Taking flight with an inquiry approach

by Kathryn Silvis

This paper airplane lesson has been used with sixth-grade students to introduce scientific terms and concepts that students need to know before they design and conduct their own inquiry experiments. Terms such as *manipulated/independent variables*, *responding/dependent variables*, and *constants* are defined within this lesson, and students come to understand the importance of changing only one variable in scientific experiments. In addition to science concepts, mathematics skills are embedded in this lesson as students measure paper airplane flights to the nearest centimeter and calculate range, mode, and median in a hands-on way. The 5E model provides a way to organize inquiry-based instruction, and focuses on actively involving students in the learning process (Carin, Bass, and Contant 2005). For this lesson, students engage in creating their own paper airplane model, explore how far their paper airplane will fly, explain the class results of paper airplane flights, elaborate by designing another paper airplane experiment with only one variable, and evaluate patterns found in paper airplane test flight data.

Engage

As students enter the room, they find at their lab tables directions for the lab and supplies for constructing a paper airplane. Each table of four to six students has a variety of different types of paper (such as construction paper, graph paper, and notebook paper), as well as markers, scissors, and tape. After students create their own paper airplane models, they can decorate their airplane as time allows using markers at their tables. There are no specific directions for making the plane, which should ensure a wide variety of models to test during the Explore phase (see Figure 1).

Students are then asked to make a prediction of how far in centimeters their paper airplane will fly, and record their prediction in their science journal. Students' predictions can be used as a diagnostic assessment of each student's ability to estimate with centimeters. For example, a student who predicts that his/her paper airplane will only fly five centimeters does not have an understanding of metric estimation. In addition to each student's personal prediction, students can predict which paper airplane created by classmates will fly the furthest distance. This prediction can be recorded on a class data chart.

This activity immediately engages students, who are often excited to make their own paper airplanes in science class. The excitement continues to build as students prepare to explore how far the paper airplanes will actually fly.

Explore

After students have created their paper airplanes and made their predictions, the teacher takes the class to the test flight site. A long, straight hallway works best for test flights, with a metric measuring tape running the length of the hallway. Some hallways have marked sections of tile on the floor, which makes it easier to estimate distances. Because students often shout out with excitement during the test flights, it is best to select a test flight site that will not disturb other classes. The test flights could also be done outside, although wind could add another variable.

After everyone has donned safety goggles, students take turns throwing their paper airplane and measuring how far it flew to the nearest centimeter, using the farthest point of the plane from the starting line. Students then record their name and flight distance on a small sticky note, which is posted at their landing point on the floor. These sticky notes will be used for a data classification activity during the Explain phase. The sticky note also serves as a placeholder for the plane, so that the paper airplane can be removed from the landing area to avoid collisions with other paper airplane flights. Students write the distance of their paper airplane flight in their science journal, and compare it to their prediction.

Once all the planes have had their test flights, there should be a set of sticky notes spread out on the floor (see Figure 2), which provides a great opportunity for students to explain patterns in the data.

Explain

One way to explain patterns in the data is to apply mathematical measures of central tendencies, including range, mode, and median. These three terms can be demonstrated in a hands-on way, using the collection of sticky note flight data. The range of the data set will be easy for students to see, as the teacher can direct students to look at the difference between the shortest flight distance and the longest flight distance. After students visualize this difference, they can make the subtraction calculation to determine the actual range (subtracting the shortest flight distance from the longest flight distance). The mode will be clearly evident if any distances occurred more than once, because there will be several sticky notes at the same spot on the floor. For example, the flight data shown in Figure 2 shows a mode of 180 cm.

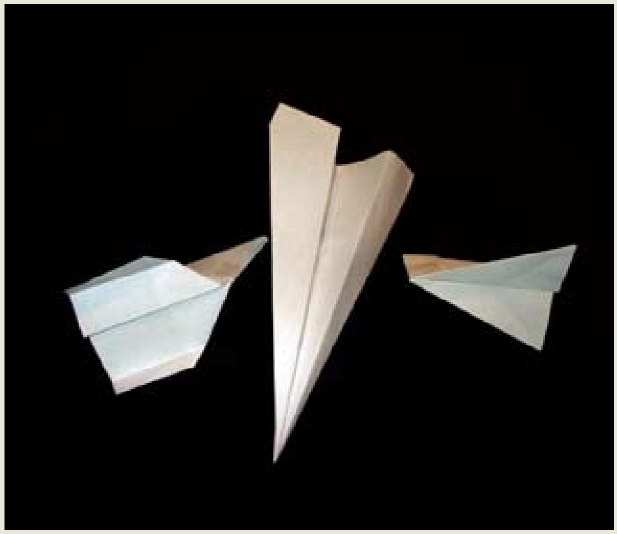
Finally, because the distances are already arranged from least to greatest, the median can be visually represented with a student demonstration. To begin the demonstration, each student stands at the landing point of his or her paper airplane. Then, the student standing at the shortest flight distance and the person standing at the longest flight distance are asked to sit down in unison. This process is repeated until one person is left standing. This person represents the median for the data set, the middle value. If two people remain standing at the end, then the class can determine the middle point between these two distances. After these mathematical calculations are made, students can continue to explain the results of the experiment.

The 5E model helps students develop inquiry skills because students are asked to interpret data to determine *why* something happened, which goes one step beyond simply making an observation (Carin, Bass, and Contant 2005). The questions that a teacher asks at the Explain stage are a critical part of guiding students to think more deeply about experimental results. For this paper airplane experiment, the teacher can ask the following open-ended questions:

- What patterns do you notice in our paper airplane data?
- Which plane had the longest flight? Why do you think so?
- Which plane had the shortest flight? Why do you think so?
- What is the best design for a paper airplane? Why do you think so?

As they respond, students may begin to make some conclusions, such as: "The planes made out of construction paper did not fly as far as the planes made out of graph paper." At this point, the teacher will want to draw students' attention to the many variables that existed in the paper airplane experiment, such as different airplane designs, different people throwing the airplane, and different paper that was used. The

FIGURE 1 Sample paper airplane models



PHOTOS COURTESY OF THE AUTHOR

FIGURE 2 The mode represented by multiple sticky notes

FIGURE 3 **Group data sheet for paper airplane flight experiment**

What variable has your group selected to test? ______________________

The variable that your group has selected to test is called the *manipulated,* or *independent, variable*.

What is your *responding,* or *dependent, variable*? ______________________

All of the other variables in your experiment need to be constant.

What will the *constants* be for your experiment? ______________________

Explain your group's hypothesis for this experiment—what do you think will happen and why? ____

____

Describe the steps of your group's experiment:

1.
2.
3.
4.

Results for the experiment:

Independent variable		
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Range		
Mean		
Median		
Mode		

Explain how your results compared with your hypothesis for this experiment.

____

____

teacher can then introduce specific terms related to variables (Carin, Bass, and Contant 2005) and relate each term to the paper airplane experiment. The *manipulated,* or *independent, variable* is the aspect of an experiment that is deliberately changed. This original paper airplane experiment has several independent variables, including airplane design, type of paper, and the force the person uses to throw the airplane. The *responding,* or *dependent, variable* is the aspect of an experiment that responds to the deliberate changes made. In the case of this experiment, the dependent variable is the flight of the paper airplane. Finally, *constants* are aspects of an experiment that are deliberately kept the same. The only constant in this experiment would be the paper airplane test site, because everyone tested their airplanes at the same site. All of the other variables were not constant. Because there are so many manipulated or independent variables in this experiment and few constants, it is not possible to make conclusions that focus on just one variable, such as, "The planes made out of construction paper did not fly as far as the planes made out of graph paper." Next, students are asked to fix this problem with the experiment by selecting just one variable to manipulate in the Elaborate section.

Elaborate

Each small group of four students should design an experiment that manipulates just one variable of paper airplane flights, while keeping all other variables constant. Students can work together to complete the data sheet shown in Figure 3.

As students are working, the teacher should be completing some formative assessment to ensure the groups are creating an experiment that has just one manipulated, or independent, variable. After groups have checked their experimental outline with the teacher, they can return to the test flight site to test and record the new flight distances. Because students will be completing several trials for each independent variable, they should calculate the range, mode, and median for each set of trials.

Evaluate

Students can share the results from their small-group paper airplane experiment with the class. Each member of the group should participate in the reporting process. One member can explain the variable that the group decided to change. The second group member can explain the variables that were kept constant in the experiment. A third member can share the results from the test flight trials, including the range, mode, and median for each trial set. Finally, the fourth member can explain whether or not the conclusions from the testing matched the hypthsesis. For individual evaluation, students can be asked to explain in their science journals at least two patterns from their small-group experiment data.

Conclusion

After students have experienced each section of this 5E lesson, they have a better understanding of how to design a scientific experiment. This lesson also draws students' attention to a common flaw in experimental designs—changing more than one variable. When the paper airplane lesson was used at the start of the year, students had greater success designing their own experiments throughout the year because they understood the importance of changing just one variable while keeping everything else constant. Students truly "take flight" with an inquiry approach as a result of this lesson!

References

Carin, A.R., J.E. Bass, and T.L. Contant. 2005. *Teaching science as inquiry*. 10th ed. Upper Saddle River, NJ: Pearson Prentice Hall.

Kathryn Silvis (*Kathryn.Silvis@LaRoche.edu*) is an assistant professor in the Department of Teacher Education at La Roche College in Pittsburgh, Pennsylvania.