Science Tools:
Powers of Ten Background

Powers of Ten (P10) refers to scale. This scale can be an excellent tool to use when framing observations. In other words, P10 is a way of putting objects being observed into context using size as the focal point. Once students understand the scale terminology, it can be used to both communicate and focus attention. For example, asking students to observe something, such as a section of the playground at the meter scale (10^0) will give them a different sense of the playground than observing it at the cm scale (which, in this case would be 10^{-2}), or likewise, at the 10^0 meter scale (10^3). In this way, P10 can be used to help students focus on smaller areas or conversely, to look at the larger picture. Powers of Ten is based on the System International (SI) units of measurement and the use of exponents.

To figure out which exponent belongs with each unit, simply add or subtract zeroes from the initial "10" – see below for a simple list. Any type of measurement (in SI units), such as distance, volume, or mass can be added to the exponents, but distance (meters) are used in this example as they are the most likely types of observations initially made by students.

10^3 = 1000 meters or 1 kilometer
10^2 = 100 meters
10^1 = 10 meters
10^0 = 1 meter
10^{-1} = .1 meter (decimeter)
10^{-2} = .01 meter or 1 centimeter
10^{-3} = .001 meter or 1 millimeter

Measurements can be expanded beyond this scale; however, the ranges given above are the ones most commonly used for the observations students usually make. Within the Mammoth Hot Springs system, P10 can be used to assist the students in describing and understanding the different physical features of a hot springs system.

As an example, the whole of Mammoth Hot Springs is measured in km, thus, describing it in terms of "ten to the power of 3" or 10^3 can be used to help students understand its size. Yellowstone itself is several Powers of Ten larger, 10^6 at 8,987 km^2*. Orange Spring Mound, one of the hot springs studied by STaRRS students, could be described using 10^1, as it is approximately 20-30m wide. The terraces (10^0), terracettes (10^{-1} & 10^{-2}), and microterracettes (10^{-3}) in the proximal and distal slope can all be described by using decreasing Powers of Ten.

*10^6 = 1,000,000m or 1000km, which is approximately 620 miles.

In order for students to become proficient with this terminology they will need to practice. This can be done by infusing it into conversations and discussions about their observation. tudents will learn to recognize that whether they are talking about large observational areas (P10: 10^3) or tiny areas or P10: $10^{-3,}$ using this terminology will assist their classmates by giving them a common reference point.

Powers of Ten can also be used in other content areas. If instructors use the vocabulary consistently, students will be prepared to use this observation tool appropriately. The following are examples of situations in which Powers of Ten may be used to help students frame size:

- The Iraq War versus a playground disagreement
- A dissertation versus a 5-paragraph essay
- A Shakespeare's complete works versus a sonnet
- A national economy versus a family's economic situation
- A tornado versus a dust devil
- A waterfall versus a faucet

A note of caution: It is necessary to help students recognize that importance is not directly correlated to individual Power of Ten. That is, 10^{-3} is not less important than 10^{3}, it is simply a different focus. Also, we can gain an understanding of a large Power of Ten concept by studying a related smaller Power of Ten. However, P10 can also be used to help students focus ideas. For example, when assisting students with ideas for a story, using P10 vocabulary can help students to narrow topics to manageable sizes.

Additional Resources:

Extreme Science: from Nano to Galactic by M. Gail Jones, Amy R. Taylor, & Michael R. Falvo through the NSTA press. ISBN: 978-1-93353-130-4. This book contains many lessons and activities related to mathematics and multiple science disciplines.

Powers of Ten websites:

http://powersof10.com/.

Description: This is a link to a P10 site that a movie was based on. There is a scroll bar on the left side that can be used to move through the powers. There are other interesting links at the site, including a listing of events related to a 1000-day celebration of P10 that began on 10-10-10. Though many of the photos are old, they are still useful.

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html.

Description: This is a link to a more modern site. It contains an embedded video showing powers of ten from 10-16 to 1023: To use this, you will need to have java already loaded. There are many additional teacher resources linked to this site.