A Content Secondary Science Newsletter from the
Southern Nevada Regional Professional Development Program

Science Dissected

Number Sense and the $100 Calculator

Imagine this scenario: Students in your Physics Honors class are introduced to the concepts of velocity. You do several example problems with them including calculating the world record velocity for the 100-meter dash. You and the students discover that the fastest human being on the planet can run just over 10 meters/second. That is really, really fast!!

Now skip ahead a few days when you engage the students in a lab activity using the velocity equation. The students have a great time being outside, running various races, measuring time and distance, etc. You grade these labs while watching college football on Saturday only to have that simple pleasure tainted by noting that a few students in each class can run at speeds exceeding 200 meters/second!! That's over 400 miles per hour. Note that 1 m/s is approximately 2.24 mph, but for simplicity sake, students can estimate by assuming each meter per second is about 2 miles per hour. But the really frustrating part is that these students did not make the connection to the problem they have already done. Their calculators told these students that they are able to run 20 times faster than world record speed. Amazing!

If it is not clear already, one of the greatest challenges as science teachers is teaching students to use number sense. Of course this dilemma is not limited to a physics class. In all branches of science, the use of the metric system is a necessary part of our measurements and calculations. However, students often view metric units with a confusion equivalent to learning a foreign language. Real life does not provide many opportunities for using the metric system in this country. It is vital for teachers to provide a linkage between the unknown of metrics and the known English units with which students are so familiar.

Numbers For Comparison

1 mile = 1.6 kilometers

1 inch = 2.54 centimeters

1 gallon = 3.8 liters

12 oz soda = 355 mL

2.2 pounds = 1 kilogram

98.6 °F = 37 °C

1 meter/second = 2.24 miles/hour

32 feet/s^2 = 9.8 m/s^2

Immersion is very successful when dealing with new language. Do we truly immerse our students in the metric system throughout the year? There are some tricks available to help students with their number sense. One such strategy is to have students keep a list of metric equivalents in the front of their notebooks or somewhere they can easily find them. This includes providing students with the metric unit, the English equivalent, and a common example that represents that measurement. Adding a visual component to their examples will allow students to draw on personal experience to make connections. For example, a centimeter is approximately the width of a pinky fingernail. Now when you say the desk is 80 cm tall, students can link to previously learned concepts and determine if that is a sensible measurement. Some other metric units may not show up until new concepts are introduced throughout the year. Examples would include units for electric charge (Coulombs), velocity (meters/second) or force (Newtons). As each new unit is discussed, their English equivalent and visual examples can be placed on that list in the front of their notebook. For example, the speed of the fastest human in meters per second, the student's weight in Newtons, the mass of a penny in grams, etc. Like most learning activities, it is vital for students to see a connection to their world. In other words, displaying a 10 gram mass and stating, "This is 10 grams" is not a connection kids have to the everyday world.

Metric Converter, *http://www.sciencemadesimple.com/conversions.html*

Archived Issues of Science Dissected, *http://www.rpdp.net/link.news.php?type=sciencedis*

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Number Sense and the $100 Calculator continued...

A second strategy is constant practice. In doing an example on the board for instance, we might state that a car's velocity is 600 m/s (then a pause). If no one corrects us, we need to review the conversion to miles/hr again along with some examples. If we are corrected, we still want to give examples throughout the year so students are always making that connection. Daily questions used to start class each day are a good way to reinforce students number sense, and provide needed practice in metric units. Even one minute giving an example of a reasonable or unreasonable measurement can go a long way in developing number sense.

The calculator can be an enemy in establishing number sense in students. Most students can tell you how many pennies make up $2.00 or how many donuts there are in 3 dozen. Yet, often students place so much faith in the answer from the calculator, they do not pause to think if this answer actually makes sense. Sometimes a calculator answer may even contradict an answer a student could easily solve in his or her head, and yet still be accepted by the student.

Again, it all seems to boil down to getting students to think in the metric language. Are we constantly asking students if their answers make sense? Are we giving students opportunities to pause and reflect on their own answers and measurements? Are we role models who blend metric and English units so that students begin to make connections between the two systems? Students know that a dollar is a big unit and a penny is small. Therefore, there should be a lot of small units to make up a big one. How is that different than knowing a kilo- is big and a centi- is small? It isn't.

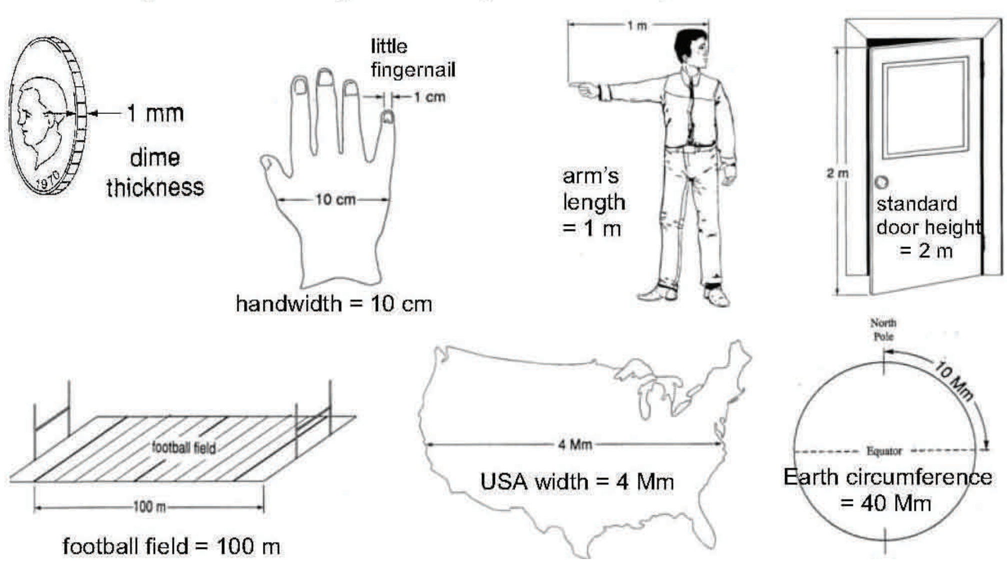
But students have had countless experiences with pennies and dollars. It is our job to make sure that we are giving them countless experiences with unfamiliar units. It is our job to consistently state how a lot of small units like centi-, electrons, and molecules make up larger units like kilo-, Coulombs, and moles.

Students can be very successful when it comes to using metrics. Students can learn to solve problems without calculators and pause to see if their answers make sense. By using immersion techniques, providing guided practice, and by giving measurements related to the everyday lives of students, teachers can ensure success and encourage high level thinking.

Figure extracted from page 4 of the Practical Guide to the International System of Units (SI) referenced below.

Figure 1. Length examples: multiples of meter

Ym	the universe
Zm	galaxies
Em	farther stars
Pm	nearer stars
Tm	solar system
Gm	star diameters
Mm	planets
km	cities
m	arm's length
cm	little fingernail width
mm	dime thickness
µm	bacteria
nm	viruses
pm	atoms
fm	protons, neutrons



Practical Guide to SI (14 page PDF), http://lamar.colostate.edu/~hillger/pdf/Practical_Guide_to_the_SI.pdf

Metric System Information for Teachers, http://lamar.colostate.edu/~hillger/#education