between two categorical variables if knowing the response of one of the variables helps to know what the response might be of the other variable. Does knowing a girl was chosen from the group help know whether she can roll her tongue? Similarly, does knowing a boy was chosen help know whether he has the ability to roll his tongue? Have each group of students present their results to the class.

Example of 'Interpret the Results'

Note: The following is not an example of actual student work, but an example of all the parts that should be included in student work.

In our biology class, we often talk about genetics, so we thought a good statistics project in our mathematics class would be to take a genetic trait and see if it is associated with gender. We chose rolling our tongues. (After our study was complete, we found out that rolling one's tongue is not actually genetic. It is a learned trait. But it was fun doing the experiment anyway.) Our statistical question was "Is gender associated with ability to roll one's

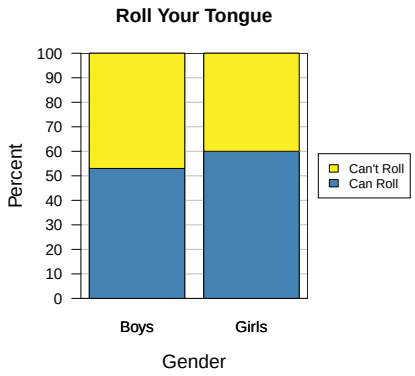
tongue?" We collected data by making a list of boys or girls and whether they could roll their tongue. We then counted how many there were in each of the four categories and organized the data in a two-way table like this one.

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	8	7	15
Girl	6	4	10
Total	**14**	**11**	**25**

So, to answer the question, some of us say boys are more likely to roll their tongues than girls are. But, we messed up because there were more boys in class than girls. So, we should be looking at percentages, not counts. When we calculated the percentages, we almost based them on 25, but realized they had to be calculated within boys' and girls' totals. So, here is our table of row percentages.

	Yes – Can Roll Tongue	No – Can't Roll Tongue	Total
Boy	8/15 = .53 = 53%	7/15 = .47 = 47%	15/15 = 1.00 = 100%
Girl	6/10 = .60 = 60%	4/10 = .40 = 40%	10/10 = 1.00 = 100%
Total			

The actual answer to our question is that a higher percentage of girls can roll their tongues as compared to boys. Sixty percent of girls could roll their tongues compared to 53% of boys. Our teacher showed us how to visualize these results in what is called a segmented bar graph. It makes it clear that the percentage of girls is higher.



But we debated whether gender and ability to roll one's tongue are associated because some of us thought that 53% and 60% are kind of close and so the variables are not associated. Others thought the percentages were far enough apart to claim the variables are associated. Our teacher said we will learn more about association in high school.

Assessment with Answers

A survey asked a group of students if they participated in a sport and if they played a musical instrument. Table 4.4.7 shows the survey results.

Table 4.4.7 Survey Results

	Music Yes	Music No	Total
Sport Yes	18	2	20
Sport No	8	22	30
Total	**26**	**24**	**50**

Use the table to answer the following questions:

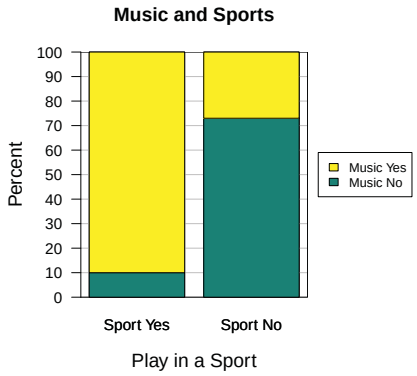
1. How many students said they participated in a sport? Twenty said they participated in a sport.

2. How many students said they did not play a musical instrument? Twenty-four said they did not play a musical instrument.

3. What does the number 8 represent in the table? The number 8 represents the number of students who said no to sports and yes to music.

4. What percentage of those who said they participated in a sport also played a musical instrument? 18/20 = .90.
5. What percentage of those who said they did not participate in a sport played a musical instrument? 8/30 = .27.

6. If a student participates in a sport, are they more likely to play a musical instrument than a student who does not participate in a sport? Use words, numbers, and graphs to explain your answer.



Students who do not participate in a sport are much less likely to play a musical instrument than those who do participate in a sport. Twenty-seven percent of students who do not participate in a sport also played an instrument while 90%

of those that did participate in a sport played an instrument. The segmented bar graph shows the big difference between the groups who do and don't play sports and whether they play an instrument. We can say that participation in sports and playing a musical instrument are associated.



Right-thumbed



Left-thumbed

Extensions

1. Ask students to collect data at home. Each student should ask one parent/guardian if he/she could roll his/her tongue. Collect data in a table during the next class period:

Possibilities	Number
Student yes – Parent/guardian yes	
Student yes – Parent/guardian no	
Student no – Parent/guardian yes	
Student no – Parent/guardian no	

   Your students should organize the data in a two-way table. Based on the table and calculated percents, students should determine if there appears to be an association between whether the parent/guardian can roll his/her tongue and whether the student can roll his/her tongue.

2. Your students could investigate if there appears to be an association between whether a person is left-handed or right-handed and whether they are left-thumbed or right-thumbed. **Note:** To determine whether one is left- or right-thumbed, have your students clasp their hands together immediately without thinking about it. Then look at the pictures to the left to determine the category. Students could collect class data and analyze the data to determine if there appears to be an association.

References

Franklin, C., G. Kader, D. Mewborn, J. Moreno, R. Peck, M. Perry, and R. Scheaffer. 2007. *Guidelines for assessment and instruction in statistics education (GAISE) report: A pre-k–12 curriculum framework*. Alexandria, VA: American Statistical Association. *www.amstat.org/education/gaise*.

Hopfensperger, P., H. Kranendonk, and R. Scheaffer. 1999. *Probability through data.* New York, NY: Dale Seymour.

National Council of Teachers of Mathematics. 2000. *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Common Core State Standards for Mathematics, *www.corestandards.org*.