



# THE NATIONAL NUMERACY NETWORK

## A Better Way to Teach Algebra: Spreadsheets and Modeling

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# Spreadsheets and Modeling Timeline

- 1996 Berea College
  - **Modeling with Computers** (Introduction to Excel)
  - Beefed it up with math content: “**pathway**” into math
  - Colleagues turned it into pre-calc: “**black box**” devoid of math
- 2010 Oberlin Program Review
  - **Oberlin Modeling Initiative** (OMnI)
  - Modeling across the curriculum using Stella, NetLogo, NOVA, Excel
  - No math pre-requisites: “**pathway**” into mathematics
  - Mathematicians Opposed: “**black box**” devoid of math
- 2005-12 *Numeracy: Communicating with Numbers* textbook project with Pearson
  - Spreadsheets and Ratios are the focus

# Spreadsheets and QR Timeline

- March 19, 2012 Bay Path College Phone-call
  - **Create new curriculum** based on spreadsheets and business math
  - Hire tenure track QR/Math faculty
- March 19, 2012 Article review
  - *Numeracy* article on spreadsheets and business math
  - From *Liber Abbaci* to **new paradigm in math curriculum**
  - *The Man of Number's, Fibonacci's Arithmetic Revolution* by Devlin
- March 23, 2012 ICTCM keynote by Conrad Wolfram
  - **Computer Based Math .org**
  - Throw out K-12 math curriculum and **create new curriculum** based on computers.



# THE NATIONAL NUMERACY NETWORK

## Quantitative Reasoning (QR)

“Quantitatively literate citizens need to know more than formulas and equations. They need a predisposition to look at the world through mathematical eyes, to see the benefits (and risks) of thinking quantitatively about commonplace issues, and to approach complex problems with confidence in the value of careful reasoning.

Quantitative literacy **empowers** people by giving them tools to think for themselves, to ask intelligent questions of experts, and to **confront authority confidently**. These are skills required to thrive in the modern world.”

*-Mathematics and Democracy 2001*

In short, how do we create a mathematics curriculum which teaches our students how to **THINK**?

# Is Algebra Necessary?

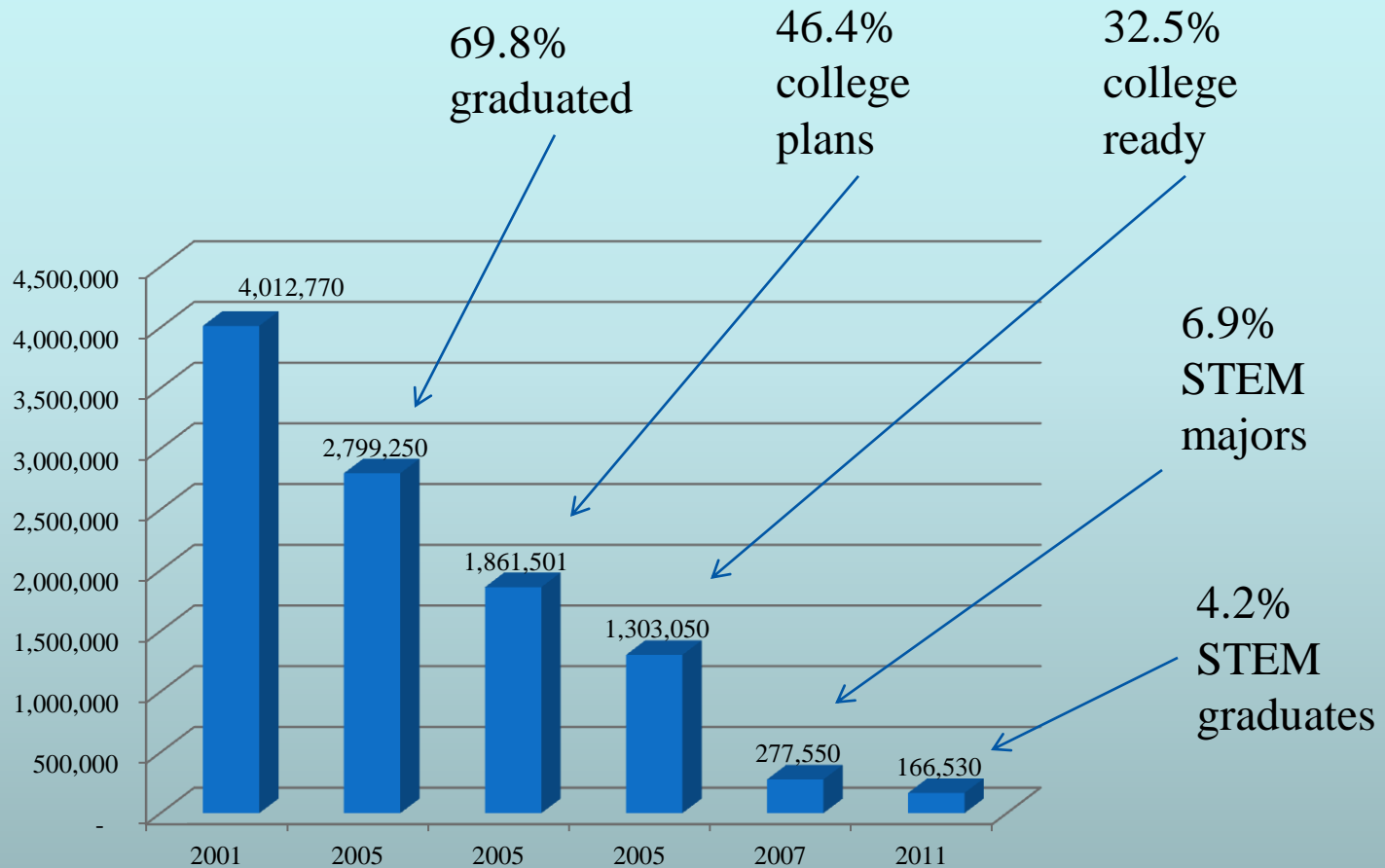
- Andrew Hacker Professor Emeritus CUNY  
New York Times July 29, 2012

“A typical American school day finds some six million high school students and two million college freshman struggling with algebra.”

“I’m not talking about **quantitative skills**, critical for informed citizenship and personal finance, but a very different ballgame.”

“What is needed is **not textbook formulas** but greater understanding of where various numbers come from and what they actually convey.”

# 2001 Cohort 9<sup>th</sup> Graders



This is not a pipeline... it is a trickle. 60% of STEM workforce is 45 and older.

# How Much Math Do We Really Need?

- Professor Emeritus U. Ill. Chicago  
Washington Post 10/22/2010

“Unlike literature, history, politics and music, math has **little relevance** to everyday life.”

“All the math one needs in real life can be **learned in early years** without much fuss.”

“Most adults have no contact with math at work, nor do they curl up with an **algebra** book for relaxation.”



# THE NATIONAL NUMERACY NETWORK

## Algebra as Business Math

“Few in business today make use of the mathematics they learned in school.

**Spreadsheets** have entirely different requirements.”

“Mathematical reasoning in workplaces **differs markedly** from the algorithms taught in school.”

“Make no mistake; the revolution in business math created by the spreadsheet is conceptual as well as physical. **It changes the way people in business think** about and approach problems as well as the way they work through results. It enables them to quantify a whole new range of problems.”



# Problem Solving vs. Modeling

*-Modeling for Insight*

Powell and Batt

- Well Structured Problems

- Objective Clear
- Assumptions Obvious
- Data available
- One right answer

- Examples:

- Solve  $2x - 5/x = 12$  for  $x$ .
- Balance the books.
- Do your taxes.
- Seriously, do your taxes!

- Ill Structured Problems

- Objectives, Assumptions, Data ambiguous

- Examples

- Should the Red Cross pay for blood donations?
- Should we tax soda?
- How much should an advertiser allocate to creative over delivery of ad?
- Should spreadsheets be taught K-12?

# Problem Solving vs. Modeling

*-Modeling for Insight*

Powell and Batt

- Ill Structured Problems are **Explored**
  - Make assumptions
  - Formulate Hypotheses
  - Generate Insights (don't "solve!")
- Modeling Process
  - Frame the Problem
  - Diagram the Problem
    - Influence Diagrams (relationships between variables)
  - Build a Model
    - **Spreadsheet Engineering**/ Parametrization
    - Sensitivity/ Strategy Analysis
  - Generate Insights
    - Iterate!

# N Ways to Apply Algebra with the New York Times

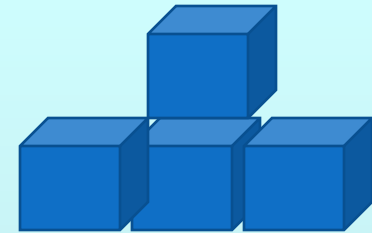
-Patrick Honner

September 26, 2012

## Modeling Process

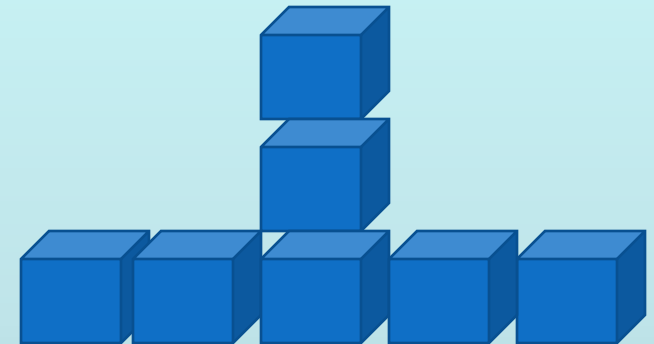
- Amortization
    - Buy versus lease
    - Make Assumptions (“solve!”)
  - Evaluating College Rankings
    - “Use data to rank schools”
  - Calculating the Best Deal
    - “Create scenarios”
  - Metro Card Math
    - Unlimited card or ride by ride?
  - Olympic Algebra
    - “Compare and contrast average speeds of athletes over time, across events, and by gender.”
  - Stock Portfolios
    - Compound interest formula, exponential growth, and compare different rates of return.
- Frame the Problem
- Diagram the Problem
- Influence Diagrams (relationships between variables)
- Build a Model
- Spreadsheet Engineering**/ Parametrization
- Sensitivity/ Strategy Analysis
- Generate Insights
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# Building Blocks



How many blocks will there be in the  $n^{\text{th}}$  building?

Building N	Number of Blocks			
n	Recursion	$1 + 3(n-1)$	$3n - 2$	
1	1	1	1	1
2	4	4	4	4
3	7	7	7	7
4	10	10	10	10
5	13	13	13	13



Building Number	Number of Blocks		
n	Recursion	$1 + 3(n-1)$	$3n - 2$
1	1	$=1+3*(A3-1)$	$=3*A3-2$
2	$=B3+3$	$=1+3*(A4-1)$	$=3*A4-2$
3	$=B4+3$	$=1+3*(A5-1)$	$=3*A5-2$
4	$=B5+3$	$=1+3*(A6-1)$	$=3*A6-2$
5	$=B6+3$	$=1+3*(A7-1)$	$=3*A7-2$

# Probability and Coin Flips

Microsoft Excel - NECQL Excellent QL 2012

Formula Bar:  $=IF(RAND()<0.5,"H","T")$

	A	B	C	D	E	F	G	H	I	J	K
1	Flip 2 coins 500 times										
2		Flip 1	Flip 2	X = # of H		X	Occurrences	Average Value of X:			
3	1	T	T	0		0	130	26.0%	1.006		
4	2	H	T	1		1	237	47.4%			
5	3	H	T	1		2	133	26.6%			
6	4	H	H	2							
7	5	H	H	2							
8	6	H	T	1							
9	7	H	H	2							
10	8	T	T	0							
11	9	H	T	1							
12	10	T	T	0							
13	11	H	H	2							
14	12	T	T	0							
15	13	H	H	2							
16	14	H	H	2							
17	15	T	H	1							
18	16	H	H	2							
19	17	H	H	2							
20	18	T	H	1							
21	19	T	T	0							

**Number of Heads (2 flips)**

Number of Heads	Occurrences
0	130
1	237
2	133

Push Button to reflip coins:

75

Taskbar: Chart1, Currency, MF Income, Financial, Lin Reg, Quadratic, Coin Flipping, Investing

# Ratio and Proportion

$$E = 4/3 * D$$

Or is it  
 $E = 3/4 * D$  ??

Microsoft Excel - NECQL Excellent QL 2012

Security Warning: Automatic update of links has been disabled

Formula Bar: =Euros/Dollars\*InputUSD

	A	B	C	D	E	F	G
1	<b>Currency Converter</b>						
2		<b>Dollars</b>	<b>Euros</b>	<b>Yen</b>			
3		\$ 4.00	€ 3.00	¥ 500.00			
4							
5	<b>Input Dollars:</b>	\$ 62.00					
6			<b>Output Euros:</b>	=Euros/Dollars*InputUSD			
7			<b>Output Yen:</b>	¥ 7,750.00			
8							
9	<b>Input Euros:</b>	€ 76.00					
10			<b>Output Dollars:</b>	\$ 101.33			
11			<b>Output Yen:</b>	¥ 12,666.67			
12							
13	<b>Input Yen:</b>	¥ 7,765.00					
14			<b>Output Dollars:</b>	\$ 62.12			
15			<b>Output Euros:</b>	€ 46.59			

Chart1 | Currency | MF Income | Financial | Lin Reg | Quadratic | Coin Flipping

# Graphing in Real Time

Microsoft Excel window: NECQL Excellent QL 2012 - Microsoft Excel

Formula bar:  $=a*D11^2+b*D11+cc$

Worksheet: Graphing Quadratics

Parameters	Inputs	Outputs
a	-12.8	1745.5
b	-12.6	1687.2
c	-12.4	1629.7
	-12.2	1573.0
Start	-12.0	1517.0
Step	-11.8	1461.7
	-11.5	1407.2
	-11.3	1353.4
Input x:	10	1300.4
Output y:	-250	1248.1
	-10.9	1248.1
	-10.7	1196.5
	-10.5	1145.7
	-10.3	1095.6
	-10.1	1046.3
	-9.9	997.7
	-9.6	949.8
	-9.4	902.7
	-9.2	856.3
	-9.0	810.7
	-8.8	765.8
	-8.6	721.7
	-8.4	678.3
	-8.2	635.6
	-8.0	593.7
	-7.8	552.5
	-7.5	512.0
	-7.3	472.3
	-7.1	433.3
	-6.9	395.1
	-6.7	357.6
	-6.5	320.9
	-6.3	284.6

Control Panel:

- a:
- b:
- c:
- start:
- step:

Taskbar: Chart1 | Currency | MF Income | Financial | Lin Reg | **Quadratic** | Coin Flipping | 100%

# Modeling Car Cost

	Focus	Prius		
Cost	<b>\$ 20,000.00</b>	<b>\$ 33,000.00</b>		
			Gallons per 100 miles	
MPG Hway	28	45	3.571	2.222
MPG City	22	37	4.545	2.703
			Gallons Used	
Miles Hway	8,000		285.71	177.78
Miles City	12,000		545.45	324.32
Price per Gallon	\$ 3.86	Total Gallons	<b>831.17</b>	<b>502.10</b>
		Cost:	<b>\$ 3,208.31</b>	<b>\$ 1,938.11</b>
	Gas Savings per year:		\$ 1,270.20	
		Extra Cost:	\$ 13,000.00	
	Years to recoup:		<b>10.23</b>	years

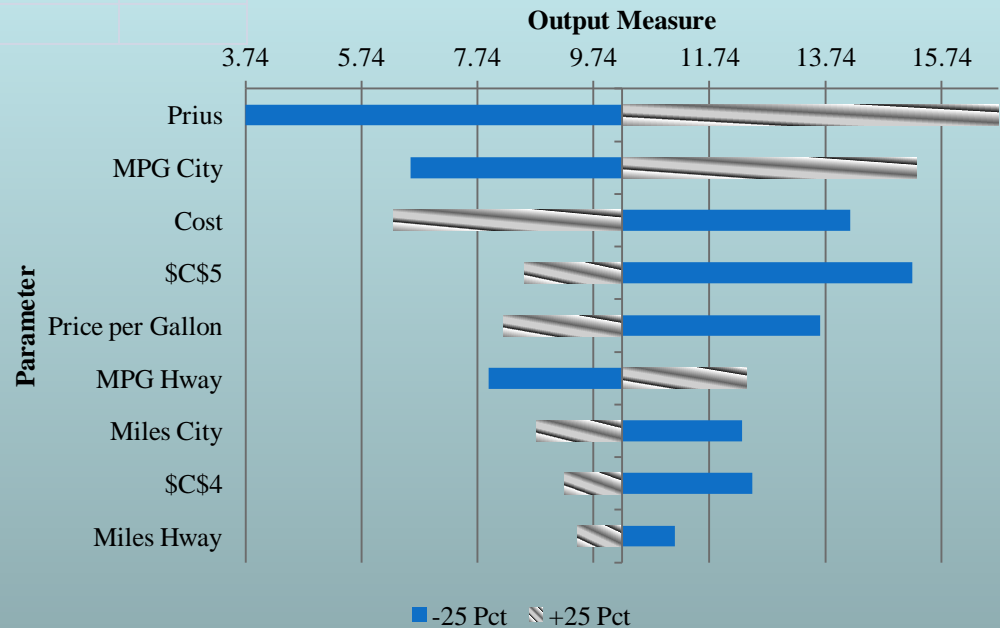


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## Tornado Sensitivity Chart



Is Algebra Necessary?  
Yes! And we can use  
spreadsheets and modeling to  
help teach students why.

Thank You.