



what if math

Learning Math as an Experimental Science

Art Bardige

sustainablelearning.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

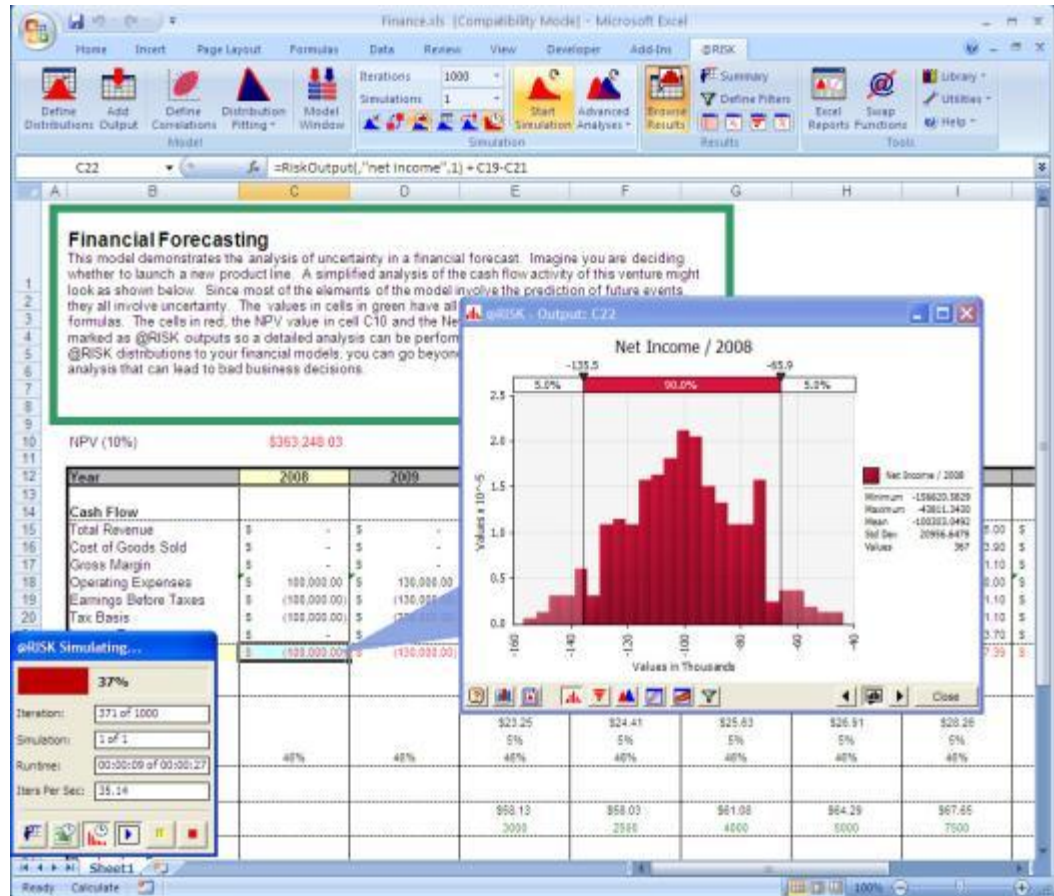


*To solve interesting
Problems that
“instill a passion”
for learning, by:*



Enrico Fermi

Building models





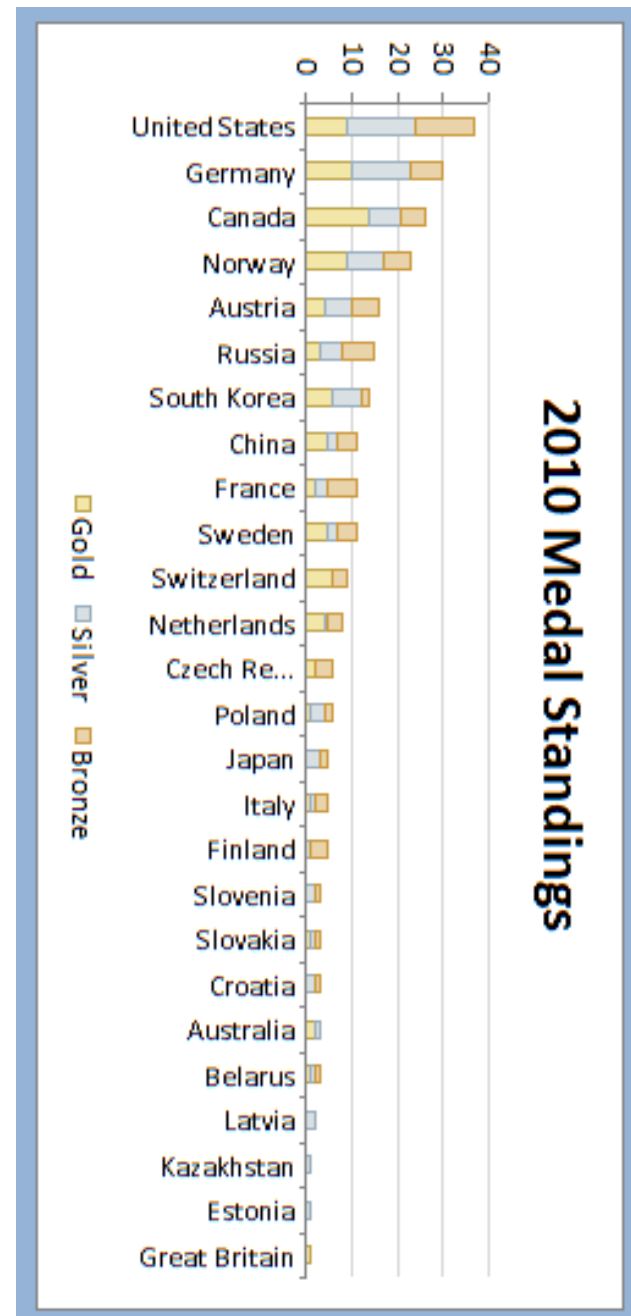
2010 Winter Olympics Medal Standings

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.

Analyzing data

Visualizing results



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

And asking

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

In the year
1202

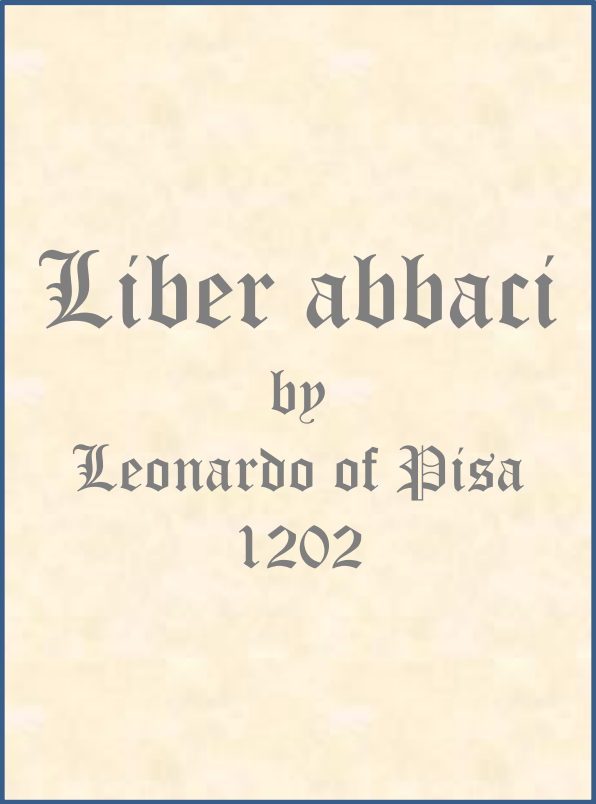


King Richard, The Lionhearted died, 1199

A revolutionary book was published



*Virtually
unknown
today*

The image shows a rectangular frame containing a title page from an old manuscript. The text is centered and written in a black Gothic-style font on a light beige, parchment-like background. The title 'Liber abbaci' is the largest, followed by 'by Leonardo of Pisa' and the year '1202' below it.

Liber abbaci
by
Leonardo of Pisa
1202

“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*





*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
CLXVIIICLXVII	II
CLXVIIICLXVIIICLXVII CLXVII	IV
CLXVIIICLXVIIICLXVII CLXVIIICLXVIIICLXVII CLXVIIICLXVII	VIII
CLXVIIICLXVIIICLXVII CLXVIIICLXVIIICLXVII CLXVIIICLXVIIICLXVII	I+VIII=IX

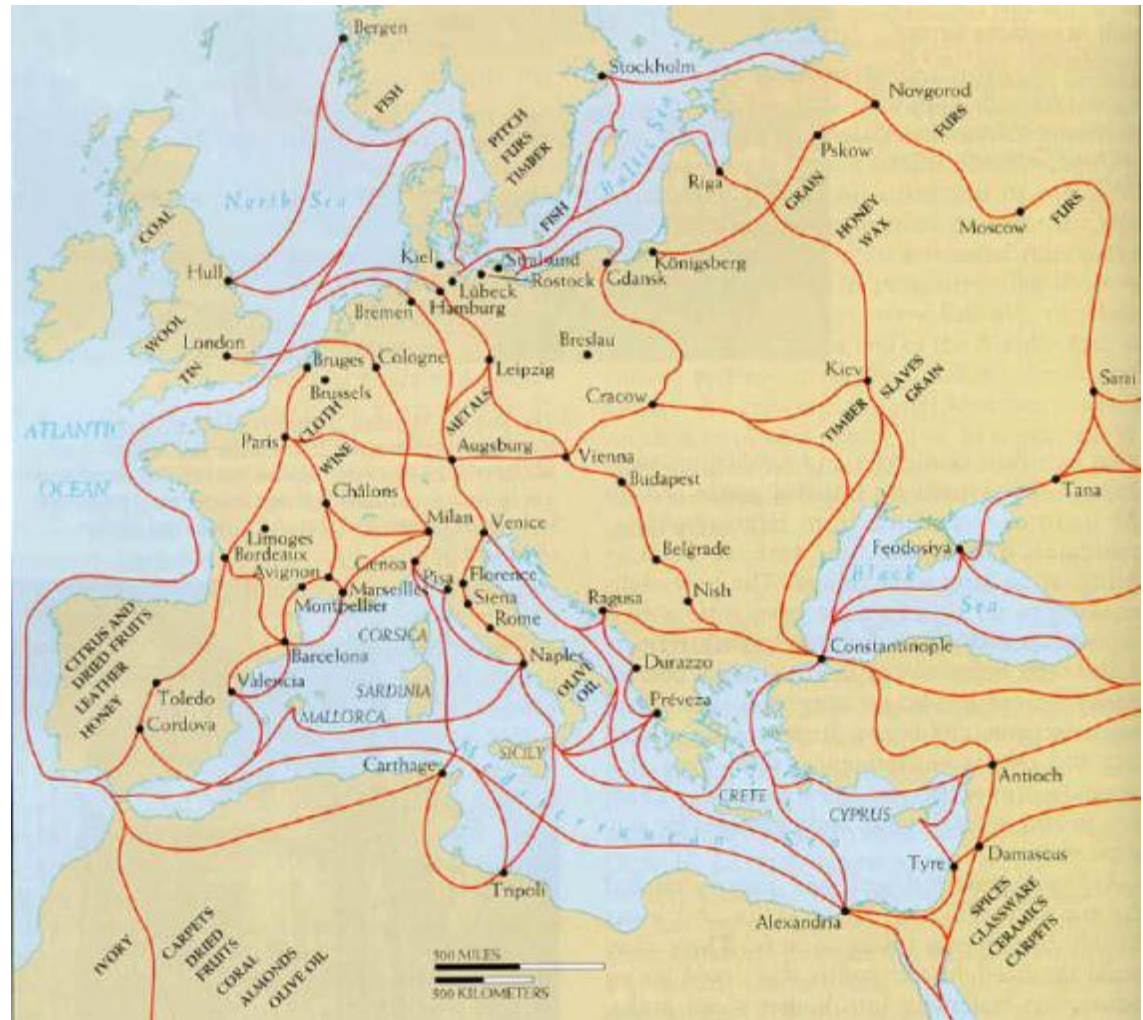
167 x 9 =

*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

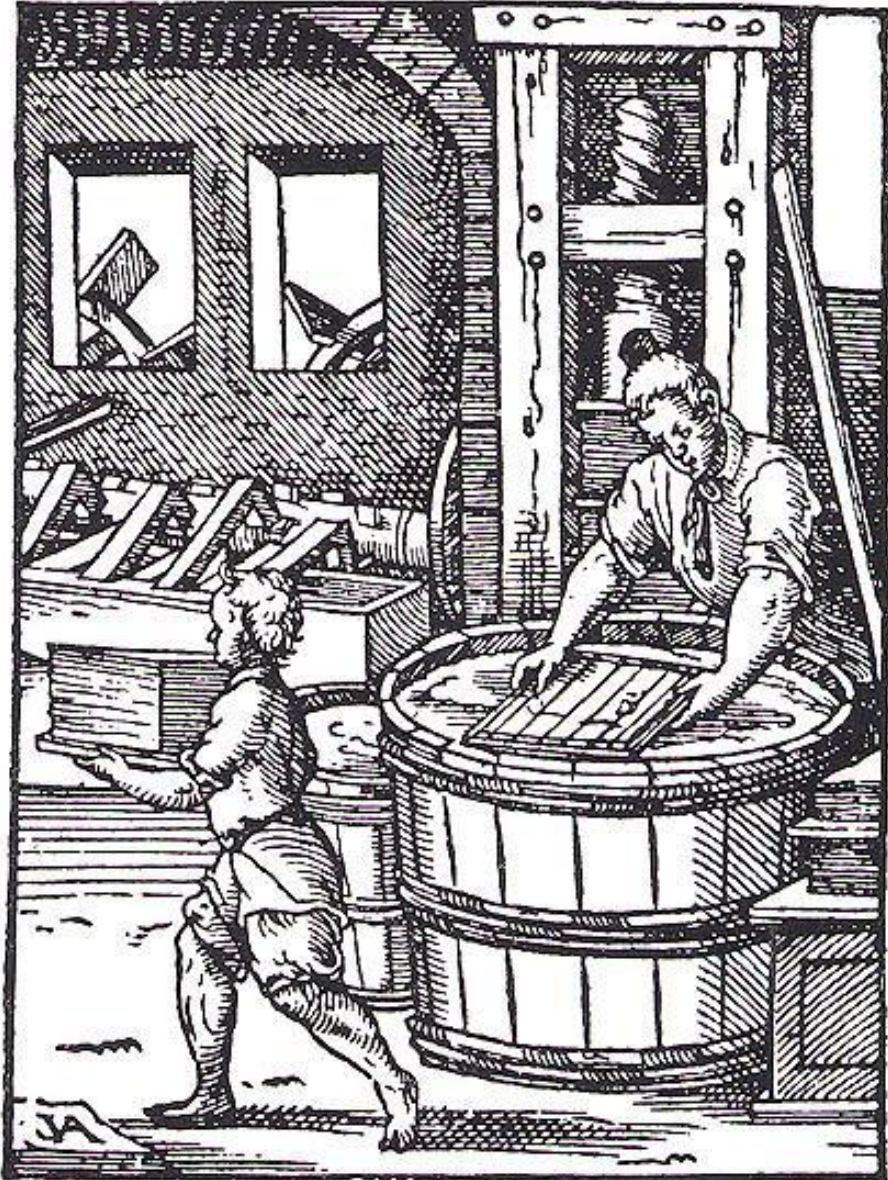


Where he learned Arabic arithmetic and algebra, become a trader and returned to Pisa in 1200



***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.*

**COMMON CORE
STATE STANDARDS FOR**

Mathematics



In the year
1979



*A technology
revolution
changed the
mathematics of
business*



*Dan Bricklin,
a frustrated*



Bob Frankston & Dan Bricklin

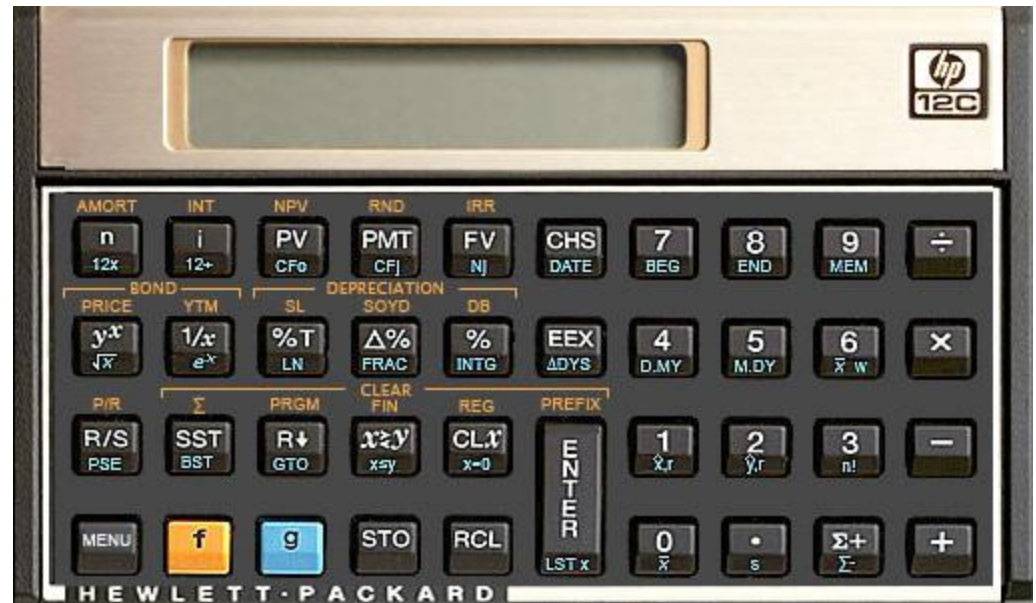
*Harvard
Business
School student*



*Working
case studies*



*Found calculators
slow, cumbersome,
and error prone*



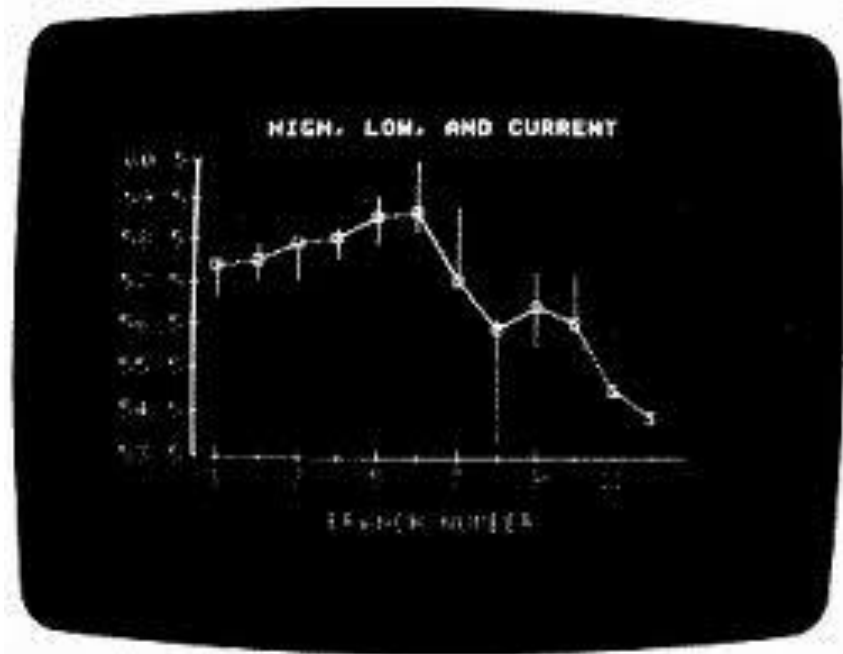
*So he invented
the spreadsheet*

The screenshot shows a VisiCalc spreadsheet window titled "HOME BUDGET, 1979". The window has a title bar with "120 (U) +H20#12" and a cursor icon in the top right corner. The spreadsheet is organized into columns labeled A, B, C, D, E, and F. The data is as follows:

	A	B	C	D	E
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	360.00	

VisiCalc the Visible Calculator (1979)

*Mitch Kapor
added graphs*



VisiPlot 1980

*And then a
database*



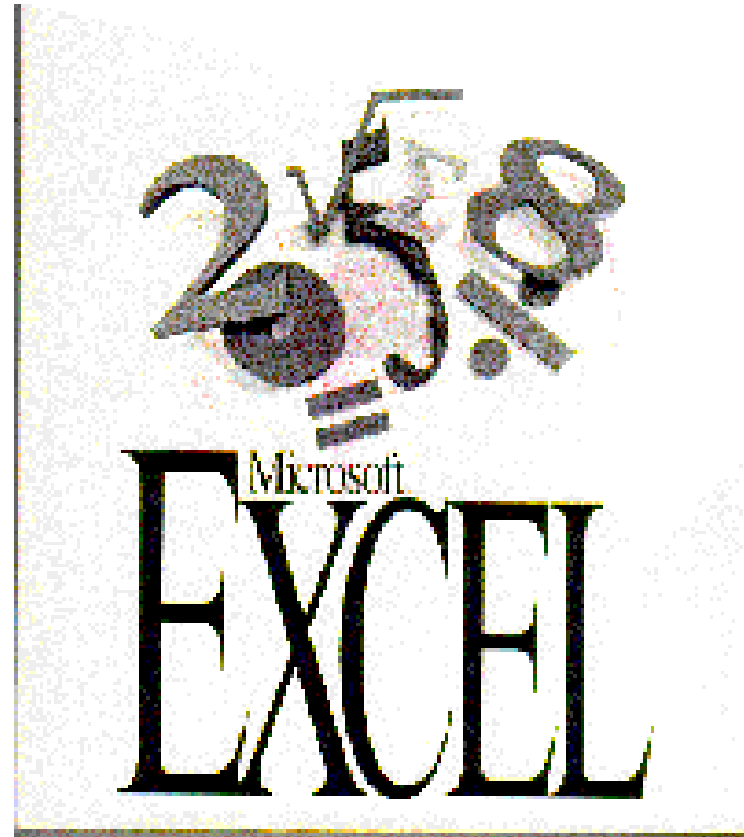
Mitch and Lotus 123 in 1982

*Putting a PC on
every business
desk and...*



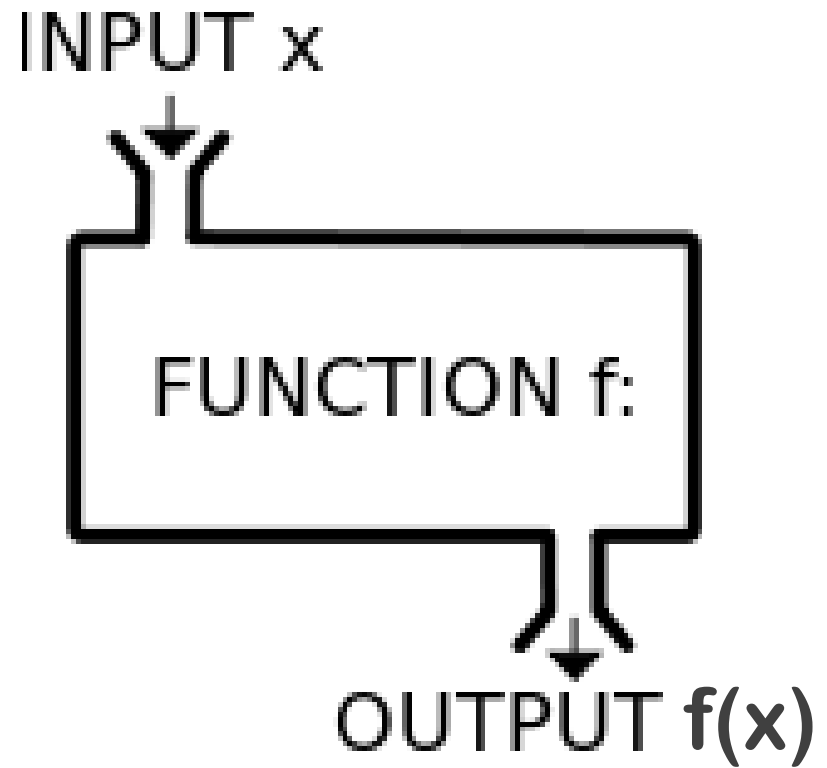
The IBM PC

*A spreadsheet
on every
computer*



1995

*Spreadsheets are
function machines*





HARVARD COLLEGE

Handbook for Students

*Function is a
fundamental
concept*

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.

Quarterly Cash Flow Projection

The ABC Corporation
First Quarter, 2010

*Enables
business to
solve dynamic
problems*

Cash Received	JANUARY		
	Estimate	Actual	Variance
Beginning Cash Balance	\$52,552	\$54,530	(\$1,978)
Cash Sales	23,821	25,485	(1,664)
Collections	59,014	61,001	(1,987)
Loans	15,121	18,452	(3,331)
Total Cash Available	\$150,508	\$159,468	(\$8,960)

Cash Disbursed	JANUARY		
	Estimate	Actual	Variance
Salaries and Wages	\$14,752	\$15,855	(\$1,103)
Lease/Mortgage	1,659	1,659	0
Insurance	1,041	1,085	(44)
Office Supplies	5,404	3,505	1,899
Utilities	7,316	7,105	211
Repairs and Maintenance	4,378	4,155	223
Operating Supplies	2,805	3,950	(1,145)
Professional Fees	3,437	1,575	1,862
Commissions	13,716	15,850	(2,134)
Travel and Entertainment	3,734	4,580	(846)
Purchases	4,140	4,500	(360)
Advertising	1,957	2,850	(893)
Transportation	14,776	13,505	1,271
Other	12,352	11,318	1,034
Total Disbursements	\$91,467	\$91,492	(\$25)

Cash Position	JANUARY		
	Estimate	Actual	Variance
Loan Payment with Interest	\$8,214	\$8,214	\$0
Capital Purchases	2,080	1,500	580
Owner's Withdrawal	12,500	15,500	(3,000)
Total Cash Paid Out	\$114,261	\$116,706	(\$2,445)
End Of Month	\$36,247	\$42,762	(\$6,515)

Estimate	FEBRUARY	
	Actual	Variance
\$36,247	\$42,762	(\$6,515)
23,819	26,468	(2,649)
62,394	63,666	(1,272)
12,329	19,109	(6,780)
\$134,789	\$152,005	(\$17,216)

Estimate	FEBRUARY	
	Actual	Variance
\$12,890	\$13,659	(\$769)
1,422	1,776	(354)
956	1,175	(219)
4,646	3,911	735
8,212	7,190	1,022
4,161	3,694	467
3,114	4,538	(1,424)
3,097	1,630	1,467
12,293	17,303	(5,010)
4,061	4,509	(448)
4,830	4,783	47
1,841	3,205	(1,364)
12,681	12,838	(157)
12,794	12,410	384
\$86,998	\$92,621	(\$5,623)

Estimate	FEBRUARY	
	Actual	Variance
\$7,318	\$8,665	(\$1,347)
2,004	1,764	240
5,000	10,000	(5,000)
\$101,320	\$113,050	(\$11,730)
\$33,469	\$38,955	(\$5,486)

Estimate	MARCH	
	Actual	Variance
\$33,469	\$38,955	(\$5,486)
25,443	26,780	(1,337)
73,702	69,487	4,215
14,513	19,452	(4,939)
\$147,127	\$154,674	(\$7,547)

Estimate	MARCH	
	Actual	Variance
\$15,042	\$14,150	\$892
1,589	1,778	(189)
980	1,328	(348)
5,395	4,676	719
6,837	7,535	(698)
4,766	4,330	436
3,247	5,170	(1,923)
3,245	1,514	1,731
11,060	19,577	(8,517)
4,546	4,923	(377)
4,161	5,129	(968)
1,700	3,499	(1,799)
10,522	14,371	(3,849)
10,630	13,920	(3,290)
\$83,720	\$101,900	(\$18,180)

Estimate	MARCH	
	Actual	Variance
\$6,353	\$8,278	(\$1,925)
2,348	1,493	855
15,000	10,000	5,000
\$107,421	\$121,671	(\$14,250)
\$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

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

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

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

$$\boxed{28468}$$

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

Write the mixed number in simplest form that is equivalent to

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

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

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

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

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

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

$$\frac{10}{7}x + 1 = \frac{3}{2}x - 9$$

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

$$\begin{array}{r} 6\frac{3}{4} \\ - \quad \frac{1}{8} \\ \hline \end{array}$$

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

$$\boxed{x = 126}$$

$$\boxed{6 \frac{5}{8}}$$

and remainder: $\boxed{14}$

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 (10)'s, (100)'s, (1/10)'s	6...10, ordinals, squares (1000)'s, (.01)'s	powers of 10 .001 to 1,000,000	powers of 2, primes expanded notation, %	roots exponent/sci. notation
	Place Value							formula for changing bases
	Bases			2, 3, 4, 5	2, 8	16		
	Unknowns		single	substitute 1, 2	in every location	changing unknowns	ratio problems	in motion problems
	Integers					negative numbers	+/- by a positive #	
	Rationals		parts of a whole	simple fractions	compare, order 1/D	compare/order N/D	equivalent, mixed #'s	conversions - fraction-dec
	Vectors		position 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 (), simplifying	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	unary 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/outside 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								
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	fractions 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

The screenshot shows a web browser window displaying the 'What if Math' website. The browser's address bar shows 'http://whatifmath.org/'. The website has a search bar at the top right and a navigation menu with links: 'Experiments', 'Interesting Problems', 'The Why of It', 'Creative Solving', 'Share', 'Support', and 'About Us'. The main content area features a large banner for 'what if math' and a central experiment titled 'Understand the Problem and Make a Conjecture' with the sub-title 'Odd Times'. The experiment includes a 'The Problem' section, a 'What if you...?' section, and a 'Lab Notes' section. A spreadsheet titled 'Odd Times Spreadsheet' is visible, showing a 12x12 grid of numbers. Below the experiment, there is a section titled '"Learn Math as an Experimental Science"' with a paragraph of text: 'Do you want to learn to be an out-of-the-box thinker, a creative problem solver, a quantitative reasoner? Do you want to learn mathematics, spreadsheets, programming? Then you should! Do our spreadsheet math experiments. Create interesting problems for new experiments. Develop spreadsheet experiments to challenge other students.' A 'Follow' button is located in the bottom right corner.

We are launching What if Math

*Practice
problem
solving not
calculating*

The **MORE** that you **READ**,
the more **THINGS** you will **KNOW**.

The **MORE** you **LEARN**,
the more **PLACES** you'll **GO!**

~ Dr. Seuss

*Perform
Spreadsheet
Experiments
Developed by
students for
students*



WIKIPEDIA
The Free Encyclopedia

*On a wide
range of
topics*



*Integrating
Science
Technology
Engineering
Math*

Green Skin		
	what if math	Sugar High
The Problem	<p>What if you had green skin and could make sugar like a plant does? You could lie in the sun all day without having to eat or to work.</p> <p>Did you ever wonder why only plants can make their own food, why animals and plants could not share this ability to turn sunlight into sugar. Imagine that a scientist claimed to have found a way to combine plant and animal DNA so that we could make our own food (sugar) just like plants do. Would that be a useful? Do you wish you could sunbath and increase your energy</p> <p>This Experiment is on estimation and surface area. Before you begin think about the difference between plants and animals. After you complete these spreadsheets I think you will find the differences fascinating.</p>	
A Plan		
A Model		
Pattern		
Explanation		
What if		
Reflection		
	<p>Would you invest in the green skin project and explain why?</p>	

Financial Literacy

Understand the Problem and Make a Conjecture

what if math **Repo Man: The Loan**
Art: Dodge, Lisa & Robert
Lashy Reeves, Ed. & Illustrations

The Problem
Principal
Rate
Time
Monthly Payments
What if...
Lab Notes

What can you afford?

Have you ever seen the Repo Man, the person who repossesses your car if you can't make the payments? When you go to buy a car, the dealer's job is to sell you the most expensive car he or she can. So when you go to the dealer you must have a good idea of how much you can afford in monthly payments and whether you are getting a fair deal on the loan.



Most of the time when we buy a big-ticket item we borrow the money. It is called "taking out a loan." A car loan can come from a bank, or a lender connected to the dealer or manufacturer. They make their money by charging you interest. The amount of interest is a product of the amount you borrow, the percentage rate and the time it takes to pay off the loan. They want to charge you the most interest they can, to make the most money. The more you know, the less you will pay. The goal of this lesson is to help you avoid the Repo Man!


Can you afford to buy a car? Describe the car you want to buy and how much you think it will cost. Then make your conjecture about how much it will cost you a month for the loan.

The Problem Principal Rate Time Monthly Payments What If Lab Notes

Sustainability

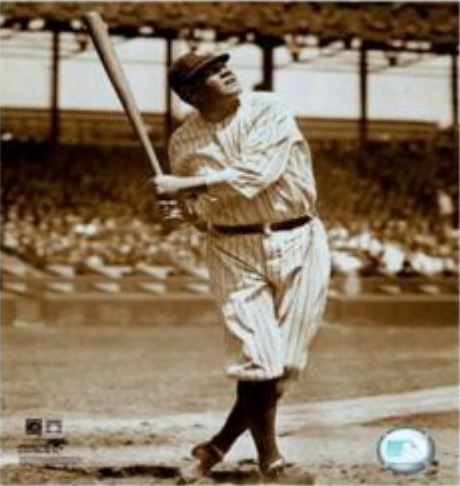
Whats Watt

The Problem	<h2>what if math</h2> <h2>Just 1 Bulb</h2> <p>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.</p> <p>Today about 15% (202 billion kWh) of all of our electrical power is used in homes just for lighting. We now have light bulbs that use much less power. Pictured at the right is a new LED bulb</p> <p>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?</p>
A Plan	
A Model	
Pattern	
Explanation	
What If	
Reflection	



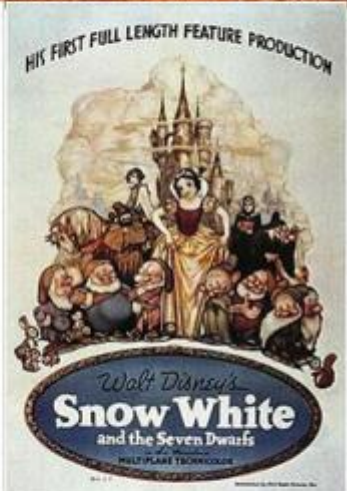
How much electrical power would be saved if every home in the United States replaced one old incandescent bulb with one of the new CFL's.

Statistical Literacy

Sports	
The Problem	<h2>what if math</h2> <h2>Hot Hands</h2> <p>Do "hot hands" really happen?</p> <p>No, I am not talking about having hands that are warm to the touch, I am talking about sports. You know when athletes get on a hot streak, not missing a ball, a basket, a pass, a shot, a goal; we say they have hot hands. It seems to them and to us that everything is just working right and in sync, "Give them the ball because they can't miss!"</p> <p>But is there really such a thing as hot hands?</p> <p>Can you tell the difference between a real hot hands streak and a randomly generated streak?</p> <p>Hot hands can happen in any sport. They can also happen in cards or in gambling. And we all believed in them until about 20 years ago some clever statisticians decided to check to see if they were real.</p> <p>Can you guess what they found? We think you may be very surprised.</p> 
A Plan	
A Model	
Pattern	
Explanation	
What if	
Reflection	
	<p><i>Do ball players really get hot hands?</i></p>

And even
the arts

The Movies	
The Problem	what if math Snow White
A Plan	
A Model	
Pattern	
Explanation	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."
What If	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 studios 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.
Reflection	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?



*Based on
Interesting
Problems*

Understand the Problem and Make a Conjecture

The Problem	<h1>what if math</h1> <h2>The Chessboard</h2> <p>by Art Berdiger, 1998 © 2000 Pearson Education, Inc.</p> <p>Chess was invented in India during the same period as the decimal system, around 600 AD, which made it possible to easily write very large numbers. There is a old Indian fable about the invention of chess that is also about very large numbers.</p> <p>The ruler of India, it is told, was so thrilled with this new game that he had the inventor brought before him.</p> <p>"Tell me, what prize can I give you for</p> <p>"The inventor replied, "If you would just give me enough rice to put <u>one</u> grain in the first square, <u>two</u> in the second, <u>four</u> in the third, doubling the number of grains in each square across the whole chessboard, I would well be satisfied."</p> <p>The ruler smiled and was about to reach out to the inventor when the Grand Vizer, a mathematician, came over and whispered in his ear. The ruler's face turned red with rage!</p> <p>How much rice do you think the inventor asked for? Was it a fair amount? Write your conjecture here and explain how you would find the number.</p>
A Plan	
A Simple Model	
A Full Model	
A Concept	
One Answer	
What if...	
Lab Notes	

The Problem A Plan Simple Model Full Model A Concept One Answer


*Introduced
with a good
story*

Understand the Problem and Make a Conjecture

what if math **Napoleon's Pyramid**
by Art Burdige, St. Francis Learning, LLC

The Problem
A Plan
A Model
Make a Table
Find a Formula
A Wall
Was he Right?
What if...
Lab Notes

During the Napoleonic campaign in Egypt in 1798, a famous battle was fought outside Cairo in Embaba, in view of the pyramids, known as the Battle of the Pyramids. It is reported that, after the battle, Napoleon and his staff officers visited the Great Pyramid of Giza. While the more adventurous officers climbed to the top, Napoleon was content to rest in the shade of the pyramid at its base to wait for them to return.



When the officers descended and rejoined him to brag about their physical strength, Napoleon announced that he had made a calculation of the amount of stone in the pyramid. There was enough, he said, to build a stone wall 3 meters high and $\frac{1}{3}$ meter thick that would enclose the whole of France.

Was Napoleon right? Write and explain your conjecture here.

The Problem A Plan A Model The Table A Formula A Wall ...

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.	<i>Write a description for each step in this column.</i>
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 an 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

Share Interesting Problems



Hot Hands



Plastic Money



Pennies to Heaven



What's Watt



Snow White



By a Hair



Could Ants be Human?



Green Skin: Sugar High



*Develop and
Share great
experiments*

Basics: Times in 2 Steps



Basics: Times in 2 Steps Experiment

Good Times



Good Times Experiment

Odd Times



Odd Times Experiment

Lights Out: Pulling Chains



Lights Out Spreadsheet

Napoleon's Pyramid



Napoleon's Pyramid Spreadsheet

Basics: Ins and Outs



Basics: Ins and Outs Spreadsheet

*Win prizes
building a
library of
thousands of
great
experiments
enabling every
student to...*



Learn math as an experimental science



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