Teaching Measurement in the 21st Century

Elizabeth D. Gray

After thirty years of teaching at the middle school through college level I still struggle with my classes on measurement. I want my students to understand the simple concept of assigning numbers to represent attributes like length, mass/weight, capacity, time or temperature. I want them to know that the units we choose are purely arbitrary. I want them to know that the choice of particular units sometimes requires a conversion to other units.

I claim that most middle school students can learn the basic concepts of measurement. And anyone who needs to measure in everyday life does it with ease (ask any carpenter or cook). So why do our students have such a difficult time?

Some reasons for the problems we face teaching measurement in 21st century classrooms in the United States are:

- We remain one of few countries (see http://lamar.colostate.edu/~hillger/week) that cling to the archaic English system.
- When we do teach the metric system we tend to teach tricks.
- We fail to use the available technology.

In a recent introductory lesson on metric measurement for future teachers, I asked the class how they made conversions in the metric system. One of the students recalled an acronym that she remembered to set up a metric converter. I was amazed when she said that

KING HENRY DIED MONDAY DRINKING CHOCOLATE MILK

helped her set up a converter, which she described as the usual one seen in textbooks.

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km hm dam m dm cm mm

Even though most of the students had not heard the acronym, they had seen the converter. They used it by placing a measure (e.g., 65.4 dm) on the converter and moving the decimal point to the right if they wanted something to the right of that point (e.g., 65.4 dm = 6,540 mm), or to the left if the new unit was to the left (e.g., 65.4 dm = 6.54 m). My questions convinced me that my students had no sense of the size of linear metric units, nor did they know why they were sliding numbers on the converter, but they liked the method because it produced the right answer.

Our lesson needed to be richer than learning to use a converter and it had to follow the NCTM standards for measurement (NCTM, 2000) which state that students should be able to:

- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.

An Actual Lesson

To motivate the students with a real world problem, I suggested that we calculate an internationally used measure of obesity called the *Quetelet index* (named after Adolphe Quetelet, the so-called father of modern statistics). This index is getting much press recently as the *body mass index* (*BMI*). My students perked up. They may not be interested in measurement, but they are interested in measuring sizes of bodies.

The body mass index for adults over 18 is given by:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Weight in kilograms divided by the square of height in meters.

The acceptable range for a *BMI* is 20-25. One is overweight with a BMI between 26 and 30. Obesity starts with a *BMI* of 30. A *BMI* of 18-20 is defined as mild starvation and severe starvation begins when a *BMI* falls below 16.

My American students use the English system of measurement, so they could not tell me their weight in kilograms or their height in meters. They also could not slide these measures along their metric converter, so we had to convert across systems. I did not give the English system version of the *BMI* (weight in pounds times 703/ height in inches squared). After all, this was my opportunity to have them use dimensional analysis for conversion. I was smiling inwardly.

We used a fictitious woman whom we labeled 5 feet 6 inches tall with a weight of 140 pounds. The students stood next to meter sticks to get the sense that the height would be between 1 and 2 meters. They placed packages on a scale to get the sense that two pounds was a little less than one kilogram. Our blackboard calculations for conversions looked like this:

$$140 \text{ pounds} \bullet \frac{1}{} = 140 \text{ pounds}$$

$$140 \text{ pounds} \bullet \frac{1 \text{ kg}}{2.2047 \text{ pounds}} = 63.5 \text{ kg.}$$

$$67 \text{ inches} \bullet \frac{1}{} = 67 \text{ inches}$$

$$67 \text{ inches} \bullet \frac{1\text{m}}{39.37 \text{ inches}} = 1.70 \text{ m.}$$

I supplied the conversion factor from pounds to kilograms and they used the meter/yard stick for a conversion to inches. We calculated on the TI-73 calculator and got *BMI* = 21.97.

If we agree with the National Research Council that "using calculators intelligently is an integral part of number sense" (NRC, 1989, p. 47), we should have no problem using them for conversions. The next generation will not need to memorize conversion factors or carry conversion tables because there is a table built into the calculator. Those who must do conversions on their jobs will remain as proficient as they are today.

Since students of the future will have access to calculators, we must show their teachers how to use these tools wisely. These future teachers were not aware of the conversion table in modern calculators. We used the TI-73 and followed these steps:

Type in the weight 140 on the home screen.

Go to second Convert, select pounds to kg and get the screen given in Figure 1.

Type in the height 67 on the home screen.

Go to second Convert, select inches to meters and get the screen shown in Figure 2.

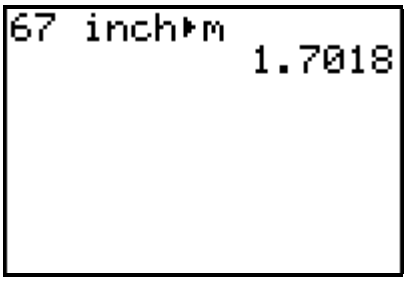

Figure 1 Pounds to Kilograms *Figure 2 Inches to Meters*

My students were amazed. They wished they'd had such calculators when they were in school. We had a discussion about the use of the calculator rather than performing the dimensional analysis that we did on the board. We discussed how fast our world is changing.

We live in a new age with access to the Internet right in our classroom. A quick search on the Internet for Body Mass Index produced several sites. We selected one whose address is

www.healthstatus.com.bmi.html

At this site we found a calculator that accepts the height of 5' 7" and weight of 140 pounds for a quick calculation of a body mass index as 22 (close enough for government work). Not only does the site report the *BMI*, but also it gave a recommended weight range between 125 and 159 pounds for our fictitious woman. The calculator is recommended for adult's ages 18 and up and gives a warning to consult a doctor before attempting any significant changes in weight based on the *BMI*.

My students were frantically calculating on the TI-73s as they left class talking animatedly about whose *BMI* they would calculate that evening. At least they were talking about measurement. Their assignment was to write a report explaining *BMI* using a fictitious man whose height was 6 feet and whose weight was given as 11 stones.

Classroom Implications

Students need to have a practical sense of measurement. They need to know a few helpful benchmarks: that the distance from New Orleans to New York is many miles, that a mile is about 1 ½ times as long as a kilometer, that there are about two pounds in a kilogram, that a liter is very close to a quart. If they are going to take science classes, they must understand the metric system of measure very well. And while our country continues to use the English system, they should understand the mathematical concept of conversion.

Formerly, students studying measurement memorized a few equivalent conversion factors, groaned over the tedious paper and pencil calculations, and had little idea as to whether they were correct. This bears little resemblance to the measurement scenario of 21st century

classrooms. In these future classrooms, we should hope that the students will be a) motivated by real world problems, b) discussing in small groups what they need to know, c) using the available technology to assist in solving the problems, and d) writing reports on their findings. Memorizing conversions units is not nearly as important as knowing which units to choose. Students should be able to speak intelligently about measurement and understand its connection to fractions and decimals. They should be able to estimate measurements reasonably.

After thirty years of teaching mathematics I am still excited by good mathematics that is driven by good mathematical principles, but I have also fallen in love with the available technology. I like the dynamics that are created in the classroom by the interplay of learning real principles of mathematics and learning how to properly use the new technology. My students are more easily motivated and they are learning skills they will take into a world that we can only imagine. We can create more interesting classes by choosing exciting problems in which the students are completely involved. Rote conversions, out of context, should be left to the past.

References

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Elizabeth Gray has been teaching mathematics in Louisiana for over thirty years. She is currently a professor of Mathematics at Southeastern Louisiana University and has been actively involved in LaCEPT and LaSIP initiatives. beth@selu.edu