In search of a place in history for mathematics: A lecture series in South Africa

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This Commentary was invited by the *South African Journal of Science* and emanates from a seminar presented by Dr Tomoko Kitagawa entitled 'The History of Mathematics: An Interdisciplinary Work in Humanities' given at the Department of Historical and Heritage Studies of the University of Pretoria on 20 September 2018. Dr Kitagawa received her PhD from Princeton University and went on to teach history at Harvard University. Prior to her appointment at Harvard, she also worked for the Ministry of Foreign Affairs of Japan. She is an author of five books in Japanese, including a national bestseller, and was also selected as one of the 100 most influential people in Japan in 2012 and one of the 100 most amazing women in Japan in 2015.

The history of mathematics entails how mathematical knowledge has developed over time. Not every university offers courses on this topic, and it could be more common to read about the history of math for pleasure. Why do academics need to pay attention to the history of math, and how do we conduct research on such an interdisciplinary subject?

History of mathematics

When mathematics started to become an independent domain of study in the mid-17th century, learned individuals were interested in looking for 'truth' (i.e. universal patterns that do not vary based on time and place) and began exchanging their ideas in writing. Some gathered various data independently to examine whether mathematical rules always hold true, and when someone claimed to have found such a pattern, others worked on proofs to evaluate it. This cycle of creating and proving led to the consolidation of a universal language that explains such universal truths.

The story of mathematics tells the process of finding truths at a basic level, i.e. the history of math is the history of fundamentals. However, the investigative process varies from one case to another and also differs from culture to culture. Let us first examine five approaches in studying the history of mathematics.

Five approaches to the study of the history of mathematics

1. Macroanalysis
2. Compare and contrast (regional analysis)
3. Accumulation of overall knowledge
4. Institutional analysis
5. Biographies and genealogies

The common method of presenting the history of math entails macroanalysis that examines significant discoveries and developments chronologically. University textbooks often take this approach[1-3], usually beginning in ancient times to create a historical narrative from several different parts of the world. However, as the timeline reaches the Age of Enlightenment, the focus is more exclusively on European mathematicians. Because the significance and consequences of 'scientific revolution' were undeniably large, it created a common impression that modern math originated in Europe and spread to other parts of the world.

This macro approach covers the history of math on a global scale, but it risks constructing a Eurocentric view. As George Gheverghese Joseph points out:

> *The standard treatment of the history of non-European mathematics exhibited a deep-rooted historiographical bias in the selection and interpretation of facts, and that mathematical activity outside Europe has as a consequence been ignored, devalued or distorted.*[4(p.3)]

The second approach, the compare-and-contrast method, considers regional variants, starting by studying specific geographical places, then comparing those mathematical traditions to those outside these cultural boundaries. Historical, comparative studies on different places were particularly useful in the 1980s and 1990s, when the notions of 'West' and 'East' increasingly were relevant, mainly because of ongoing geopolitical issues. Consequently, historiography followed this trend of seeing the world as West and East, with scholars often comparing the uniqueness of cultural spheres, again frequently focusing on the European tradition. As a result, studies revealed the 'divides' between the West and East.

The third approach focuses on the accumulation of knowledge, and often describes technical developments in math. Represented well in the history of mathematical constants – e.g. pi (π) or the proof for Fermat's Last Theorem – this approach examines a specific problem, method, formula or proof, and demonstrates the process of solving it.[5-7] However, this approach assumes that knowledge is an ever-expanding, ever-evolving entity. What if the assumption were wrong? What if the basic understanding that we take for granted were wrong? (Knowledge that had been taken for granted has been shaken to its core more than once in history, e.g. the Copernican Revolution.)

The fourth approach focuses on a specific academic institution and examines its internal development and dynamics. Analysing the educational system and its influence on mathematical activities, this approach highlights the importance of institutions among professional mathematicians.[8,9]

Finally, the fifth approach concerns biographies. It is a popular research theme to recount great mathematicians' life stories[10] and explore the various scholars associated with eminent mathematicians.

Global perspectives

As for the global history of math, which approach should one take? Because global history deals with a wider area, we need to combine some elements from the above and illustrate a detailed picture of the international exchange of knowledge that has not been done before. For example, my ongoing research examines: (1) the development of dimensions associated with mathematical problems; (2) an understanding of the universe based on the movement of stars; and (3) syncretic visions of mathematical logic that cultural interactions facilitate. Observing math in the context of the 17th century, I began to see in many places that the imagination triggered the expansion of existing mathematical knowledge worldwide.

Employing a bird's-eye view to survey broader regions, I have traced how ideas move across national borders. Cross-cultural perspectives, which often have helped blend works from both the humanities and sciences, are vital and effective. They also create a clear contrast against the study of material culture. Studies on 'things' and 'knowledge' are, by their nature, different. For example, in studying the global movements of material goods, Paula Findlen eloquently wrote about the concept of 'global':

> *The global can lie within objects, interwoven into the very fabric of a thing, shaped by craft, knowledge and materials that migrate over time from one place to another. The global is also about the misconception of objects, including efforts to simulate, but not entirely replicate, something observed elsewhere. Things – and the ability to make them – travel, but they do not remain the same.*[11(p.244)]

Can we say the same about mathematical knowledge? Let us examine an example that conveys the sense of global knowledge currents, which, essentially, have remained the same.

The example comes from a mathematical textbook published in 1627 in Kyoto, Japan. This book, *Treatise for the Ages* (*Jinkōki*), often has been called a primer[12], presenting mathematical basics, e.g. numerical tables, abacus techniques and arithmetic operations. Although not a good source for studying technical advancements in math, *Treatise for the Ages* cited questions from European and Chinese math textbooks, so this book is a unique historical artefact that shows how exchanges of ideas had been occurring in the 17th century:

Question: There is 1 *to* [a unit of volume, which is equivalent to 18 litres] of oil. Two people are going to have one half each. There are a 3 *shō* [one tenth of 1 *to*] and a 7 *shō* measuring cups available for them to divide 1 *to* into 5 *shō* each. Find a way to share the oil equally using these two measuring cups.

This problem was not in Chinese math textbooks, but Niccolo Fontana Tartaglia (1449–1557) presented it in his book, using red wine instead of oil. Reflecting Kyoto's commercial culture, which included many oil merchants, the original author chose oil as the relevant liquid, but the problem, method and answer worked just the same with wine.

It turned out that mathematical knowledge was brought to Japan via several different routes. Two major routes were used to make the long-distance voyage from Europe to Japan: one was the major trade route, from Europe south to the tip of South Africa, then east to India, South Asia and on to Japan, and the other entailed sailing west from Europe to the southern tip of Latin America and crossing the Pacific Ocean. Thus, this mathematical knowledge did not come straight from Europe to East Asia, but was carried by those who stopped at ports in South Africa, India and Southeast Asia. Without travelling through the southern hemisphere, sailors on either route were unable to transport books to Japan.

How and where can we see Europeans' impact on South Africa? Both cultures likely were unable to communicate well enough to discuss scientific knowledge because of differences in language or logic. For example, the numerical system is a good reference point on differences in mathematical thought. In South Africa, the principal counting system was said to be two or 20[13], as opposed to Europeans' 10-based (i.e. the decimal system) or 60-based (i.e. clocks' hours, minutes and seconds) systems. Thus, differences in their intellectual cultures must have been rather ubiquitous.

What about exchange rates? When foreign sailors arrived at the harbour of South Africa, would they not be gathering supplies to continue their journey to the East? Considering the history of slavery and colonisation, reciprocity cannot be expected, but basic trade activity must have occurred, e.g. negotiating arrangements for bartering or exchanging goods for currency, using units and numbers. Math, especially when used in everyday conversation, reflected the ways in which people coded certain information – a context in which people examined knowledge from foreign cultures in detail. The study of global travel, including maritime and colonial history, enriches the history of mathematics greatly.

When taken together, humanities and science reveal the blind spot in existing scholarship. If we had focused solely on the political, cultural and social aspects of global travel, we would miss the scientific aspects of interactions. If we focused only on mathematical techniques, we would not perceive the interactions of knowledge among different cultures. History and math must be discussed together to demonstrate how we see the dynamics of intellectual currents, pushing and pulling mathematical ideas across cultural and national boundaries.

My interdisciplinary project reflects the effect of globalisation on academic studies. As my research progressed, I encountered another problem concerning the timeline. The historical narrative usually shows a linear progression, most frequently marked by years, but the adaptation of multiple timelines often is necessary for a project on global history. For example, sailing from Amsterdam to Kyoto in the 17th century took at least 2 years. This simple fact makes it apparent that we must deal with multiple timelines when writing a global history.

Furthermore, several communication pathways exist between Europe and East Asia. Because the transmission of ideas took a few different routes, several conversations happened concurrently over time. While a history that progresses with time is simple and clear in its presentation, we sometimes need to break away from perceptions of historical time as being the one and only method for structuring a historical narrative. With a single timeline, we ignore time's complexity. Thus, my research on global history aims to reconsider the meaning of time.

What is next?

Overcoming ethno-mathematics is an urgent task. In the context of South Africa, the nation has a richly diverse population, and scholars of both history and math could offer more insights into this intellectual world. The study of math's global history is like a lightbulb: when turned on, it illuminates surrounding areas that had been hidden in the dark.

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