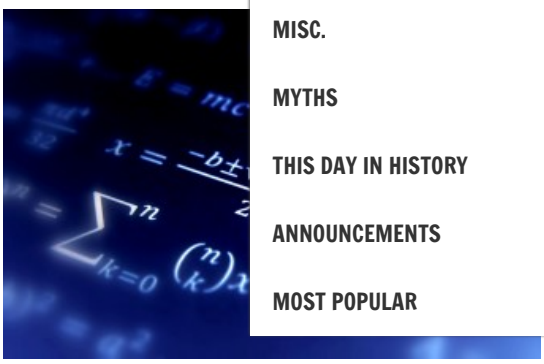
THE ORIGINS OF THE MATHEMATI
OF USING "X" AS THE UNKNOWN

November 11, 2014 | Melissa | 13 comments

Linda P. asks: Why do we always use "x" fo



For hundreds of years, x has been the go-to symbol for the unknown quantity in mathematical equations. So who started this practice?

Algebra was born in the Middle East, during the Golden Age of medieval Islamic civilization (750 to 1258 AD), and its early form can be seen in the work of Muhammad Al-Khwarizmi and his 9th century book, *Kitab al-jabr wal-muqabala* (*al-jabr* later morphing into algebra in English). During this heyday, Muslim rule and culture had expanded onto the Iberian Peninsula, where the Moors encouraged scholarship in the sciences and math.

So what does this have to do with the letter "x" in math? In a recent TED talk, the director of *The Radius Foundation*, Terry Moore, posited that the the use of "x" in this way began with the inability of Spanish scholars to translate certain Arabic sounds, including the letter sheen (or shin). According to Moore, the word for "unknown thing" in Arabic is *al-shalan*, and it appeared many times in early mathematical works. (For example, you might see "three unknown things equals 15," with the "unknown thing" then being 5.)

But since Spanish scholars had no corresponding sound for "sh," they went with the "ck" sound, which in classical Greek is written with the chi symbol, X. Moore theorizes, as many others before him have done, that when this was later translated into Latin, the chi (X) was replaced with the more common Latin x. This is similar to how Xmas, meaning Christmas, came about from the common practice of religious scholars using the Greek letter chi (X) as a shorthand for "Christ."

The principle problem with Moore's explanation is that there is no direct documented evidence to support it. More speculatively, people translating the works would not care about phonetics, but the *meaning* of the words. So whether they had a "sh" or not one would think would be irrelevant. Despite the lack of direct evidence and flaws in the argument, it nonetheless remains a very popular origin theory, even among many academics. (Do a quick Google search and you'll find many a PhD in mathematics parroting this theory.)

The 1909-1916 edition of Webster's Dictionary, among others, also puts forth a similar theory, although stating that the Arabic word for the singular "thing," "shei," was translated into the Greek "xei," and later shortened to x. Dr. Ali Khounsary also notes that the Greek word for unknown, *xenos*, also begins with x, and the convention could simply have been born of an abbreviation. But here, again, we have a lack of any direct documented evidence to support these theories.

As for a documented theory, we turn to the great philosopher and mathematician, René Descartes (1596-1650). It's entirely possible Descartes did not come up with the practice of using "x" for an unknown, perhaps borrowing it from someone else, but at least as far as documented evidence that has survived to today goes, he seems to be the creator of the practice, as noted by the OED and the phenomenal work by Florian Cajori, *A History of Mathematical Notations* (1929). At the least, Descartes' helped popularize the practice.

Specifically, in his landmark work, *La Géométrie* (1637), Descartes solidified the movement to symbolic notation by instituting the convention of using the lowercase letters at the beginning of the

alphabet for known quantities (e.g., a, b and c) and using those at the end of the alphabet for unknown quantities (e.g., z, y and x).

Why? And why x more than y, and z for unknowns? Nobody knows. It has been speculated that the prominence of x being used more than y and z for unknowns in this work had to do with typesetting; one story goes that it was Descartes' printer who suggested x be the principle unknown in *La Géométrie* because it was the letter least used and so the one he had more letter blocks available to use. Whether this is true or not, Descartes used the x to be an unknown at least as early as 1629 in various manuscripts, well before *La Géométrie*. And, indeed, it would seem he had not come to any hard rules on x, y, and z indicating unknowns; in some manuscripts from this time, he actually used x, y, and z to represent known quantities, casting even further doubt on the supposed "unknown thing" translation theories listed above.

So, in the end, by all appearances, Descartes simply arbitrarily chose the letters to represent different things in his works as was convenient and it just so happened in his landmark work, *La Géométrie,* he decided the specific variable nomenclature, perhaps, on a whim.

Whatever the case, as with Descartes' notation for powers (x^3), after the publication of *La Géométrie,* the use of x as a principle unknown (as well as the more general tradition of a, b, c = knowns and x, y, z = unknowns) gradually caught on. And the rest, as they say, is mathematical history.

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Bonus Facts:

- The equal sign ("=") was invented in 1557 by Welsh mathematician Robert Recorde, who was fed up with writing "is

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equal to" in his equations. He chose the two lines because "no two things can be more equal."

- Other early symbols used to represent unknowns in mathematics before Descartes' landmark work include Benedetto of Florence's 1463 *Trattato di praticha d'arismetrica* where he uses the Greek letter rho; Michael Stifel's 1544 *Arithmetic integra* where he uses q (for quantita) as well as A, B, C, D, and F; Francois Vieta's late 16th century nomenclature where vowels are used as unknowns and consonants are used as constants, among others. (Incidentally, if you're curious: What Makes a Vowel a Vowel and a Consonant a Consonant?)
- In modern English, x is the third least used letter, occurring in only about 0.15% of all words. The least used letters are q and z.
- The word "algorithm" comes from none other than al-Khwarizmi's name. If you distort the name slightly when you say it, you'll get the connection.
- The mathematical volume of a pizza is pizza. How does that work you say? Well if z = radius of the pizza and a = the height then $\Pi * \text{radius}^2 * \text{height} = \text{Pi} * z * z * a = \text{Pizza}$.
- As mentioned, *La Géométrie* was a ground-breaking work. In it, Descartes introduced the idea that eventually became known as Cartesian coordinates; this included the ideas of two perpendicular lines called axes, naming the horizontal one x and the vertical axis y, and also designating the point of intersection as the origin. Descartes is also credited with one of the most famous lines in all of Western thought – *Cognito ergo sum* (I think, therefore I am.)
- That said, while Descartes is famous for the notion of "I think, therefore I am," he was not the first to express such an idea. For instance, Aristotle said something similar in *Nicomachean Ethics*, "But if life itself is good and pleasant… and if one who sees is conscious that he sees, one who hears that he hears, one who walks that he walks and similarly for all the other human activities there is a faculty that is conscious of their exercise, so that whenever we perceive, we are conscious that we perceive, and whenever we think, we are conscious that we think, and to be conscious that we are perceiving or thinking is to be conscious that we exist…" Of course, "I think, therefore I am" is a lot more succinct. 😉
- Muhammad Al-Khwarizmi was one of the first directors of the House of Wisdom in Bagdad. Having supervised the translations of important Indian and Greek mathematical and astronomical works, Al-Khwarizmi became an advocate for the adoption of the Indian numeric system (1-9 plus 0) and is the father of algebra. With the publication of *The Compendious Book on Calculation by Completion and Balancing*, Al-Khwarizmi introduced using abstract analysis in problem solving (although with words, rather than symbolic notation). He also introduced the algebraic method of reducing (rewriting the expression to ever simpler, but equivalent,

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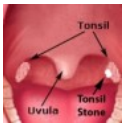

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forms), as well as that of balancing (doing the same things to each side of the equation – again to make it simpler).

- The Programme for International Student Assessment (PISA) assesses the competencies of 15-year-olds in 65 countries and economies, including in math. For 2012, the country/economy with the highest scores in math was Shanghai-China, which was closely followed by Singapore, Hong Kong-China, Chinese Taipei and Korea. Notably, Canada ranked 13th, Australia 19th, Ireland 20th and the United Kingdom 26th. The United States' kids ranked 36th. In fact, according to PISA, the performance of one of our highest-scoring states, Massachusetts, was so low, it was as if those students had two fewer years of mathematical education than the students in Shanghai-China. PISA also noted that although the U.S. spends more per student than most countries, this doesn't translate into performance. In 2012, per-student spending in the U.S. was listed at $115,000, while in the Slovak Republic, a country that performed at the same level, they spend only $53,000 per student.
- It should be noted of the PISA's results, though, that they are drastically over simplified. For instance, as noted in a report by Dr. Martin Carnoy of Stanford and Richard Rothstein of the Economic Policy Institute, American students actually perform better than the much higher ranked Finland in algebra in general, but worse in fractions. Further, when you normalize the results between the countries adjusting for the relative poverty of the students taking the PISA tests, the U.S performs significantly better, ranking 6th in reading and 13th in mathematics, a huge jump in both categories. They further note in their report *What Do International Tests Really Show About U.S. Student Performance?* that when you divide the kids based on family wealth, the actual gap in performance isn't so stark between countries, with a not insignificant portion of the ultimate ranking of each nation being based on how many impoverished vs. middle class vs. wealthy students are taking the tests. For reference, about 40% of the schools the PISA used in the U.S.'s sample had more than 50% of their students eligible for free lunch.
- Despite their results being oversimplified, the PISA identified several weaknesses in American students' math skills and these included developing a mathematical model to solve a real-world problem and reasoning with geometry. PISA noted that were the Common Core Standards successfully implemented in the U.S., it should yield significant performance improvement.
- The Common Core Standards seek to focus mathematics education on developing conceptual understanding of key math ideas, as well as mastering basic math skills. To date, Common Core standards have been adopted by 43 states. An important thing to note, however, is that although the states have adopted these standards, each is free to choose the curriculum it implements. Some have chosen a curriculum that is


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unrecognizable to many parents, who are now frustrated and identify this as a problem with the Common Core, when in fact Common Core is just a list of competencies kids should know by the end of each school year, not how they should learn these concepts. As for implementations, one math curriculum under fire is *Everyday Math*, developed by The University of Chicago. With methods previously not seen by many American parents (lattice multiplication anyone?), the new curriculum has some pulling their hair out. As one mom said, "I hate the Common Core . . . .I can't help my kid with his homework and I don't understand the new methods at all." But, again, this particular complaint in truth has nothing to do with Common Core, but with *Everyday Math*.

- With that said, here's a relevant video (particularly from about the 3 minute 10 second mark on) from Henry Reich at MinutePhysics on *The Order of Operations*. If you've made it this far in this article, I imagine you'll find this video quite interesting from start to finish:

Expand for References

13 COMMENTS

Doug November 11, 2014 7:58 am

Also, Al-gebir is where we get the word “gibberish” from.

Reply

Anton Sherwood November 11, 2014 11:11 am

“the ck sound”? Oh Come On.

In Castilian Spanish up to at least the time of the conquest of México, the Latin letter ‹x› represented the sound we call ‘sh’. Relics of that pronunciation include the English word for wine from Xerez: ‘sherry’.

The distinction between ‹x› and ‹j› was later lost, and they’re *now* both pronounced like, well, Greek chi; that city’s name is now written Jerez.

Reply

Robert Martinez September 8, 2015 6:27 am

Asturian, a language related to modern castellano (Spanish) can be traced back at least until 1085 AD when Alfonso VI issued the fuero d’Avilés. The moors were never successful is permanently conquering Asturias, and were driven out by Pelayo’s forces in the early 700s. Asturian uses the letter pronounced like the English”sh” is many words. “Xana” (kind of water fairy), xabon (soap), echar la xata (to vomit), and many other examples abound. Asturian (asturianu) is still spoken in Asturias in northern Spain, and in small pockets of descendants of Asturian emigrants in other areas, including some towns near Clarksburg, West Virginia.

Reply

P Smith November 20, 2014 7:39 pm

So that’s why “x” is the common variable? I thought it was because most other letters were already used for standard notations and universal constants (e.g. e, c, k in summations, i and j in table indices, f for functions, r and d in geometry, etc.) and somebody chose x because it was little used.

Regarding “Common core”, it’s not the solution to the US’s education problem, it’s a phony idea intended to fool people into believing something is being done.

The US’s education problem is an economic one. Funding for schools is taxed based, and ONLY at the local level. So if you live in a wealthy area (valuable property, wealthy taxpayers) the school district is well funded and offers a good education. But if you live in a poor area (renters, low income housing) schools get little or no funding and the quality of education is poor. Very few areas are rich while many are poor, so few

kids get good educations. Poverty begets poverty, which is exactly what the wealthy in the US want.

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In most other countries, taxes are collected at the regional or national level and distributed equally on a per-student basis. That means ALL school districts can offer the same high level of education, and countries end up with a more educated and wealthy populace. Education needs to be socialized for the benefit of all just as much as like police, roads, and fire departments are.

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And then there's the US's screwed up post-secondary education system which puts many people $100,000 in debt by age 25, including "private universities" which offer useless "degrees" that won't get people jobs. Canada leads the world with 51% – FIFTY ONE – of adults who hold at least a Bachelor's Degree college education, and yet tuition is a third of what it is in the US, even at the most prestigious universities (e.g. U of Toronto, ranked #20 in the world, and only the US has more in the top 50).

Reply

H Amar February 26, 2015 1:48 pm

The exact word used by Muhammad Khawarzmi in his book was "Shei", which means " a thing". It's very likely that it was replaced by the letter "x".

Reply

Neil Hicks September 5, 2015 10:31 am

The PEMDAS rant was fun, but the conventional order of operations has no ambiguity about 8 -2 + 1.
As pointed out in many comments on the U-tube web site for this video, addition and subtraction are on the same level and in the absence of parentheses, these operations are performed from left to right. Similarly for multiplication and division. Drinking too much coffee and talking rapidly is not the same thing as having revolutionary insight. Morally wrong? Humans into robots? While I found the information in "The Origins of Mathematical Conventions…." useful and entertaining, perhaps you should consider removing the link to this silly PEMDAS rant.

Reply

Paul Hartzer September 23, 2015 11:43 am

Yeah, I wish he'd redub the video without that error in it. It's P E (MD) (AS). Everything he says except that part at the beginning is solid. Since there are many students who do indeed think that multiplication comes before division and addition before subtraction (the former confusion causing Internet fights with people from BODMAS

countries), he could even leave the example in but change the voiceover to point out that PEMDAS leads to this confusion.

Reply

Marly September 8, 2015 5:50 am

Intriguing. I'd expected it to be that X was a major number in Roman numerals, marking the 10, and there was no similar-looking character in the Arabic numerals. Looks like I was wrong!

Reply

Fiji24 September 9, 2015 9:13 am

Cogito ergo sum

Cogito ergo sum is a Latin philosophical proposition by René Descartes usually translated into English as "I think, therefore I am". The phrase originally appeared in French as je pense, donc je suis in his Discourse on the Method, so as to reach a wider audience than Latin would have allowed. It appeared in Latin in his later Principles of Philosophy.

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