Teacher Tune-up

Quick Content Refresher for Busy Professionals

In science, what do we mean by fair?

Naturally, students have lots of opinions about what is fair. Fairness in a general ethical sense can certainly come up in science, for example in the matter of human test subjects' informed consent. But students should also become aware of a more narrow, specialized meaning of the word "fair" when conducting scientific experiments. Fairness in this context is essentially about making sure that experimental comparisons are as meaningful and reliable as possible.

The word frequently comes up when testing something or developing a procedure for an experiment. There are three concepts that the SciGen materials emphasize to help students think about being more fair in science:

1. Controlling variables appropriately
2. Conducting multiple trials or repeating procedures
3. Using an objective form of measurement that others can use the same way

Control of Variables

Scientist work to create controllable conditions for experiments. Teachers can share this idea with students through simple examples: "What if you were testing paper airplanes over several days outside, but one day was really windy and the other days were calm?" Students should readily comment that that would be an inappropriate way to test paper airplanes because changing wind conditions would make flight comparisons meaningless or misleading. It would not be a fair test.

Going further with the paper airplane testing example, students could be invited to think about all the ways conditions may vary (how the plane is thrown, from what height, etc). If the goal is to be scientific about the test, then students should aim to create matching conditions every time they test. The only change from trial to trial should be the independent variable related to the test. So if the goal is to test a narrow-winged design against a wide-winged design for distance flown, then it's important to think through how to prevent outside factors (such as wind) from interfering with the test. Perhaps this concern would lead the tester of the paper airplanes to an indoor space like the school gym, where the lack of wind would allow fairer testing.

Along these lines, as students advance through the grades, they will also encounter the term "control" used another way. A control condition in an experiment is often essential when gathering data in science. A simple example of this might be when students are testing, say, how much plant fertilizer supports the growth of bean plants. In addition to making sure that all the bean plants in the test are in matching conditions, there should also be a "control" that receives no fertilizer. Including this control makes the comparison among those plants that do receive various doses of fertilizer more meaningful.

Conducting multiple trials or repeating procedures

Scientists work to create experiments that other people can repeat so their hypotheses can be supported, modified, or overturned by further research. But even within a single experiment, it is often important for students not to enter into a "one and done" mindset. For example, it would be inappropriate to claim that one paper airplane design flies farther than another based on a single flight of each one. In this case, it would be better to conduct multiple trials and establish patterns by looking at all the data. Sometimes a measure of average (such as median or mean) might to appropriate.

Using an objective form of measurement that others can use the same way

Finally, teachers should encourage students to use objective forms of measurement (and to avoid subjective descriptors such as “best” without stipulating more measurable criteria). For example, consider the popular student activity of “paper towel testing.” Students can use various objective measurements, depending on what they are really testing the paper towels for. Are they investigating the strength of a saturated paper towel, or the speed with which a paper towel absorbs water, or the amount of water a paper towel can absorb? If the latter, milliliters would be an appropriate unit to use. Students could put a set amount of water in a beaker, submerge the paper towel, remove the paper towel from the beaker, and note the amount of water that remains in the beaker after the towel is removed.

Moreover, teachers could challenge students to think through additional points of procedure: does the amount of time the towel is submerged matter? Do all of the paper towels being compared have the same area? Again, fair comparisons control variables other than the ones the experimenter intends to compare might be appropriate.