

Experimental Science Skill Module: Sizing Up a Measuring Device

When you collect quantitative data, you either count or you measure. If you are fortunate you will use something to do the counting or the measuring other than your voice or the width of your fingers, which are nice in a pinch, but hardly the most precise or accurate devices out there. In fact, over time devices with which you gather quantitative data have become increasingly fast, accurate, precise, and if under computer control, capable of generating and storing large amounts of information.

Seasoned scientists have an intuitive feel for how to approach any new device they use to make measurements. They immediately develop a sense of the device's upper and lower limits of measurement, reproducibility, accuracy, sensitivity and dynamic range. Knowing this information quickly defines the range of possible experiments that can be performed with a device. For example, good scientists immediately know not to use a water thermometer to measure boiling points over 100°C or know that a particular optical filter in a photometer needs to be removed because it is blocking the violet light.

Sadly, most unseasoned users of measuring devices can't be bothered to figure out the utility of a device and instead launch immediately into measurements that are off scale or too insensitive or poorly resolved to answer the question originally posed. And the result? Useless data and an inquiry returned with comments about knowing your measuring device.

Now it is our strong preference that you not generate useless data in your second inquiry, and consequently you are asked to consider the following questions BEFORE you begin your inquiry.

Assignment: Select a measuring device from PAI 4.14 and explore its capabilities. Assess the device to determine answers to the bulleted questions below and then write a one page paper with an exciting title like:

“My Friend the Tape Measure” or “Photometers Light up my Life”

in which you discuss the capabilities and limitations of the measuring device. Ideally you will use this measuring device in your Inquiry 2, but it is not requirement of the skill module. Do appreciate, though, that any device you use to make a measurement needs this consideration before you begin collecting real data.

- Name and type of instrument?
- What is measured?
- What are the units of measurement?
- What is the largest amount that can be measured?
- What is the smallest amount that can be measured.
- How many resolution elements are possible with the device?
- How sensitive is the device (the slope of the response that is measured?)
- What is the dynamic range of the device (the number of orders of magnitude of measurement?)
- Make 10 measurements with the device. What can you say about its precision?
- How accurate is the device? What is it that limits the accuracy?
- How fast can the device make a measurement?
- Is the device automated? If so, how much information can it acquire?
- What are the trade-offs in speed, accuracy and precision with the device?
- If you could change one thing about your device to make it better, what would it be?

Not all of these questions apply to every device. However many answers are only realized after you spend some time contemplating concepts like sensitivity or dynamic range in the context of the device you are using. Be thoughtful about your responses because understanding your measuring device will likely determine how successful your science inquiry will be.