Paper Drop

Name(s): _____

In this activity, you will drop a piece of wadded-up paper onto a target 30 times, and measure how close the paper lands to the target (a coin). You will use two types of paper, one heavy and one light, to see whether weight makes a difference.

As you do the experiment, you'll record your data and make a plot that you think helps to answer the question of whether one type of paper lands closer to the target than the other.

Collect the following materials for your group:

- 2 pieces of paper, one heavy and one light
- 1 coin
- 1 ruler
- 1 Paper Drop Data Table
- 1 piece of poster paper
- Colored pens

1. Without collecting any data, which type of paper do you think will tend to land closest to the target? Explain.

Perform the Experiment and Make a Plot

2. Come up with a name for your team. Write your team name at the top of the Paper Drop Data Table.

3. Working as a group, collect your data. Put a coin target on the floor and drop the paper toward the target using the procedure your class has agreed on. Drop the heavy piece of paper first, then the light piece, then heavy, then light, and so on, until you have dropped each 15 times, for a total of 30 drops. Record your results in order on the Paper Drop Data Table.

4. On a piece of poster paper, make a plot of your results that helps to show whether one type of paper lands closer to the target than the other. You'll post this plot on a wall for all to see, so make it large enough to be readable from a distance.

5. As a team, write a short statement that makes an argument based on the data for which type of paper (if either) lands closer to the target.

Record Your Results in TinkerPlots

6. Make sure that each team member has a copy of the team's results.

7. Working individually or in pairs, open the document **Paper Drop.tp**.

8. Record your team's results, entering the distance for each case under the *Distance* attribute. Also enter your team name in all 30 cases. (You'll probably find it quickest to type the team name into the first cell, copy it, and then paste it into the other 29 cells.)

9. Save the document by selecting **File | Save As**. Name the document using your group name first, and then your name, as directed by your teacher.

Examine your Group's Performance

10. Using TinkerPlots, make a plot of the data that looks similar to the one you made on paper.

11. Experiment to see if you can make plots of your data that look like the plots that other groups made on paper.

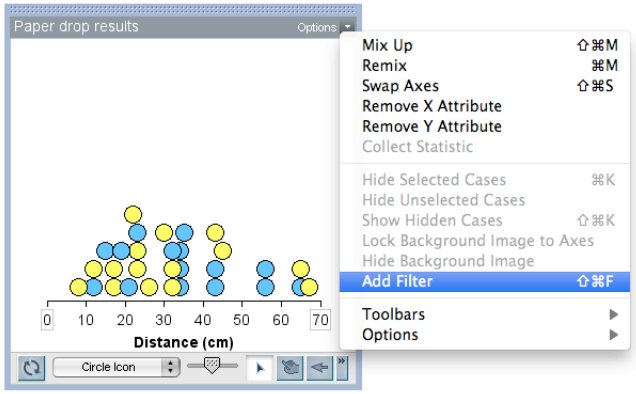
With the data in TinkerPlots, you can now look at some things that would be hard to do without the computer.

Replaying the data over time, for example, can help you detect trends—this technique adds one case at a time to the plot, in the order you gathered the data.

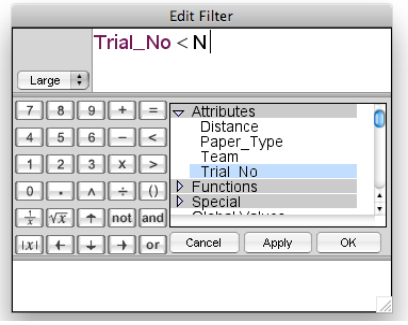
To do this, you can build a filter that controls which cases you see in the plot and control that filter with a slider. What you get will look something like the plots shown here.

12. To add a filter to a plot and control it with a slider:

    a. Choose **Add Filter** from the plot's **Options** menu.

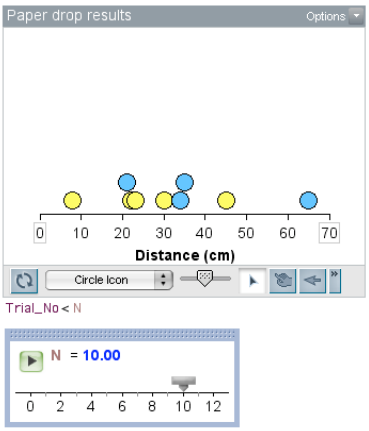


b. In the dialog box, enter the formula "`Trial_No<N`" and click **OK.**



c. Choose **Object | New | New Slider** to add a slider to the document.

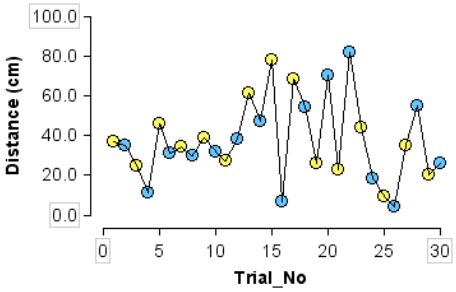
d. Double-click the name of the slider (V1) and type "`N`." Now drag the slider's thumb to control how many cases you see—you'll see all cases with a trial number less than *N*. You can click and drag a number at the end of the slider's axis to adjust how many cases you see.



e. If the axis of the plot changes as you add cases, double-click the maximum value on the axis. In the dialog box, enter a value that is greater than your longest distance. Do the same for the minimum value, setting it to zero.

13. Use the slider to replay your data. Describe any trends in performance you see over trials.

14. A *time-series plot* is another powerful way to show how something changes over time. Make a time-series plot of your results by fully separating *Trial_No* on the horizontal axis and *Distance* on the vertical axis. Then, click the **Line** button in the upper plot toolbar so your plot looks like the one shown here.



15. Does it appear from the time-series plot that your team's performance got either better or worse with practice? Explain.

16. In many cases, very good drops (small distances) tend to be followed by poor drops (large distances), and very poor drops tend to be followed by good drops. Why do you think this tends to happen?

17. Make a plot that helps show how you did, on average. Describe your average performance. How did you measure your average? Why did you choose this measure?

18. Make a plot that allows you to see how variable your group's data are around your average distance. Describe the variability of your data with respect to the average, using a specific number if possible.

19. Open the document **Paper Drop Class Data.tp.** These are the combined data from your entire class.

20. Which group had the best overall results? Explain.

21. Why might different groups get different overall results?

22. Which group was the most consistent? The least consistent? Explain your choices.

23. Propose a method for measuring consistency. Your measure should allow you to say, for example, that Group 1 is twice as consistent as Group 2.

24. What group showed the most improvement over the 30 trials? Explain.

25. Considering all of the data together, what do you conclude now about which type of paper tends to result in the most accurate drop? Explain.