

# Quantitative Literacy in Secondary School Mathematics

In-Context Mathematics and Statistics for Informed  
Citizenship and College Readiness

Gregory D. Foley, PhD

Robert L. Morton Professor of Mathematics Education

Ohio University

Athens, Ohio



Our society thrives on numbers, yet many high school graduates are ill-equipped to make informed judgments using quantitative information.

Many graduates are not ready for the mathematical and statistical demands of college, with over 37% of college mathematics enrollments in remedial courses. (1.2 million out of 3.2 million in Fall 2005)

## What is quantitative literacy?

Definitions of *quantitative literacy* (QL) vary greatly. Some authors use *numeracy* and QL interchangeably.

For Paulos (1988/1990), *numeracy* was the ability “to deal comfortably with the fundamental notions of **number** and **chance**” (p. 3), coupled with **logical reasoning**.

Steen (1990) took a broader view of *numeracy* as grounded in **pattern**, and including **dimension**, **quantity**, **uncertainty**, **shape**, and **change**.

# What is quantitative literacy?

**Quantitative literacy** is a form of general literacy that includes

- Numerical reasoning (Paulos's numeracy),
- A working knowledge of measurements and indices,
- Statistical reasoning (ASA—Franklin et al., 2007),
- All of Steen's components,
- The ability to link contexts with appropriate mathematics (modeling), and
- Facility in the *mathematics register*, academic mathematical speaking and writing (Schleppegrell, 2007).

## The mathematics register

### **Linked representational modes**

- Oral and written natural language
- Numerals and other mathematical symbols
- Tables of data, matrices, and other numerical representations
- Cartesian graphs and other graphical representations
- Diagrams and geometric figures
- Physical models and simulations

## The mathematics register

### **Peculiar linguistic patterns**

- Technical vocabulary
- Syntax of mathematical definitions
- Tacit and implicit logical relationships
- Uses of the verbs *to be* and *to have*
- Technical meanings of *and* and *or*
- Complicated and dense noun phrases

# Language and Mathematics

Rotman (1988) analyzed the tight interplay between a mathematician's thinking and "scribbling" in a mixture of words, symbols, and diagrams, making a strong case for the role of written mathematical language in mathematical thinking and sense-making.

Vygotsky (1934/1987), on the other hand, focused attention on the importance of shared oral language for students to develop ideas, which are then internalized individually.

Both written language and oral language are critical to the development of quantitative reasoning.

## *Thinking as Communicating*

Mathematical problem solving, mathematical thinking, and mathematical language are inextricably interconnected, and multiple linked representations are essential *cognitive tools* in the development of what Sfard (2008) calls *commognition* (communication combined with cognition).

## 21st century or timeless?

Sfard's ideas mesh nicely with the inquiry-based methods of H. P. Fawcett, R. L. Moore, G. Polya, and A. E. Ross of the early to mid 20th century, which in turn closely match the *mathematical practices* espoused by the RAND Mathematics Study Panel (2003) for the “equitable attainment” of *mathematical proficiency*.

## QL includes **mathematical proficiency**

In keeping with the National Research Council's "comprehensive view of successful mathematics learning" (2001, p. 5), teachers should develop their students' quantitative literacy in a classroom environment that balances and interweaves *conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition* to develop overall **mathematical proficiency**.

## NCTM *Math Takes Time* (2006):

- Every student should study mathematics every year through high school, progressing to a more advanced level each year.
- At every grade level, students must have time to become engaged in mathematics that promotes reasoning and fosters communication.
- Evidence supports the enrollment of high school students in a mathematics course every year, continuing beyond the equivalent of a second year of algebra and a year of geometry.

## Some related groundwork in Ohio

1. The Ohio Core Curriculum (SB311, Class of 2014)
2. Mathematics Program Models for Ohio High Schools (ODE, 2007)
3. New course in *Modeling and Quantitative Reasoning*
4. The Governor's Education Plan (2009)

A series of related funded projects

## **Projects already funded**

1. PATH A2E vertical teaming project for teachers of Grades 7–11 (supported by ODE)
2. QUANT *Advanced Teacher Capacity* building (supported by OBR, SEOCEMS, ODE)

## **Proposal under review by NSF**

3. AQR curriculum research and development in Ohio, North Carolina, and Texas (2009–10 through 2013–14)

# ***QUANT:***

## *Quantifying Uncertainty and Analyzing Numerical Trends*

- **Topics:** Data types; Measurement and data collection; Experimental design; Statistical problem solving; Modeling and regression; Combinations and permutations; Probability; Informal statistical inference: making decision based on data.
- **Objectives:** To provide activities and strategies for Ohio's Data Analysis and Probability standard; To develop capacity to teach the probability and statistics in *Modeling and Quantitative Reasoning*; To develop teachers' facility with the TI-84, TI-nspire CAS, CBR 2, CBL 2, data collection, and statistical software; to help teachers incorporate data use and probability across the curriculum.

**Advanced Quantitative Reasoning (AQR)** is a quantitative literacy course for high school seniors or juniors. The AQR course will provide a model for a post-Algebra II alternative to Precalculus.

The AQR project will—

- (a) write, pilot, and hone student text materials;
- (b) offer professional development to build teacher capacity;
- (c) investigate the nature and level of the student and teacher learning that takes place.

The AQR course content will incorporate Ohio, North Carolina, Texas, and national recommendations.

# Advanced Quantitative Reasoning course outline

## **Part A.** Explorations, Activities, Investigations

1. Numerical Reasoning
2. Statistical Reasoning
3. Discrete and Continuous Modeling
4. Spatial Reasoning

— “Numbers Everywhere” vignettes throughout —

## **Part B.** Course Research Project

5. Project Planning
6. Project Implementation and Report Writing
7. Public Presentation of Project Results

# Implementing QL in Ohio schools

- Staffing
- Teacher preparation in statistics, discrete mathematics, modeling, and cross-disciplinary topics
- Teacher preparation in inquiry-based mathematics, creative uses of technology, and project-based instruction
- Teacher professional development in these same areas
- Student materials with the appropriate content at the appropriate level with investigations and projects
- Curriculum development, pilot testing, and implementation
- Roles of technology and needed technology resources
- Supplementary materials: on-line and in periodicals
- Differentiated instruction
- Others???

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