Quantitative Literacy More Than Ever Before

(The Most Important Mathematics Course You Will Ever Teach)

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at Denver
Quantitative Literacy

An individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments, and to engage in mathematics in ways that meet the needs of that individual’s current and future life as a constructive, concerned, and reflective citizen.

_Beyond Crossroads, AMATYC, 2005_
Quantitative Literacy

“...practically no one knows what they’re talking about when it comes to numbers in the newspapers. And that’s because we’re always quoting other people who don’t know what they’re talking about, like politicians and stock-market analysts.”

Molly Ivins (1944 - 2007)
Mathematics for ...

College
Core requirements
Natural and social sciences courses
Pre-service teachers.

Careers
Broad cross-disciplinary critical thinking
Real world problem solving
Explanation and presentation

Life
Personal: mortgages, insurance, finance, taxes, gambling
Citizenship: economy, health, environment, voting
Percentages in the News

Teen-age smoking rates are still lower than in the 1970’s. But the percentage of 12th graders who smoked daily last year jumped 20% since 1991, to 22 %, according to the most recent edition of the University of Michigan’s Monitoring the Future Survey. … The rate among 10\textsuperscript{th} graders jumped 45%, to 18.3%, and the rate for 8th graders is up 44%, to 10.4%.

New York Times
Bloopers!

“According to Lancaster Insurance, five out of four drivers between 17 and 21 have some sort of accident. The figure is correct because some have two accidents.”
Bloopers!

Tornado deaths from 1987 to 1996 dropped 300 percent from the 1940s when 1,176 deaths were attributed to tornadoes, an average of 179 per year.

Associated Press
Critical Thinking

Ballot Initiative: Amendment to the Colorado Constitution (1992)

Shall there be an amendment to the Colorado constitution to prohibit the state of Colorado and any of its political subdivisions from adopting or enforcing any law or policy which provides that homosexual, lesbian, or bisexual orientation, conduct, or relationships constitutes or entitles a person to claim any minority or protected status, quota preferences, or discrimination?
Polling!

1936 presidential election

Literary Digest Poll  \( N = 10 \text{ million} \)

Alf Landon (R) 57%  FDR (D) 43%

Actual results: FDR 62%

“How could the polls get it so wrong?”

Footnote: George Gallup \( (N = 3000) \) got it right.
Presidential Voting

U.S. Constitution (Article II, Section 1, modified by the 12th Amendment)

The Electoral College was invented by the framers as a way to protect states with smaller populations to prevent the “tyranny of the majority” (John Adams) and to cure “the mischiefs of faction” (James Madison).

There are 538 electoral votes and a candidate needs a majority of the votes (at least 270) to win the Presidency.

The number of electors runs from 3 in several states to 55 in CA.

No provision for winner takes all in the states.
Presidential Voting

A candidate can win the electoral vote (in a two-candidate race) by winning only the 11 largest states. Assuming that it takes 50% of the votes to win a state, this amounts to slightly more that 25% of the popular vote nationwide.

A candidate can also win the electoral vote by winning 40 of the smallest states. Assuming that 50% of the vote is required to win a state, this amounts to about 22% of the popular vote nationwide.

Instability: A small number of voters (0.009% of all voters in Florida in 2000) can command a large number of electoral votes.
Presidents Losing Popular Vote

1876: Hayes (185) v. Tilden (184)

1888: Harrison (233) v. Cleveland (168)

2000: Bush (271) v. Gore (266)

2016: Trump (306) v. Clinton (232)
Electors per Person by State

WY: 6.6, DC: 5.8
CA, FL, GA, TX: 1.6
Modifications of Electoral Rules

• Divide electoral votes according congressional districts (as in Maine and Nebraska).

• Divide electoral votes precisely according to the popular vote in the state.

• 270 Contract

• Use the popular vote!

• Faithless (electoral) voters
Explaining Trump

Question 1

Option A: I give you $100.

Option B: Flip a coin.
   Heads: I give you $200.
   Tails: I give you $0.
Explaining Trump

Question 2

Option A: You give me $100.

Option B: Flip a coin.

    Heads: You give me $0.
    Tails: You give me $200.
Explaining Trump

- When it comes to gains, we are risk-averse.
- When it comes to losses, we are risk-seeking.

(Tversky and Kahneman)
March 2003. American Airlines CEO takes 85% salary cut to avert budget crisis. The cut reduces his salary to $500,000. What was his original salary?

a. $1.85 \times 500,000$

b. $500,000 / 0.85$

c. $1.15 \times 500,000$

d. $500,000 / 0.15$
Write a sentence:
Old salary – 85% of old salary = $500,000

Not:
Old salary = $500,000 + 85% of new salary
Simplify 1:
100% of old salary – 85% of old salary = $500,000

Simplify 2:
0.15 \times \text{old salary} = $500,000

Solve:
Old Salary = \frac{$500,000}{0.15} = $3.3 \text{ M}
Suppose that 1000 people are given a drug test that is 98% accurate and that 50 of the people actually are drug users. What percentage of the positive tests are false positives (nonusers who test positive)?

- 50 are real users and could be falsely classified as non-users (false negatives)
- 950 are real non-users and could be falsely classified as users (false positives)
## Drug Test Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Test Accurate</th>
<th>Test Wrong</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonusers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(true negative)</td>
<td>(false positive)</td>
<td></td>
</tr>
<tr>
<td><strong>Users</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(true positive)</td>
<td>(false negative)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>1000</td>
</tr>
</tbody>
</table>
# Drug Test Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Accurate</th>
<th>Error</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonusers</strong></td>
<td>931</td>
<td>19</td>
<td>950</td>
</tr>
<tr>
<td>(true negative)</td>
<td></td>
<td>(false positive)</td>
<td></td>
</tr>
<tr>
<td><strong>Users</strong></td>
<td>49</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>(true positive)</td>
<td></td>
<td>(false negative)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>980</td>
<td>20</td>
<td>1000</td>
</tr>
</tbody>
</table>

Percentage of false positives among all positives
= 19/68 = 28%
Statistical Displays

![Graph showing the ratio of men to women over years]

**Ratio of men to women**

- **Ratio:** 0.5, 0.62, 0.74, 0.86, 0.98, 1.1
- **Groups:**
  - All ages
  - <5
  - 65+

The graph illustrates the trend in the ratio of men to women over the specified years, with different symbols representing various age groups.
Statistical Displays

Sources: U.S. Census Bureau, Census 2000 Summary File 1 and 2010 Census Summary File 1.
Music and Exponential Growth

Frequency doubles every 12 steps
Music and Exponential Growth

\[ F_0 = 260 \text{ cps (Middle C)} \]

\[ F_{12} = 520 \text{ cps (C above middle C)} \]

\[ F_n = F_0 \alpha^n \text{ for } n = 0, 1, 2, \ldots \]
Music and Exponential Growth

What is $a$?

$a^{12} = 2$

$a = \sqrt[12]{2} \approx 1.05946...$
Periodic Drug Dosing

You take 100 milligrams of antibiotic every 12 hours. The half-life of the drug in your blood is 12 hours; that is, every 12 hours, the amount of drug in your blood decreases by 50%.
Periodic Drug Dosing

\[ D_0 = 100 \text{ mg} \]
\[ D_1 = (0.5 \times D_0) + 100 = 150 \text{ mg} \]
\[ D_2 = (0.5 \times D_1) + 100 = 175 \text{ mg} \]
\[ \vdots \]
\[ D_{n+1} = (0.5 \times D_n) + 100 \]
\[ \vdots \]

???????????????????????????????
Periodic Drug Dosing
One tenth of the land on earth is tundra. At any time, it is raining on only 5 percent of the planet’s surface. Lightning strikes the planet about a hundred times every second. The insects outweigh us. Our chickens outnumber us four to one.

One fifth of us are Muslims. One fifth of us live in China. And every seventh person is a Chinese peasant. Almost one tenth of us live within range of an active volcano. More than 2 percent of us are mentally retarded. We humans drink tea – over a billion cups a day. Among us we speak 10,000 languages.
From *The Wreck of Time*, by Annie Dillard

Every 110 hours a million more humans arrive on the planet than die into the planet. A hundred million of us are children who live on the streets. Over a hundred million of us live in countries where we have no citizenship. Twenty-three million of us are refugees. Sixteen million of us live in Cairo. Nearly a thousand of us a day commit suicide.
HEAD-SPINNING NUMBERS CAUSE MIND TO GO SLACK, the Hartford Courant says. But our minds must not go slack. How can we think straight if our minds go slack? We agree that we want to think straight.

From The Wreck of Time, by Annie Dillard