History of Zero
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Most mathematic students and people around the world don't often think about the history of zero and its origin. Its usage is very common and found everywhere and without it most of our discoveries and advancements wouldn't exist. It is a fundamental part of everyday life and it serves as a significant role in society's function. The number zero is used internationally and it is addressed and expressed in many different languages and symbols. Zero, sifr, zilch, and zippo are few of the ways in which countless people around the world respond to a question/statement. Even though zero means nothing, its concept took hundreds of years to develop and expand. It also took centuries for numerous mathematicians around the world to comprehend it and to develop theories and explanations regarding it . Without the interest of mathematical geniuses around the globe, many of our daily life necessities such as computers, financial accounting, calculus, etc wouldn't exist. It was only relatively recent that the Arabic number system (originally from India) is used. For thousands of decades people used to count using symbols and figures and it took centuries for the idea of zero used as a placeholder to emerge.

In order to understand the history of zero, one needs to understand what zero truly is. The concept of zero is something that is odd and it goes against people's common sense and belief. It can be something that is valid and nonexistent all at the same time. It serves as both a number and numerical digit. As it was stated by Rajput, "It fulfills a central role in mathematics as the additive identity of the integers, real numbers and many other algebraic structures". Zero was a foundation for various science divisions that would not have existed without it. Binary system and computers would not have been invented if it weren't for the number zero. Regardless of its size and significance, the number zero cannot be overlooked and should always be acknowledged. (Rajput)

Zero can be regarded as a digit that can be used as both a number and “an empty place indicator in our place-value number system. Hence in a number like 2106 the zero is used so that the positions of the 2 and 1 are correct. Clearly 216 means something quite different” (O’Connor and Robertson). Zero written in the form 0, is used as a number which mostly signifies a notion, symbol and label. Regardless, the two ideas describes above are tremendously powerful but in a way a little different.

Here are some of the properties of zero described by Rajput:

“The sum of zero and a negative number is negative. The sum of zero and a positive number is positive. The sum of zero and zero is zero. The sum of a positive and a negative is their difference; or, if their absolute values are equal, zero. A positive or negative number when divided by zero is a fraction with the zero as denominator. Zero divided by a negative or positive number is either zero or is expressed as a fraction with zero as numerator and the finite quantity as denominator. Zero divided by zero is zero.”

Without the application and understanding of these basic properties it would be nearly impossible to expand mathematically and technologically. Even though people might not realize the importance of these rules, they still serve as a huge role in their lives.

In order to keep track of cattle, horses, and donkeys it was the Sumerians that created the counting system. The Sumerian’s positional technique was passed down to the Akkadians around 2500 BC and then to the Babylonians in 2000 BC. The Babylonians were the ones to discover that a digit is not present in a column−for instance, 0 in 2023 indicating that there exist no hundreds place in that number. We currently have access to some of the texts of the Babylonians. “The Babylonians wrote on tablets of unbaked clay, using cuneiform writing. The symbols were pressed into soft clay tablets with the slanted edge of a stylus and so had a wedge-shaped appearance” (O’Connor and Robertson). Since their notations of numbers was based on 60 and

not 10, it is quite different from what we are used to (O'Connor and Robertson). Even though this was a huge breakthrough in mathematics, the number zero as we know it appeared many centuries later. (Wallin)

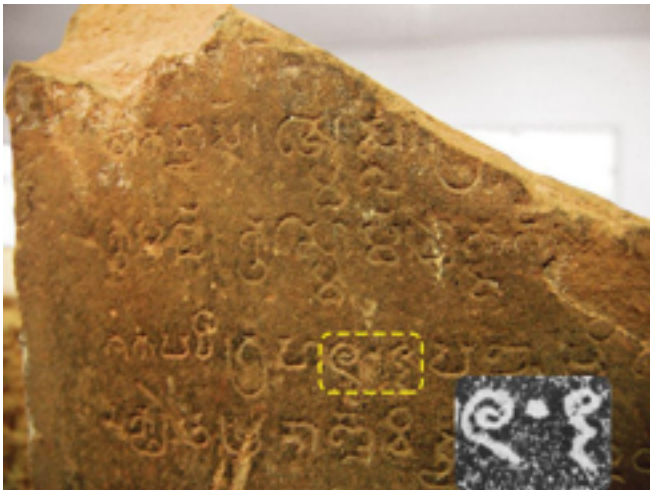
The Babylonian sexagesimal system and the empty place holder zero was used by Ptolemy in the "Almagest" in 130 AD. Ptolemy used 0 both between digits and at the end of numbers. Since his usage of the symbol zero is so prominent one would think that it would carry on for generations to come but unfortunately that was not the case at all. This phenomena of establishing and using zero will occur multiple times because it finally sticks through. (O'Connor and Robertson)

The Mayans, 600 hundred years later and 12,000 miles from Babylon, realized how zero plays a role in being a placeholder. In 350 AD, zero as a placeholder was used in their complex calendar systems. Zero had many important applications and utilization in Mayan society. However, even though the Mayans were mathematically advanced and inclined, at that time, they never used zero in mathematical problems. As described by Kaplan, the invention of zero by the Mayan can be described as the "...Most striking example of the zero being devised wholly from scratch". (Szalay)

Ultimately, the Indians are the ones who conceptually understood zero and who created a symbol for it. Around 650 AD, Brahmagupta was the one who expressed arithmetic operations using zero. The way he expressed zero as a symbol is by using dots beneath numbers. The dots were called "sunya", meaning empty, and "kha", meaning place. The procedures of attaining zero through the operations of additions and subtractions and results of functions with zero were written by Brahmagupta. He wrote in his book "Bramhagupta Siddhanth" (i) A + 0 = A (ii) A – 0

= A (iii) A × 0 = 0 (iv) A / 0 = 0 (Rajput) . His only mistake were his rules regarding the division by zero, which is later addressed by Isaac Newton and G.W. Leibniz. He told it as Zero instead of infinity. (Wallin)

In year 830, approximately 200 years after Brahmagupta wrote about his theories regarding zero, Mahavira published "Ganita Sara Samgraha". Mahavira's work was basically an updated version of Brahmagupta's. Mahavira accurately claims that "...A number multiplied by zero is zero, and a number remains the same when zero is subtracted from it" (O'Connor and Robertson). On the other hand, his attempt to correct Brahmagupta's statement about dividing by zero was still false. He wrote, "A number remains unchanged when divided by zero" (O'Connor and Robertson). Mathematicians around the world seemed to have pondered about the idea of zero and its applications for centuries which is what caused it to eventually appear in the right and final way. (O'Connor and Robertson).



"This inscription, written in Old Khmer, reads 'The Caka era reached year 605 on the fifth day of the waning moon.' The dot is now recognized as the oldest known version of our zero" (Aczel)

Also, there exist an engraved stone tablets that dates back to year 876 and that has to do with the town of Gwalior, 400 km south of Delhi. This particular town, "...Planted a garden 187 by 270 hastas which would produce enough flowers to allow 50 garlands per day to be given to

the local temple" (O'Connor and Robertson). The numbers 270 and 50 are written almost exactly the same way we denote them today except that the zero is slightly smaller and a little bit raised. (O'Connor and Robertson)

Some say that it was Aryabhatta, one of the most respected mathematician-astronomer, who created zero. Aryabhatta invented a number system that had no zero as a positional system but took into account empty spaces. Some findings demonstrate that a dot was used in older manuscript to indicate an empty space in positional notation. Aryabhatta was one of the very first mathematicians to comprehend and use zero in his work. He incorporated zero when identifying decimal systems and included it in his calculations. Even though, Aryabhatta did not use the symbol zero, it is said that his knowledge and understanding of zero is clear especially in his usage as a place holder for the powers of ten with null coefficients. (Rajput)

It wasn't until few centuries after Brahmagupta's discovery that the concept of zero got to Europe. It was primarily the Arabian travelers that helped spread the texts of Brahmagupta and his colleagues from India along with spices and exotic products. It wasn't until 773AD that zero arrived at Baghdad, Iraq. Arabian mathematicians adopted the Indian number system and started to develop and build on it. In the ninth century, Mohammed ibn-Musa al-Khowarizmi found what is known today as Algebra. Al-Khowarizmi referred to zero as "sifr", which is where our cipher comes from. The number zero as we know it (an oval) was expressed in 879 AD. (Wallin)

After the invasion of Spain by the Moors, zero started spreading in Europe. In the middle of the twelfth century, Al-Khowarizmi's discoveries were translated and used in England. In 1202, Fibonacci, the famous Italian mathematician, expanded on the work of Al-Khowarizmi with algorithms which are found in his "Abacus book". The abacus was used a device to solve

algorithmic operations. In his book, "...He described the nine Indian symbols together with the sign 0 for Europeans in around 1200 but it was not widely used for a long time after that" (O'Connor and Robertson). Fibonacci addresses 0 as a sign while regarding 1,2,3,4,5,6,7,8,9 as just plain numbers (O'Connor and Robertson). Fibonacci's discoveries served a great deal to Italian merchants and German bankers. The books of accountants were balanced when the positive and negative total of their financial obligations equalled zero. Governments were unsure about the validity of zero because of how simple it was to alter one symbol into the next so they banned it from being used altogether. Traders used zero in secret by encrypted messages, or in other word cipher, meaning code, which is derived from the Arabic term "sifr". (Wallin)

Even though ancient Greek philosophers gave the world important mathematical discoveries such as the Pythagorean Theorem, Euclidian Geometry and the fundamentals of Number Theory, zero was never associated with their discoveries. Since the Greeks Christian clerics considered entities by essence, then "...a zero elephant and a zero bacterium by not owning an essence were physically the same and indistinguishable" (Murray). "Elements" by Euclid was one of the most popular book sold worldwide. However, because it was based on geometry and it dealt with numbers as the length of lines, the Greek mathematicians did not need to identify/name their numbers (O'Connor and Robertson). The Greeks never considered zero to ever be a number which is surprising with all of the great discoveries that they came up with. (Murray).

Rene Descartes left his mark in the world with his development of the Cartesian coordinate system. Descates' origin is (0,0) which can be seen/understood when a triangle or a

parabola is graphed. During that time, the usage of zero was widespread but it wasn't until Newton and Leibniz discovered calculus that zero was finally understood. It was easy to add, multiply and subtract by zero but dividing by zero was a hard concept to grasp for many of the most brilliant mathematicians. In 17th century, Newton and Leibniz developed what is known today as calculus. They worked with numbers as they approached zero which facilitated the establishment of the formation of physics, engineering, and many aspects of economics and finance. (Wallin)

Mathematics is a universal language and zero is a concept and symbol that is used globally and in people's every day interactions and languages. Zero was known as 'shunya' in India. It was then known as 'sifr' for the Arabs. From sifr, 'zephyr' came about in Latin. Then it finally became zero in different countries since Latin is the foundation to many languages. Zero is called, cyfra in Poland, cifra in Spain, zero in France, ziffer in Germany, siffra in Sweden and meithen in Greek, etc... All of which mean the same thing and describe the same concept. (Rajput)

Today, we use zero so often that we don't appreciate its existence and how it came about. It is important to understand its history and to know its vital functions because it is what allowed society to progress to the point it is today. One of the greatest achievements in human history is the evolution and progression of zero. The number zero is used everywhere and by everyone and it can be consistently found in people's basic daily life and interactions. Zero will forever play a pivotal role in the many advancements that are yet to come, therefore acknowledging it and working on expanding some of the theorems associated with it is something that needs to done consistently. (Wallin)

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