QUANTITATIVE LITERACY, MATHEMATICS, AND CIVIC ENGAGEMENT

Teaching the Importance of Quantitative Literacy for a Healthy Democracy

Panelists:

Maura Mast, Andy Miller, Rob Root, Kay Somers

Organizer in absentia: Kira Hamman

MathFest 2007, San Jose, CA, August 2, 9-10:20 AM

QL: understanding & enhancing social justice

Chronicle of a first-year seminar

Rob Root Lafayette College Easton, Pennsylvania

A QL & Social Justice Course

- No required mathematical content
- Improving student writing a primary goal
- 1st year Students primarily interested in quantitative majors, engineering, math, science and primarily male & white

Course Plan—4 Modules

- What is Quantitative Literacy?
- Wealth & Income Inequality in contemporary United States
- Acquiring Quantitative Literacy as an Issue of Social Justice
- Applying Fair Division to Social Justice

What is QL?

- Key Reading—"What the Numbers
 Say" by Neiderman & Boyum
 - Excellent intro to QL
- Personal QL assessment paper
 - Students found personal strengths and weaknesses difficult to assess

Wealth & Income Inequality

- Key Reading—"The Winner-Take-All Society" by Robert Frank & Philip Cook
 - Students found structure complicated
- Paper describing quantitative aspect of an issue of social justice
 - Closest assignment to a research paper, but more like an op-ed piece

Acquiring QL as SJ

- Key Reading—"Radical Equations: Civil Rights from Mississippi to the Algebra Project" by Robert Moses & Charles Cobb
 - Connects math education to civil rights but misses QL
- Community Service Project
 - Tutoring middle school students or shopping with single mothers

Fair Division/Final Paper

- Key Reading—"The Win-Win Solution" by Alan Taylor & Steven Brams
 - Interesting and pragmatic, but limited value for SJ
- Paper comparing QL of student with that of "other" as tool for understanding issue of social justice

End-of-semester Party



Student Response

- □ This was a lot of work
- Especially appreciated community service experience
- Didn't get much out of many of the readings
- □ Final paper taxed their abilities

Instructor's Response

- □ This was a lot of work
- Students don't know what social justice is
- Students not self-aware in use of QL
- Accessible readings more valuable than comprehensive readings

Next Time

- Explicit introduction to social justice
- Less reading overall, more emphasis on writing as thinking, break writing assignments down
- Begin community service earlier in semester

MATHEMATICS and DEMOCRACY

Maura Mast University of Massachusetts, Boston Boston, Massachusetts



Urban mission: To provide an affordable, high quality education to the people of the greater Boston area.

Our student body:

- Median student age is 24
- Large percentage of first generation college students, large minority population
- Student have other demands: many are working, have families, and are paying for their own education



The Math/QR requirement at UMB

Students in the College of Liberal Arts satisfy this by:

- Taking a standard College Algebra course...OR
- Taking one of several Statistics courses offered by Math, Psychology, Sociology, Economics ...OR
- Placing into a higher level math course... OR
- Taking the Math Department's Quantitative Reasoning course
 - Topics include descriptive statistics, basic numeracy, linear and exponential modeling.
 - All topics are motivated by real data.
 - Students use Excel and the web daily.
 - Focus is on speaking, reading, writing, and reasoning using quantitative information.

When we teach Mathematics as a social justice activity, we show:

- The power of mathematics as a means to *understand* the world and our society.
- The power of mathematics as a means to change the world and our society.

Fall 2006: "Mathematics and Democracy" course in the UMass Boston Honor's Program

The importance of mathematics (and quantitative literacy) for participation in a democracy

The contributions of mathematics to a democratic society

Syllabus and coverage



What is numeracy? Why does it matter? Savings models Borrowing models Social security The economics of resources Social choice Manipulating voting systems Weighted voting systems The electoral college Fair division Apportionment

Prerequisites: Quantitative Reasoning or higher-level math course

Savings and borrowing models

Topics included:

- Interest rates, simple vs. compound interest
- Arithmetic vs. geometric growth (Example: Malthusian dilemma)
- How to compare interest rates for savings and loan products
- Consumer Price Index and inflation
- Different types of loans
- Conventional loans and amortization; credit card debt
- Annuities and retirement planning



How is this relevant to civic engagement?

- Federal minimum wage
 - When was it at its peak?
 - When was it at its lowest point?
 - Should we use real or nominal dollars to describe it?



🖶 US Nom 🤻 US Real

- Can a household making the median income in the city of Boston afford to buy a house at the median selling price in the city of Boston?
- Social Security and Medicare: will we run out of money?

Economic consequences of quantitative illiteracy

- Credit card debt
- Payday loans
 - A borrower writes a check for \$300, post-dated to your payday (in 2 weeks). You pay \$45 in fees and receive \$255 cash.
 - Often, borrowers cannot pay back the entire loan on their payday. They can roll-over the loan, paying another \$45 in fees - they still owe the original \$300 and must pay the \$45 every two weeks until they can pay the \$300 back. (Alternative - they borrow \$300 to pay the original loan back and immediately get into a new loan).
- Rent-to-own
- Rapid refund tax refunds

Other topics

- Voting and social choice:
 - How can a group best arrive at a decision?
 - Is there a "perfect" voting system
 - How can voting systems be manipulated?
 - Understanding weighted voting systems and measuring voting power
- Fair division
 - How can we divide objects or share contents in such a way that everyone feels that they got their fair share?
 - Goal: The division is equitable, envy-free and optimal.
- Apportionment
 - Mathematical problem how to round a set of fractions so that their sum is not changed.
 - Direct application how to determine the number of Congressional representatives for each state
 - Various methods but no "perfect" method (cannot avoid problems)

What worked:

- Students found the material relevant, interesting, and provocative.
- They felt that they learned important material that they could use in real life.
- It was interesting for me to teach.

What was challenging:

- Varied math background in the class
- Some of the material is difficult and mathematically sophisticated
- Not all of it was obviously applicable
- Could have emphasized QL more
- I learned as I taught

Teaching a Model for Income Inequality

Andrew Miller Belmont University Nashville, TN

Module Context

- Classroom context
 - Unit in a "liberal arts" mathematics course which is one possible choice (out of three) to fulfill mathematics general education requirement
 - Module used to show students that interesting mathematics can be applied to serious realworld issues.
- Social context
 - Decades of rising income inequality in the U.S.



Source: Pikkety and Saez, Income inequality in the United States, 1913-1998



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Income inequality metrics for U.S., 1970-2005

		Income ratios		
Year	Gini	90/10	80/20	20/50
1970	0.394	9.22	3.98	0.42
1975	0.397	8.53	4.07	0.43
1980	0.408	9.09	4.21	0.42
1985	0.419	9.69	4.38	0.42
1990	0.428	10.12	4.42	0.42
1995	0.450	10.11	4.52	0.42
2000	0.462	10.58	4.56	0.43
2005	0.469	11.17	4.78	0.42

Source: U.S. Census Bureau

Winner-take-all markets

- A cause of rising inequality: "winner-takeall" markets. (*The Winner-Take-All Society*, Robert Frank & Phillip Cook.)
- Characterized by:
 - Reward in market captured mostly by few top performers
 - Participants in market judged by relative quality instead of absolute quality
 - Participants leverage small differences in ability into large differences in results

Potters and singers

Workers in a community have two choices:

- Become a potter with a guaranteed income of \$10,000.
- Enter a singing contest. The winner gets a large reward. Losers earn nothing.

How many people will enter the contest?

How many contestants?

- Notation: K = # of contestants; V(K) = reward to winner of contest with K entrants.
- "Self-interest" optimum: - Largest value of K so that $\frac{V(K)}{K} \ge 10,000$ • "Social interest" optimum: - Largest value of K so that $V(K) - V(K + 1) \ge 10,000$
 - Or, approximately, $V'(K) \ge 10,000$

Result: Too many contestants



Source: Frank and Cook, Winner-take-all markets.

Student Response: Positive!

- Results of informal end-of-semester survey:
 - Out of 33 responses, 25 (76%) had positive reactions to the unit, 7 (21%) were neutral, and 1 (3%) was negative.
 - 26 out of 34 students agreed that the course would be beneficial to their future studies or life after college. (An improvement over past results for this course.)

Student Response (cont.)

- Some positive comments
 - "This was my favorite unit! I wish we had spent more time on it."
 - "It was interesting to see economics applied to the human condition."
 - "This was the most useful topic all semester."
 - "This was the only part of the course I enjoyed."

Social Awareness Issues Integrated into an Activity-based Quantitative Reasoning Course

Kay Somers Moravian College Bethlehem, Pennsylvania

Goals of the Course

Develop and increase students' ability to

- formulate, analyze and solve real problems
- reason quantitatively; make numerical arguments
- explain and interpret their results
- use technology and internet resources

Improve students' attitudes

Our Reasoning for Choice of Topics

- Emphasize the quantitative concepts an educated person should know.
- Emphasize contextual interpretation.
- Encourage wise use of Excel or a graphing calculator and internet information.
- Use contexts relevant to students.

Topics

Section I: Numerical Reasoning

Section II: Logical Reasoning

Section III: Statistical Reasoning

Contexts for Applications History; Sports and Games; Science Social Awareness Issues

Economic Issues

Consumer Price Index and minimum wage Percentage of children living in poverty Credit cards

Health

Secondhand smoke risks

• Ecology

Temperature trends over time Hazardous waste site data

Education

Student loans

Sociology-related

Rating system to measure well-being of children

Crime-related

Murders in NYC over time

Workplace Issues

Union membership over time

What Students Do

- Current events
- Examples
- Explorations
- Activities
- Projects

Sample Current Event For Topic 1 Organizing Information Pictorially "The Richest of the Rich, Proud of a New Gilded Age" www.nytimes.com/2007/07/15/business/15gilded.html



Sample Worked-out Example

From Topic 3 Graphs of Functions

Example 3.3: The graph (page 50 in text) shows fluctuations in annual mean temperature in New York City's Central Park for the years 1876 to 2003. Disregarding small oscillations, explain the general behavior of annual mean temperature in Central Park.

Sample Exploration

From Topic 16 Averages and 5-Number Summary

- Use the table that appeared in the NYTimes giving median yearly earnings for families with mothers ages 40 to 44, by Manhattan neighborhood and # of children $(1, 2, \geq 3)$
- Describe trends
- Explain why median instead of ...
- What other information would be useful?
- Present the data graphically.

Sample Activity

Activity 8.2 from Topic 8 Indexes and Ratings

Use the table giving the median weekly earnings of full-time adult workers, by educational attainment (high school only; 1 to 3 years of college; 4 or more years of college) for the years 1980 to 2000 to:

Answer prelim questions; create graphs; convert to constant dollars; write about it!

Sample Project

For Topic 7 Logarithms and Scientific Notation

Explain what the United Nations' Human Development Index is designed to measure and how it is set up. (A useful website might be <u>http://hdr.undp.org/</u>.) Also explain how and why logarithms are used in this index.

Assessment Attitude Survey (2000 - 2001)

Pre-test and post-test

• Basic Skills test (2000 - 2001)

Pre-test and post-test

 Course completion data—in 15 sections from Fall 2000-Spring 2007, 92% completed course with passing grade

Sample Student Comments:

- "I enjoyed this class. As a student who usually struggles with math I thought the analytical skills and useful real life examples will help in the future."
- "Using the explorations w. activities really helps because you see the explorations being applied to real life scenarios. It makes them easier to understand.
- "I really struggle in Math especially on tests. The graded class assignments allowed me to do well by not being only graded on tests but I could prove I knew the information on a daily basis."
- "Working with Excel was beneficial. I believe it informed many of the basics, especially me. The professor coordinated our excel activities very well with what we were learning at the time. She also varied classes occasionally, with group activities."

To see a sample topic and activity and a list of activities: www.keycollege.com/QRTools

Sevilla and Somers, *Quantitative Reasoning: Tools for Today's Informed Citizen*, 2007, Key College Publishing

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