Statistics

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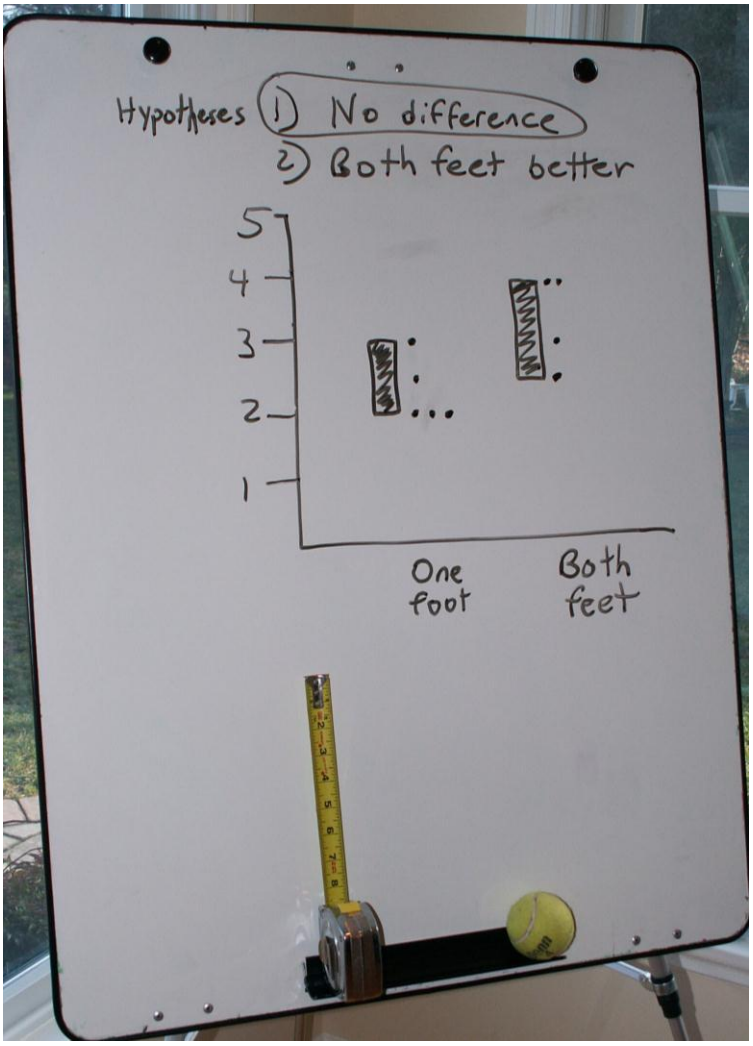
Recommended as second YTA lesson

Materials (see picture below):
Tennis ball
Tape measure
White board or other writing surface

Key Words:
Statistics, range, significant

1) Discuss the general educational path to working in science and technology, indicating that it takes about 12 years to achieve a high school diploma and 4 years in undergraduate school to be a college graduate. Then discuss the additional schooling necessary, after the undergraduate degree, to achieve a doctor of philosophy or Ph.D. (about 5-9 years). Ask the students, "why, after 16 years of school, someone wishing to become a scientist needs to go to school for 5-9 more years?"
2) Ask students what scientists do. Lead them to understand that while scientists use their knowledge to come up with an idea, or "hypothesis," they must also prove to other scientists that their idea is correct or incorrect. During the 5-9 years of extra school after achieving the college degree, scientists especially learn methods for proving things. Discuss ideas for how to prove that an idea is correct.
3) Tell the students you have a hypothesis: If you drop a ball from a high height (over your head) it will bounce higher than if you drop a ball from a low height (knee level)
    a) Drop a ball from a high or low height, five times each, and have two students use the tape measure to record the bounce height.
    b) Draw a large graph plotting high or low on the x-axis, and the height of the bounce measured on the y-axis. For equal measurements make the dots separate.
    c) Interpret the results, discussing strategies to determine whether or not the hypothesis should be considered correct. Lead the conversation to a discussion of the "error" or "variability" in the number of bounces in each group. Suggest writing a shaded area next to each group of measurements (high or low), to be called the "range" that a measurement is usually found within. Define the range for a group as a bar from the highest to the lowest measurements in the group. Next suggest that we say that the two groups are different and the hypothesis is correct if the ranges do not overlap. Ask the students for opinions on that method or rule, and note that there is no clear answer; we just have to all agree as scientists on the rules for saying that the two groups are different, or that the difference between these groups is "significant." Once everyone agrees, write the "Statistical Rule" on the board: <u>If the ranges do not overlap the difference is significant</u>.
4) Tell the students that now you are wondering if a person can jump further from a resting position, if the person jumps with one leg or both legs. Have the students suggest hypotheses and write them on the board. Be certain to include the null hypothesis, that there is no difference between the two types of jumping.
5) Have a child come up and guide him/her to draw a graph on the board, with labels for the vertical (distance jumped) and horizontal (one or both feet) axis. Have the vertical axis go from zero to 5 feet.
6) Have one child jump with one and both feet while other children measure the distances jumped for plotting on the graph. There should be one measurement for each of the types of jumps.
7) Ask the students which hypothesis is correct, and guide them to the conclusion that we cannot use our statistical rule because we cannot draw a range; we need more data.
8) Have a number of students come up and jump with one or both feet, and keep adding the data points to the graph, interacting with the students on where the data points should go, and how the hypotheses are doing.
9) After a good number of data points are graphed (>5 for jumping with one or both feet), have the children discuss the results. Lead a selected student through the construction of range bars and ask the class whether we can determine if any of the hypotheses were correct. If the ranges overlap the null hypothesis is accepted based on the "Statistical Rule" the scientists in the classroom all agreed to. If they do not overlap then there is a difference and the graph will tell which of the groups jumped the furthest.

10) Note to the children that our conclusions may have been different if they had established a different Statistical Rule. If the conclusion in Step 9 was that there was a difference, multiply the range bars by 5 in size and test the changed rule, "if the range bars times 5 do not overlap then the difference is significant", which should now result in accepting the null hypothesis. If on the other hand the conclusion in Step 9 was that there was no difference, divide the range bars by 5 or 10 so that they do not overlap, and test the rule, "if the range bars divided by (5 or 10) do not overlap then the difference is significant," which will result in the conclusion that there was a difference.
11) Ask the children if it seems fair to change the rule after you have already made and graphed the measurements. Discuss the implications if scientists allowing statistical rules to be determined in this way. Lead them to the conclusion that some would change the statistical rules after seeing their data, so that their hypothesis was correct. So the Statistical Rule has to be agreed upon **before** the experiment is started.
12) Ask the students for a hypothesis they would like to test at home, and guide selected students through the design of a study to test that hypothesis, and the labeling of the axis on a graph of study data. Plot made-up data for these studies, and ask the children to make conclusions regarding significance. If there are no volunteered hypotheses, some examples that could be suggested are:
    i) If a student studies for 30 minutes for a spelling test, they do better than when they study for 15 minutes.
    ii) An aluminum bat will hit a baseball further than a wooden bat.



Statistics lesson highlights checklist

- ☐ Educational timeline, ending with Ph.D.
- ☐ Scientists learn how to prove things with statistics in graduate school
- ☐ Compare height bounced by ball dropped from high versus low starting height
- ☐ Statistical Rule: Non-overlapping ranges defines significance
- ☐ Jumping distance for one versus both feet
- ☐ Need more than one data point per group to test hypotheses
- ☐ Cannot make up statistical rule after seeing the data
- ☐ Model the testing of additional proposed hypotheses