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Zero to Infinity A Review of Charles Seife's ZERO: The Biography of a Dangerous Idea

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Introduction

"Nil", "Nunca", "Nada", "Nil", "Nothing", "Zero". Sounds of a multilingual class of mathematics, perhaps. No, it is the sounds around the family table card game as we all declare the number of tricks that we would like to take in a card game called Wizard. The speaker is telling the scorekeeper that they would not like to take any tricks. They would like to take "zero" tricks as if they could gather the zero cards. We all know that we do not want any tricks and we do our best not to take any if we declare that we want zero tricks.

I immediately thought about the family card games as I read the book *Zero: The Biography of a Dangerous Idea* (Seife, 2010). This is a story about zero, its history, its challenges to be accepted, and its effect on mathematics and society. I could not imagine a world without zero until I read this book and understood the struggle zero took to be accepted. Earlier in my career as a secondary school teacher, I always said that mathematics was patterns and infinity. Little did I know how long it took for infinity to make its appearance in mathematics. These two concepts, now well-known to mathematics learners around the world, had a battle to be accepted in the West. In this review, I will briefly outline some of the struggles that zero and infinity faced and how these two concepts lie in the heart of scientific discovery.

There are many reviews of this book, and it is tempting to read what others have said about it. However, all reviewers who have read this book come with different perspectives, depending on their understanding of mathematics and history of mathematics. Having an honours degree in mathematics and a 40-year career teaching mathematics, I read with interest the history of mathematicians and how zero had such a struggle to find its way into the mathematical and scientific world. It remained such a mystery how so many

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early mathematicians felt it was important not to include zero. However, the historical record cannot be looked at without factoring in the importance of religion. Early mathematicians needed to appease the religious leaders of the time, and they did so by not acknowledging the existence of zero, since the existence of God was tied to it. However, without zero, we would not be able to explain the physics of our world, including the big bang and the big crunch.

Infinite Insights

In the second chapter (labelled Chapter 1 *Doing Nothing*), Seife provides graphics to illustrate the numerals of different cultures. In my secondary school classroom in the 1980's, I would teach my students about the Roman and Babylonian numbers/numerals. The Babylonians used a base of 60 and introduced a symbol to represent zero as a placeholder for the place value of the numbers; it did not have numerical value of its own. In this case, "zero was a digit, not a number" (Seife, 2000, p. 15).

The figures in the book are very illustrative of the points Seife makes. The mystical monochord (figure 7, p. 30), the Greek universe (figure 8, p. 31) and the Parthenon, the chambered nautilus and the golden ratio (figure 9, p. 33) helped to clarify the importance of ratios and geometry in early Egyptian, Greek and Pythagorean mathematics. Because zero did not make much sense in geometry, especially with ratios, the Greeks did not embrace zero in mathematics. Seife provides insightful stories about the reasons why the Greeks were frightened of the infinite and the void.

"Luckily, not all civilizations were so afraid of zero" (Seife, 2000, p. 61). In chapter 3 *Nothing Venturers [ZERO GOES EAST*], Seife provides the reader with the many reasons why the East welcomed zero. As mentioned earlier, the Babylonian system of numeration used zero as a placeholder and so zero did not have a value. In the fourth century BC, Alexander the Great was conquering lands left and right until his troops arrived in India. During this time [it was thought that], the Indian mathematicians were introduced to the Babylonian system of numbers and about zero [it is no longer thought that]. Eventually, the base-10 numbering system rose to prominence and the symbol for zero was used as a placeholder (again!). The Indian mathematicians did not have the same attraction to geometry, so they were able to do more than just measure objects. This expansion of the use of numbers led to what we now call algebra. Hence, the rise of zero as a number and a place on the number line. The usefulness of place value comes from the Middle Eastern mathematician al-Khwarizmi in 820AD (Joseph, 2008, p. 43). Brahmagupta's seventh century text Brāhmasphuṭasiddhānta states that "a zero divided by zero or by some number becomes zero. Likewise the square and square root of zero is zero. But when a number is divided by zero, the answer is an undefined quantity" (p. 42). Soon, division by zero lead to infinity and the rest, as they say, is history.

Jumping ahead a few hundred years, we find zero and infinity playing a big role in the development of calculus. Calculus brings together differentiation and integration into one package, says Seife (2000). Isaac Newton investigated tangents and areas under the curve and developed mathematical notations to generate answers to his problems. Not long later, Gottfried Wilhelm Leibniz developed calculus using different notations.

Chapter 5 *Infinite Zeros and Infidel Mathematicians* [ZERO AND THE SCIENTIFIC REVOLUTION] is a very interesting read if you want to understand the interactions and discoveries of the many 1600s and 1700s mathematicians. I read about many of these mathematicians from *The History of Mathematics* (Boyer, 1991) as a young elementary school teacher. I also used the Boyer book while teaching my teacher education classes at the University of Toronto. I see now that Seife (2000) will be a great addition to my class to describe interesting antidotes about the development of zero and infinity.

After a deep discussion about limits, Seife describes the rise and fall of infinity (Chapter 6 *Infinity's Twin* [THE INFINITE NATURE OF ZERO]). To better understand infinity, mathematicians had to learn more about rational numbers and the world of imaginary numbers. The collection of rational and irrational numbers gave us the real number system and, by adding the imaginary numbers, we get the complex number system. One of the greatest mathematicians of the 18th century was Carl Friedrich Gauss. Born in Germany, he worked on numerous topics of mathematics, including his work on graphing complex numbers. Seife (2000) explains the geometric concepts of complex numbers as a way to provide a geometric understanding of zero and infinity as they relate to a sphere. For me, the most interesting part of the book is about the history of mathematicians and how they were building on each other's knowledge and stealing each other's findings to further the understanding of mathematics.

In chapters seven and eight, Seife describes quantum theory, quantum mechanics, theory of relativity, and the speed of light. As he did throughout the book, he provided figures to illustrate the concepts. I found the analogy of space and time to a gigantic rubber sheet (figure 51, p. 180) very helpful to understand the distortion caused by gravity. This analogy was used to first explain the orbits of the planets, and then the concept of a black hole as "a star so dense that nothing can escape its grasp, not even light" (Seife, 2000, p. 179). The description of black holes sent me back to my copy of *A Brief History of Time* (Hawking, 1998), where I read a little more about the origin, development and structure of the Universe. This book is an insightful companion to the Seife book.

A Gift

Suppose that you are a secondary school student and you received this book as a "book" prize for doing well in mathematics. I think this reader would be fascinated by the beginning of the book (called chapter *0* [Null and Void]) and the story about the USS *Yorktown* as it received new software that had a hidden zero in the code that was not removed during installation. As the computer system attempted to divide by zero, the engines shut down and the ship had to be towed to port. As a prize winner, this student would fully understand the results of dividing by zero and yet these programmers did not take enough care to check for this potential calculation (or miscalculation in the case of the USS *Yorktown*).

Suppose you are in a physics field and you decide that you want to read this book because you heard that there is something really important about the origin of the universe and quantum theory and theory of relativity. The connection between Einstein and string theory helps to explain the beginnings of the world and how quantum theory and relativity theory were able to make sense to many people. String theory depends on ten dimensions, and it is very difficult for the human mind to understand even four dimensions (Zwiebach, 2009). We have to believe that there are six more dimensions, mostly by faith, but they help explain what it is we are trying to do with string theory. Zero, as Seife (2010) says, "is behind all of the big puzzles in physics" (p. 214).

The target audience of this book should be those who are interested in STEM. The beginnings of zero and infinity through the mathematical world is really focusing on how we understand our physical and scientific world. The exploration of calculus in mathematics, quantum mechanics in science, engineering required to build the Hubble telescope and space exploration are discussed in the book to help the reader better understand how engineering and technology help us better understand our world. This is really the definition of STEM and this book helps with the application of these concepts to help move the field along.

Summary

Seife (2000) ends his book with chapter ∞ *Zero's Final Victory* [END TIME]. It seems a little too early to write chapter ∞. I am still so curious about the use of zero and infinity in other mathematical models and scientific concepts. In the 22 years since Seife wrote his book, there have been a number of books that explore zero and infinity (i.e., Barukcic, 2020; Glynne-Jones, 2012; Goldsmith, 2012; Reid, 2006). I have my summer reading list ready!

I want to return briefly to the McDougall family card games. As I hear my older sister, Deb say "Zero" in a German accent, I think about the resistance in Europe to accept zero as a mathematical concept and number. I think about the mathematicians and scientists who went against the norm to better understand rational, irrational, and complex numbers. Carl Friedrich Gauss, a German mathematician, and his student, Georg Friedrich Bernard Riemann, helped us understand projective geometry and complex numbers. This gave us a geometric understanding of zero and infinity. The rest, as they say, is history.

But the present is not yet history. I will still do whatever I can so that my older sister is not successful in getting “zero” tricks. I will hopefully find a way to play a card lower than hers so that she does take a trick and is not able to achieve her “zero” tricks. It is similar to a zero-sum game. The tricks I give away are the ones that I am not going to get for myself. Like this book, zero has meaning in my life. As we read and reread Seife’s book, we learn more about mathematicians who were building on each other’s knowledge and finding ways to make sense of zero and infinity. I hope you find ways in your life where these concepts make sense as well.

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