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A Comparative Analysis of Japanese Mathematics in the Edo Period in Terms of Cultural Dimensions with Other Global Mathematical Traditions

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Abstract. The development of modern mathematics has been largely shaped by Western traditions, while distinct mathematical systems emerged in the East. During Japan's Edo period, the isolationist policy Sakoku restricted external influences, fostering the unique traditional mathematics Wasan. This study explores how Wasan diverged from other global mathematical traditions in cultural dimensions, focusing on differences in conceptualizations, research agendas, and problem-solving methodologies. The analysis contrasts Wasan with traditions like Ancient Greek mathematics, drawing on historical texts (e.g., Funki Jinko-Ki), scholarly works, and examples of mathematical practices (e.g., pi calculation, algebraic methods). Wasan prioritized elegant, practical solutions over logical proofs, influenced by Edo's artistic culture. Its focus on real-world applications and unique algebraic systems (e.g., Seki Takakazu's methods) distinguished it from theory-centric traditions. With the end of Sakoku, Wasan declined, but it remains a notable example of mathematics evolving in isolation.

Keywords: Wasan, Sakoku, Ancient Greek mathematics, Edo period, mathematical traditions

1. Introduction

The development of modern mathematics has been significantly molded by the intellectual contributions of Western civilizations, such as Ancient Greece and European civilizations during the Renaissance. Nevertheless, beyond the Western sphere of influence, a distinct traditional mathematical framework emerged and evolved in the East. Wasan, the traditional Japanese mathematical system, thrived between the 17th and 19th centuries during the Edo period [1]. A pivotal event profoundly influencing Japan's mathematical development during this era was the national isolation policy, known as Sakoku. Under Sakoku, Japan's interaction with the outside world was severely restricted, with international trade, foreign travel, and even the dissemination of external knowledge largely prohibited. As a result, this isolation shielded Japan from the contemporary mathematical advancements occurring in the West. Remarkably, however, mathematical progress did not stagnate. Instead, Japan nurtured Wasan, a unique mathematical system which prioritized practicality and elegant expression over logical proof, developed distinctive algebraic methods, and adopted special problem-solving approaches [1]. This essay

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focuses on contrasting Wasan with other global mathematical traditions to unravel its uniqueness. Such exploration offers insights into how culture shapes mathematical development, providing valuable insights for mathematical history and cross-cultural studies.

2. Comparison

2.1. Divergent conceptualizations

2.1.1. Logically-focused traditions

In modern mathematics and many historical mathematical cultures, the logical justification of ideas (commonly referred to as "proving") was central to identifying new patterns and formulating theorems. Greek mathematics, in particular, exerted a profound influence on modern mathematical practices. Ancient Greek mathematicians dedicated themselves to uncovering the underlying logical principles governing problems and patterns they observed. Many proofs developed during this period, such as the Pythagorean Theorem and Euclidean geometry, remain foundational today [2].

Ancient Greek mathematics tended to emphasise detailed explanations of each step (including text and illustrations), the presentation of geometric measurement, and the logical reasoning that summarised the entire process. Additionally, they emphasised the theoretical and abstract dimensions of the discipline. Euclid's Elements systematically expounded and explored definitions, inferences, and theories related to geometry and number theory (Figure 1) [2].

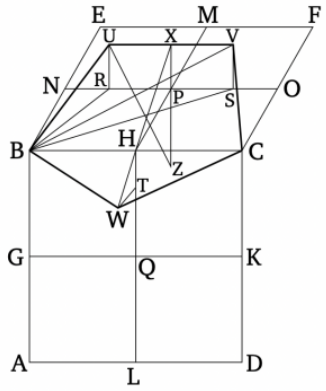


Figure 1. Proposition 17 from book 13 of Euclid's Elements [2]

2.1.2. Wasan

By contrast, Wasan mathematicians prioritized the attainment of elegant solutions with less emphasis placed on explicating the theoretical rationale behind problems [3]. This phenomenon can be attributed to the sociocultural context of the Edo period. Widely regarded as the most influential and prosperous era in Japanese art history, the Edo period witnessed artistic development outpacing mathematical progress [4]. The cultural prioritisation of artistic innovation over academic rigour shaped the intellectual landscape, giving rise to numerous globally renowned artworks, such as the celebrated ukiyo-e print "Under the Wave off Kanagawa (Kanagawa oki nami ura)"(Figure 2) [5].

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Figure 2. Under the Wave off Kanagawa (Kanagawa oki nami ura) by Katsushika Hokusai (1760–1849) [5]

This artistic atmosphere shaped the overall research methods of Wasan mathematicians, whose primary focus was on the final results, making Wasan practitioners more akin to artists than to mathematicians [3]. This unique understanding of mathematical content is reflected in some mathematical works of the same period. For example, Funki Jinko-Ki describes a mathematical method for measuring an elephant, involving weighing the rocks that cause a boat to sink to the same depth as when the elephant is on board (Figure 3) [6]. Notably, the text's most striking feature is its elaborate illustrations, which occupy a significant portion of the text. However, these visual depictions fail to convey the solution to the problem, as the steps of the measurement process cannot be discerned from a single illustration of an elephant on a ship. This highlights the dominant mindset surrounding wakan during the wakan period, which placed greater emphasis on the final result and the published work itself. This markedly different approach contrasts sharply with mainstream mathematical traditions such as those of ancient Greece, which primarily focused on revealing the logical principles underlying patterns and phenomena [7,8].



Figure 3. Funki Jinko-Ki [6]

https://www.cut-the-knot.org/pythagoras/SangakuArt.shtml

2.2. Distinct problem-solving approaches

2.2.1. Pi calculation

The famous Greek mathematician ArchWhile Wasan mathemimedes calculated the value of pi using regular polygons and their corresponding circumscribed polygons (Figure 4). Regular polygons (inscribed in a circle) are those with vertices lying on a circle, where each vertex touches the circle’s

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circumference. Circumscribed polygons, by contrast, are structured the opposite way. Archimedes steadily increased the number of sides in both types of polygons.

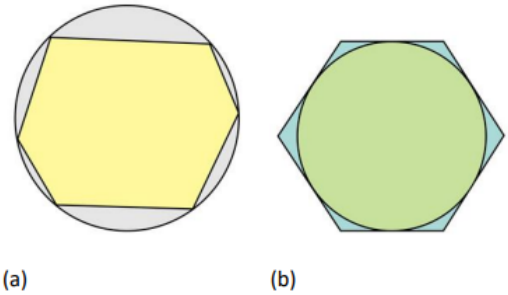


Figure 4. Methods for calculating inscribed regular polygon; (b) circumscribed polygon

https://mathmonks.com/polygon/inscribed-and-circumscribed-polygons

Wasan mathematicians, too, devoted themselves to calculating pi over time, though their method stood apart from Archimedes'. Rather than employing both types of polygons, they relied solely on regular polygons. Shigekiyo Muramatsu, a Wasan scholar, computed the circumference of a regular polygon with 2^{15} sides, arriving at a value for pi of 3.14 [3]. Later, another Wasan mathematician, Murase, expanded the number of sides to 2^{17}, narrowing pi down to approximately 3.1415. From a scientific standpoint, the regular polygon yields a lower bound for pi, while the circumscribed polygon provides an upper bound. Archimedes' approach, which incorporates both, yields a more precise result by accounting for both limits. While Wasan mathematicians' calculations were less precise than Archimedes, they still produced sufficiently close approximations with no practical shortcomings. Owing to the historical context of Sakoku, mathematics was viewed primarily as a tool for meeting real-world needs. Even today, in everyday calculations, pi is typically approximated as 3.14—evidence that Wasan's estimates fulfilled the core requirements for measuring real-world objects, making the level of precision achieved by Archimedes unnecessary for their purposes. Thus, using only regular polygons to approximate pi represented a more streamlined choice in their calculations [9].

2.2.2. Algebraic systems

Additionally, Seki Takakazu, an irreplaceable figure in Japanese mathematics, developed a uniquely Japanese method of algebra, distinct from the approaches of other cultures. Prior to Sakoku, Japanese mathematics had been influenced by Chinese traditions, and Wasan's formation was rooted in this Chinese mathematical foundation [3]. Chinese, unlike many Western and Japanese languages, uses characters where each symbol carries a unique meaning. In Western algebra, letters (such as the modern "x") serve as symbols for unknown variables. However, the nature of Chinese characters made it ambiguous to use them to represent unknowns. Following Sakoku, Seki devised a system using Chinese characters to denote unknowns [1]. For instance, he coined the term "ko beki" (using existing Chinese characters) to represent the square of an unknown (x^2) and "ko san" for its cube (x^3). Driven by the practical need to solve common problems through algebra, Seki made the bold decision to set aside the original meanings of Chinese characters—a choice that was both pragmatic and distinctive to set aside the original meanings of Chinese characters was both pragmatic and distinctive—a sharp contrast to Chinese mathematical traditions [10].

Further differences emerged between Wasan algebra and Western algebra. In Western systems, higher powers of unknowns are denoted using exponents, as in "x^2" for the square of an unknown.

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Seki, by contrast, employed distinct terms to represent higher orders, such as “ko beki” for the square. This approach stemmed from his exploitation of a unique feature of Chinese characters: some characters could simultaneously convey the idea of an unknown variable and its power (e.g., “square”). These examples clearly illustrate how Wasan mathematicians approached shared problems in their own way, guided by the goal of turning mathematical inquiry into a practical tool [11].

2.3. Summary

When compared to other mathematical traditions, Wasan mathematics of the Edo period exhibited distinct characteristics in its style, practices, and subject matter. Its core concepts, research priorities, and approaches to approaches to shared problems carved out a unique niche. The primary driver behind this distinctive mathematical tradition was the Sakoku policy of the Edo era, which cut Japan off from external knowledge. As a result, Wasan mathematicians turned their focus to the artistic and practical dimensions of mathematics, shaped by both the cultural emphasis on art and the demands of daily life. This shift reduced attention to the logical and theoretical foundations that formed the backbone of mainstream mathematics. Evidence of this can be seen in various Wasan works, which prioritized elegant results and solutions with direct real-world relevance.

With the end of Sakoku, foreign mathematical traditions—richer in theoretical depth—began to spread in Japan, bringing Wasan to a close. Today, Wasan is rarely taught or discussed in educational institutions, even in Japan. Nonetheless, it remains fascinating to explore how mathematics might have evolved in isolation, and it is regrettable that we cannot witness the further development of this unique mathematical tradition.

3. Conclusion

This essay has explored the uniqueness of Wasan, Japan’s traditional mathematical system during the Edo period, by contrasting it with Western and other Eastern mathematical traditions. Key distinctions emerged: Wasan prioritized practicality and elegant expression over logical proof, as seen in its focus on final results in works like Funki Jinko-Ki; adopted streamlined methods (e.g., using only regular polygons for pi calculations); and developed a distinctive algebraic system using repurposed Chinese characters, exemplified by Seki Takakazu’s innovations. These features were deeply shaped by the Sakoku policy, which isolated Japan and fostered a culture emphasizing art and real-world utility over theoretical rigor.

However, the analysis has limitations. It focuses primarily on comparisons with Greek and Chinese traditions, leaving less exploration of interactions with other Asian mathematical systems. Additionally, deeper examination of specific Wasan texts’ reception and practical applications in Edo society could enrich the analysis. Future work could expand by integrating more cross-cultural comparisons (e.g., with Indian or Islamic mathematics) and investigating how Wasan’s practical techniques influenced daily life in Edo Japan. Such efforts would further illuminate the interplay between culture, isolation, and mathematical development.

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