Preparing your students for the ASLO/TOS Conference:
Teaching the scientific method

The scientific method is taught slightly differently depending on the textbook, class, and the level of the students. The main sections of a scientific poster or report remain the same, and the basic steps of developing an experiment are also always the same. This is an example of the steps and how you could teach them.

The scientific method is the process by which scientists test ideas to explain the natural world. It has 9 steps:

1. **Observe the world/universe around you:** In this step, scientists observe what happens naturally around them. If a certain phenomenon is of interest, they study it more closely.
2. **Idea/ question:** From making the observations of the natural world, often a question arises of how something works or what would happen *if* something new were to enter the system or to change the conditions. The question must be clear and answerable.
3. **Research the background:** Once a question is developed, it is essential to research what is already known on the subject. It would be a waste of time and valuable resources to repeat an exact experiment that was already completed. Also, an experiment may have been performed that had interesting results that may alter the researcher's initial question. The background information can lead you to a reasonable guess or hypothesis as to the results of the planned experiment.
4. **Hypothesis:** This is the logical and reasonable guess as to the results of the experiment.
5. **Plan and design the experiment:** In this step, the details of the experiment are determined. The plan and design must be precise so that the experiment could be repeated exactly by anyone anywhere in the world.
6. **Perform the experiment:** Now it is time to perform the experiment. Everything that occurs must be written down in a logbook.
7. **Observe the results and collect data:** All results must be observed and recorded.
8. **Graph and analyze the data:** The data is then analyzed to see if there are any trends or patterns in the data.
9. **Infer a conclusion from the results:** Last, based on the analysis, scientists infer a conclusion or a reason for the results that were obtained.

The best way to have the students become familiar with the scientific method is to have them perform experiments. Often, the best way to learn the importance of each step is to forget one! ✍ If you do not have the time or resources to perform experiments, or if you want to be sure they understand the steps prior to your first experiment, a "mock experiment" can be planned. One example of a mock experiment is described below.

Mock biology experiment:

A native plant has been found in the mountains where people do not often travel. Only a few plants of this type were found, and only at one specific location on the mountain. We need to grow more of this plant so we can study it.

The first two steps of the scientific method are completed for you- observing the natural world and developing a question. The question is "What are the ideal growth conditions of this plant?"

As a class: Brainstorm the growth requirements for plants
[Light, nutrients, water, carbon dioxide, soil type]

Step 3: **Research the background**.

1. A soil sample could be collected where the plants were found to determine the soil type.
2. What is the normal range of light, nutrients, water, and carbon dioxide for all plants?

Goal: In groups of four students, design an experiment to determine how much _____ (any of the growth requirements the class brainstormed) it needs to grow.

Step 4: **Hypothesis.** Based on the background information gathered, come up with a hypothesis for how much _____ will make the plant grow *best*.
[*Be sure to determine how you will determine which plant grew* best. *Is it the tallest, the greenest, the most leaves, or something else? This level of detail will be included in the plan and design of the experiment.*]

Step 5: **Plan and design the experiment.**

1. The first thing to determine is what you will measure and record regarding plant growth.
    a. Will you measure height? From the soil to the top leaf? To the top of the stalk? What if the plant is bent over or limp?
    b. Will you count the number of leaves? Color of leaves?
    c. How often will you measure it?
2. Under what conditions will you grow the plant?
    a. It is important that all growth conditions other than the one you are testing are consistent from plant to plant. In other words, if you are testing light, the water, nutrients, and soil must be the same for all plants.

    b. What levels of light/water/nutrients will you test for your experiment? How will you measure it to be sure they are the same from day to day? How often will you water or fertilize the plants?
3. How long will the experiment last?
4. How many plants will you use for each condition?
    a. Ideally, you should have at least 3 for each treatment (i.e. three plants at the lowest light/nutrient/water level, three plants at the next level, etc.)
    b. Will you have a control? It is important to have controls in experiments whenever possible. In this case, the control might have no water/light/nutrients.