Leonardo Pisano, later called Fibonacci, has been referred to as the “first great mathematician of the western world” (Gullberg, 91). His life and mathematical works significantly changed the field of mathematics to make it what it is today. Fibonacci is most commonly known for the sequence that is named after him, but had many other more substantial advances that people rarely know to attribute to him. Fibonacci has a great legacy, but many of his works have been forgotten or left behind over time. The work of Leonardo Pisano must be recognized beyond the Fibonacci sequence, as it is not one, but all of his mathematical discoveries that earned him the nickname of the greatest western mathematician of the Middle Ages.

Early Life & Education

Very few historical records exist about Leonardo, so there is little actually known about Pisanos life aside from his mathematical works. The lack of biographically details leads us only to speculate where and when Fibonacci was born, when he died, if he married or had children, what he looked like, and what else he did throughout his life besides math. From the typical custom of naming at the time, it is clear that Fibonacci was from Pisa, as “Pisano” or “de Pisa” means “of Pisa.” The exact location of his birth is unknown, but most likely occurred sometime around 1170 (Devlin, 27).

It is also suspected that Leonardo’s schooling was fairly basic, as during the 12th century, education was controlled by monasteries and cathedrals. He was mostly taught to read, write, write Roman numerals, and possibly some practical geometry. Any writing was most likely completed by scratching a wax tablet with a bone stylus, and an abacus was probably used for math calculations (Devlin, 37). Fibonacci’s mathematical education continued in North Africa, where his father brought him while on business (Katz, 336). The father and son traveled to the port of Bugia, which is part of modern-day Algeria. Here, various teachers taught Leonardo about the Hindu-Arabic number system, as well as other math that was developed by Indian and Arabic mathematicians. Leonardo was about fifteen years old when he came in contact with Arabic traders and scholars that taught him about their system of writing numbers and performing calculations, which were developed much earlier in India (Devlin, 16). He learned different ancient mathematics like Greek, Babylonian, Indian, and Arab mathematics. Leonardo returned to Pisa around the age of thirty, and brought this math with him (Debnath, 338).

Liber abbaci

In 1202, Leonardo presented the mathematics that he learned throughout his travels in his book, Liber abbaci, which translates to “Book of Calculation”. Fibonacci’s Liber abbaci led to the teaching of arithmetic throughout Italy and eventually Europe. Liber abbaci introduced the Hindu-Arabic numerals, the concept of zero, and basic algorithms like addition, subtraction, multiplication, and division. Fibonacci wrote the text in an understandable manner, had practical concepts to help merchants, like the calculation of profits, currency conversions, measurements, and other topics (Katz, 342-344). He also included both examples from everyday life, as well as whimsical problems, such as “Fibonacci’s Problem of the Birds” (Devlin, 68).

“Fibonacci’s Problem of the Birds”

“Fibonacci’s Problem of the Birds” stated that a man bought “30 birds which are partridges, pigeons, and sparrows, for 30 denari. A partridge he buys for 3 denari, a pigeon for 2 denari, and 2 sparrows for 1 denaro, namely 1 sparrow for ½ denaro.” The question is to find out how many birds the man buys of each kind. The problem, however, is that typically three unknowns require three different equations. In this problem we get the following two equations:

\[x + y + z = 30\]
\[3x + 2y + ½z = 30\]

Fibonacci understood that the value of all three unknowns must be positive whole numbers, as the man would never buy a fraction of a bird, and it is given that he buys three different kinds of birds (Devlin, 68). He then noted that for 5 coins, he could buy 5 birds: 4 sparrows and 1 partridge. He also noted that he could buy 3 birds for 3 coins with 2 sparrows and 1 pigeon. This provided him with the equations:

\[4z + x = 5\]
\[2y + z = 3\]

Then by multiplying the first equation by 3 and the second by 5, Leonardo produced the following equations:

\[12z + 3x = 25\]
\[10y + 5z = 15\]

These two equations were then added to find the solution \(x = 3, y = 5, \) and \(z = 22\) or 23 partridges, 5 pigeons, and 22 sparrows (Katz, 344).

The Fibonacci Sequence and the Golden Number

The later sections of Liber abbaci introduce the Fibonacci Sequence, or the rabbit-breeding problem. Fibonacci developed his sequence after considering a pair of newborn rabbits breed, which creates the sequence,

\[1, 1, 2, 3, 5, 8, 13, 21, 34, 55, \ldots\]

which creates the recursion formula,

\[F_n = F_{n-1} + F_{n-2}\]

stating that each number is found by adding the two preceding numbers. There is no evidence that Fibonacci did any other exploration with this sequence after defining the recursive formula (Gullberg, 286).

Fibonacci numbers are closely connected to the golden ratio, \(\phi\), or phi. The number, \(\phi\), is approximately 1.61803… but is an irrational number. The connection to the Fibonacci numbers is observed by dividing each Fibonacci number by the one that comes before it. These values grow closer to the golden number as the Fibonacci numbers increase (Devlin, 146-147).

\[
\phi = \frac{1 + \sqrt{5}}{2}
\]

The golden number also exists in nature, like in spiral shaped seashells and again in the heads of sunflowers (Pearson, np).

Other Works

Leonardo continued to write mathematical works, starting with Practica Geometriae in 1220. He cited Euclid’s definitions, axioms, and theorems in his text and presented methods for geometric calculations. Leonardo discussed methods for measuring rectangles, which included solving quadratic equations. He also completed work on the value of pi, which is written as \(\pi\). In his section on circles, Leonardo used the standard value of 227 for pi, but also showed how he calculated this value using a 96-gon (Katz, 333).

Another significant work of Leonardo was the Liber Quadratorum, or the Book of Squares, which was written in 1225. In this text, Leonardo introduced the idea of congruous numbers, which are numbers \(n\) of form \(ab(a+b)(a-b)\) when \(a+b\) is even and \(4a^2-b^2\) when \(a+b\) is odd. Leonardo found that solutions to \(x^2+n=y^2\) and \(x^2-nz^2\) can only be found when \(n\) is congruous. This book showed Leonardo’s clear mastery of the mathematics he had learned throughout his travels and explorations of Arabic mathematics (Katz, 347).

Legacy

Fibonacci is remembered physically in Pisa with a marble statue and a stone inscription with this sequence after defining the recursive formula (Gullberg, 286).

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References:


