

How numerals travelled: India, Baghdad and Pisa

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Core question

How did a numerical notation become globally influential through repeated translation, adaptation and teaching rather than through a single act of transmission?

Historical and evolutionary context

The decimal positional numerals now often called "Arabic numerals" originated in South Asia, were studied and transformed in Arabic-speaking mathematical cultures, and reached Latin Europe through several routes. Al-Khwarizmi's lost Arabic work on Indian reckoning became known through later Latin traditions associated with the word *algorismus*. Numeral forms also developed differently in eastern and western Islamic regions.

Latin Europe encountered Hindu-Arabic numerals before Fibonacci. The *Codex Vigilanus* (976) records most of the numeral forms in northern Iberia, and Gerbert of Aurillac used abacus practices associated with the new numerals around the end of the tenth century. Leonardo of Pisa, Fibonacci, later learned commercial mathematics in the Mediterranean world and powerfully promoted the system in his *Liber Abaci* of 1202. Yet European adoption remained gradual: Roman numerals, counting boards and merchant practices persisted for centuries.

What could communities know before this transition?

European and Arabic mathematical communities already possessed effective arithmetic practices; positional written algorithms offered a different combination of efficiency, portability and scalability.

What changed?

A notation originating in India became a **transcultural computational standard**. Its journey required translation of concepts, reshaping of numeral forms, teaching institutions and commercial use.

Why could this capability emerge?

Trade connected India, the Islamic world and Mediterranean Europe. Arabic mathematical texts circulated through al-Andalus, Sicily and translation centres, while merchants had strong incentives for efficient calculation.

What later forms of knowledge did it enable?

Widespread positional arithmetic lowered the cost of written calculation and supported later bookkeeping, algebra, astronomy and mathematical education. Its importance lies as much in social adoption as in technical superiority.

New limits and risks

Transmission narratives can become civilizational relay races in which each culture merely hands an unchanged object to the next. In reality, notation, terminology and methods changed in each setting.

What changed in the architecture of human knowledge?

A powerful computational representation became **portable across languages, institutions and continents**.

Loss, exclusion and uncertainty

The exact routes and timing of numeral transmission are complex. Al-Khwarizmi's original arithmetic text is lost, and Latin witnesses are later and transformed. Fibonacci was an influential advocate, not the single person who introduced the numerals to Europe.

Dependency map

- DIRECT ← PIO-031 Indian zero, positional notation and astronomy
- DIRECT ← PIO-033 Al-Khwarizmi and algebraic procedures

- INDIRECT ← PIO-032 Translation, commentary and original science in the Islamic world
- INDIRECT → PIO-041 Medieval universities and organised disputation
- INDIRECT → PIO-056 Probability, censuses and error: Pascal to Quetelet

References

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2. Sigler, L. E. *Fibonacci's Liber Abaci: A Translation into Modern English of Leonardo Pisano's Book of Calculation*. Springer (2002).
3. Berggren, J. L. *Episodes in the Mathematics of Medieval Islam*, 2nd ed. Springer (2016).