

## Promoting Understanding of Numbers that Matter: Why Mathematicians Can't Do It Alone

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### Numbers that matter affect:

- The decisions students make in their personal and professional lives
- Students' understanding of the political and social issues that are part of citizenry
- The way people vote, and the policies they support.

### Chair of a pharmacology department in a medical school:

"The idea of using a computer for something other than email or downloading documents to print is one that only a small fraction of our class is comfortable with. I would say the same thing about things numerical.....The number of incidents due to miscalculated drug doses becomes more understandable."

These are numbers that matter!

### Journalist:

"In journalism we tend to use statistics frequently..... I believe it is important to learn the implications of statistics, what you can and cannot learn from it....."

I think an important tool is the ability to guesstimate or have a rough idea of the outcomes of arithmetic and algebraic problems: the ability to roughly convert measurements, to understand how interest is calculated, to understand relationship of time, distance and speed, and so on..... I notice that many people, some quite intelligent, do not have these tools.....

### What is Quantitative Literacy?

- The ability to identify, understand, and use elementary mathematics in everyday contexts.
- Fluency in adapting this ability to new contexts.
- A *habit of mind*; not a particular piece of knowledge or a particular skill.
- Looking for quantitative patterns everywhere

### Is Quantitative Literacy Different from Mathematical Literacy?

#### Mathematical Literacy: Requires

- Wide knowledge of mathematics
- Ability to abstract away from context

#### Quantitative Literacy: Requires

- Fluency in elementary mathematics
- Thinking in context

### Is It Possible to be Mathematically Literate Without Being Quantitatively Literate?

- A certain level of mathematics is needed for quantitative literacy.
- However, it is possible to have learned the mathematics without being able to apply it in context.

### Strike Over Gas Prices in UK

In fall 2000, caller to *The Talk of the Nation*<sup>1</sup> pointed out that a tax of £8 out of £10 spent on gas is a 400% tax, not the 80% tax that the British Government was claiming.<sup>2</sup>

- Was the caller mathematically literate?
- Was the caller quantitatively literate?

1. PBS, September 18, 2000.

2. BBC web page: BBC News/World Fuel Crisis/UK Fuel Tax: The Facts, September 21, 2000.

### UK Gas Prices: £8 out of £10 spent on gas was tax

A group of US students who heard this story knew what 8 percent was of 10, and what percent 8 was of 2, but not where the caller got 400% and 80%.

- Were these students mathematically literate?
- Were these students quantitatively literate?

### Are Calculus Students Necessarily Quantitatively Literate?

If  $f(t)$  is the population of the US in millions at time  $t$  in years, what is the meaning of the statements  $f(2006) = 300$  and  $f'(2006) = 2.87$ ?

How do these statements relate the BBC's observation<sup>1</sup> that a new person is added to the US population every 11 seconds?

- Some calculus students could answer; some could not.

1. BBC web page: BBC News/Americas/US population reaches 300 million, October 17, 2006

### What Mathematics is Needed for Quantitative Literacy?

People can reasonably differ. A possible list:

- Arithmetic, including percentages, graphs.
- Estimation.
- Elementary probability and statistics.
- Basic geometry of measurement (volume, area, perimeter).
- Elementary growth patterns: linear (constant quantity per unit time) and exponential (constant percentage per unit time).

### Watching your Blood Pressure: Pre-Hypertension

Risk of Heart Disease and Stroke doubles for every 20 point increase in systolic blood pressure and every 10 point increase in diastolic blood pressure over 115/75

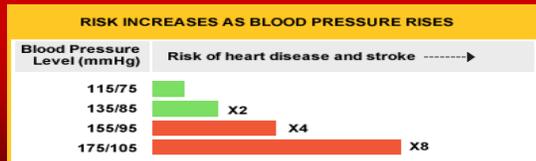
Gina Shaw, WebMD, September 11, 2003

(Systolic blood pressure is the first number, diastolic is the second)

### What Does this Mean in Practice?

If your blood pressure is

- 135/85, you have TWICE the risk
- 155/95, you have FOUR TIMES the risk
- 175/105, you have EIGHT TIMES the risk



Mathematically, this is exponential growth

### What Does Your Credit Card Cost?

- Suppose your credit card charges 18% interest per year, compounded monthly, and requires you to pay at least 2.5% of your balance each month.
- If you charge \$2000 to your credit card for a new computer, and pay it off at the minimum rate, how long will it take? How much will you eventually pay?

- Over 30 years
- \$4925.72; nearly \$3000 more than original loan

If you add \$1 to monthly minimum payment

- Time reduced to 22 years
- Payments reduced to \$4531.43, a savings of \$394.29

If you pay \$50 per month

- Time reduced to just over 5 years
- Payments reduced to \$3076.84, a savings of \$1848.88

Mathematics: Exponential growth and Geometric series, or Excel

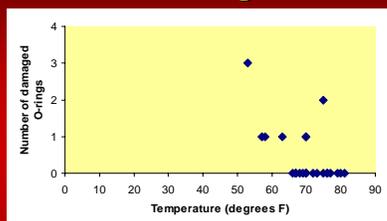
### On January 28, 1986, Space Shuttle Challenger Exploded

- What was cause of disaster?
- In early 1987, Richard Feynman showed the following data to a congressional hearing
- This data was available to NASA in January 1986.

Temp (F)	O-rings damaged	Temp (F)	O-rings damaged
53	3	70	1
57	1	70	1
58	1	72	0
63	1	73	0
66	0	75	0
67	0	75	2
67	0	76	0
67	0	76	0
68	0	77	0
69	0	79	0
70	0	80	0
70	0	81	0
70	0		0

What could this data have told NASA?

### A Graph Shows the Effect of Temperature on O-Rings



- O-rings more likely to break at low temperatures
- Temperature on January 28, 1986, was 31°F

Mathematics: Graphing, Exploratory Data Analysis

### Deaths in Two Tragedies

Event I	Deaths	Event II	Deaths
Men	1364	Men	89
Women	126	Women	284

- More than 10 times as many men died
- Original population 2/3 men
- Sinking of Titanic, April 14, 1912
- Almost 4 times as many women died
- Original population half women
- Tsunami, village in Indonesia, December 26, 2004

Mathematics: Ratios and Approximation

## Compressing 12-15 Billion History of Universe into One Year

(Dr Karen Kolehmainen, physics, CSUSB)

- January 1: Big bang
- Early February: Milky Way and Other Galaxies
- Mid August: Our Solar System Forms
- Early September: Life Starts on Earth
- Dec 31, evening: Early Man
- Dec 31, half a minute before midnight: Human Civilization begins

Mathematics: Scaling, Ratios, and Approximation

## The Human Cost of the War in Iraq Mortality Study 2002-2006

- Estimate of 654,965 excess deaths since 2003
- Cluster sample to estimate death rate (deaths/1000/year)
- 95% confidence interval for violent deaths: (426,369, 793,663)

Mathematics: Statistical Inference

## Is There Racial Profiling in LA?

LAPD motor vehicle stops resulting in search (01/01/04-06/30/04)

	Race of driver		
	White	African-American	
Search	5849	9882	15731
No search	106104	49439	155543

## Approximating the Data

	Race of driver		
	White	African-American	
Search	6,000	10,000	16,000
No search	110,000	50,000	160,000

## Numbers in Thousands

- About 5% of white drivers were searched when stopped
- About 20% of African-American drivers were searched when stopped

	Race of driver		
	White	African-American	
Search	6	10	16
No search	110	50	160

Mathematics: Estimation and Percentage

## Some Further Questions about LAPD data

- Could the differences in percentages have happened by accident if there has been no racial profiling?
- The data was for January 1- June 30, 2004. Might a different period have shown substantially different percentages?
- Is the difference between 5% and 20% large enough to provide evidence that the LAPD uses racial profiling?

Mathematics: Statistical Inference

### **How Do We Teach Quantitative Literacy?**

- **Basic mathematics needed.**
- **How do we get students to use mathematics in diverse contexts?**
- **Your ideas?**

### **Teaching Quantitative Literacy**

- **Students only see mathematics as useful when they see it used in other fields**
- **Many applications should involve making a decision (not a calculation).**
- **Faculty should model quantitative literacy themselves.**
- **Coordination between faculty teaching quantitative literacy is important.**

### **How Do We Teach Quantitative Literacy?**

- **It takes a “conspiracy”**
- **How does one foster such a conspiracy?**
- **Your ideas?**