Conventions

THE METRIC ADVANTAGE

Many veteran science teachers are saddened that some legislators are opposing the current carefully-measured conversion to metric units on road signs and in business usage. Although the conversion is long overdue, there is a serious possibility that the next generation of science students will continue to be crippled by our cumbersome "barleycorn"* system.

THE SUPERIORITY OF THE METRIC CONVENTION

"Joe, how far is your home from school?" asks the teacher.
"About two-and-a-half miles," Joe replies.
"How many feet is that?" the teacher queries. Joe panics. Two-and-a-half times 5,280 is not an easy mental calculation, if Joe remembers 5,280!
"How many inches?" continues the teacher. And there are dozens of additional valid and important engineering and physics questions that can be asked about the work done and the energy required getting him to school. Even if they can remember the internal conversion factors of our cumbersome system (1,760, twelve, etc.), even our brightest "Janes" and "Joes" have to reach for a scratch pad or calculator to grind out these simple answers.

But consider Yuko in Japan or Hans in Scandinavia.
"How far is your home from school?" asks the teacher.
"About three-and-a-fourth kilometers."
"How many meters is that?" queries the teacher.
"3,250 meters," comes the reply instantly and without any resort to paper or calculator!
"And how many centimeters?" continues the teacher.
"325,000 centimeters," is the answer. (And millimeters and Angstrom or nanometer units are just as easy.)

Simply, metric is the language of science, and everyone except American students are native speakers! All of our foreign students have internalized the centimeter and the gram since they were infants. But when our students walk into and sit down in physics or

*An inch is equal to three barleycorns placed end-to-end.
engineering classrooms, they are crippled by having little, if any, fluency in metric. With no "feel" for the approximate weight of a kilogram and no day-to-day practice in the easy shifting of the decimal point among the crisp "deci-" and "milli-" units, the U.S. student takes minutes to fumble through a conversion table and accomplish what the foreign student can mentally do in seconds.

The problem isn’t that foreign students are brighter, but that our policy-makers are stubborn and somewhat disingenuous. And the price we are paying for this Luddite policy is overwhelming.

LACK OF METRICS CRIPPLES U.S. STUDENTS

In 1987, The Scientist published tabulations from the National Research Council’s Doctorate Records File. The number of U.S. doctorate degrees at American colleges and universities awarded to foreign-born engineering students rose from under 20% in 1971 to over 50% in 1983. By 1991, 71 percent of U.S. civil engineering doctorates and 65 percent of U.S. mechanical engineering doctorates went to non-U.S. citizens! While engineering shows this drastic shift to foreign-born students, American students also are becoming a minority in graduate programs in physics and chemistry. In biology, where metrics is less pervasive but still important, foreign students now earn over a third of U.S. doctorate degrees, and the percent is growing each year. Foreign students are not forcing U.S. students out of science classroom seats, but are taking up empty seats left by students who have chosen not to pursue science, mathematics, and engineering. Although the factors underlying the problems in the U.S. science "pipeline" are complex, it is obvious that the more a science discipline involves metrics, the fewer the U.S. students who persevere to complete degrees.

HISTORY OF THE METRIC CONVENTION IN THE UNITED STATES

It will come as a surprise to many Americans that, as the only system recognized legislatively, the metric system is our only lawful measurement system. Moore (1989) summarizes the development of the metric system firmly established in France in 1837, Italy in 1859, Germany in 1872, and Japan in 1921. The rest of the developed world converted by 1970. Metric would have been compulsory in the U.S. according to a bill introduced to Congress in 1866 if it had not been amended to merely "permissible."
In the U.S., the yard and pound were defined by using the meter and kilogram in 1893. The U.S. National Bureau of Standards adopted the metric system in 1964. The Metric Conversion act signed in 1975 by President Gerald Ford encouraged, but did not require use of the metric system. Although opposition to metricalization has often been strongest from conservatives, it was President Ronald Reagan who signed the Omnibus Trade Act in 1988 that designated the metric system as the preferred system for U.S. trade and commerce. This Act finally had "teeth" by requiring federal agencies to use metric units in their purchasing. Because the federal government (including the Department of Defense) buys a lot of everything, many science teachers have regained hope that they can now begin to complete the task of getting our students back into math-filled science and engineering.

BAD TEACHING AND BAD ENVIRONMENT

Why didn’t the 1970s push for metric education succeed in producing a generation of science students who "spoke metric" as a first language? Two important factors stand out as a lesson in ineffective teaching.

Many of the metric teaching materials, and much of the metric teacher-inservice, focused on teaching students to convert between the U.S. customary system and the metric system. At desks across Kansas, students struggled with a kilogram equalling 2.2 pounds and an inch equalling 2.5 centimeters. Instead of discovering how elegant and simple metric units are internally, students found the new system to be artificially complicated. By constantly translating back into U.S. units, many students never gained fluency in the new system or came to understand its unquestioned elegance.

Metric education also suffered from less-than-inspired materials and teaching. Lehman (1987) at Bethel College complained rightfully when his daughter was assigned exercises to combine metric prefixes and units in "repetitive, useless exercises" that produced hectoliters and dekameters and other hypothetical units that in reality are never used.

However, the most devastating failure of the 1970s metric movement was the failure of the society at large to reinforce the classroom lessons. Even when students were well-taught to work only within the metric system, our students exited the school in the
afternoon only to read mileage on the roadsigns and Fahrenheit degrees on the bank marquee signs. Even when some weather announcers and bank signs gave the temperature in Celsius in addition to Fahrenheit, we could all wait a few seconds until the old familiar units appeared. In spite of gas pumps that read liters and speedometers that read kilometers per hour, the old system remained everpresent. We never had to change. We never had to speak in the new language because our old language was right there alongside the new. Only the world travelers among us are aware of how easy it is to get used to 28 degrees (C) being warm, when that is the only temperature being reported. An American family that moves overseas finds themselves thinking and fully functioning in kilometers and grams and centigrade units within a week!

METRIC NOW!

Immediate conversion to the metric system is a critical factor in stopping our downhill slide into science illiteracy. As a science teacher, you are in a position to take action both inside the classroom and outside in the community. The following steps should all be taken as soon as possible:

No science textbook should be adopted with non-metric units. And be sure to write the publisher to tell them why you didn’t adopt.

You shouldn’t use non-metric in class, either. Break the habit. No more feet and miles, acres, and Fahrenheit degrees in class. If you aren’t comfortable with hectares and kilometers and grams and milliliters, your students won’t be comfortable, either. Trash those classroom rulers that have centimeters and millimeters on one side and inches on the other; metric only!

Forget the U.S. customary system and conversions from that system. Yesterday’s students could hold up fingers and approximate an inch; tomorrow’s students must be able to approximate a centimeter as their finger width, a millimeter as a pencil-lead-width, etc.

Fight to get the metric system into society and the U.S. customary system out! Leaving the old system in might seem considerate of the older generation, but it completely negates all of our teaching effort and oppresses the next generation. A mental conversion that could occur in weeks will drag on for years, or perhaps never predominate.
Write to those legislators who don’t understand the role of metrics in science, math, and engineering. Most are for better science education. Explain how the U.S. customary system works to undo your classroom lessons.

Write to the weather reporters; first to get metric into the weathercast, then to get mon-metric out. Talk to the bank tellers and officers—same strategy. Compliment distributors when they move to provide products and services in metric units; criticize them when it is possible and they don’t.

Most conventions discussed in this series (north is up, clockwise, etc.) have "settled in" over time. Not only does everyone accept the convention, often there is no real advantage whether north or south is at the top of a map, whether clocks run counterclockwise, or whether we drive on the right or the left side of the road—just as long as everyone agrees to the convention. However, the mathematical elegance of metric and lack of elegance in the cumbersome U.S. customary system makes this convention an important exception.

REFERENCES


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