From Altars to Algorithms:

The Enduring Legacy of Vedic Mathematics for Holistic Education

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Abstract

This essay explores the interconnectedness of mathematics and religion in ancient India, particularly during the Vedic period (1500-600 BC). It argues that mathematical knowledge served not just utilitarian purposes, but also played a vital role in holistic education. The essay examines the Sulbasutras, texts on constructing sacrificial altars, which demonstrate the application of geometry and the underlying belief in cosmic order. It then explores the work of Vedic scholar Pingala, who used permutations and combinations to analyze poetic meter, showcasing the application of mathematics beyond religious contexts. Furthermore, the essay discusses the development of the zero and place-value system in Indian mathematics, including the work of Brahmagupta on handling zero and negative numbers. This paved the way for more advanced mathematical concepts. The Bakhshali Manuscript, a collection of problems on arithmetic and algebra, is also presented as evidence of a shift towards practical applications of mathematics in the evolving system of holistic education. The essay concludes by acknowledging the decline of Indian mathematics during British colonization, attributing it to economic disruptions and the absence of a commercial revolution that fueled scientific advancement in Europe.

Keywords: *mathematics education, religion, holistic education, India*

This essay delves into relationships between mathematics and religion, focusing on thinking and reasoning from ancient India's Vedic period (1500 BC to 600 BC), which showed us that the pursuit of mathematical knowledge transcended simple utility and played a crucial role in the holistic education of the time.

The Sulbasutras, for example, a collection of texts dedicated to constructing sacrificial altars, showcase the application of geometry. These texts demonstrate how precise calculations were crucial for the efficacy of rituals, emphasizing the underlying belief in order and harmony within the universe. This served as a practical application of mathematical concepts through holistic education, where intellectual pursuits were intertwined with religious and spiritual development.

Furthermore, advancements in astronomy, where mathematics played a crucial role in calculating celestial positions and developing calendars, are exemplified by the Vedic scholar Pingala's work on meter in poetry through the use of permutations and combinations. This demonstrates how mathematical concepts were not restricted to religious contexts but also found application in artistic endeavors, further enriching holistic education of individuals.

Additionally, the concept of zero was further explored in Indian mathematics for the development of a place-value system, including symbols for zero, and its impact on mathematical operations. Mathematicians like Brahmagupta established rules for handling zero and negative numbers, paving the way for advanced mathematical concepts.

The Bakhshali Manuscript, also developed during this time period, offers a glimpse into a period where mathematics knowledge transitioned from religious contexts to everyday applications. The manuscript focuses on arithmetic and algebra, tackling problems like profit and loss calculations, interest computations, and square root extraction. It showcases process oriented approaches to solving problems, including stating rules, providing examples, and verifying solutions. This manuscript highlights the shift towards a more practical application of mathematics within the evolving holistic education system.

The essay concludes by acknowledging the eventual marginalization of Indian mathematics as a result of economic disruptions and exploitative policies introduced during British colonization and India not experiencing a commercial revolution, which was the main driver for advancing the scientific field in Europe (Khun, 1962, Mokyr, 2002, and Roy, 2012).

Vedas and Mathematics

The Vedas, the foundational scriptures of Indic Vedic Knowledge System, commonly known as Hinduism, offer a rich source for understanding the development of mathematics in ancient India. Beyond the main hymns themselves, the Vedangas provide even deeper insights. These six branches of knowledge encompass diverse topics like phonetics, grammar, and astronomy. However, the most significant contributions to mathematics are found in the last two Vedangas: Jyotisha (astronomy) and Kalpa (rituals and ceremonials) (Joseph, 2011).

The knowledge within these Vedangas is often presented in concise and poetic forms of writing termed sutras. Sutras condense information through minimal verb usage and lengthy compound nouns, making knowledge easier to memorize and preserve with minimal writing materials. This style of writing became prevalent not only in mathematics and philosophy but also in statecraft texts.

Within the Vedanga-Kalpa, the sutras provide instructions for constructing sacrificial fires throughout the year including measurement and construction of sacrificial altars. The term “sulba”, originally referring to the rope used in the layout of the sacrificial altar, later came to describe the geometric principles involved. The sutras around the term sulba are the primary source of knowledge about Vedic geometry, and they also showcase the use of very large numbers, far exceeding ancient Greek numeracy (Joseph, 2009).

Hindu epics like the Ramayana also showcase a comfort with astronomical figures. The epic describes scenes where the armies of the opposing forces of Rama and Ravana use numbers reaching into the trillions and quadrillions, demonstrating a level of mathematical sophistication that went beyond utility in everyday life.

The Sulbasutras: A Blend of Religion and Utility

Religion influenced not only social and political structures in ancient India, but also the development of scientific knowledge. For instance, astronomy was used to determine auspicious times for rituals. The 36 verses from the Vedanga-Jyotisha provided methods for calculating the positions of the sun and moon relative to zodiac signs, which was crucial for accurate timing of ceremonies (Joseph, 2009). Similarly, the study of phonetics and grammar ensured perfect pronunciation of prayers and chants, believed to be essential for their effectiveness.

While much early astronomical work in India has been lost, evidence suggests significant advancements were made during the first millennium AD. The core goal of mathematical astronomy during this time was to accurately predict the positions of celestial bodies for creating calendars, astrology, or navigation. By the early centuries AD, a unique blend emerged between traditional Indian astronomical and calendar concepts with Hellenistic influences, including plane trigonometry and geocentric models involving spheres and planetary eccentrics and epicycles (Joseph, 2009, 2011). This period of intellectual exchange most likely ended before the rise of Ptolemaic astronomy in the 3rd century AD.

The Sulbasutras also paint a more nuanced picture. These texts, composed by Baudhayana, Apastamba, and Katyayana around 800-500 BC, were likely manuals for priest-craftsmen who constructed altars (*vedi*) and maintained sacred fires (*agni*) for rituals. The instructions incorporated geometric concepts like the Pythagorean theorem, a method for approximating the square root of 2, and area-preserving transformations for circles and rectilinear shapes. This eventually led to Sulba geometry, which arose from the need for precise altar construction which was as vital to ritual efficacy as flawless chant pronunciation.

Development of Mathematical Sanskrit

The close relationship between literacy and numeracy in India might be rooted in the development of Sanskrit. During its formative period, knowledge, both religious and scientific, was primarily transmitted orally. As Sanskrit transitioned to a written language, three distinct scientific variants emerged: grammatical, logical, and mathematical Sanskrit. According to Staal (1995), these variations most likely had significant implications for comparing the historical trajectories of Indian and European mathematics because Indian mathematical Sanskrit did not transform into an artificial language and was rooted in the context where it was used. In European mathematical thought, like we see with algorithms, external symbols and abbreviations were developed that are associated with the universality of mathematics.

The Intriguing Zero in Indian Mathematics

Sanskrit texts on mathematics and astronomy from the time of Brahmagupta (around 6th century AD) also often contain a section called shunya-ganita, meaning computations involving zero. Understanding the concept of shunya, or zero, in Indian mathematics involves three key aspects: its place within the place-value system, the symbols used to represent it, and the mathematical operations involving it.

The concept of zero has intrigued Indian mathematicians for centuries. Brahmagupta, in his 7th-century text Brahmasphutasiddhanta, treated zero as distinct from positive and negative numbers, considering it the boundary between them. He established rules for basic operations with zero, including multiplication resulting in zero and division by a non-zero number yielding zero (Joseph, 2009). Although Brahmagupta struggled with division by zero, his work on shunya ganita represents a significant contribution to the development of mathematical understanding.

Early Indian Contributions to Permutations and Combinations

A 2nd-century BC text called the Chandahsutra explored methods for calculating the number of ways to combine different poetic meters. During this period, music relied heavily on variations in short (*laghu*) and long (*guru*) sounds. Pingala, the author of the Chandahsutra, examined a three-syllable meter where these sounds could be combined in four ways: three gurus, two gurus and one laghu, one guru and two laghus, or three laghus (Joseph, 2009, 2011). Unfortunately, the original sutras on this topic have not been fully understood and more research is needed to further comprehend them.

The Bakhshali Manuscript: The Shift from Rituals to Utility

The Bakhshali Manuscript, likely a handbook filled with rules, examples, and solutions, focuses primarily on arithmetic and algebra, with some geometry and mensuration problems. It most likely bridged the gap between the Vedic Sulbasutras and the mathematics of the Classical period (around 500 AD). Notably, the Bakhshali Manuscript is the earliest known example of Indian mathematics free from religious or philosophical influences (Hayashi, 2002).

The Bakhshali Manuscript also offers insights into early mathematical notation. The symbol "+" appears to have been used for negative numbers, though later replaced by a dot above the number. For fractions, the concept is similar to our modern system with a numerator above and a denominator below, but lacking the dividing line. Compound fractions are represented by stacking three numbers vertically. Multiplication is signified by placing numbers side-by-side, and the dot can represent zero, an empty space, or even a variable like x (Joseph, 2011).

The Bakhshali Manuscript builds also upon the work of the Sulbasutras and provides a more accurate formula for approximating the square root of non-square numbers. This sutra instructs us to subtract the nearest perfect square from the given number, then divide the remainder by twice the nearest perfect square. Half the square of this result is then divided by the sum of the approximate root and the original fraction. Finally, subtracting this value yields the corrected square root (Joseph, 2011).

Unfortunately, only portions of the manuscript have been properly understood. The surviving sections reveal a range of topics including fractions, square roots, financial calculations (profit/loss, interest), and the "rule of three" (proportions). Algebraic problems delve into linear and simultaneous equations, quadratics, and both arithmetic and geometric progressions.

Conclusion

Practical mathematics in ancient India remained static for a millennium before being eclipsed by the rise of European mathematics (Joseph, 2011). Problems involving everyday concerns like profit and loss, material purity calculations, wages, and travel logistics became the focus after the Bakhshali Manuscript. However, it is important to recognize that ancient Indian mathematics was not solely concerned with utility and that it also thrived within a system of holistic education, where mathematical concepts were intertwined with other disciplines and spiritual pursuits. This approach aimed to cultivate individuals with a deep understanding of the world around them.

The decline of this system, as mentioned earlier, can be attributed to multiple colonializations on the subcontinent of India and the commercial revolution's social shifts (Mokyr, 2002 and Roy, 2012). Even traditional occupations like astrology and architecture, which still utilize remnants of this Indigenous numeracy, have survived but are only used in a few communities. The broader impact of these once-thriving methods has diminished. This highlights the importance of examining minoritized narratives in mathematics, as it can offer unique perspectives on the development of the field, enrich our understanding of the past, and potentially inform more holistic approaches to education in the future.

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Author Bio

Dr. Deepa Srikantaiah is an educator, artist, and researcher. Her works explore culturally sustaining pedagogies, postcolonial studies, and comparative histories and international education to better understand how education can address contemporary issues of minoritization and racism in mathematics and science education..

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