Math (Pi)oneers of Safety!

Audience: Middle School Age Educators

Overview: This lesson helps students understand rail safety by building ratios. Students will start with the ratio of pi to develop an understanding of size including diameter (part) to circumference (whole). The second lesson will focus on how students can impact data through choices.

Suggested Lesson Time: Two, 55-minute lessons to be taught as an introduction to ratios (introductory lesson to include pi) with an optional extension into percentages.

Objectives: Students should:

1. Discern between the *part* and *whole* of a data set.
2. Understand the relationship of size between a train and standard vehicle relative to weight.
3. Identify parts and whole from a word problem.
4. Demonstrate the steps to set up a functional ratio.
5. Determine the percentage of data based on a ratio.

Materials: You will need:

1. Scratch paper
2. Infographic slide of *train size* (see resource image pages at the end of this lesson)
3. Recommended: *Slides at the end of this lesson plan*
4. Empty soda can(s): any size
5. Masking/Painters Tape (Day 2)

Lesson Day 1:

Core Safety Message: Trains are bigger than you think! Trains collide with cars with an average of 4000 to 1! That's the same average force of a car crushing a soda can!

Procedures: Review with your class slides at the bottom of the lesson plan

Prepare for lesson by reviewing the definition of a ratio (expressions of data as *part* of a *whole)*

- Review the ratio of pi including the following definition:
  - Diameter: distance of the width of a circle through its center point
  - Circumference: distance around a circle
  - Definition of pi: The distance around a circle is a little more than 3 times the distance across a circle
- π (pi) is the ratio, how we express a part of a whole. How many parts does it take to make a whole? In the case of pi, 3.14

Motivation: Introduce students by reminding them how π is written. This expresses an infinite equation: or an equation that has more digits after the decimal point that can never be written!

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Introductory Activity: Reviewing pi.

1. Write the following word problem for students: *My car steering wheel has a diameter of 13.5 inches across. What is the circumference of my steering wheel?*
2. **Write the expression: 13.5π**
3. Solve the equation: $\mathbf{13.5 \times 3.14}$
4. **Answer:** 42.39
5. Now, write the following equation to further find π: *My car steering wheel's radius is 6.75. What is the circumference of my steering wheel?*
6. **Write the expression: C=2πr**
7. Solve the equation: $\mathbf{2 \times 3.14 \times 6.75}$
8. **Answer:** 42.39

ASK: Ratios are used to find parts of a whole. What are some things this knowledge can help us to find, or solve?

Possible Answers: Share some answers. *How much flour to use in a pie, how much water you need to use with a plant, how to mix oil and vinegar for salad dressing, how much water a bottle can hold.*

Today, we are going to look at a different type of ratio. Just how big is a train?

Activity 1: Set the Ratio.

1. Pass out copies of the "Trains Are Heavy" visual at the end of the lesson plan (or share on the screen *4000 to 1 visual): The size of a train relative to the average car.*
2. Ask students:
    a. Just how big do you think a train is? **(ANSWER: Average freight train is 12 million pounds**)
    b. Do you think a train stops quickly? (**ANSWER: Trains can stop, but it can take them up to a mile or more to come to a full and complete stop**).
3. When we compare 12 million pounds, it can look like:
    a. 36 BIG blue whales
    b. 400 school buses
4. Let's talk about the ratio, **4000 to one.** When we are looking at the "Trains are Heavy" visual that means a train will collide with a car with a weight ratio 4000 times greater than the car. That is the same ratio when a car crushes a soda can.
5. Let's set up a ratio to look at this force: *Instructor should write the ratio on the board.*

$$\frac{\mathbf{4000}}{\mathbf{1}}$$

Activity 2: Investigating the Ratio

1. Pass out empty soda can(s)—you can give each student their own *or* put students into groups and give each group a soda can.
2. Ask students to guess how hard it would be to completely crush this soda can.
3. Have students generate a list of ways they could physically crush the can. Examples may include:
    a. With their hand holding a book from a seated position. (*NOTE: Students should not try to crush the can with bare hands; it could hurt. Use a book and have students apply pressure to the book to avoid discomfort).*
    b. With their hand holding a book while in a standing position. (*NOTE: Students should not try to crush the can with bare hands; it could hurt. Use a book and have students apply pressure to the book to avoid discomfort).*
    c. Applying pressure using your foot.

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4. Make a 3-column t-chart on the board, asking students to copy as well:

CRUSHED SITTING	CRUSHED STANDING	CRUSHED WITH FOOT

5. Allow students to try to safely crush the can using each of their generated lists.
6. Record the number of students who were able to crush the can using each idea.
7. After students have been able to explore the ease by which they could crush the can, ask:
    a. If you were able to crush the can from a sitting position, was it difficult?
    b. What did you notice about holding the book steady?
    c. Did you have to work hard to get the can to crush, no matter what method you used?

Activity 3: Analyze Data

1. While looking at the data t-chart, ask your students to help you find the percentage that *each* category fills.
2. Remember that percentages are *ratios: parts of a whole.*
3. Tell students they will be identifying the part of the class that was able to complete the crushing of the can as it relates to the overall number of students in the class.
4. Set up a ratio, asking students to copy:

$$\frac{\text{Number of students able to crush the can while sitting}}{\text{Total number of students in the class}}$$

5. Repeat the ratio for the OTHER two categories.
6. Tell students that they can read this data as _____ out of _____ students (*fill in with your class numbers)*.
7. Ask students:
    a. What was the *easiest way* to crush the can?
    b. Describe which action led to the flattest cans.
    c. Do you think that a car will crush a can even flatter, and faster, than it took you?
    d. Do you agree that it takes *less effort* for a car to crush a can than a person to crush a can?

Synthesize Data Collection: After students have completed their ratios for their peers, ask:

1. What are some other things you could set up with this ratio? *Examples include:*
    a. How many students out of the class have pets, siblings, or any other commonality.
    b. How many students prefer types of activities (reading, watching movies and/or hanging out with friends).
2. Revisit the Core Safety Message:
    a. Trains are BIG! —they can weigh over 12 million pounds.
    b. Trains can't stop quickly! —it can take them a mile or more to come to a full and complete stop.
    c. Trains impact a car at the same ratio that a car will crush a can. **Review ratio of *4000 to 1*.**
        i. If the average weight of a middle schooler is 90 pounds and the average car weighs 4100 pounds, what is that ratio? *That's only approximately a 45 to 1 ratio! Imagine how great 4000 to 1 is!*

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1. If interested, this can be set up and solved as a ratio:

$$\frac{4100}{90}$$

ii. This means that at a 4000 to 1 ratio, a train has an impact force ratio of more than 182,222 middle schoolers! *This can be solved by multiplying the force rate (4000) by the force rate of a child (45):*

$$4000 \times 45$$

Extension: If you are using ratios to introduce percentage, complete the following extension activity.

Extension Activity: Introduce Percentage

1. Give students the definition of a *percentage*: *a rate, number, or amount by each 100.*
2. Students will find the *percentage* of their peers who were able to crush the cans in diverse ways by considering that the class is a WHOLE amount.
3. Write the equation:

$$\frac{n}{100}$$

4. Tell students that this is the expression used for part of the *whole.* Students already KNOW the parts of their whole class who can crush the can in several ways and now they can learn to express it as a percentage of the class.
5. Complete the ratio by *setting equal*:

$$\frac{n}{100} = \frac{\text{Number of students able to crush the can while sitting}}{\text{Total number of students in the class}}$$

6. For this first introductory ratio, show students how to *cross-multiply* through an expression.
7. This means that you will write the expression on the left-hand side as:

$$\text{Total number of students in the class} \times n$$

8. Show students how to cross multiply through the other side.
9. This means on this side of the expression, students can write:

$$\text{Number of students able to crush the can while sitting} \times 100$$

10. Follow the rules to isolate the variable:

$$n = \frac{\text{Number of students able to crush the can while sitting} \times 100}{\text{Total number of students in the class}}$$

11. After demonstrating and finding the percentage, write the other two columns of the t-chart as a set of ratios.
12. Solve for **n** using the sets above as new ratios.
13. Ask Students:
    a. Once you set up the ratio as a percentage, were you surprised by the number of students who were able to crush the can with each action?

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b. Can you think of ways you have seen percentages used in your everyday life? *Examples might include sales and discounts, adding taxes*.

14. **After this extension activity, consider reviewing the rail safety education messages. For additional facts and statistics around train safety and incidents in your state, visit https://oli.org/track-statistics**

Lesson Wrap-Up

1. Continue practicing ratio building and the procedures for creating a ratio.
2. Research other examples of a 4000 to 1 ratio or other objects that total 12 million pounds to understand the size of a train.

Lesson Day 2:

Core Safety Message: You can make safe choices near Tracks and Trains!

Teacher Preparation for Day 2:

- Define key terms for students on the white board/smart board:
  - *Trespassing:* entering property without the owner's permission
  - *Probability:* how likely an event is to occur or how likely it is that a proposition is true

Key Learning Objectives: Students will:

- Explore how probability is impacted by human decisions.
- Explain how human interference creates different outcomes of probability.

Review: Review the *ratio lesson.*

1. Consider asking students to raise their hands if they crossed tracks to get to school today. Write the number as a ratio where _____ (number of students) out of _____ (total number of students) crossed tracks.
2. Ask the same question but framing as if students *did not* cross tracks to get to school. Write this number as a ratio, too.
3. Show students that by adding the *two parts,* they get the whole number of students asked.

Activity 1: Introduce Probability.

1. Ask students to design a series of yes or no, or either/or questions relating to the topic of "trespassing." Sample questions to get started might be:
   a. Do you know how many of you know where the train tracks are in this town? Ask the class.
   b. Do you know how many of you have *seen someone else* walking near the tracks? Ask the class.
2. Have students count the total number of answers and write them as a ratio.
3. Explain to students that they have created a statistical survey and can now interpret the data to make inferences about their peers.

Activity 2: Using ratios to make inferences.

1. Define the word *inference* for students: A conclusion based on reasoning.
2. Ask students to draw conclusions *about their class,* based on the ratios that they have created.
3. Ask students to look at the ratios they have written and make conclusions based on these ratios. Examples may include:
   a. There are no train tracks near me.
   b. I don't pay attention to tracks because I don't see them regularly.
   c. Most people already know to stay off the tracks.

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4. Share with students this safety statistic about being near trains and tracks:
    a. Every 3 hours in the United States, a person or vehicle is hit by a train. How many people *per day* is that (8)? How many people *per year* is that (2,920)?
5. Considering these facts, revisit your inferences. Do you think that they are still true? Why or why not?

Activity 3: Distance determines perception.

1. Using painter's tape, tape a 2-foot, vertical line at the front of the classroom.
2. Measure three feet horizontally and tape another 2-foot vertical line at the front of the classroom.
3. Measure another three feet horizontally and tape another 2-foot vertical line at the front of the classroom. You should end up with three parallel vertical sets of lines at the front of the classroom.
4. Have a volunteer stand directly beside the first line and mimic taking a selfie.
5. Explain to your students that standing beside this painter's tape mimics standing next to a train track. Ask the students that while they know this is illegal, do they think it is dangerous?
6. Set up a ratio to support the data set who felt that this was dangerous. *Number of students out of the total number of students in the class.*
7. Ask another student to join directly in front of the second line. Explain to students that this is how far a train hangs over tracks. Is the first person safe at all? *No!*
8. Ask the second student to mimic taking a selfie.
9. Repeat the question: Is this dangerous? Create this answer as another ratio. Did students think this was dangerous? **Explain to students that if a train were to run along the track, who would be hurt at this moment (even though no one is on the tracks). BOTH people.**
10. Ask a third person to stand on the third line, mimicking six feet from the tracks. Have the third student take a selfie. Create a third ratio while asking students if they think this is still dangerous? YES! While they are standing more than 6 feet from the line representing the train, this is still dangerous and they could get hurt while standing.

Synthesize the data.

1. Look at the three ratios that reflect the number of students who agreed with a statement out of the total number of students in the class.
2. Convert each ratio to a percentage by setting up the expression:

$$\frac{n}{100} = \frac{\text{Students who agreed with a statement}}{\text{Total number of students in the class}}$$

3. Following the method of cross multiplying and isolating the variable, solve for the percentage of students.

4. **Ask** if students were surprised by the numbers and if this impacted their perception of danger.

Activity 4: How human behavior can shape statistics.

1. Using painter's tape, tape a box 3 feet by 3 feet on the ground.
2. Now ask a group of three students to stand in the box. Have one student in the group mimic taking a selfie. Ask: Did everyone fit?
3. Add another student, take another selfie.
4. Continue to add students until there is no way that they can all fit into the box.
5. At this point, ask the students if they thought that it was dangerous to take a selfie from inside the box? Ask students to recall if they stepped outside of the box to get everyone in their picture.
6. Ask students to imagine this box was near a train track. **Remind students that trains are wider than tracks, it is extremely dangerous (an illegal) to be near railroad tracks.**

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7. Set up two ratios to reflect the number of students who felt taking the selfie from inside the box was dangerous *and* the number of students who felt it was dangerous once they considered the box to be near a railroad track.
8. Ask students: if you consider something to be dangerous, would you reconsider doing it? *Continue to point out that being anywhere near a railroad track—even when no train is present is dangerous (and illegal)—this activity is meant to show how your perception of danger changes.*

Lesson Wrap-Up:

1. Review the definition of pi and the symbol for pi (π).
2. Review the definition of a ratio as *part of the whole.*
3. Review the 4000 to 1 ratio: **A train crushes a car with the same force that a car crushes an aluminum can.**
4. Consider and discuss how did creating ratios and data sets affects your perception of safety around train tracks:
   a. Is safety something you considered before, or based on your data perceptions, is it something that you didn't think about?
5. Based on inferences of data, do you think that these same experiments would yield similar outcomes in other classes and with your friends? Why or why not?

Additional Resources:

- Safety tips: https://oli.org/safety-near-trains
- Additional Teaching Resources: https://oli.org/safety-near-trains/additional-info/teachers

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