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Research Article

# Cross-Sectional Study of the Ability of those Educated Using the Imperial System of Measurement to Estimate Weights and Measures Relative to those Educated Using the Metric System

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## Abstract

**Objective:** To determine whether those educated using the metric system (i.e., the International System of Units) are better able to estimate weights and measures than those educated using the imperial system, including temperature, speed, weight, volume, and distance. This information is prospectively useful in evaluating whether the United States Patent and Trademark Office (USPTO) should require weights and measures in U.S. patent applications to be expressed in the metric system or the imperial system.

**Competing Hypotheses:** (1) Because the metric system uses base 10 standard units, the metric system is easier to understand and better suited for use for scientific and lay use; and (2) Because the imperial system uses base units which have been organically derived, the imperial system is more intuitive.

**Setting:** Office centers and controlled outdoor environments in the United States.

**Participants:** A variety of men and women from varying professions and vocations, with varying educational and socioeconomic backgrounds, raised in different countries, of varying ages, including inter alia teachers, computer programmers, contractors, police officers, writers, soldiers, students, accountants, engineers, convicted criminals, therapists, postmen, physicians, models, migrant workers, tradesmen and repairmen.

**Methods:** A total of 103 participants participated in the study between 2019 and 2021. Each participant was asked to estimate 17 weights and measures. Participants were asked to estimate the weight of a steel pipe in pounds and kilograms. Participants were asked to estimate the speed of a vehicle shown in a video in miles per hour and kilometers per hour (the vehicle moving in front of recognizable points of reference). Participants were asked to estimate the temperature of water in a fishbowl in Celsius and Fahrenheit, the distance between two visual points, and the volume of fluid in a vile. Importantly, participants were also asked to the estimate the weight of a book in the imaginary unit of a "marble" to determine if weight could be intuitively estimated in terms of smaller, intuitively-understood, control units. Statistical analysis of the results was undertaken in January and February of 2022.

**Results:**

(1) **Volume.** There was no statistically significant difference in the abilities of those raised and educated using the metric system and those raised and educated using the IMPERIAL system to estimate the volume of water in a hot tub using gallons and liters.

(2) **Weight.** Participants raised and educated using the imperial system were better able to estimate weight than those raised using the metric system.

(3) **Speed.** Participants raised using the imperial system were slightly better able to estimate speed in miles per hour than individuals raised using the metric system were in kilometers per hour.

(4) **Distance.** Participants raised using the imperial system were better able to estimate distance in feet than individuals raised using the metric system were in meters.

(5) **Small Volume.** There was no statistically significant difference between those raised and educated using the imperial system and metric system to estimate small volumes in milliliters versus fluid ounces. Medical professionals were better able to estimate small volumes in milliliters.

(6) **Temperature.** Participants raised using the imperial system were better able to estimate temperature in Fahrenheit than participants raised using the metric system could in Celsius.

(7) **Weight in Imagined Units.** There was no statistically significant difference in the ability of those raised using the metric system and imperial system to estimate the weight of a book in marbles. Those educated

raised using the metric system were statistically better able to estimate the weight of a book in marbles than they were a steel pipe in kilograms.

**Conclusion:** In general, participants raised using the imperial system were able to accurately estimate weights and measures in the imperial system than individuals raised using the metric system were in the metric system.

## Introduction

The U.S. Patent and Trademark Office issued a directive on January 15, 1992, instructing that weights and measures submitted in U.S. Patent applications be presented in the metric system rather than the imperial system and codified this directive in the Manual of Patent Examining Procedure (MPEP) § 608.01. Patent attorneys in the United States have largely ignored this directive, and controversy exists in the United States, specifically in the context of patent law, as to whether weights and measures should be expressed in the imperial system or metric system. Controversy also exists generally as to whether the United States as a whole should "metricate" (accept the metric system as a superior system to the imperial system). This study was conducted to help give guidance to those determining whether weights and measures are better expressed in units of the imperial system or metric system before the U.S. Patent and Trademark Office (USPTO).

## Background

The metric system had its origins in 1791 during the French Revolution when it was developed by Pierre-Simon Laplace. Thomas Jefferson rejected European pressure to convert, as did John Quincy Adams. Gradually, most of the countries in Europe converted to the metric system over the next 200 years. The United States has resisted pressure to do so. In 1975, the United States enacted the Metric Conversion Act, amended by the Omnibus Trade Act of 1988, in an attempt to compel America citizenry to adopt the modern metric system as their official system of measurement. The U.S. National Institute for Standards and Technologies also established the U.S. Metric Board in the 1970s, which was eventually disbanded, for this purpose. Pressure from continental Europe on Asia has resulted in most Asian countries adopting the metric system over the last century. Efforts to persuade the United States to adopt the metric system have failed.

### Data Source and Study Sample

Participants were solicited from the public and universities using printed advertisements run in local newspapers, with an emphasis on trying to solicit participants studying and working in diverse technical and vocational fields, particularly prospective participants raised in foreign countries where said participants were educated using the metric system. Some prospective participants were contacted directly by administrators of the study. Most participants were paid between $7.50 and $20.00 for participating in the study.

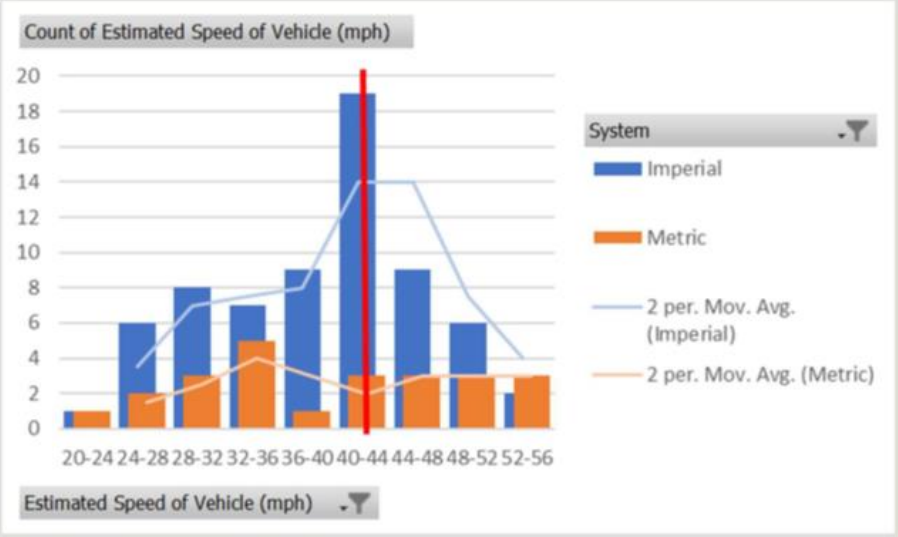
### Summary and Statistical Analysis

The results of the study were analyzed using a two-sample Z test for proportions of successful participants using a two-tailed approach. First, successful estimators of weights and measures were determined to be those who successfully estimated the measure presented within 0.67 standard deviations of the actual measure, with some adjustments made for outliers creating large standard deviations. Secondly, successful estimators of weights and measures were determined to be those who successfully estimated the measure presented within 1.0 standard deviations of the actual measure, without adjustments made for metrics having many outliers creating large standard deviations. The results of both approaches were compared and averaged based on alpha and p-value results, with a 95% confidence interval.

## Results

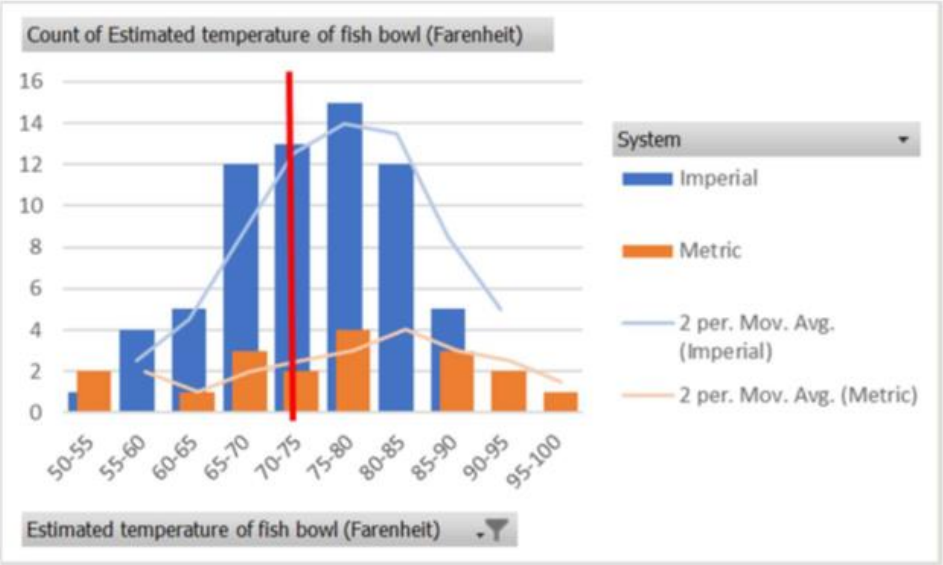
### Speed

Based on these guidelines, participants raised and educated using the imperial system were successful in estimating vehicular speed 72% of the time, while those raised and educated using the metric system were successful in estimating speed 63% of the time.



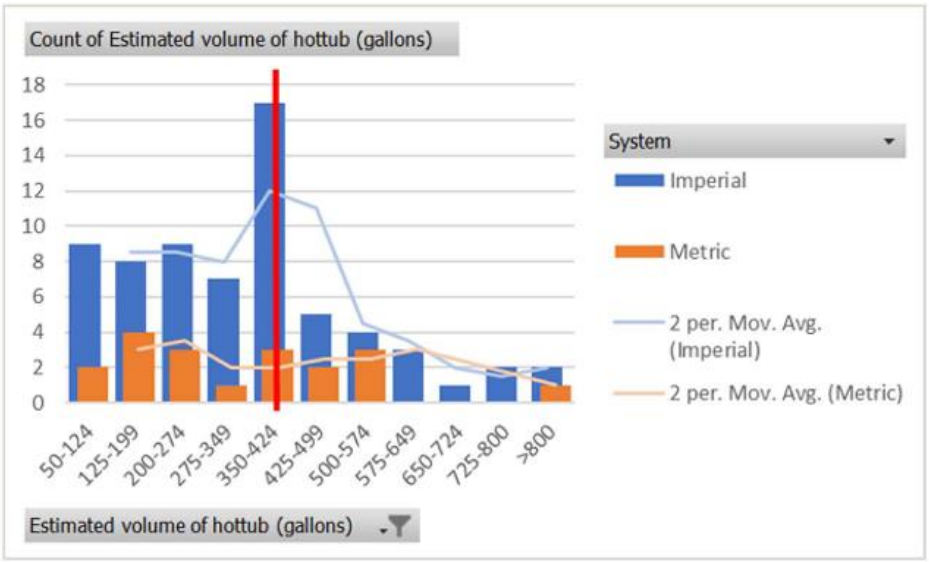

### Weight

Participants raised and educated using the imperial system were successful in estimating the weight of a steel pipe (weighing 4.2 lbs) 71% of the time, while those raised and educated using the metric system were successful in estimating the weight of the same steel pipe only 38% of the time. Those raised and educated using the imperial system were statistically more adept in estimating weight than those raised and educated using the metric system.




### Volume

Participants raised and educated using the imperial system were successful in estimating the volume of 390 gallon tub 63% of the time, while those raised and educated using the metric system were successful in estimating the same volume 63% of the time. There was no statistically significant difference in the ability to estimate volume of those raised and educated using the imperial system relative to those raised and educated using the metric system.




### Weight in Imagined Units

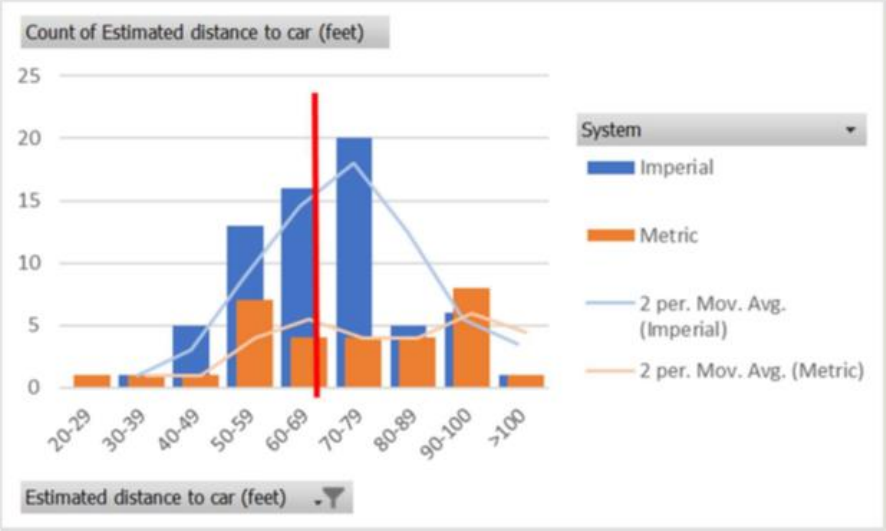
Participants raised and educated using the imperial system were successful in estimating the weight of a book in marbles (an imaged unit) in 63% of cases, while those raised and educated using the metric system were successful in estimating the same weight in marbles in 54% of cases. Those raised and educated using the imperial system were statistically equivalent in their ability to estimate the weight of a book in marbles as those raised and educated using the metric system.

### Volume of a Vile

Participants raised and educated using the imperial system were successful in estimating the volume of a vile (of 0.85 fluid ounces) in 98% of cases, while those raised and educated using the metric system were successful in estimating the same volume using milliliters in 100% of cases. Those raised and educated using the imperial system were statistically equivalent in their ability to estimate volume. Physicians were better able to estimate this volume than other subjects.

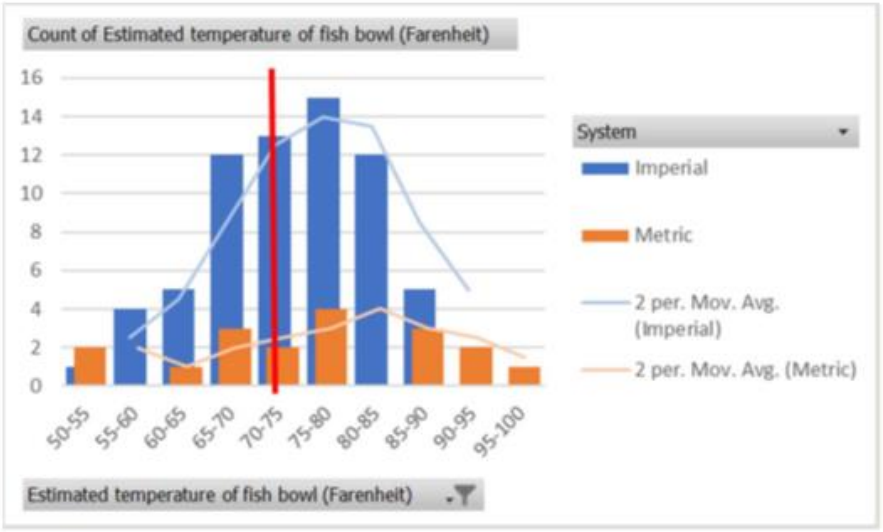
### Distance

Participants raised and educated using the imperial system were successful in estimating the distance to a car from a fixed observation point (the distance being 69 feet) in 72% of cases while those raised and educated using the metric system were successful in estimating the same distance in meters to the car in 48% of cases. Those raised and educated using the imperial system were better able to estimate distance than those raised and educated using the metric system.




## Temperature

Participants raised and educated using the imperial system were successful in estimating the temperature of a fishbowl in 78% of cases while those raised and educated using the metric system were successful in estimating the same temperature in 50% of cases. Those raised and educated using the imperial system were better able to estimate temperature than those raised and educated using the metric system.




## Results Summary

In general, participants in the study who were raised and educated using the imperial system were better able to estimate weights and measures than those raised and educated using the metric system. In general, blue-collar vocational workers in both the United States and elsewhere were better able to estimate weight, speed, distance and temperature than professionals in white-collar fields (with the exception of physicians, who were better able to estimate temperature and small volume in the metric system).

## Limitations

The relatively small sample size of 103 participants makes statistically significant conclusions with respect to some of the estimates less certain. No attempt to measure time was made in this study, as both the imperial system and metric system have adopted the UTC time standard (based on canonical hours defined in the *Didache* and the sexagesimal subdivisions of Persian scientist Al-Biruni in 1000 CE). No attempt was made to study the nautical/aeronautical units of the imperial system, including knots. Although subjects from many countries were included in the sample, all of these participants were residing in the United States at the time the study was conducted, potentially limiting the geographic applicability of the study.

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