what if math

Learning Math as an Experimental Science

Art Bardige

sustainablearning.org

In the year

1988

The Hubble Space Telescope starts operating

Mathematics became
"The Science of Patterns"

Professor Lynn Steen, 1988

The rapid growth of computing and applications has helped cross-fertilize the mathematical sciences, yielding an unprecedented abundance of new methods, theories, and models. Examples from statistical science, core mathematics, and applied mathematics illustrate these changes, which have both broadened and enriched the relation between mathematics and science. No longer just the study of number and space, mathematical science has become the science of patterns, with theory built on relations among patterns and on applications derived from the fit between pattern and observation.

What if…

students could learn mathematics as an experimental science?

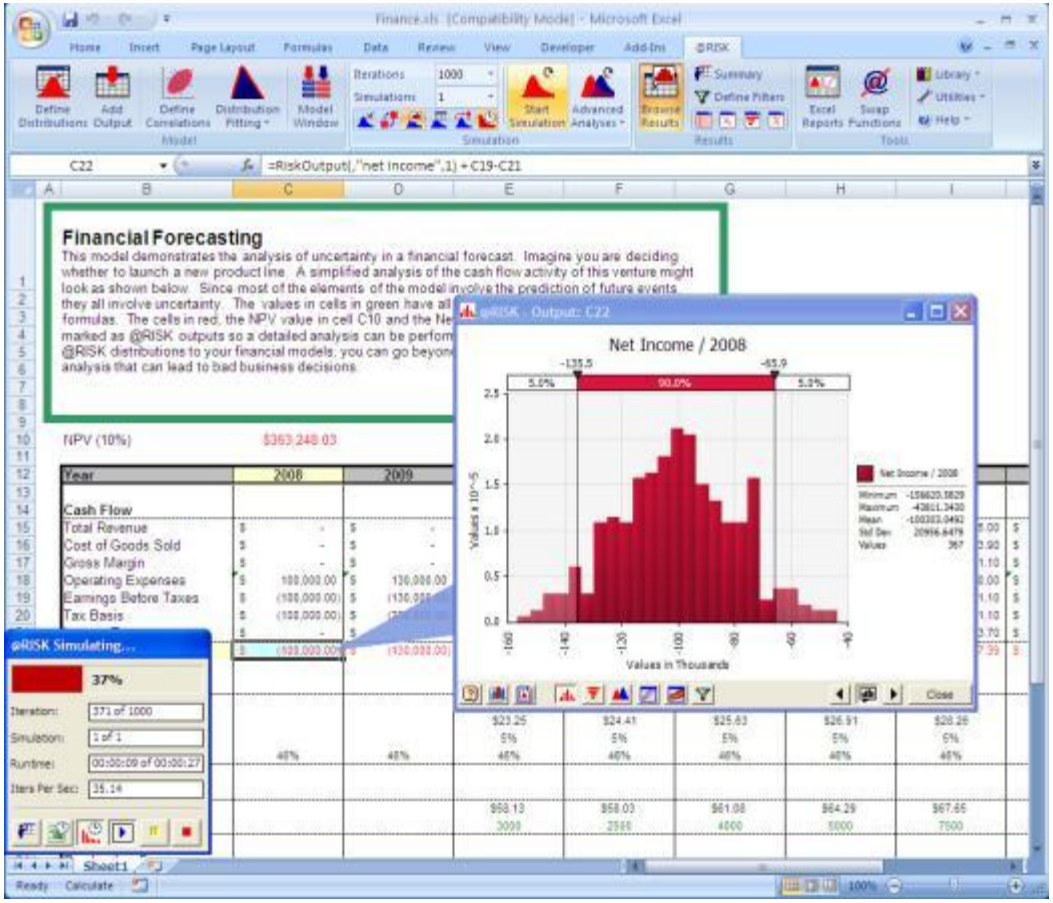
Using spreadsheets as laboratories

Google Docs

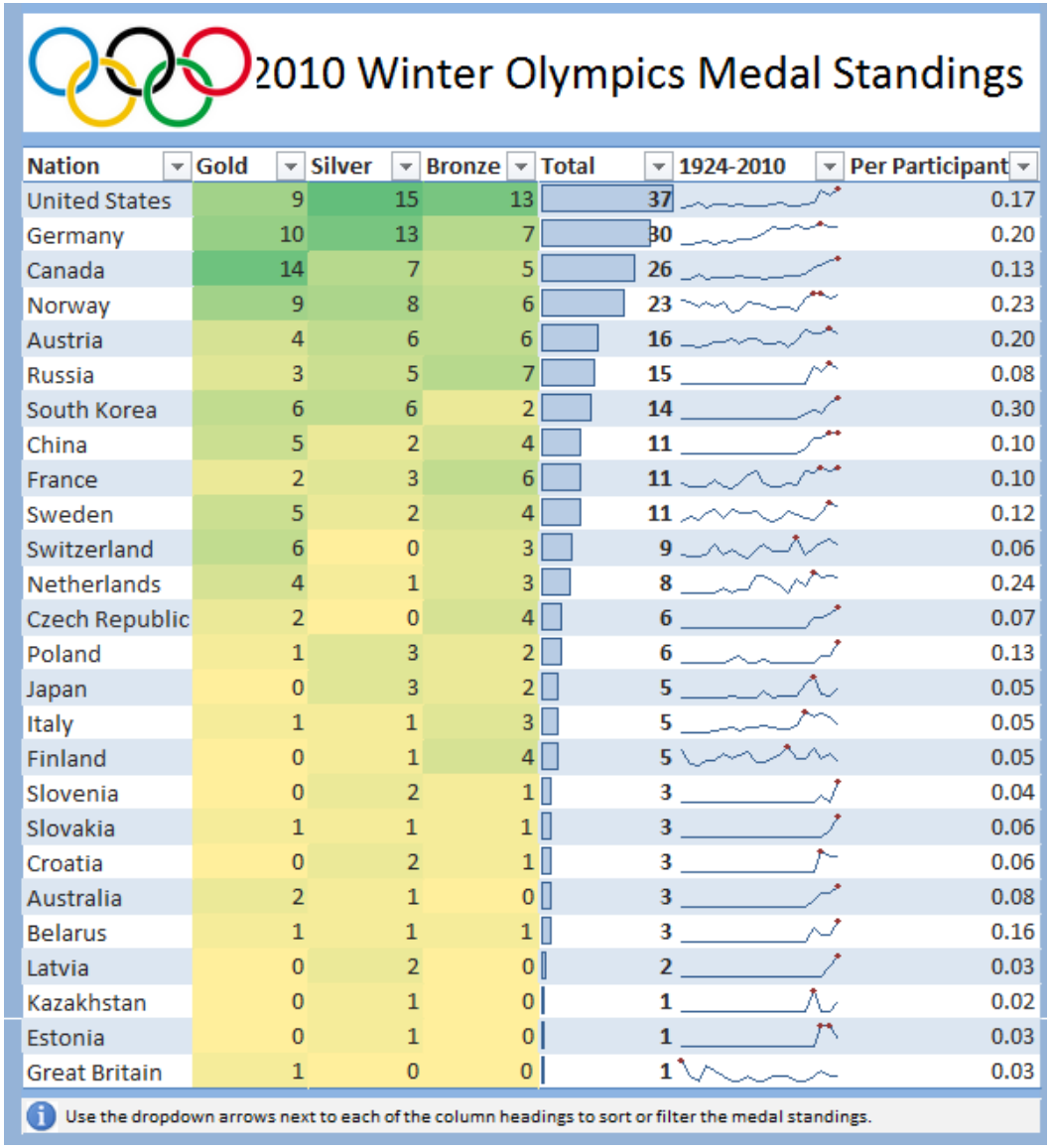
To solve interesting Problems that "instill a passion" for learning, by:

Enrico Fermi

Building models



Analyzing data

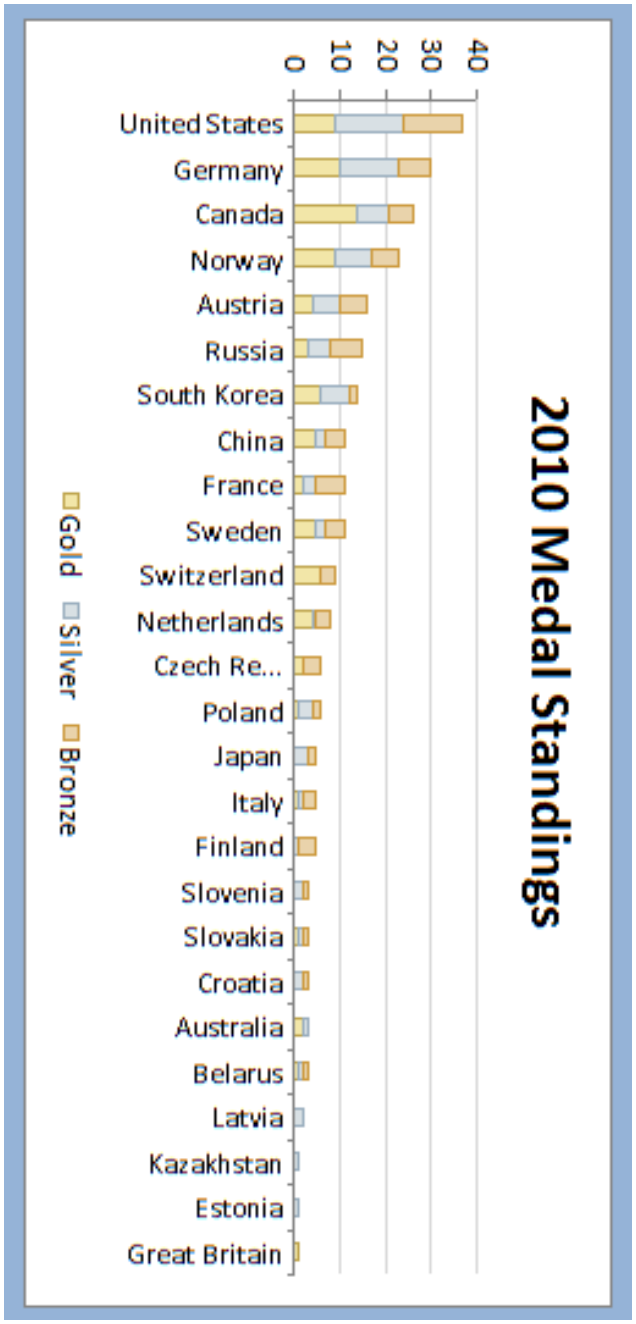


2010 Winter Olympics Medal Standings

Nation	Gold	Silver	Bronze	Total	1924-2010	Per Participant
United States	9	15	13	37		0.17
Germany	10	13	7	30		0.20
Canada	14	7	5	26		0.13
Norway	9	8	6	23		0.23
Austria	4	6	6	16		0.20
Russia	3	5	7	15		0.08
South Korea	6	6	2	14		0.30
China	5	2	4	11		0.10
France	2	3	6	11		0.10
Sweden	5	2	4	11		0.12
Switzerland	6	0	3	9		0.06
Netherlands	4	1	3	8		0.24
Czech Republic	2	0	4	6		0.07
Poland	1	3	2	6		0.13
Japan	0	3	2	5		0.05
Italy	1	1	3	5		0.05
Finland	0	1	4	5		0.05
Slovenia	0	2	1	3		0.04
Slovakia	1	1	1	3		0.06
Croatia	0	2	1	3		0.06
Australia	2	1	0	3		0.08
Belarus	1	1	1	3		0.16
Latvia	0	2	0	2		0.03
Kazakhstan	0	1	0	1		0.02
Estonia	0	1	0	1		0.03
Great Britain	1	0	0	1		0.03

Use the dropdown arrows next to each of the column headings to sort or filter the medal standings.

Visualizing results



And asking

what if...

เกิดอะไรขึ้นถ้า

ماذا لو

만약

如果

Hvad nu hvis

Que faire si

Cosa succede se

Was ist, wenn

¿Qué pasa si

quod si

Τι θα συμβεί αν

どのような場合

מה היה קורה אילו

Что делать, если

E si

Hvað ef

Before we look into the future let's see from whence we came.

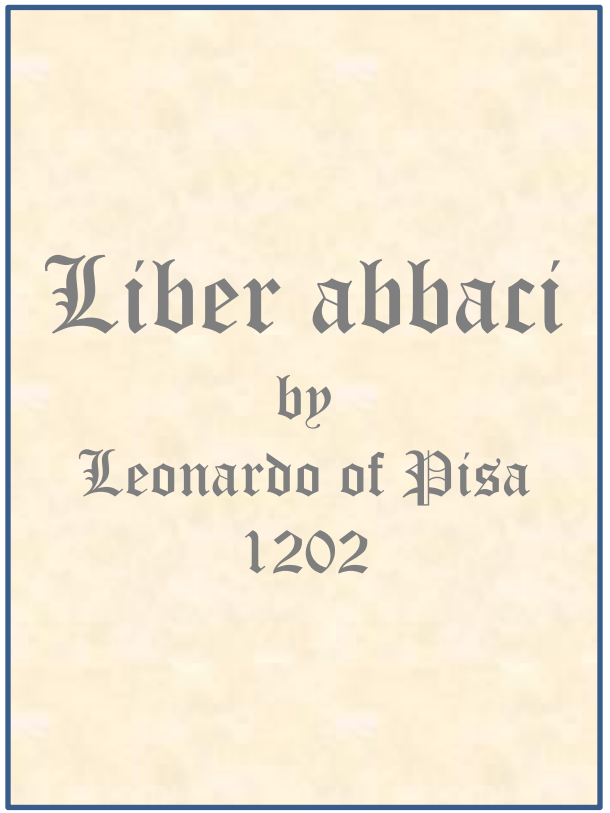
In the year

1202

King Richard, The Lionhearted died, 1199

A revolutionary book was published

Virtually unknown today



“The Book of Calculation”

By Leonardo of Pisa

aka “Fibonacci”

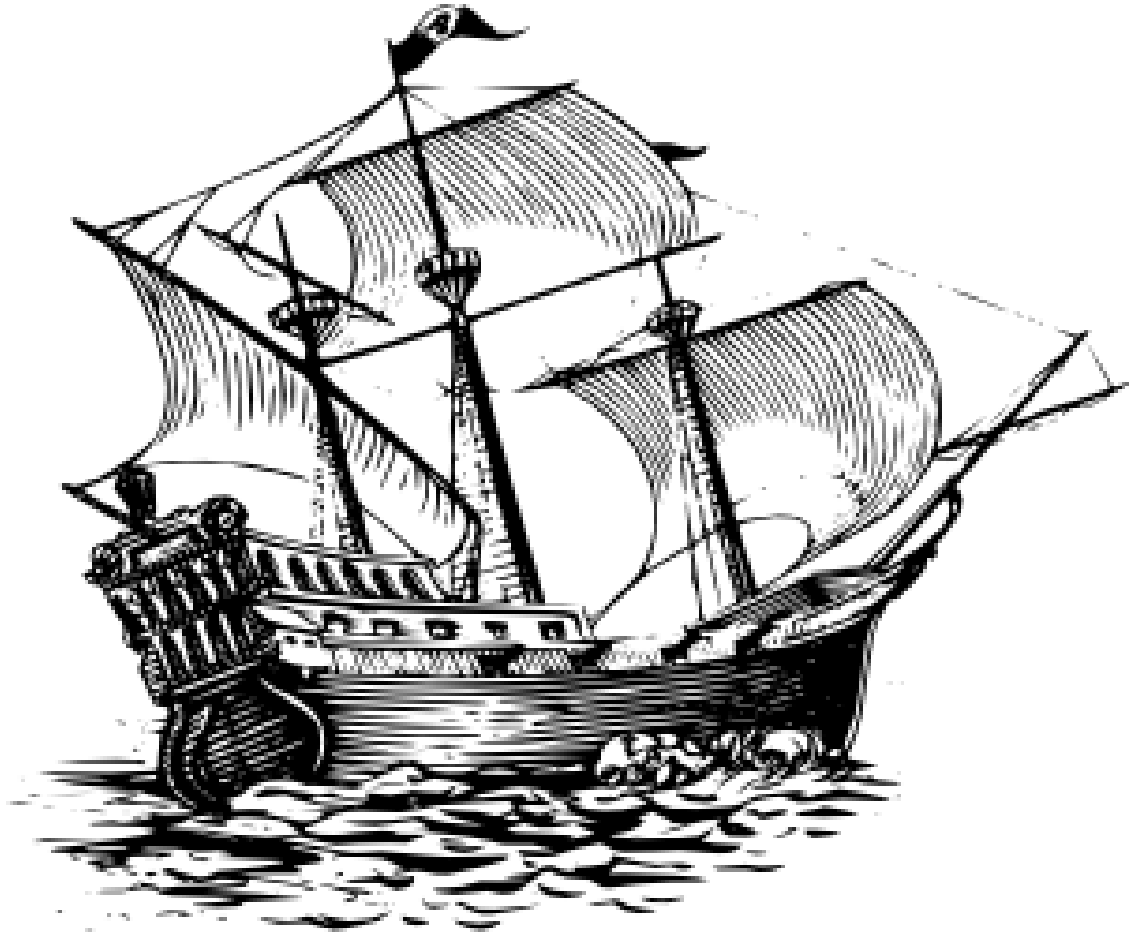
Leonardo Di Vinci

It had a greater impact than the works of the other Leonardo

Born in Pisa

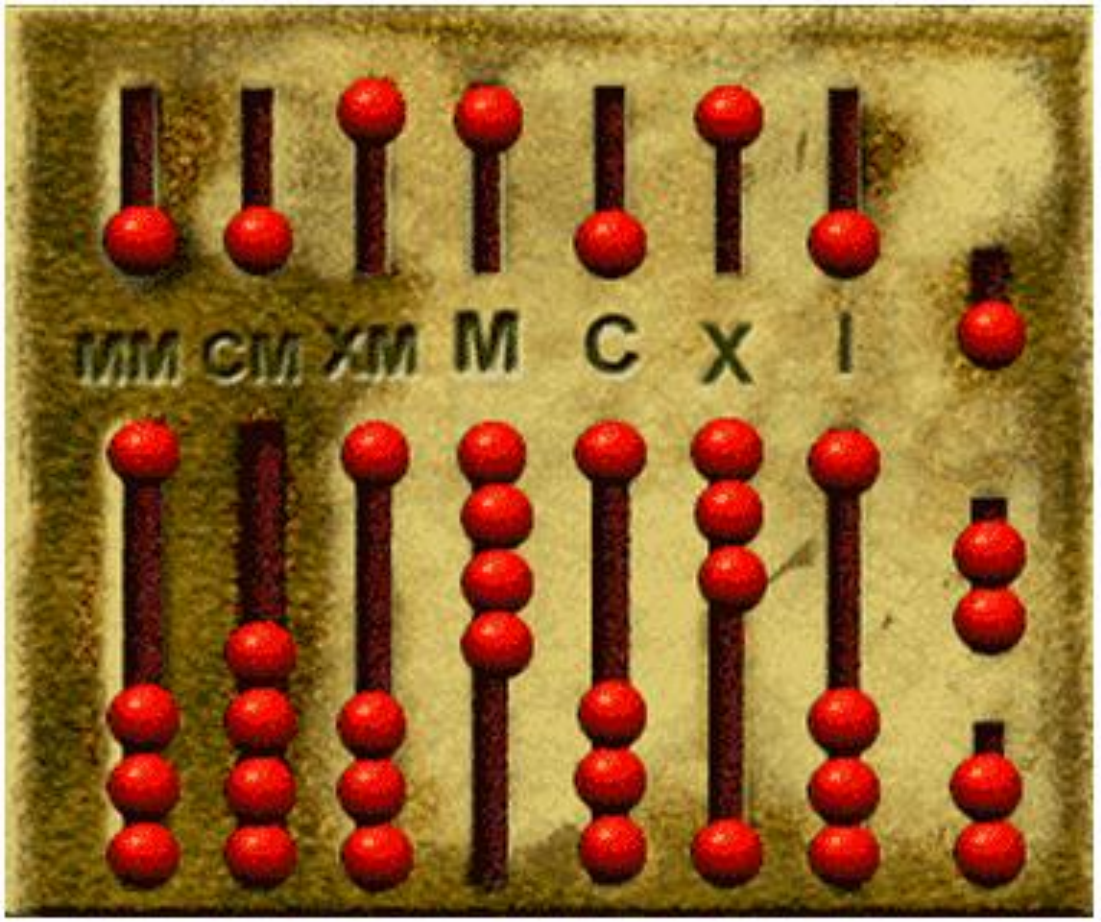

Pisa
Mer de Marseille
Golfe de Lyon
Mer de Corse
Mer de Toscane
Minorca
Mer de Sardagne
Sardagne
E Ponant
E R M E D I T E
Mer d'

He grew up in the 1170's along with the Leaning Tower



When Pisa was a great trading city

Merchants and traders used Roman math and an abacus to calculate



But multiplying by doubling was slow, cumbersome, and error prone

CLXVII	I
CLXVIICLXVII	II
CLXVIICLXVIICLXVII CLXVII	IV
CLXVIICLXVIICLXVII CLXVIICLXVIICLXVII CLXVIICLXVII	VIII
CLXVIICLXVIICLXVII CLXVIICLXVIICLXVII CLXVIICLXVIICLXVII	I+VIII=IX

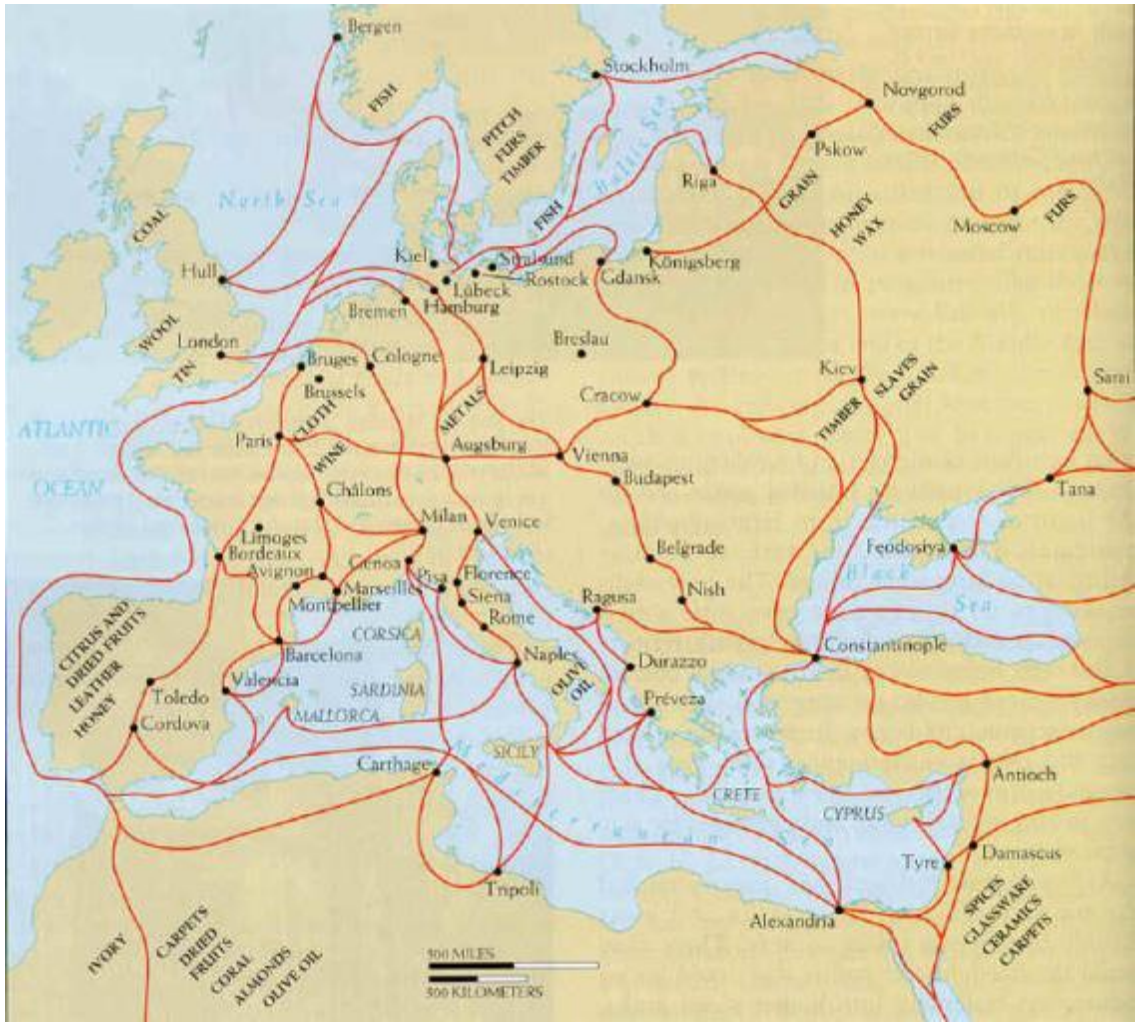
167 x 9 =

It worked for the Empire

None of the cities should be allowed to have its own separate coinage or a system of weights and measures; they should all be required to use ours.

Dio Cassius

But not for medieval trade when city-states had



Different weights, measures, and currency

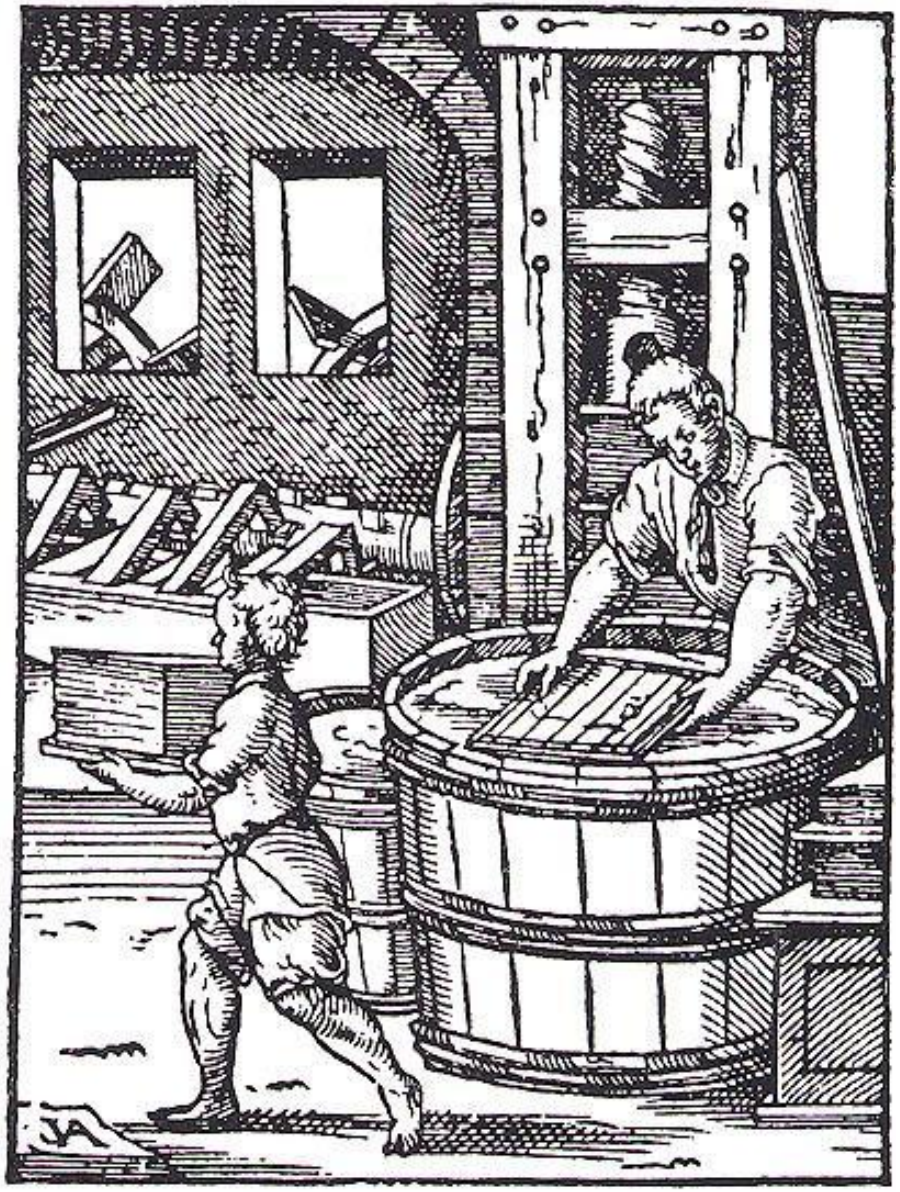
Leonardo joined his father, a trader, and customs official in Algeria

Where he learned Arabic arithmetic and algebra, become a trader and returned to Pisa in 1200

The Compendious Book on Calculation by Completion and Balancing

by al Khwarizmi

Enabled by the new technology of paper to track algorithmic calculations



Paper was introduced into Europe around 1100.

Leonardo developed a revolutionary mathematics for business.

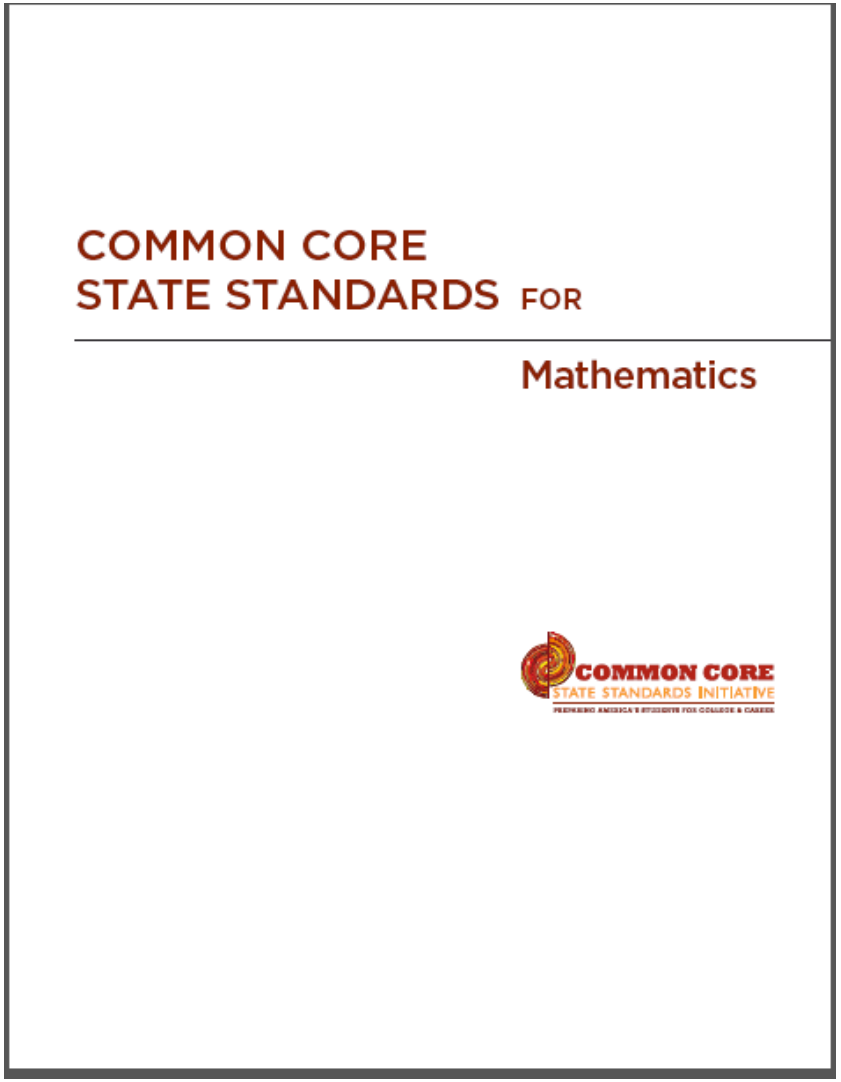
The Chapters in Liber abbaci (1202)

1. **On the recognition of the nine Indian figures and how all numbers are written with them.**
2. **On the multiplication of whole numbers**
3. **On the addition of them, one to another**
4. **On the subtraction of lesser numbers from greater numbers**
5. **On the division of integral numbers**
6. **On the multiplication of integral numbers with fractions**
7. **On the addition and subtraction and division of numbers and fractions and the reduction of parts to a single part**
8. **On the buying and selling of commercial things** ***(ratio & proportion)***
9. **On the barter of commercial things** ***(rate)***
10. **On companies made among parties** ***(percents)***
11. **On the alloying of money** ***(mixture problems)***
12. **On the solutions of many problems** ***(Fibonacci sequence)***
13. **On the rule of elchataym by which problems of false position are solved.** ***(solving linear equations)***
14. **On the finding of square and cube roots, on binomials and their roots.**
15. **On the pertinent rules of geometric proportions**

Leonardo's algorithmic math "arithmetic necessary to merchants" Fully symbolic by 1600…

Algorist vs. abacist (1508)

…continues to be the basal arithmetic and algebra every student is required to master.



In the year

1979

A technology revolution changed the mathematics of business

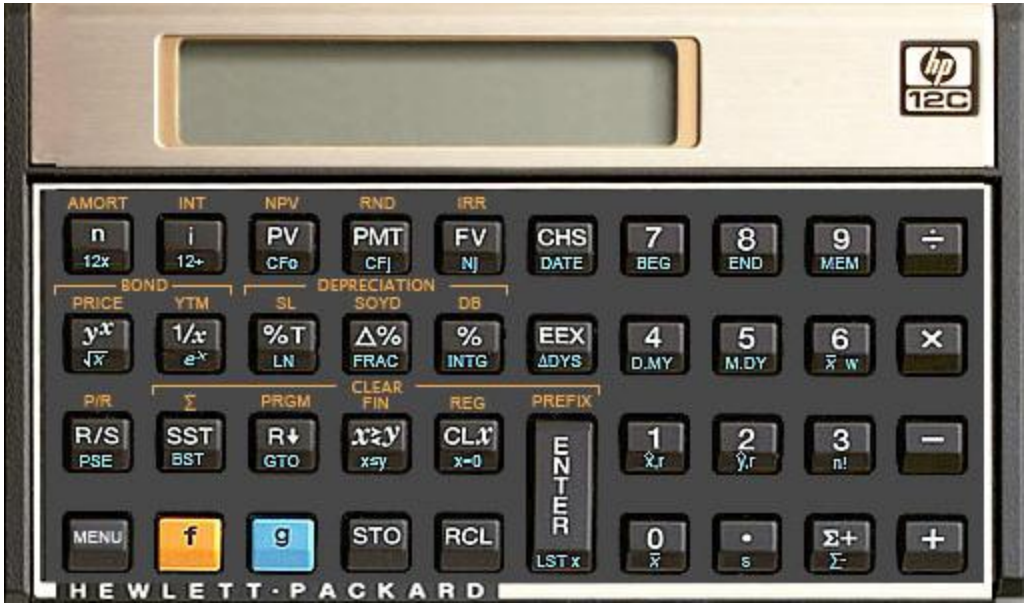
Dan Bricklin,
a frustrated

Bob Frankston & Dan Bricklin

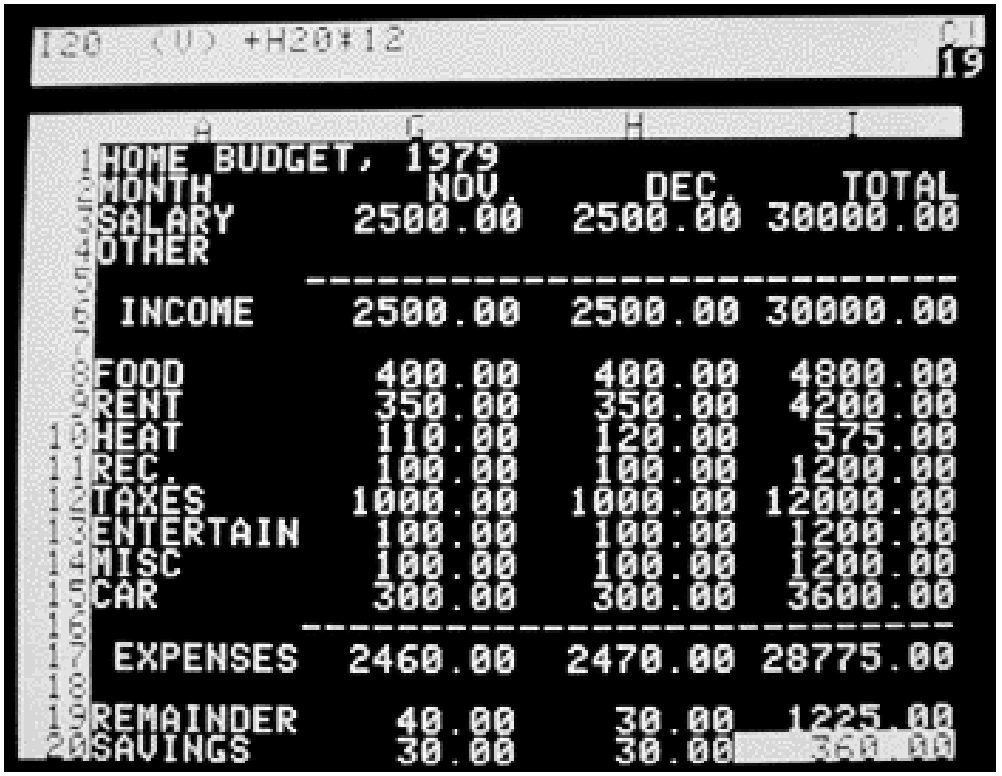
Harvard Business School student

Working case studies

Found calculators slow, cumbersome, and error prone



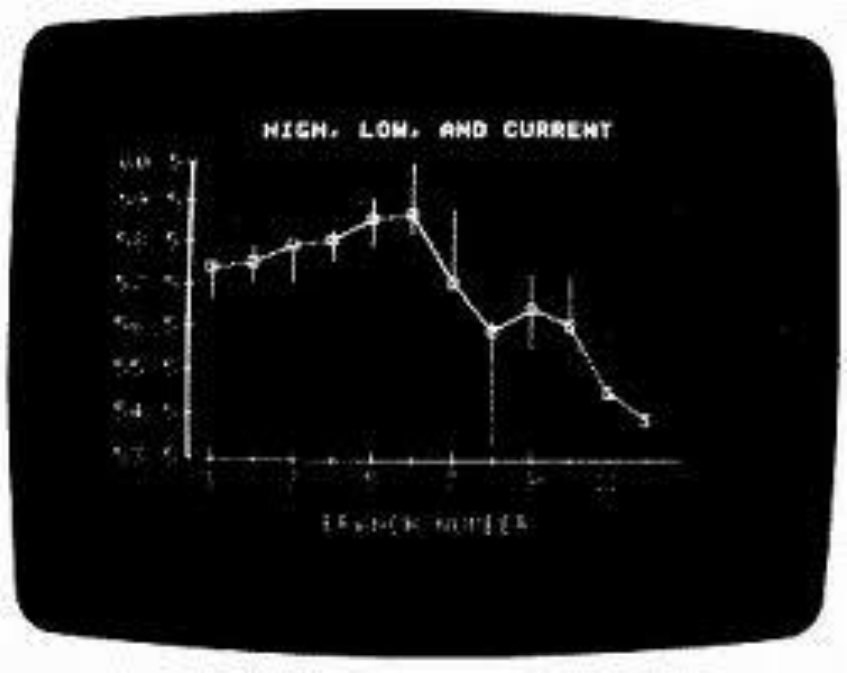
So he invented the spreadsheet



	G	H	I
HOME BUDGET, 1979			
MONTH	NOV	DEC	TOTAL
SALARY	2500.00	2500.00	30000.00
OTHER			
INCOME	2500.00	2500.00	30000.00
FOOD	400.00	400.00	4800.00
RENT	350.00	350.00	4200.00
HEAT	110.00	120.00	575.00
REC.	100.00	100.00	1200.00
TAXES	1000.00	1000.00	12000.00
ENTERTAIN	100.00	100.00	1200.00
MISC	100.00	100.00	1200.00
CAR	300.00	300.00	3600.00
EXPENSES	2460.00	2470.00	28775.00
REMAINDER	40.00	30.00	1225.00
SAVINGS	30.00	30.00	

VisiCalc the Visible Calculator (1979)

Mitch Kapor added graphs



VisiPlot 1980

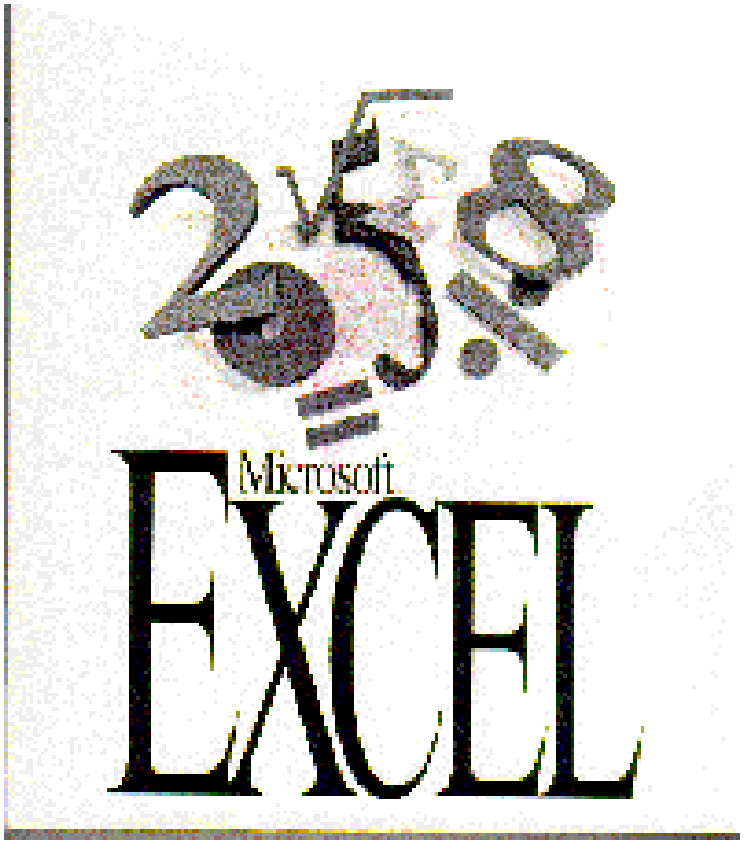
And then a database

Mitch and Lotus 123 in 1982

Putting a PC on every business desk and…

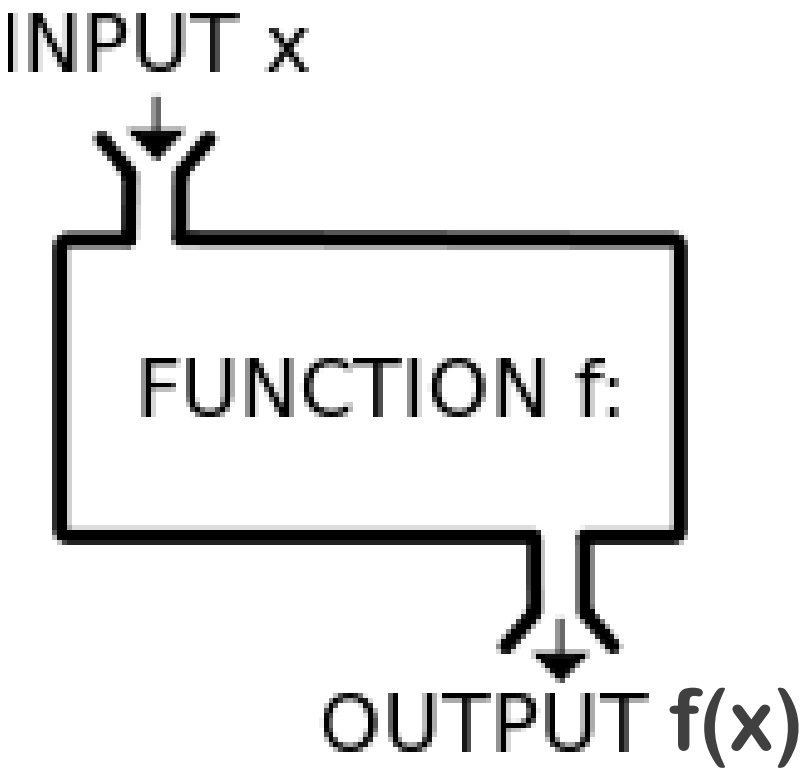
The IBM PC

A spreadsheet on every computer



1995

Spreadsheets are function machines



Function is a fundamental concept

HARVARD COLLEGE
Handbook for Students

Mathematics
Professor Peter Kronheimer, Director of Undergraduate Studies
Mathematics is the science of order, and mathematicians seek to identify instances of order and to formulate and understand concepts that enable us to perceive order in complicated situations.

Perhaps the most important concept of mathematics is that of function, which provides us with the means to study dependence and change.

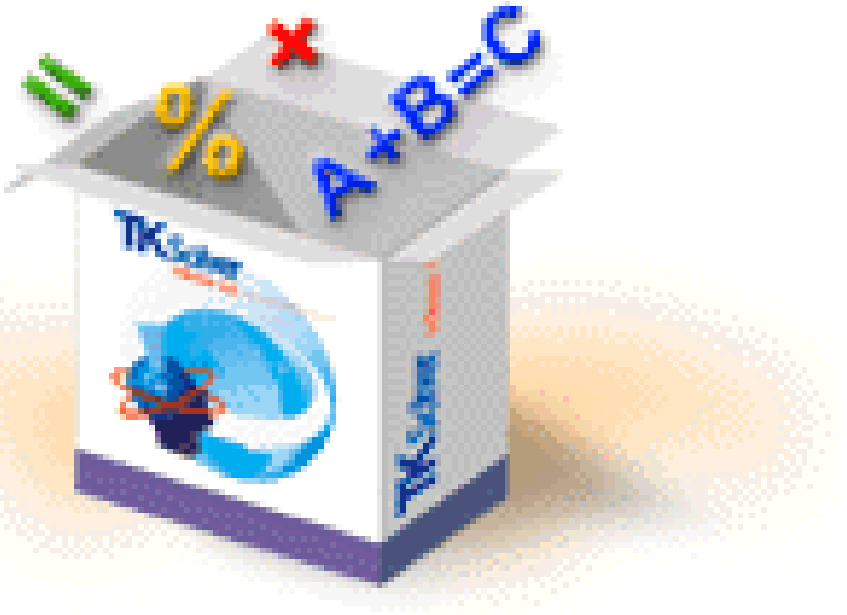
Enables business to solve dynamic problems

Quarterly Cash Flow Projection

The ABC Corporation
First Quarter, 2010

Cash Received	JANUARY			FEBRUARY			MARCH		
	Estimate	Actual	Variance	Estimate	Actual	Variance	Estimate	Actual	Variance
Beginning Cash Balance	$52,552	$54,530	($1,978)	$36,247	$42,762	($6,515)	$33,469	$38,955	($5,486)
Cash Sales	23,821	25,485	(1,664)	23,819	26,468	(2,649)	25,443	26,780	(1,337)
Collections	59,014	61,001	(1,987)	62,394	63,666	(1,272)	73,702	69,487	4,215
Loans	15,121	18,452	(3,331)	12,329	19,109	(6,780)	14,513	19,452	(4,939)
Total Cash Available	$150,508	$159,468	($8,960)	$134,789	$152,005	($17,216)	$147,127	$154,674	($7,547)
Cash Disbursed									
Salaries and Wages	$14,752	$15,855	($1,103)	$12,890	$13,659	($769)	$15,042	$14,150	$892
Lease/Mortgage	1,659	1,659	0	1,422	1,776	(354)	1,589	1,778	(189)
Insurance	1,041	1,085	(44)	956	1,175	(219)	980	1,328	(348)
Office Supplies	5,404	3,505	1,899	4,646	3,911	735	5,395	4,676	719
Utilities	7,316	7,105	211	8,212	7,190	1,022	6,837	7,535	(698)
Repairs and Maintenance	4,378	4,155	223	4,161	3,694	467	4,766	4,330	436
Operating Supplies	2,805	3,950	(1,145)	3,114	4,538	(1,424)	3,247	5,170	(1,923)
Professional Fees	3,437	1,575	1,862	3,097	1,630	1,467	3,245	1,514	1,731
Commissions	13,716	15,850	(2,134)	12,293	17,303	(5,010)	11,060	19,577	(8,517)
Travel and Entertainment	3,734	4,580	(846)	4,061	4,509	(448)	4,546	4,923	(377)
Purchases	4,140	4,500	(360)	4,830	4,783	47	4,161	5,129	(968)
Advertising	1,957	2,850	(893)	1,841	3,205	(1,364)	1,700	3,499	(1,799)
Transportation	14,776	13,505	1,271	12,681	12,838	(157)	10,522	14,371	(3,849)
Other	12,352	11,318	1,034	12,794	12,410	384	10,630	13,920	(3,290)
Total Disbursements	$91,467	$91,492	($25)	$86,998	$92,621	($5,623)	$83,720	$101,900	($18,180)
Cash Position									
Loan Payment with Interest	$8,214	$8,214	$0	$7,318	$8,665	($1,347)	$6,353	$8,278	($1,925)
Capital Purchases	2,080	1,500	580	2,004	1,764	240	2,348	1,493	855
Owner's Withdrawal	12,500	15,500	(3,000)	5,000	10,000	(5,000)	15,000	10,000	5,000
Total Cash Paid Out	$114,261	$116,706	($2,445)	$101,320	$113,050	($11,730)	$107,421	$121,671	($14,250)
End Of Month	$36,247	$42,762	($6,515)	$33,469	$38,955	($5,486)	$39,706	$33,003	$6,703

We no longer use Leonardo's math to solve equations or to calculate on paper.



TK!Solver by Bricklin and Frankston 1982, long forgotten

$$\frac{x}{x+3} - 4 = \frac{x+4}{x+3}$$

$$\begin{array}{r} 647 \\ \times 44 \\ \hline \boxed{28468} \end{array}$$

$$\frac{-x}{x^2-6x+5} + \frac{-x-1}{x^2-10x+25}$$

$$\sqrt[3]{6x-4} = \sqrt[3]{5x+8}$$

Write the mixed number in simplest form that is equivalent to

$$\frac{15}{5}$$

$$\frac{15x^2+8x-4}{3x+1}$$

$$\sqrt[3]{64} + \sqrt[4]{81}$$

$$3x^2 - 18x = -36$$

$$5w^2 - 34w + 24$$

$$2x^2 - 8x + 14$$

$$\frac{9}{5} + \frac{4}{2} = \boxed{19/5}$$

$$\frac{10}{7}x + 1 \quad \frac{3}{5}x - 8$$

$$\frac{5}{6} \div \frac{-7}{12}$$

$$6\frac{3}{4} - \frac{1}{8}$$

$$\begin{array}{r} 439 \\ \div 25 \\ \hline 17 \end{array}$$

and remainder: $\boxed{14}$

$\boxed{x = 126}$

$\boxed{6\ 5/8}$

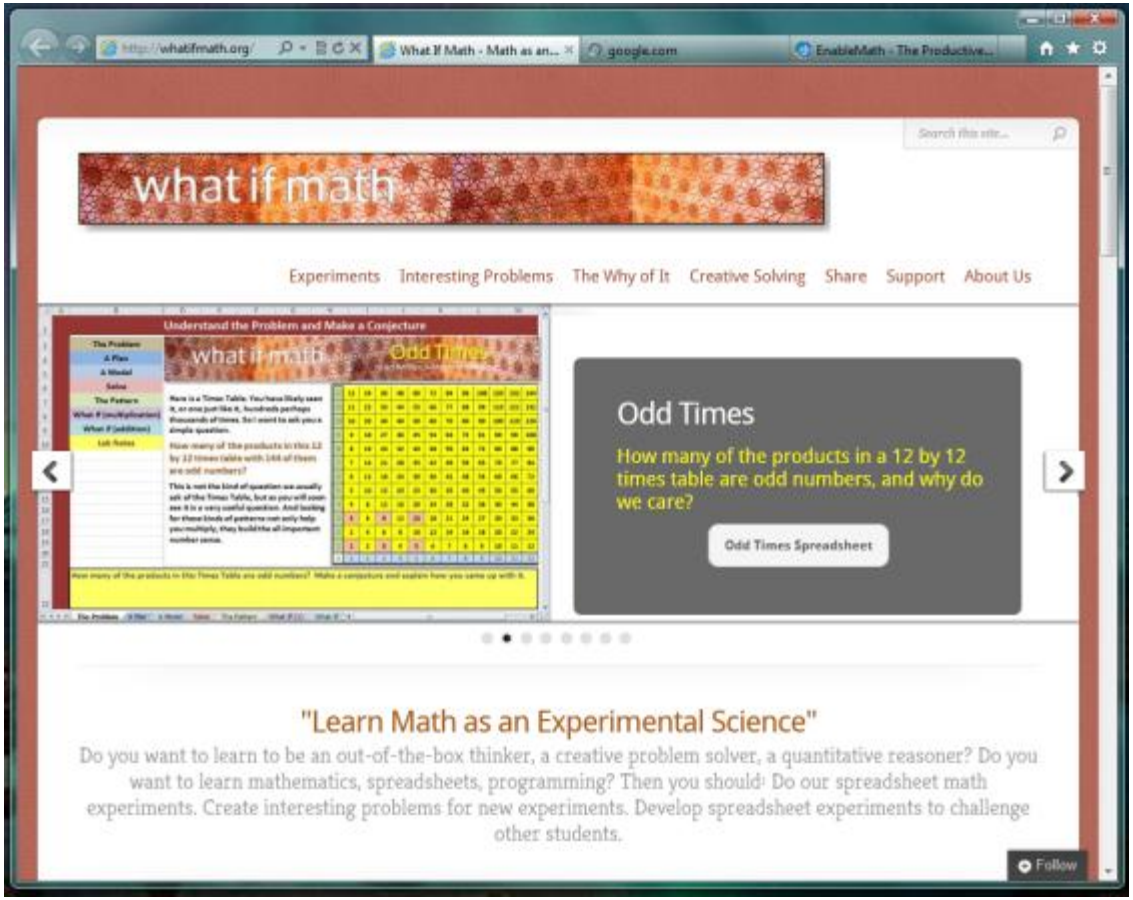
Leonardo's algorithmically defined scope and sequence is unnecessary.

Mathematics Scope & Sequence		Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade
Arithmetic								
Numbers	Wholes	objects, tallies, #0-20	1, 2, 10's even/odd	1…5 to 100, 1st-10th	6…10, ordinals, squares	powers of 10	powers of 2, primes	roots
	Place Value			(10)'s, (100)'s, (1/10)'s	(1000)'s, (.01)'s	.001 to 1,000,000	expanded notation, %	exponent/sci. notation
	Bases				2, 3, 4, 5	2, 8	16	formula for changing bases
	Unknowns		single	substitute 1, 2	in every location	changing unknowns	ratio problems	in motion problems
	Integers					negative numbers	+/- by a postive #	
	Rationals		parts of a whole	simple fractions	compare, order 1/D	compare/order N/D	equivalent, mixed #'s	conversions - fraction-dec
	Vectors		postion on a numberline	interval on # line	direction on a numberline	direction on a numberline	+-* by a constant	motion
Expressions	Evaluating	1 to 1 correspondence		single ()	multiple ()	embedded (), siimplifying	evaluate	Boolean logic
	Grouping	sort objects	group by 2, 10's	group/partition	regrouping, arrays	factors & multiples	order of operations	properties of arithmetic
	Operations	compare/order sets	+, - objects	+, - facts to 20	+, * facts, +, - same denom	facts to 12's, +, - fractions	fraction-whole: powers	%; =- integers
Relations	Algorithms	counting on	+, - columns	+, - (2 places)	+, -, regrouping	*, /	+-*/ decimals	alternative algorithms
	Equations	equalize groups	<, >, =, +, -	+, - open sentences	+, -, sentences to 100	*,/ sentences	ratios	numerical equations
	Functions			oriented operations	uinary operations	*, / by 10's, 100's	formulas	functional notation
Statistics								
	Probability			intuitive	chance	as a ratio	random sample; decimal	Pascal's Triangle
	Statistics	collect data	collect data	graphical average	numerical average	Mean	Standard Deviation	Mode, Median, Range
	Representation	picture graph	bar graph			line graph	area under a graph	"Bell Curves"
Geometry								
Shapes	Shapes	describe	2 dimensional families	classify	regular, irregular	rays, segments, solids	polygons, polyhedra	circles
	Symmetry	relate to objects		symmetry/congruency	lines of symmetry	parallel, perpendicular	construction of triangles	similarity, scale drawings
Relations	Angles	patterns	parts of a shape		compare angles	right angles	construct angles	rules of symmetry
	Perimeter	inside/outside		measuring	regular shapes	inside/ouside angle	sum of angles in a polygon	
Metric	Area		closed paths	counting squares	compare/order	regular polygons	polygons; formulas	circumference, p
	Volume		covering space			squares, rectangles	polygons	formulas, circles
Mapping	Direction	location	order/connect points	N, S, E, W	units of distance	self-derived formulas	polyhedra	spheres
	Position	above, below…	left, right, top, bottom	label points	N, S, E, W (globe, map)	locating points grid		
Graphing		picture, bar	labeled bar	grid locations	collect data	ordered pairs		
Measurement					reading graphs	line		
Time	Events, Durations	before, during, after	order durations	order many events	duration between events	1/10's, 1/100's		
	Clocks	day, night	hour/half	5 minutes	minutes	digital displays		
	Calendar	days, seasons	order days, name months	order months, seasons	calendars	century, decades		
Objects & Space	Distance	compare, order, equalize	compare	rulers	factions of an inch	miles, km		
	Volume	big, small, closer to	invented measures	scales, liquids	liter			

they were unanimously of opinion "that a radical change in the teaching of arithmetic was necessary. *The Committee of Ten 1894*

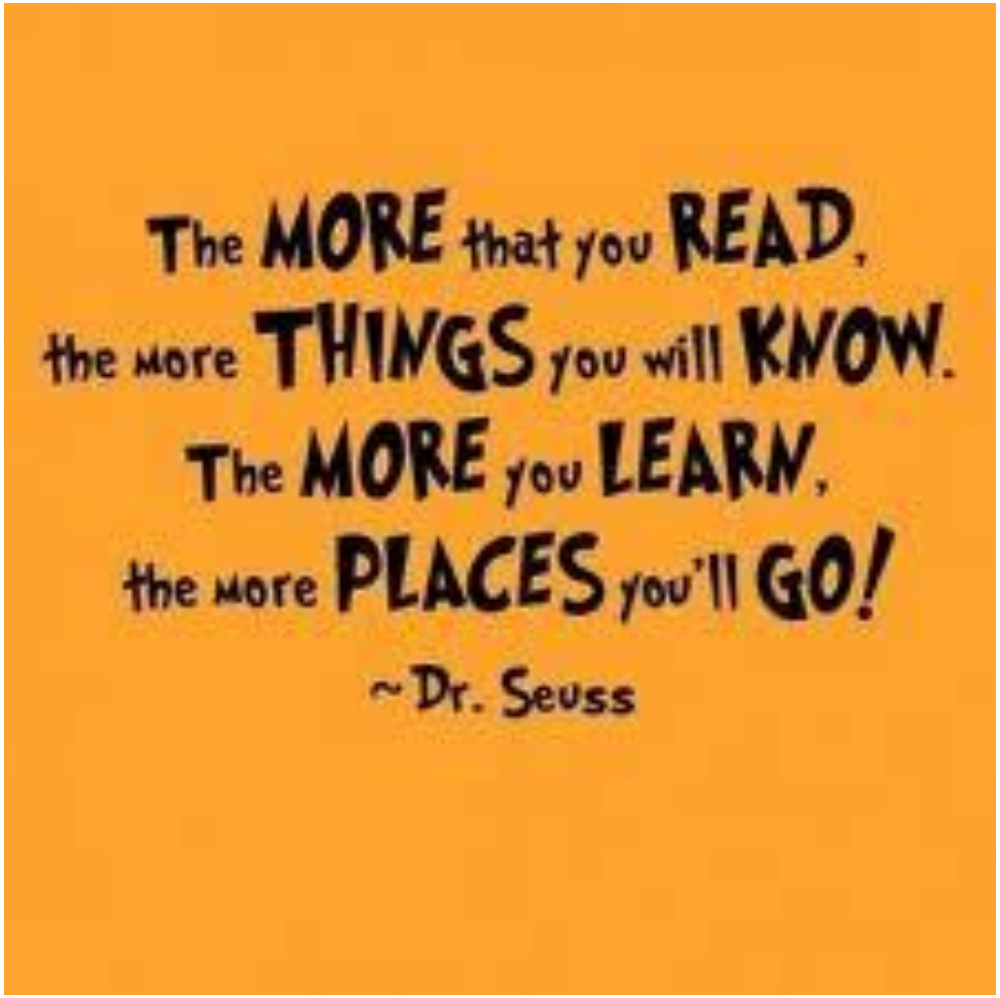
In the year

2013



We are launching What if Math

Practice problem solving not calculating



Perform Spreadsheet Experiments

Developed by students for students

On a wide range of topics

Integrating

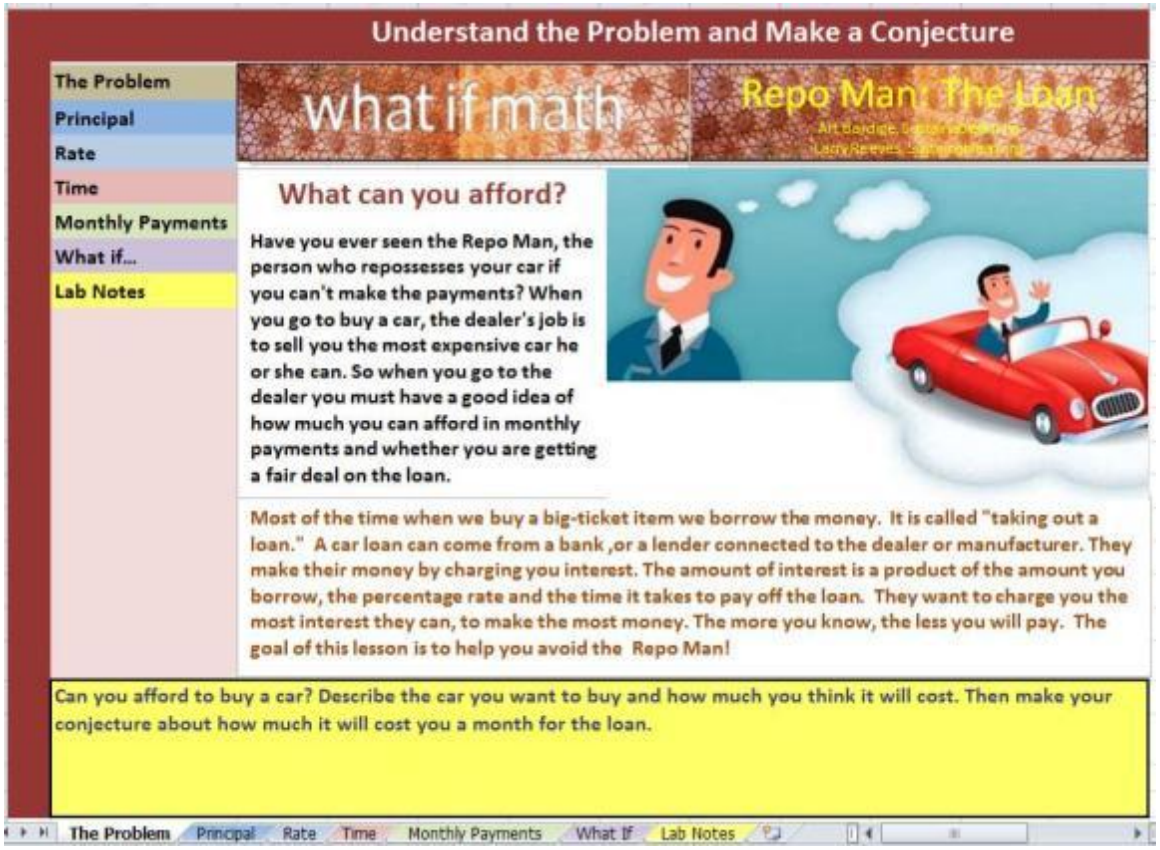
S*cience*

T*echnology*

E*ngineering*

M*ath*

Financial Literacy



Sustainability

Whats Watt

The Problem
A Plan
A Model
Pattern
Explanation
What If
Reflection

what if math Just 1 Bulb

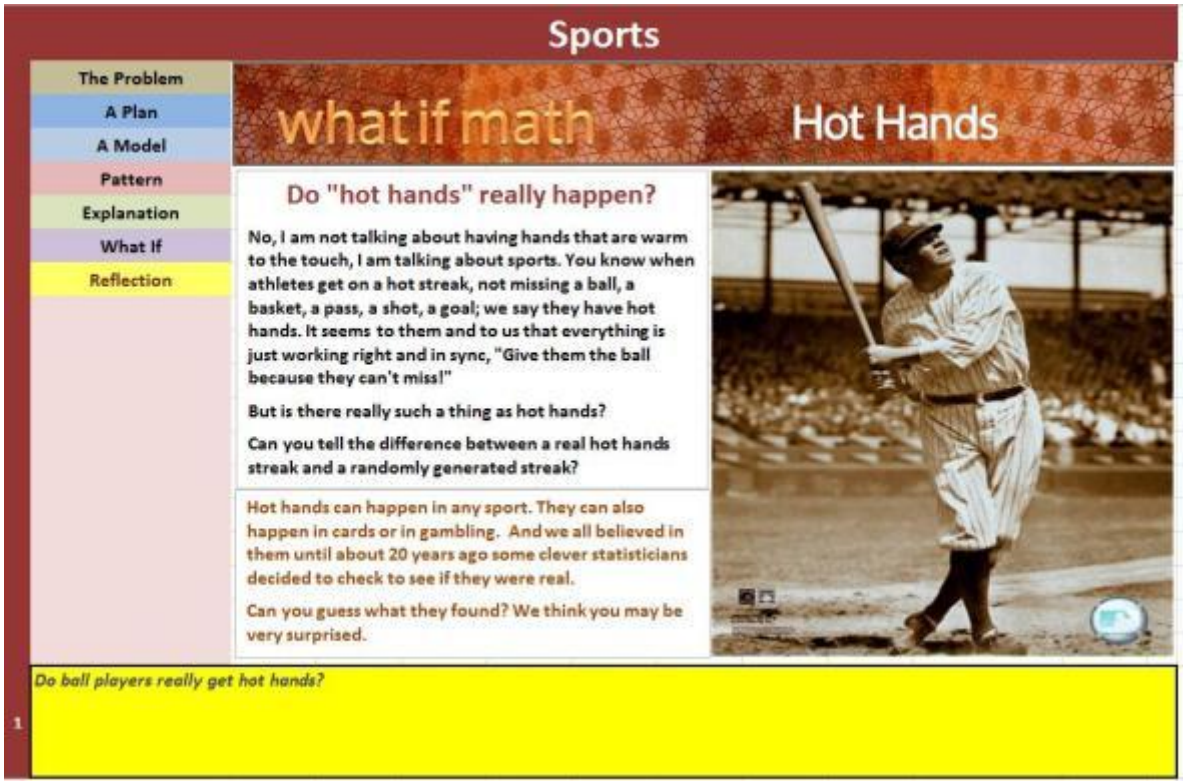
James Watt was a Scottish engineer and inventor who perfected the steam engine around the time of the American Revolution. We celebrate him and his invention that created the Industrial Revolution by naming our unit of power, the "watt," after him. A watt is the measure of the amount of energy we are using each second. For example, we measure the electrical power a light bulb uses in watts.

Today about 15% (202 billion kWh) of all of our electrical power is used in homes goes just for lighting. We now have light bulbs that use much less power. Pictured at the right is a new LED bulb

Conserving energy is important to all of us, and the Federal Government has ruled that over the next few years we will not be allowed to buy the old incandescent light bulbs. Is this a good idea? How much electrical power would it save?

How much electrical power would be saved if every home in the United States replaced one old incandescent bulb with one of the new CFL's.

Statistical Literacy



And even the arts

The Movies

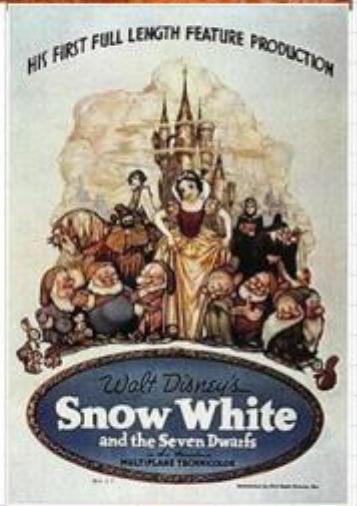
The Problem
A Plan
A Model
Pattern
Explanation
What If
Reflection

what if math — Snow While

In the mid 1930's Walt Disney, who was having success with short Mickey Mouse cartoons, decided to bet the ranch on a full length animated movie, Snow White and the Seven Dwarf to be ready for the next Christmas. He created a story board and then brought in his artist/animators into a room and asked them how long it would take them to draw this movie. They noodled for a while and then said, "It was impossible! We could never do this in one year."

You see, animated movies at that time were drawn by hand. And each frame of the movie had to have its own drawing, its own "cel." Discouraged, Walt left the studies and went for a walk in downtown Hollywood where all the stores were decorated for Christmas. As he looked into the big Christmas window all painted up, he got a brilliant idea that enabled him to revolutionize animation.

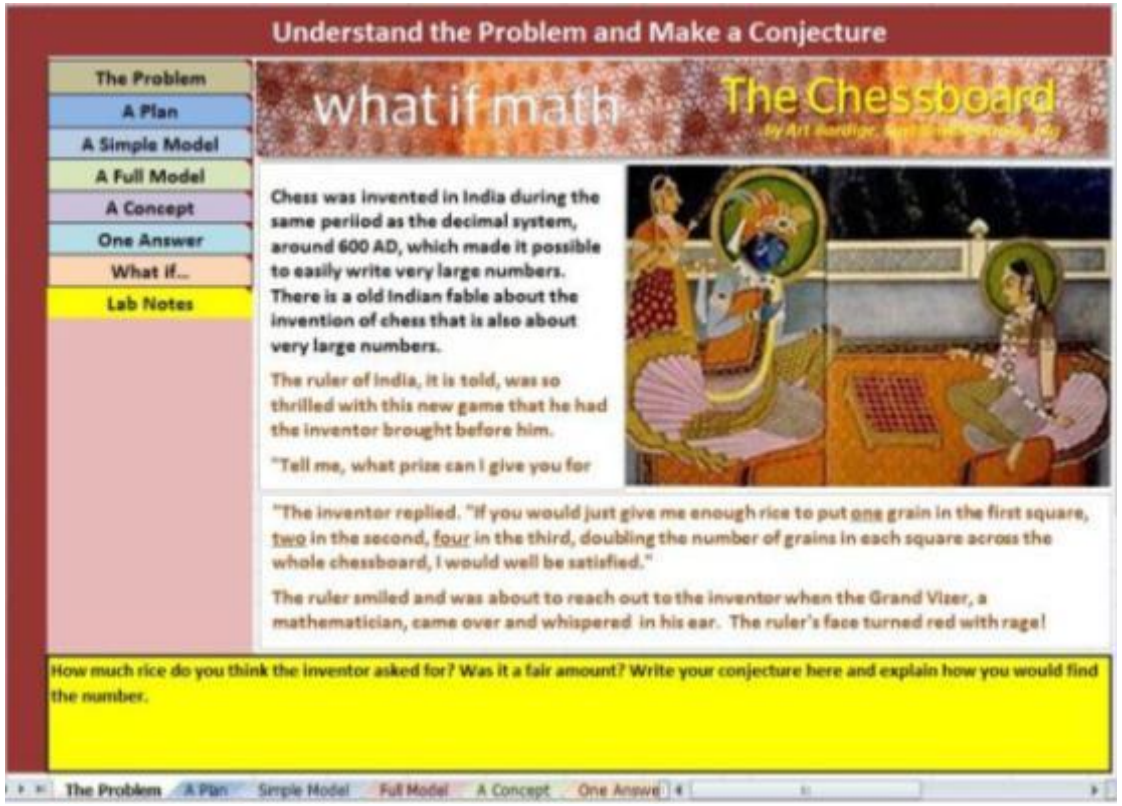
How many cels do you think the animators figured out they needed to draw by hand? And what was Walt's brilliant idea that enabled him to make Snow White and get it out the following Christmas.



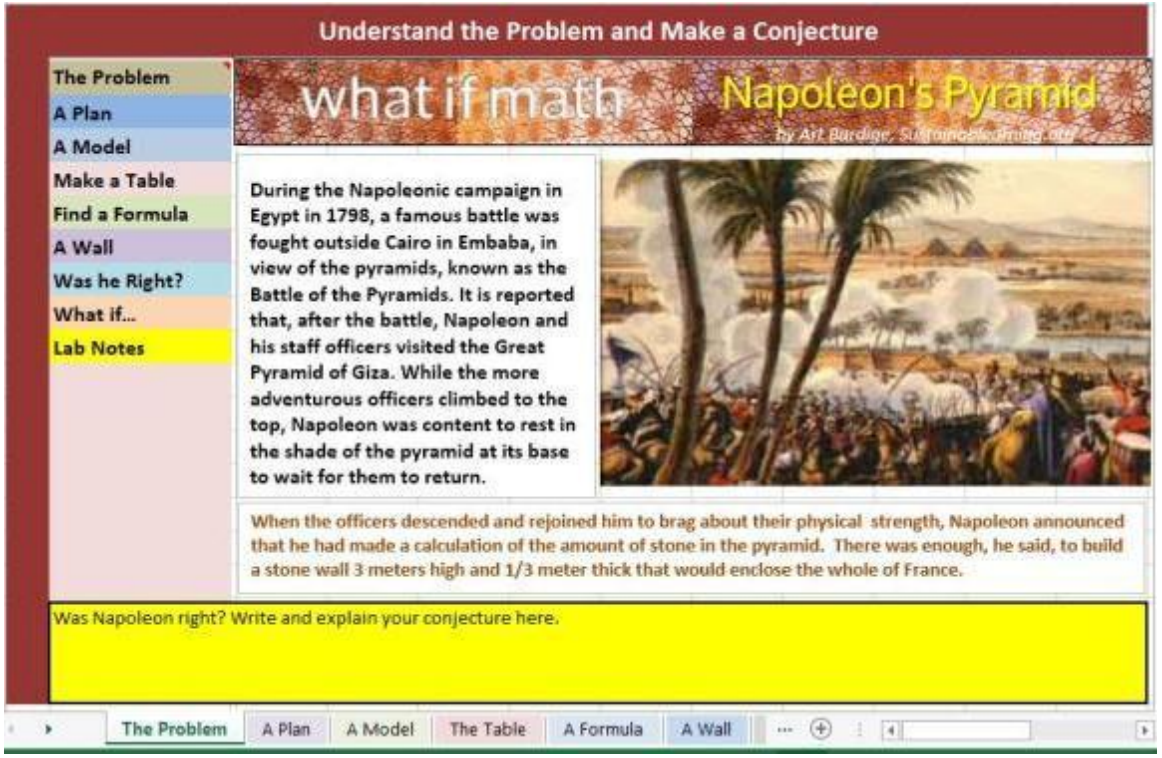
What was Walt's brilliant idea, and was he able to get Snow White out by the next Christmas?

1

Based on Interesting Problems



Introduced with a good story



Following a consistent experimental method

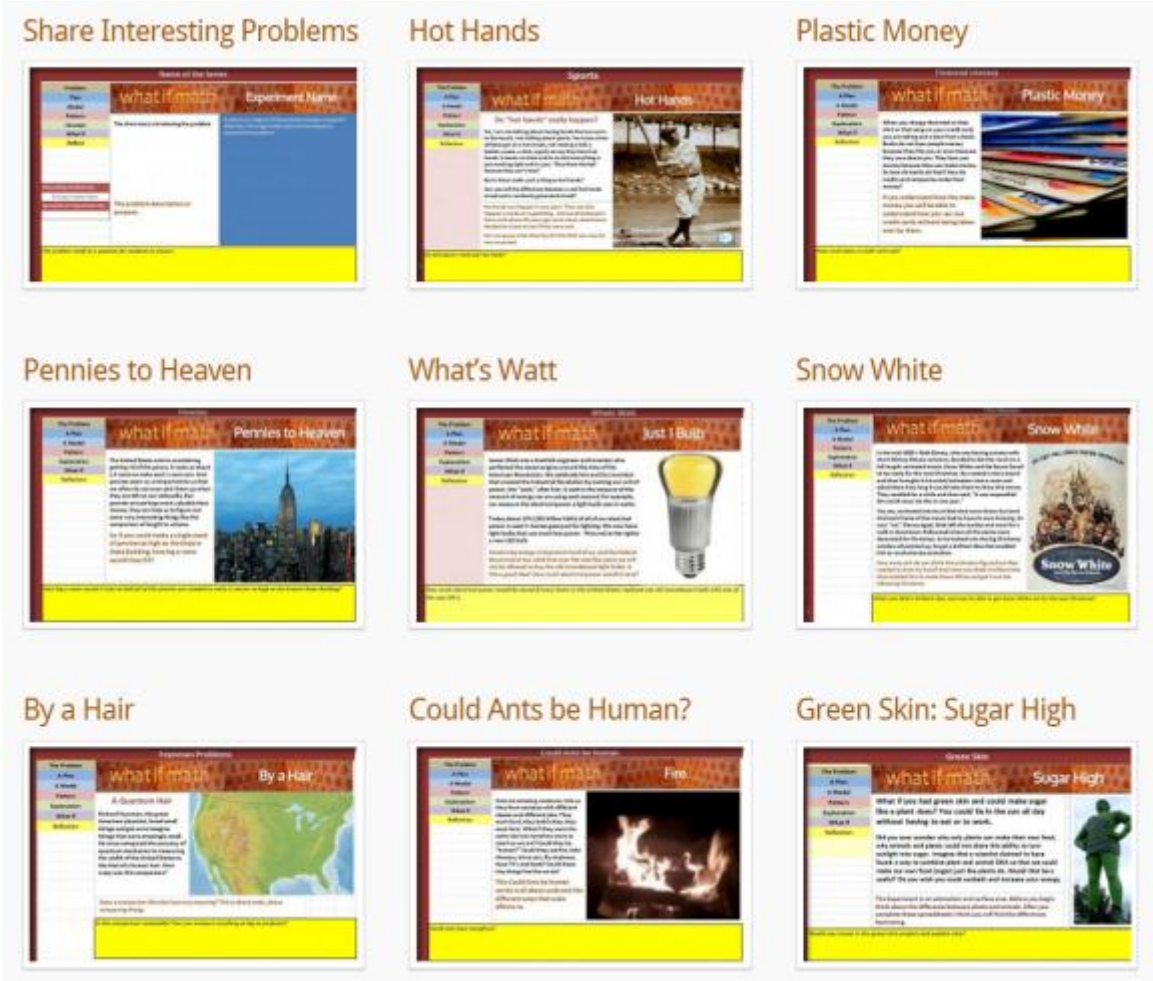
what if math			Experimental Plan for	(Fill in the title)
Steps			Your Description	
1	Problem	Formulate a question or a problem that would interest other students and tell a short story to capture their attention.	*Write a description for each step in this column.*	
2	Plan	Describe a sequence of steps to solve the problem. "What are we going to do in our spreadsheet lab?"		
3	Model	Start by building a simple mathematical model for students to use, for example a simple table.		
4	Pattern	Extend the pattern. Add scope, data, or complexity to build a more complete model.		
5	Concept	Develop a explanation for the pattern, where it comes from, and how it illuminates a solution.		
6	What if...	Suggest What if... questions that lead students to explore the pattern more deeply.		
7	Reflect	Think of "What did I learn today?"questions for the Student Lab Notebook.		

Focused on patterns and patternmaking

Spread the word we want ***Nerds***

Rich Twp. H.S. Rocket Club 1959

To create and share Interesting Problems



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