OVERVIEW

The main focus of this activity is identifying and describing important features of a set of data, specifically identifying which data values meet or surpass a given standard. Although the idea is not complex, the execution will require students to create multiple plots in TinkerPlots and add reference lines or dividers. Hence, the activity may require an extended amount of time.

It is helpful, although not mandatory, for students to have already done Who Has the Heaviest Backpacks? Using that activity first gives students prior experience with the backpack data and illuminates some relevant patterns (i.e., that students in the higher grades tend to carry heavier backpacks than students in the lower grades).

This activity relies heavily on the concept of percent, which may make it more challenging than Who Has the Heaviest Backpacks?, especially for students in grades 4–5. On one level, students need to understand that the attribute *PercentWt* represents each student's backpack weight relative to his or her body weight. On another level, students need to be able to identify the percent of *PercentWt* values that exceed a given standard.

If you prefer, you could delete the attribute *PercentWt* before distributing the document and require students to create their own attribute for *PercentWt* using a formula that will calculate the appropriate percent. This gives students deeper experience using TinkerPlots and further develops their conceptual understanding of percents. (*Note:* You'll want to similarly modify Step 1 under Plot and Investigate on the student worksheet.) The easiest way to delete the attribute is to select it in the data cards and choose **Delete Attribute** from the **Edit** menu. Students can add a new attribute by double-clicking **<new attribute>** and naming the attribute; they define the formula by double-clicking the **Formula** cell for the new attribute or highlighting the attribute and choosing **Edit Formula** from the **Edit** menu.

Note: The attribute *PercentWt* is rounded to the nearest percent. If you have students define their own attribute with a formula, you may want to have them similarly use the *round* function.

The opening questions, in Steps 1–3, often ignite a lively class discussion. Students may see this as an opportunity to argue for less schoolwork. If you have enough time, you may want to hold a class discussion about this, including ways that backpacks could be lightened without actually reducing the amount of schoolwork. Students could do additional research on legislation that formally limits the weight of backpacks and methods that some schools are taking, such as electronic textbooks and online assignments.

Activity Time: One class period

Objectives

- Calculate, compare, and order percents.
- Compare related sets of data.
- Make observations about differences between groups.

- Describe important features of a set of data.
- Justify conclusions based on data.
- Represent data with graphs.

Common Core Standards Addressed

Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

Grade 6, Statistics and Probability Standard 2

Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

Grade 7, Statistics and Probability Standard 2

Prerequisites

- Students need to know the word *percentage,* understand the mathematical concept of *percents,* and be able to calculate them.
- Students should know the basics about TinkerPlots *data cards* and *plots.* During this activity, students will probably want to use *reference lines, dividers,* or *percents,* so you'll need to have previously introduced these buttons or you'll need to make plans to introduce them during the course of this activity.

Materials

- Is Your Backpack Too Heavy For You? worksheet (one copy per student)
- **Too Heavy Backpacks.tp**

Lesson Plan

Think About It (10 minutes)

Hand out the Is Your Backpack Too Heavy For You? worksheet. Read through the introduction as a class.

Encourage students to work in pairs or small groups to write answers for the Think About It questions, or have students write individual answers and then discuss them in groups. Involving students in group discussions will foster communication, help make apparent common expectations about the data and questions, and illuminate alternative ideas.

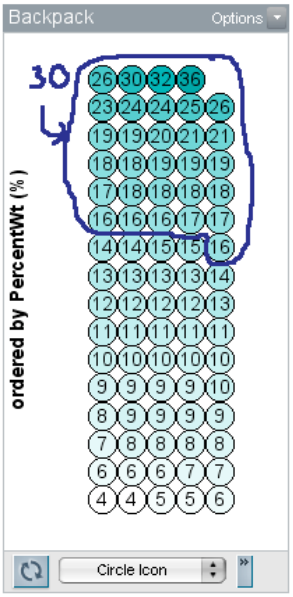
After students complete Step 2, and possibly having a class discussion, you may want to suggest that students revisit Step 1. After considering the factors that influence one's ability to carry a heavy backpack, some students may realize that their answers to Step 1 were unnecessarily

absolute ("10 pounds is a safe weight for a backpack"). They may now want to further qualify their answer ("10 to 15 pounds is a safe weight for a backpack for seventh-graders with average physical development").

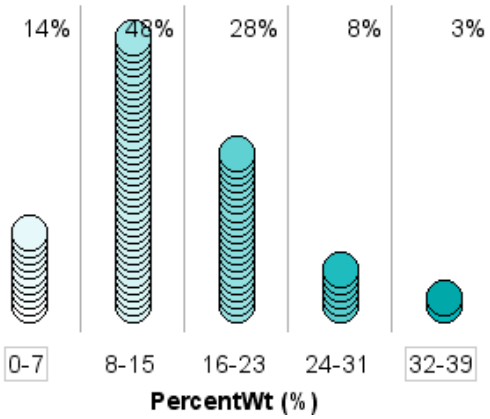
Plot and Investigate (40 minutes)

Have students move to computers and open the file **Too Heavy Backpacks.tp** to explore backpack weight data.

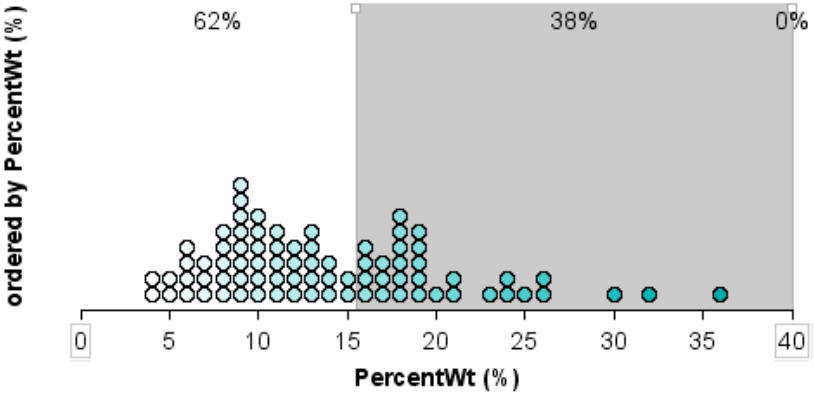
Students could create a variety of plots for Steps 5 and 6. The simple plot at right orders and labels the cases by *PercentWt*. Students could then count the icons with values greater than 15 to find 30 cases above 15%. Students could then manually calculate that this is about 40.5%.



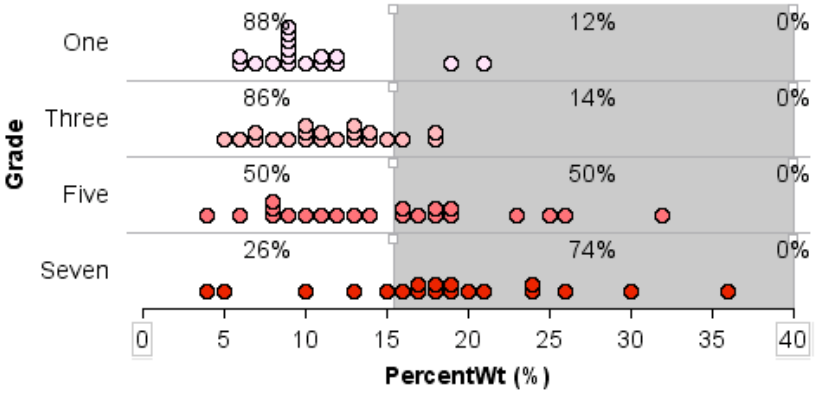
Students could also separate *PercentWt* into bins with one of the bin lines at 15%. They can count and calculate or use the **Counts (%)** button to find that 39% of cases are above 15%. Note: The difference in this answer is attributed to the **Counts (%)** button, which rounds up to the nearest whole percent.



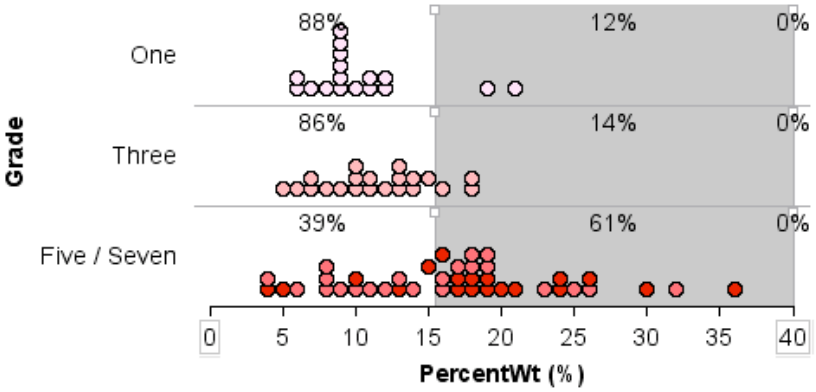
Lastly, students could fully separate *PercentWt* and use reference lines, dividers, and percentages to find that 38% of cases are above 15%. (Note: This plot shows two divisions. However, by default, dividers create three divisions. You can show students either how to use **Number of Divisions** from the pop-up menu or how to drag the rightmost divider past the last case icon so that the last division has 0%.)



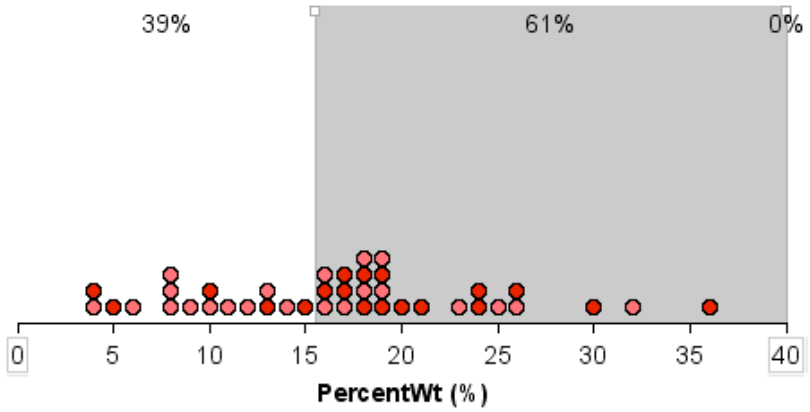
For Steps 7 and beyond, any of the plots used for Steps 5 and 6 can be embellished by adding *Grade* to the other axis. Students can then find the counts or percentages of students carrying too much for each grade. For example, on the next page is a fully separated dot plot with *Grade* added.



Some students may interpret the question in Step 8 to mean grades 5 *and* 7, collectively. Using the plot above, students could pull a case from the seventh-grade group towards the fifth-graders, which will make a new combined group called "Five/Seven."



Alternatively, students could filter out the first- and third-graders by selecting the first- and third-graders (by drawing a selection marquee around them) and then choosing **Object | Plot | Hide Selected Cases**.



If some students do find the individual percentages while others find the collective percentage, you can have a class discussion about why the average of 50% and 74% is not 61%. (Because there is a different total number of students in each grade.)

To answer Step 10, most students will probably use the plots and percentages that they found for Steps 8 and 9—that as the grade increases, the percentage of students carrying backpacks above 15% of their body weight increases from 12% to 14% to 50% to 74%. Students in grades 6–8 might also use the median or mean to show how the average percentage of body weight increases by grade. For example, the means increase from 10.3% to 11.3% to 15.1% to 18.5%.

Wrap-Up (10 minutes)

Have a couple of students with different kinds of plots present them to the class. Have students share how their plots helped them answer Steps 8–10.

Extensions (optional)

1. Have students conduct their own study, collect data about backpacks at your school, and analyze the results. Compare the results from your school with the results for the data in **Too Heavy Backpacks.tp.** You may want to do this along with a talk about *samples* and *populations*, discussing whether students think data from any one school are likely to be representative of schools across the country. Students could even plan ways to collect more representative data (for example, by collecting data at several different schools or by gathering statewide or nationwide data via the Internet).

2. Hold a discussion about things that students could do to lighten their backpacks or about the proper way to carry a backpack to minimize stress. See the links in the TinkerPlots Online Resource Center for more information. If students conduct their own study, they may want to collect additional data about the way each student carries his or her backpack and whether each student has experienced back pain.

3. Have students revisit Step 1 and, in light of the data, state specific cutoff weights for the backpacks of students in each grade. For example, students might find that the mean body weight of a seventh-grader is 94 pounds, so 15% of that, or 14 pounds, is the maximum safe weight for a seventh-grader's backpack. (Some students might argue for using the minimum or maximum body weight or for using a range of values rather than one absolute value.) You might extend this into a discussion about how teachers, parents, and school board members might use this information when adopting textbooks or shaping school policy.

4. This activity focused on differences between grade levels. Ask students to continue analyzing the data to find differences between genders or body weights. Body weight is particularly interesting because students can debate to what degree body weight depends on grade level. (This raises the distinction between *correlation* and *causation*. Does gaining body weight *cause* students to carry heavier backpacks? Probably not. Rather, as students get older, their body weight increases, they move into higher grades, and they have more homework.)

   For students in grades 6–8, you can even begin to look at bivariate relationships between attributes. For example, what does a scatter plot of *BodyWeight* and *PackWeight* tell you? (As body weight increases, the backpack weight tends to increase, but there are plenty of exceptions.) If students are novices with scatter plots, other types of plots, such as binned scatter plots, may be an easier way for them to recognize the relationship between the two attributes.

ANSWERS

1. Answers will vary.

2. Students will probably recognize that many factors influence how much someone can safely carry. They may mention factors such as age, height, weight, gender, physical development or disability, and overall strength.

3. a. 15 pounds

   b. 22.5 pounds

6. 38% of students are carrying backpacks that are more than 15% of their body weight. (*Note:* Depending on the plot used and whether *PercentWt* is rounded, student answers could vary between 37% and 41%.)

8. 50% of students in grade 5 are carrying too much, and 74% of students in grade 7 are carrying too much. Collectively, 61% of students in the higher grades (grades 5 and 7) are carrying too much. Either answer should be considered correct.

9. 12% of students in grade 1 are carrying too much, and 14% of students in grade 3 are carrying too much. Collectively, 13% of students in the lower grades (one and three) are carrying too much. Either answer should be considered correct.

10. Yes, students in higher grades tend to carry backpacks that weigh a higher percentage of their body weight than students in lower grades. Explanations must include how the plot supports their answers.