29 August 2006

National Mathematics Advisory Panel
United States Department of Education

Subject: Metric Usage for the United States to Be Globally Competitive

Dear Panel Members:

It comes as no surprise that President George W. Bush has made an appeal to the American public concerning the dire need of the United States to regain its competitive edge in math, science and technology. There have been many recent, supporting articles published about the decline of American talent in these fields. By tracing the roots of this issue, our schools are no doubt held accountable for the curriculum taught to children, as this knowledge gets passed down and absorbed into the mainstream way of thinking, generation to generation. One facet of this matter that has hardly ever made the public spotlight is the persistent teaching of the English measurement system (also commonly referred to as the Imperial, US Customary or Inch-Pound measurement system). Why does this subject even amount to significance, one may ask – it is because our usage and way of thinking no longer conform to the common global thinking used elsewhere in the remaining world, namely the Metric measurement system (also known as the International System of Units).

There are a surmountable amount of points arguably in favor of the Metric system. Through a person's constant usage of the metric system, the benefits will speak for themselves, namely the absence of fractional dimensions, the consistent and rational relationship of units to their subunits (e.g. 1000 m = 1 km instead of 5280 feet = 1 mile), and its general ease of arithmetic use. The strongest point I would like to convey is that in order for America to be highly competitive, it behooves our society to conform to the de facto standard that is accepted, embraced and utilized by 95 percent of the world. This is unequivocally the Metric measurement system.

Current Practical Applications

I am currently employed as an engineer for the California Department of Transportation (Caltrans). Regarding the profession, the ideas, concepts and designs that are formulated toward the attainment of executing highway and bridge projects heavily rely on the precision and accuracy of numbers and figures. Caltrans has experienced the implementation of both the English and Metric systems of units. I have already mentioned that the benefits of utilizing Metric speak for themselves, but I do want to point out the importance of accepting a universal standard understood by all. The word "universal" binds the entire world (not just the United States) to a common theme or medium of thought. One can no longer say that products used for construction are sourced entirely within the USA. The recently built Carquinez Bridge, a suspension bridge type in Northern California, is a remarkable example of such. The steel cables and their appurtenances were manufactured and shipped from the United Kingdom. The equipment used to spin the cables originated from Norway. The components of the deck section were assembled and fabricated in Japan. The material for the deck riding surface came from Australia. The contribution of products from each of these countries exclusively employs the Metric system of units. Certifications and reports have been specified completely in Metric. Supporting engineers and construction workers on site did not only comprise

American, but Norwegian, Japanese, British and Dutch as well. Had we insisted that these countries specify their products in English units, we probably would not have that bridge today as we know it. As of the date of this letter, the current San Francisco – Oakland Bay Bridge Project is yet another example where structural steel components are emanating from a foreign source, China. It is noteworthy to mention that both of these projects contained "breakthrough" concepts of which American engineers had very limited expertise in their design and construction. It is no wonder that these same engineers reached out to gain insight from foreigners who already have the experience in handling these "breakthrough" ideas and concepts.

History of the Metric Conversion Process

Perhaps you may or may have not been aware – the United States has incepted the thought of adopting the Metric system since the time of the American Revolution in 1775. Benjamin Franklin, a key ambassador to France, had witnessed the unfolding of significant reform in European society – one facet of which was the concept of a coherent decimal measurement system. Naturally inspired, he shared this concept with some of the other American forefathers. The idea seemed to make sense. The problem with propagating this thought, however, was that resources were extremely limited, obviously because of the lack of development in communication and transportation. Ironically during this time, a decimal currency system had seemed to gain popular favor over the fractional system because the arithmetic proved much easier.

And so the Metric concept lingered, but never implemented, as developments continued to take shape in transportation and communication. The USA entered two world wars. After the end of World War II, the USA experienced tremendous pride as a technological innovator and superpower. Suburban development flourished and the Interstate Highway System was built, attributed primarily to Dwight Eisenhower's inspiration of the awesome German Superhighway network. The concept of adopting the Metric system became reincarnated and had fermented in the talented minds of American leaders. Thus began the drive to move America forward toward supreme dominance. A probable theme during the 1950s was "The Metric measurement system is a concept that can be enjoyed by everyone, even the minimally educated, because it falls in line with the decimal philosophy, as does our currency." There is no cumbersome arithmetic to contend with. Even one may argue that more people will gain a greater interest in mathematics.

The strongest push to secure popular support of Metric came about in the 1970s. The US government appeared to have a sound game plan in mind -- the only legitimate way to establish the impetus for public acceptance was for it to legislate laws for eventual execution throughout American society. During this time, schools have already begun teaching the fundamentals of the Metric system alongside the customary English system. Unfortunately, there have been a myriad of factors that interfered with this plan. The biggest opponents have been industries, who lobbied and argued that the changeover process would warrant an indefinite and undetermined amount of resource. When long term benefits are taken into consideration, I don't believe anyone has performed an arduous and detailed analysis to prove the notion that the USA would expend unnecessary resource to complete the conversion process as quickly as possible. Interestingly enough, in the years that have succeeded the metric push of the 1970s, it could well be argued that we have perhaps already incurred a great deal of wasted resource by having to convert back and forth between the two measurement systems for the last 30 years. Sadly, our government, who supposedly in its supreme wisdom in deciding matters that affect its citizens' well being, conceded to the industries' rationale, hence diminishing the Metric conversion drive. The government failed to foresee that the big "push" to convert to Metric would have perhaps quelled, once and for all, the public's misconceptions, negative perception and attitude about the Metric system.

And here we are, three decades later, with another generation that has virtually no grasp of the Metric system, another generation that continues to abide by the misconception that American society will continue to thrive under its current use of the English system, another generation that is closed minded about understanding the benefits of embracing Metric to compete in global commerce and technology. More than likely, this generation will teach its current ideals to its descendants.

Students Can Decide for Themselves

In the field of mathematics, students deal with the association of an array of numbers in producing a final result. Anyone would agree that the two common formats in performing computations are *fractional* and *decimal*. There can be no question that decimal arithmetic is *quicker* and much more *efficient* than fractional arithmetic.

In analyzing the characteristics of the *fractional* system there are many cumbersome "preparations" that have to be accomplished in order for arithmetic operations to be thoroughly executed.

Example 1 - Adding $2\,{}^{3}/_{4} + 5\,{}^{7}/_{16}$.

Solution. One has to first determine the least common multiple of the denominator. In this case it is 16. We convert the first term to where the denominator is 16, therefore 2 ¾ becomes $2\,{}^{12}/_{16}$. Now that the denominators match, we add the whole numbers 2 + 5 = 7, and then we add the fraction ${}^{12}/_{16} + {}^{7}/_{16} = {}^{19}/_{16}$. So the final answer is $7\,{}^{19}/_{16}$, correct? Not quite. ${}^{19}/_{16}$ is actually ${}^{3}/_{16}$ over the value of 1. We clean up the result by adding 1 to the integer value and then leaving the fractional term less than 1. Therefore, the final answer is $8\,{}^{3}/_{16}$. Was that efficient or what?

Example 2 - Adding 9 feet $8\,{}^{7}/_{8}$ inches + 13 feet 5 ½ inches.

Solution. This gets more interesting; not only do we have to add fractions but now we have to take into account mixed units in the entire value! Let's proceed. First, the common denominator is 8. So the second term becomes 13 feet $5\,{}^{4}/_{8}$ inches. Now we add the values, first the units of feet: 9 + 13 = 22 feet. Now the inches: $8\,{}^{7}/_{8} + 5\,{}^{4}/_{8} = 13\,{}^{11}/_{8}$ in. Is the final answer 22 feet $13\,{}^{11}/_{8}$ inches - far from it. $13\,{}^{11}/_{8}$ inches must be reduced to $14\,{}^{3}/_{8}$ inches. So now we have 22 feet $14\,{}^{3}/_{8}$ inches. But there are over 12 inches in the second term meaning to say it is not reduced enough. Subtracting 12 inches from the second term yields $2\,{}^{3}/_{8}$ inches. We now take this "floating" foot and apply it to the first term – it becomes 23 feet. The final answer is 23 feet $2\,{}^{3}/_{8}$ inches. Easy and fast, right? You decide.

Example 3 - A structural member consisting of 4 x 6 lumber is exactly 17 feet $7\,{}^{3}/_{8}$ inches long. It has to be marked out exactly in 4 equal segments to accommodate for bolts that line up with the flange of a beam behind it. What is the length of each segment?

Solution. For this problem, the operation entails dividing the entire length of 17 feet 7 $^{3}/_{8}$ inches into 4 parts. There are several ways to tackle this problem, but probably the most efficient approach is to convert everything to inches: 17 feet = 204 inches. We add this to the second term: 204 inches + 7 $^{3}/_{8}$ in = 211 $^{3}/_{8}$ in. Let's now tackle the fractional term. To divide by a divisor, we take the reciprocal of it and multiply it to the dividend. The reciprocal of 4 is ¼. So we multiply $^{3}/_{8}$ X ¼. Multiplying the numerators yields 3 and for the denominators yields 32. The fractional term is $^{3}/_{32}$. Now we divide 211 by 4 which yields 52 ¾. We add 52 ¾ + $^{3}/_{32}$ (which again have to employ the least common denominator) and we get 52 $^{24}/_{32}$ + $^{3}/_{32}$ = 52 $^{27}/_{32}$. 52 inches is actually 4 feet 4 inches. So the final term becomes 4 feet 4 $^{27}/_{32}$ inches. I'll bet you (or even carpenters) cannot easily locate the $^{27}/_{32}$ graduated mark on a typical measuring tape! First of all, English tape measures are typically graduated in $^{1}/_{16}$ inch increments. You would first have to determine what $^{28}/_{32}$ inch is. When we reduce this, it becomes $^{14}/_{16}$ or $^{7}/_{8}$ inch. Therefore the $^{27}/_{32}$ mark comes $^{1}/_{32}$ inch before $^{7}/_{8}$, or in essence it falls between $^{13}/_{16}$ and $^{7}/_{8}$ inch.

When we compare the characteristics of fractional arithmetic vs. decimal arithmetic, there is no deniable truth that *decimal* arithmetic is *quicker* and more *efficient* than fractional arithmetic.

Example 4 - For the side paneling of a house, the overall dimension is preliminary designed to be 12.5 m. The owner desires vertical panels for interior aesthetics. Each panel comes in 300 mm size widths. How many whole panels can be theoretically installed? What would the overall dimension be redesigned to?

Solution. To begin with, we can either work in millimeters or meters. By choosing meters, a panel width becomes 0.3 m. We divide 12.5 m by 0.3 m and get 41.667. Therefore 41 whole panels can fit but there will be a fractional remainder. We can either shorten or lengthen the overall dimension; let's say the owner wants it lengthened. Thus, we bump up the number of panels to 42 and multiply by 0.3 m and get 12.6 m. This is the final result of the revised overall dimension. Were there any peculiarities in need of addressing?

If one should ever wonder why so many American students nowadays are disinterested in mathematics, then perhaps the previous examples should suffice as evidence of the cumbersome methodology of manipulating fractions. Decimal arithmetic has an unmistakable advantage over fractional arithmetic. Decimal use goes hand-in-hand with Metric while fractional use gets associated frequently with feet and inches.

Envision

Have we ever stopped to deeply contemplate the thought of industries being fully metric? How many more construction workers and engineers would there be, on the premise that arithmetic would be much more user-friendly? How many more scientists would be produced on the premise that the idiosyncrasies of converting between English units (or worse, converting from Metric to English and vice versa) would be non-existent?

A Dose of Reality

Think realistically about how many people even care, with profound thought, about the English units we currently utilize. As an example, a typical person sees measurement on the road in miles. I'll bet the average person does not have a sense of what 200 miles is, anyway. He will most likely think of his travel in terms of time (e.g. 3 hour trip). When an average person sees a road sign expressing "Lane Merges, 1000 feet" do you honestly think he has a sense of what 1000 feet will be before he decides to change lanes? Does he even have a vague sense that 1000 feet is about 0.2 miles? I challenge anyone to perform a survey and determine how much the average person even knows that there are 1760 yards in one mile or 43 560 square feet per acre. How many people even realize that there is a distinction between ounce (by weight) and fluid ounce (by volume)? For that matter, how many people know the mathematical association between fluid ounces, cups, pints, quarts and gallons? How many people know there is an Imperial gallon vs. US gallon or statute mile vs. nautical mile or long ton vs. short ton. The laundry list is endless.

Metric in Mathematics Produces Speed and Efficiency

The science of mathematics is by far the strongest tool in facilitating computational operations that affect the efficiency and accuracy of day-to-day things that we take for granted such as cars, airplanes, bridges, satellites, banking and finance, computers, just to name a few. Mathematics also plays a big role in science as in medicine, biology, chemistry and physics. The importance of *efficient* mathematics cannot be overemphasized in these fields. Our scientists and engineers are dealing with a highly competitive world – computation must be done swiftly for this to be successful. Speed and efficiency are big factors in making our leaders highly competitive. I have already elaborated in detail the characteristics of *speed* and *efficiency* of the Metric system.

Philosophical Analogies

Teaching two measurement systems does not prove to be productive in helping children reinforce a strong fundamental base of any one particular measurement system. The following scenarios attempt to stimulate the logical thinking process of our rational mind:

- In an imaginary scenario, an elementary school child is studying English and French in the USA where the child has been born to both English speaking parents and exposed to the daily influences of English speaking society. Rhetorically speaking, what do you think the child will be comfortable speaking? Unless the child spends some quality time in France, there is little or virtually no reinforcement or incentive for the child to retain the understanding of the French language, and he will gradually lose it over time. It goes without saying that the child will have a justification to embrace the English language even more because of its obvious importance in society. Now let's apply that scenario in a parallel case where we are teaching both English units and Metric units simultaneously in our classrooms. Keep in mind again that the child is inherently exposed to English measurements in daily living (e.g. miles on the road, body weight in pounds, Fahrenheit temperature, etc.). Now conclude for yourselves, what type of concept would the child expect to retain -- English measurements or Metric -- given the daily circumstances?

- In another scenario, let us imagine that this same child, born to both English speaking parents and living in the USA is taught only French in school and there is absolutely no English curriculum taught in this school. To make this scenario more interesting, the child is taught only French for 5 consecutive years (say Grades 2 through 6) with again no English curriculum. This begs another obvious question – do you think the child will have forgotten English entirely? He may not speak English as educatedly as we would hope, but anyone could arguably conclude that he would now have a strong foundation and grasp of the French language. Once again, in applying this circumstance to a parallel case where Metric units are the only measurement units taught in the classrooms, the key questions that beg logical answers are -- (1) would the child completely forget the English measurement system given his daily exposure to it and (2) would the child now have a solid grasp of understanding the Metric system? If your answer to question number 2 was "yes", I need not tell you if you were right or wrong, but it leads to a follow up question – would these same children have inspiration (or better yet, motivation) to effect change in society by gradually implementing the overall use and benefits of the Metric system for the profit of our society's well being?

Concluding Remarks

Ladies and Gentlemen of the Mathematics Advisory Panel, the opportunity for you to make a strong impact to the next generation has now availed itself through the President's appeal for competitive leadership and innovation in the field of mathematics, science and technology. This is yet another chance to rectify the problem at the root cause, in order to produce long lasting benefits. In light of the history and facts presented in this letter, I hope that you now have a heightened awareness, a broader array of knowledge, and an enlightened perspective to help motivate you to make strong solid decisions in the curriculum that we teach to our children. I have always believed that education is the strongest tool that builds the foundation of ideals that characterize the future of our society. I appeal for you to intently consider the circumstances surrounding this issue.

Please remember, the theme of this letter is for America to regain its competitive edge in the global world of mathematics, science and technology. I strongly believe that all of the aforementioned ideas expressed are contributing factors to the attainment of success in this endeavor. You have the ultimate power to decide what is best for our country's future.

Yours truly,

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