Japanese Mathematics Before the 18th Century

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"The general expression of wonder that comes from the study of number, of forms . . . is indicated in the language and traditions of Japan as in the language and traditions of all other peoples" (Smith & Mikami, 2004, p. 3). Japan, a country largely isolated from the Western world until recent history, has nonetheless experienced a rich mathematical history. For the Japanese, curiosity about the world of numbers, shapes, and patterns has led to mathematical discoveries, as well as various applications and tools, over the course of Japanese history.

In nearly every culture, no matter how complex or simple, mathematical discoveries have been an integral part of society. Japan is no different. Much of Japan's mathematics were based on the Chinese system of mathematics, and very little is known about the mathematics that existed in Japan prior to its contact with Chinese mathematics. What is known is that Japan had some sort of base-10 system for writing numbers before the 7th century; however, any specific information about this system of writing numbers has been lost to time (Hidetoshi & Rothman, 2008). Figure 1 is an example of a possible representation of the ancient numerical system (Hidetoshi & Rothman, 2008, p. 4).

Ancient	*Modern*	*Ancient*	*Modern*
1 hito	ichi	100 momo	hyaku
2 futa	ni	1000 chi	sen
3 mi	san	10000 yorozu	man
4 yo	shi	100000 so yorozu	jiu man
5 itsu	go	1000000 momo yorozu	hyaku man
6 mu	roku	10000000 chi yorozu	sen man
7 nana	shichi	100000000 yorozu yorozu	oku
8 ya	hachi	1000000000 so yorozu yorozu	jiu oku
9 koko	ku		
10 tō	jiu		

Figure 1

The Nine Chapters was imported into Japan at the beginning of the 8th century and was used for taxation and other administrative purposes, becoming the foundation of Japanese mathematics for centuries to come (Hidetoshi & Rothman,

2008). Originally, mathematical books imported from China were only read for their practical uses. However, the Samurai class, looking down on such "common" math, began to explore more abstract, and less practical, uses for mathematics (Masayoshi & David, 1978). As a result, private academies for talented individuals were opened. One of these gifted individuals was Yoshida Mitsuyoshi, who, in 1627, wrote the first complete mathematics book in Japan, *Large and Small Numbers*, basing it off of the Chinese mathematician Cheng Da-Wei's *Systematic Treatise on Arithmetic* (Knobloch et al., 2013). It included the extraction of square and cube roots and the calculation of pi by using an n-sided polygon inscribed in a circle. Similarly, one of the most renowned mathematicians in Japan, Seki Takakazu, is credited for multiple mathematical advancements. For example, Seki developed a theory of determinants before Leibnitz (Hidetoshi & Rothman, 2008). Seki also independently improved upon the Chinese remainder theorem by addressing the problems that arose in the case of moduli not being coprime (Knobloch et al., 2013). In order to approximate π, Seki inscribed polygons in a circle, beginning with a square and then doubling the number of sides up to 131,072. He then performed calculations such that a = perimeter of a regular polygon of 32,768 sides, b = perimeter of a regular polygon of 65,636 sides, c = perimeter of a regular polygon of 131,072 sides. Finally, he calculated $b + \frac{(b-a)(c-b)}{(b-a)-(c-b)}$ which is 3.14159265359 (Knobloch et al., 2013, p.191). All of these discoveries, though commonly known today, had a great effect on the advancement of mathematics in historical Japanese culture.

Both abstract and practical mathematics have been used by the Japanese in unique ways. One of the most striking applications of mathematics from ancient Japan is temple geometry, found in both Shinto and Buddhist temples throughout Japan. Originally, paintings on wood

depicting gifts would be placed at Shinto and Buddhist shrines. In the 1600's, people began leaving paintings depicting the solutions of geometrical problems (Hidetoshi & Rothman, 2008). This temple geometry, called "sangaku," primarily dated back to the 17th century (Hidetoshi & Rothman, 2008). These sangaku were displayed on the temple walls as a challenge for other viewers and as a sacrifice to the gods. While most of the 900 tablets that exist today were created by the scholars and social elites of the Samurai class, others were created by women, children, and students (Hidetoshi & Rothman, 2008). These tablets mostly depicted geometrical theorems, some of which would not be discovered by Western mathematicians for over a century (Normile, 2005). Figure 2 depicts the mamakodate problem, which was solved on a sangaku. The problem involves 15 non-step children and 15 step children standing in a circle, where every 10th child is eliminated until only the non-step children remain (Smith & Mikami, 2004, p.82). Aside from temple geometry, mathematics were used by farmers for calculations involving crops. These farmers were taught by a dying Samurai class, who had to take on additional jobs as the wages for protecting local dignitaries plummeted (Hidetoshi & Rothman, 2008). As expected, mathematics was routinely used for taxes and other administrative duties necessary to society. All of these applications of mathematics were invaluable to Japanese society; however, many of these calculations required proper mathematical tools.

Figure 2

In order to advance mathematical discoveries and applications, the Japanese adopted different tools throughout the ages. Like the Chinese, the Japanese used sets of bamboo sticks, which they called “sangri,” to do mathematical calculations. These sangri were based off of the Chinese counting rods, and were imported to Japan between 593-628 (Smith & Mikami, 2004).

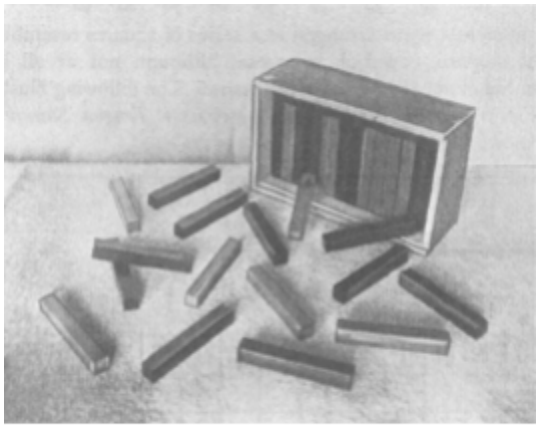

Figure 3

Figure 3 is an example of what a set of sangri look like (Smith & Mikami, 2004, p.23). Somewhere between the 14th and 16th century, the “soroban,” the Japanese abacus, was also imported from China (Smith & Mikami, 2004). However, the soroban did not immediately replace the sangri as the primary mathematical tool. This was largely due to the fact that the Japanese performed many high-degree calculations that were better suited for sangri than the soroban (Hidetoshi & Rothman, 2008). For example, the Goin shrine problem involves a 1,024th degree equation, which was better suited with sangri than soroban (Hidetoshi & Rothman, 2008). Both the sangri and the soroban were used widely in historical Japan, though, today, they have been replaced with calculators.

In conclusion, the Japanese expressed their curiosity about the mathematical world by making mathematical discoveries, applying their discoveries to relevant needs in their society, and developing tools to support their endeavors. All of these discoveries, applications, and tools together form the mathematical history of Japan.

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