Name: _____ Period:____

Annotation

Sources of Error

Annotation Key:

It is important to understand the concept "sources of error" in science when you are considering the conclusions of an experimental procedure. Identifying sources of error is a valuable tool in verifying that your work represents what is actually happening in an experiment. It also demonstrates to the reader of your lab summary that you understand how changing variables affect the outcome of your experiment.

First, sources of error are not the same as mistakes. When something goes wrong in an experiment, or an equation is used incorrectly, that data should be discarded and the affected portion of the experiment repeated if possible.

Even if everything goes as planned, it is unlikely that successive measurements of the same variables will have identical results. This is not necessarily due to mistakes, but is likely due to legitimate sources of error.

Error can generally be broken down into several broad categories: systematic error, random error, instrumental error, procedural error, and estimation/human error. There are other, finer subdivisions, but we will focus on these five.

Systematic error occurs when some measurement is consistently off by the same amount. Think about measuring the height of an object with a wooden ruler. On most rulers, the "zero" mark is not the edge of the wood, but 1-3 mm from the edge. You can easily correct your measurements by subtracting the 1-3 mm from each height measurement.

Random error can have many causes, but the result is that a measurement tends to fluctuate around the fixed value. An example of random error might be trying to measure the surface area of objects with rough or irregular edges or sides, which makes simple calculations like length times width ambiguous. Another example might be trying to measure the wind direction on a gusty day. The way to correct for random error is to make multiple separate measurements or have multiple trials in an experiment.

Instrumental error occurs when the measuring tool does not provide as precise a value as could be provided. Instrumental error can be corrected by using more precise measurement tools (if available), or taking steps to offset or prevent possible tool errors. For example, an air conditioner blowing on a sensitive electronic balance can cause fluctuations in the mass reading, which can be corrected by moving the balance to another part of the room, or using a cover or screen. An electronic tool may need to be calibrated (though this may cause systematic error), or a measuring device may not have the fine resolution to resolve small fluctuations in the measurements. An example might be using a centigram scale to measure mass where a few milligrams of difference vastly affects the outcome.

Sources of Error (continued)

Procedural error occurs when changing the steps in a procedure or how a measurement is taken has an effect on the measurement or outcome. If I poll shoppers at a mall about their spending habits during the middle of the day, I am likely to poll only those who do not work full time. This sort of procedural error introduces bias into my experimental results that may be corrected for if suitable data is available from other times of day. Another might be the decision to estimate area by counting squares on a graph versus using geometric formulas for the same object, or obtaining data from the slope of a best-fit line or curve rather than some other method that may be more or less appropriate under the circumstances.

Estimation/Human error comes from measurements that must be estimated. When measuring using a ruler the smallest subdivisions are generally millimeters, or 0.1 cm. I should be able to estimate between these markings to the nearest 0.1 mm, or 0.01 cm, but my measurements and those of another observer may be different. Estimating liquid volume to the hundredths or thousandths of a milliliter in a buret or pipette would be another example. When these estimations are done by a device such as a centigram balance, we typically categorize them as instrumental error even though the last digit on a digital device should always be considered an estimate. When the estimation is done by a human, we may call this estimation error or human error. Be careful however, that we do not confuse "human error" with mistakes like incorrectly using equipment, transcribing values, or using wrong equations. All of these are mistakes and should be corrected. Sources of error cannot be eliminated from any experiment. Being able to identify sources of error in your experiment demonstrates that you have a good understanding of how the experiment works, what measurements affect the outcome, and by how much. Always identify sources of error in every experiment, and suggest ways of minimizing them to the next experimenter.

G. W. Franz (2021)