Brahmagupta, The Jewel of Indian Mathematicians: Inventing the Idea of "Nothing"

Annotated Bibliography

Primary Sources

Artifacts:

Silver Darchan(Coin) -Gupta Dynasty, Kumar Gupta I- 415-55 AD-Rohan Singh-*Personal Collection*

As an avid coin collector, I like to collect old coins as well. In my collection, I have a coin which was from the era of the Gupta Dynasty in India. The coin was made in honor of the current ruler Kumar Gupta the First who's lineage lasted from 415 to 55 AD. This is not exact but it does relate to Brahmagupta as Brahmagupta lived from 598 AD to 668 AD. Since it is difficult to find artifacts from this time period, I decided to use it when I provide historical context. I am still learning new info from the coin as it is still unclear of its true dates.

Photos:

Arithmetices Elementa-*Mathematical Association of America*- Title Page-

Mathematical Treasures - Peurbach's Elements of Arithmetic | Mathematical Association of America.

https://www.maa.org/press/periodicals/convergence/mathematical-treasures-peurbachs-elements-of-arithmetic - Accessed 20 May 2020.

This is a picture of the title page of the "Arithmetices Elementa" made in 1544 by Georg von Peurbach. This book is about arithmetic and includes ideas of the Hindu-Arabic Numeral System. At this time in Europe, zero was becoming more and more acceptable so mathematicians such as Georg von Peurbach decided to create books to teach the ideas.

Al-Khwarizmi-Commemorative Soviet Stamp-*Muslim Heritage*

https://muslimheritage.com/al-khawarizmi

I had found this picture of the famous Persian mathematician Al-Khwarizmi who had used zero to create Algebra. I wanted to have a picture in “The Brahmasphutasiddhanta” section, so I searched and found this commemorative stamp of Al-Khwarizmi. I also talk about him in the section along with providing the stamp.

Babylonian symbol for an absence of numbers-bbc.com. *BBC*

https://www.bbc.com/future/article/20161206-we-couldnt-live-without-zero-but-we-once-had-to

This picture shows the Babylonian symbol for an absence of numbers. Babylon was one of the first cultures to have ideas of zero. This was a good picture as I wanted to have different representations of the ideas of zero from other cultures to show the audience how the earliest ideas of zero looked like and how we have changed.

Binary Code- *Harvard University - Accessed 5 May 202*0 -

https://undergrad.gov.harvard.edu/ (Picture in the middle of the website)

This picture is a picture of binary code. I feel that this picture would be good in my “Significance of Zero” section of my website as the picture will show the audience an idea of binary code.

Chinese Rod Numeral System Key Picture- *University of Utah*. Accessed 4/10/2020

https://3010tangents.wordpress.com/category/chinese-mathematics/page/2/

This picture shows the Chinese Rod-Numeral system key. This picture was useful in my East Asia section of my website as I talk about Chinese rod numerals. I feel like this picture helps the audience understand the system more as the audience will be able to see what rod formations equal a number.

Example of the Chinese Rod-Numeral System- *Iowa State University*- Accessed 18 May 2020

https://orion.math.iastate.edu/mathnight/activities/modules/count/countright.pdf

This is a depiction of zero expressed in the Chinese Rod-Numeral System. An empty space is used to represent zero. I felt that an example of zero being used in the system would make the viewer understand zero in the system completely.

Example of the early Greek symbol for zero (lower right corner) from a 2nd-century papyrus. *Lund University Library*-

http://www.papyri.info/apis/lund.apis.42?rows=3&start=21&fl=id,title&fq=idno_led_path:P.+Lund.+I;*;*;*&sort=series+asc,volume+asc,item+asc&p=22&t=885 -Accessed 5/5/20

This is a picture of a Greek symbol for zero which is on 2nd century papyrus. As I wanted to have different representations of zero from other cultures, this was a great picture. This picture is in fact incredible as Greek mathematicians at first had doubts about zero and most Greek thinkers believed that the number would not be possible and this picture shows how they changed. This picture truly is a great addition to my East Asia section of my website. I have cropped the image to better show the Greek symbol.

Fibonacci Picture - *Saint Andrews University - Accessed 21 May 2020*

http://mathshistory.st-andrews.ac.uk/Mathematicians/Fibonacci.html

This is a picture of the Italian mathematician Fibonacci. Fibonacci was instrumental in zero being in Europe. He had learned zero from his Arabic teacher and had brought it to

Europe. Overall, he is a very important figure in mathematics and the history of zero so I feel this would be a good photo for the audience.

History of Computers. *University of Cambridge*- Accessed 14 Feb. 2020. https://www.cl.cam.ac.uk/relics/jpegs/edsac_wilkes.jpg

This picture was a great example of how zero has changed our lives. This is a picture of an old computer from the University of Cambridge. When I talk about the significance of zero, I mention that zeros use in binary code revolutionized our online technology. Before, computers as big as rooms were usually slow and inaccurate. Now with binary code, we are able to have much more advanced technology. I feel that this picture will show the audience how much zero has improved our online technology.

Illustration from the Codex Vigilanus- *Vanderbilt University* -Accessed 10 March .2020. https://www.vanderbilt.edu/olli/class-materials/Medieval_Spains_Session_5.pdf- Page 14/27 (I found this picture on page 14 and have used the picture on my website)

This is a section of the Codex Vigilanus which was made in the 10th century AD in Spain. This is the first mention and representation of Arabic numerals in Europe. This picture is a great addition in my “From The Middle East to Europe” section of my website as I wanted to have a representation of some of the early uses of zero in Europe.

Illustration from the Margarita Philosophica- *Harvard University, Houghton Library*- https://iiif.lib.harvard.edu/manifests/view/ids:12844554 - Accessed 13 March. 2020.

This was my favorite photo. It is an Illustration from Margarita philosophica, 1503, by Gregor Reisch. This picture depicts the abacus versus the Hindu-Arabic Numeral System. In the early days of the Hindu-Arabic Numeral System, many people argued which system was better; the new Hindu-Arabic Numeral System, or the current Abacus Counting System. The reason this is my favorite picture is because of the facial

expressions of the people in the illustration. The person depicted using the abacus seems sad and afraid when the person using the Hindu-Arabic Numeral System seems proud. This was very interesting to me as I wondered why.

Mayan Base-20 System Picture- *Texas A&M University*- Accessed 10 February. 2020 https://www.math.tamu.edu/~roquesol/M629_6.html

This is a picture of the Base-20 counting system which was employed by the Mayans. In the picture, the viewer can see here that zero was represented as a shell. This picture was useful in my “Zero in the Americas” section of my website as I wanted to show a visual of the Mayan’s counting system and how it differentiates from different systems. It was also useful as it included a visual of the Mayan’s symbol for zero. I feel that this would be a great picture for the audience as they will see how past cultures thought about counting systems and zeros.

Numbers in Arabic | *Arabic Language & Culture*. http://www.ar-l.org/12-numbers-in-arabic/ Accessed 6 Feb. 2020. Arabic Numbers Key

The picture is a picture showing the Arabic numbers. I use the picture in my “Middle East to Europe” section of my website. The picture includes our present-day numbers to show which numbers are the Arabic numbers. I wanted to show the audience what the Arabic numerals exactly were and what they looked like as I talk about Arabic numerals heavily in my “Middle East to Europe” section of my website.

Painting of Sir Isaac Newton-Godfrey Kneller (1646-1723)-*The National Portrait Gallery*, London.

https://www.npg.org.uk/collections/search/portrait/mw04660/Sir-Isaac-Newton

This picture is a painting of the famous mathematician and physicist, Sir Isaac Newton. In my Significance of Zero page, I talk about the branch of math calculus and its

significance. Calculus was invented independently by the German mathematician Gottfried Leibniz and Sir Isaac Newton. I felt it would be good to have a visual of the inventors so I had looked out and found that the National Portrait Gallery had such a visual so I decided to use it on my website.

Painting of Gottfreid Leibniz-Cristoph Bernhard Francke (1660-1729)- *Encyclopedia Britannica* . https://www.britannica.com/biography/Gottfried-Wilhelm-Leibniz

This is a painting of the German mathematician and philosopher, Gottfried Leibniz. Gottfried Leibniz was one of the inventors of calculus, which I talk about in my "Significance of Zero" page. Same as the painting above, I wanted to have a visual of one of the inventors so I had used the painting of Gottfried Leibniz on my website.

Picture of Chinese Counting Rods in a Japanese Mathematics Book- Seki Kowa- Published 1708-*Mathematical Association of America*- https://www.maa.org/press/periodicals/convergence/mathematical-treasures-seki-kowas-essentials-of-mathematics

This is a picture of Chinese counting rod numerals in grids in a Japanese mathematics book written in the 17th century AD. I included this picture because I wanted the audience to see how the system was used in its time. This picture is a great addition to my "East Asia" section of my website.

Pictures of the Bakshali Manuscript. *National Geographic - Accessed 7 May 2020* https://www.nationalgeographic.com/news/2017/09/origin-zero-bakhshali-manuscript-video-spd/#close

I thought that these were amazing photos as these photos are the earliest representations of zero as a numeral. I chose this photo as it would go extremely well to show and inform the readers about the history of the numeral zero. The Bakshali

Manuscript has the oldest inscription of zero as a number in its own right so this was a very unique photo.

Picture of the La Mojarra Stela 1-Created 4 March 2017- *Science Magazine - Accessed 8 May 2020 - https://science.sciencemag.org/content/277/5323/207/tab-figures-data*

This is a picture of the La Mojarra Stela 1 which contains Mayan text. I feel like this would be an interesting picture for the viewer as they would be able to see an example of Mayan script.

Sumerian Placeholder for Zero- *The Internet Archive - Accessed May 7 2020 https://archive.org/details/TheOriginAndDevelopmentOfBabylonianWriting/page/n7/mode/2up*

This is a picture of the ancient Sumerian placeholder for zero. In my “Beginnings of zero and Zero in the Americas” section, I talk about the ancient Sumerians. Around 4,000 to 5,000 years ago, the Sumerians were the first to develop a counting system. Their counting system included a placeholder for zero. This is a great picture as this is one of the earliest recorded uses of zero as a placeholder.

Interviews:

Gobets, Peter-Email Interview-March 11. 2020

I reached out to Peter Gobets as I believed that he could provide me with some more sources and information about zero. Peter Gobets is the secretary of the ZerOrigIndia foundation which is researching zero's past. This was my most useful interview as Mr. Peter Gobets provided me with several sources which I used for research. I had also used some of Mr. Peter Gobet's words on my website as quotes.

Nieto, Menakshi. Phone Interview- 15 Jan. 2020.

This was my first interview and was very useful to me. The main thing that Mrs. Menakshi had helped me with was choosing my topic. We discussed some potential topics and she suggested the topic of Brahmagupta and his invention of zero as a number. I had known about Brahmagupta beforehand but she gave me some facts and some information about Brahmagupta which I had not known. Overall this was a great interview as Mrs. Menaski had helped me choose my topic.

Rana Dhirendra Prasad. In Person Interview- 20 Jan. 2020.

This interview helped me learn zeros impact on engineering. I reached out to Mr. Rana as he is a retired electrical engineer who was in India's Core of Engineers. I learned that without zero, engineering would have been extremely difficult. In his job, he often deals with mathematics and large numbers. Without zero, writing those large numbers would have been very hard. Mr. Rana also explained to me that without zero, a lot of his work would've been near impossible as he on a daily basis had dealt with extremely large numbers as an engineer.

Rana, Pankaj. In Person Interview-14 Feb 2020

This was one of the best interviews because I gained valuable insight on coding and my website. Mr. Rana has a degree in Computer Engineering and owns a website creating company. He viewed my website and gave me valuable advice to further enhance my website. He had also answered some questions that I had about coding. The main thing that Mr. Rana helped me with was the design of my website. He recommended that I change the brightness of my background to make sure the background does not distract the audience. This overall was a great interview.

Shanker, Prem. Phone Interview- 12 Feb. 2020

Mr. Shanker has a degree in electrical engineering so I reached out to him to understand how he uses zero in his job. He told me that zero and math were used heavily when he was in college trying to get his engineering degree. He told me he often worked with advanced calculus. He didn't know much about Brahmagupta, but he told me that he often worked with large numbers and calculus.

Singh, Neelam. In Person Interview- 8 Feb. 2020

I asked Mrs. Singh for an interview as she is a retired teacher from India and I wanted to learn about how Brahmagupta was being taught in schools in India. After I had inquired about why Brahmagupta was not being taught in schools, I had learned a lot about how India's school system had changed. When the British came, they completely changed the way the schools had operated and had westernized it. It had overall made the system much worse. Mrs. Singh felt that if the school system was not changed, then Brahmagupta would've probably been taught in schools.

Singh, Rinkey. In Person Interview-10 Feb. 2020.

I reached out to Mrs. Singh as she is an architect and a city planner. She is originally from India and has been a city planner for many years. This interview helped me learn how zero is used in different jobs and in the workforce. I learned that Brahmagupta is not well known in India but she had some awareness of who he was. She gave me information about how she uses math in her job and how zero has made her life simpler as she often deals with large numbers and uses mathematics in her work frequently.

Secondary Sources

Lectures:

“GRESHAM COLLEGE WITH THE BRITISH SOCIETY FOR THE HISTORY OF MATHEMATICS.” GRESHAM COLLEGE WITH THE BRITISH SOCIETY FOR THE HISTORY OF MATHEMATICS. 10 2020, *Gresham College*. “Zero is Hero”

This was a great lecture which provided me with great information about the significance of zero and its applications. I have used some of the information from this lecture on my “The Barriers Broken” section of my website. I had learned that zero is used in binary code which is what our computers and online technology use to process instructions. This lecture was overall useful and prompted me to research more on the significance of zero and its many uses.

Professor M.D.Srinivas Prof.M.S.Sriram, National Programme On Technology Enhanced Learning. *“Mathematics in India - From Vedic Period to Modern Times .”* Mathematics in India - From Vedic Period to Modern Times . 15 Jan. 2020, Bombay. *IIT Bombay*

This lecture gave me good information about the Bakshali Manuscript and some more information about Brahmagupta. Some things that I had learned was that the Bakshali Manuscript contains the earliest use of zero as a number. Even though zero was used in earlier civilizations, it was not used as a number in its own right. The idea of zero as a number was originally from India but had later spread to the Arabic culture. This lecture was also useful for creating my timelines that I would use to organize my website.

Prof.K.Ramasubramanian, Prof. M.D.Srinivas Prof.M.S.Sriram. *“Mathematics In India.” Mathematics In India. Bombay”* 19. Jan 2020.

This lecture gave me great information on the Gupta Dynasty which was the time period which Brahmagupta lived in. I have used some of the information from this lecture and I have paraphrased some of the information I got onto my website. What I had learned was that the Gupta Dynasty is regarded as the “Golden Age” of India as there were big

advancements in the arts, sciences, mathematics and others. I had also learned about Aryabhatta who I had originally thought had invented zero. However this is a misconception and Brahmagupta had invented zero, which I have confirmed thanks to this lecture.

Books:

Butterworth, Brian. "*The Mathematical Brain"*. Papermac, 2000

This book talks about the concept of numbers to humans. The main thing that I had got from this website was a quote that I had gotten from the author, Brian Butterworth. The quote was, "The ability to use numbers such as zero raised us from cave-dwellers using stone tools to creators of great cities and modern science." I have used this quote on my "Barriers Broken" section of my website.

Downey, T. (2004. *"The History of Zero: Exploring Our Place-Value System"- New York: Rosen Publishing*

This book talks about the history of our current number system. It compares our current system with the Hindu-Arabic Numeral system, Chinese numerals, and Babylon symbols. Our current system including 1s, 2s and so on are derived from the Hindu-Arabic numeral system. Along with information, this book helped me think of ideas on my website. For example, I included a picture of the Hindu-Arabic numeral system after learning about it in this book. This book overall was useful to me.

Ifrah, G. (1987). *From One to Zero: A Universal History of Numbers*. New York: Penguin Publishing.

This book talks about the history of number systems of different cultures and civilizations. The numerical systems include the Sumerian's system, Egyptian system, Chinese, Roman, Greek, Babylonian, and Mayan systems. It also includes the use of zero in these systems. This site was useful because it talks about Hindu-Arabic Numeral system which I talk about on my website. I also learned some more information about zero in different cultures.

Indian National Academy of Science. Bose, D. M.; Sen, S. N.; Subbarayappa, B. V. (1971)- *A Concise History of Science in India*

This book gives an overview of the history of science and mathematical advances in India. In the book, they briefly mention Brahmagupta and his works. The book especially talks about Brahmagupta's major book, The Brahmasphutasiddhanta. Something that I learned was that Brahmagupta had stated that zero divided by zero equals zero. This is incorrect as we now label it as undefined.

Kaplan, R., & Kaplan, E. (2005). *The Nothing That Is: A Natural History of Zero*. Oxford: Oxford University Press.

This book was the most useful book that I had used while doing research. This book was a great reference and gave me lots of information. I paraphrased a lot of Kaplan's ideas and used some quotes from the book. This book talks directly about the history of zero. I have used Robert Kaplan's(the author) quotes on my website. The book gave me an overview of zero being used in the ancient Sumerian culture, the Babylon culture, India, the Mayans, Europe, and Baghdad. This book was especially useful as it gave a great timeline by talking which culture had the idea first and then were it spread to.

Levy, J. (2017). Exploring the Mysteries of Mathematics. New York: Rosen Publishing.

This book provided me some knowledge about Brahmagupta and furthermore talked about other ancient counting systems used in different cultures such as the Hindu-Arabic Numeral System. The main thing that I learned from this book was that there are four types of counting systems. The first is a grouping system. Roman numerals are an example of a grouping system. The second is a multiplicative system. The next is a cipher system. An example of a cipher system is the Egyption hieratic numeral system. The last is a positional system. An example of a positional system is the Hindu-Arabic Numeral system.

McElroy, T, Ph.D: (2005). *Notable Scientists-A To Z of Mathematicians*. New York: Facts On File.

I used this book to learn some more info about Brahmagupta. This book was useful as this was one of the rare books which had a good description about Brahmagupta's life and achievements. What I learned in this book was that the concept of zero was foreign to Indian mathematicians but even then, Brahmagupta was able to define zero as a number in its own right. Brahmagupta believed in a stationary Earth which we know now that is wrong but there is a possibility that Brahmagupta believed that the Earth was not stationary but it would've been dangerous for him to speak against his religion. Brahmagupta influenced later Indian mathematicians such as the Indian mathematician Bhaskara II who improved on the knowledge of negative numbers and the properties of zero. Considering Brahmagupta's time period,he was quite advanced; at the time, no mathematics was being done in Europe. He is most notable for his definition of zero as a number which has had an enormous impact on civilization.

Paeth, A. K. (2000). The History of Zero.

This book talks about the history of the number zero. This book basically provided me a general overview of zero and its history. What I learned from this book was some information about other numeral systems such as the Hindu-Arabic numeral system and others.

Puttaswamy, T. K. (2012). *Mathematical Achievements of Pre-Modern Indian Mathematicians*. Chennai: Elsevier Publishing.

This book talks about important Indian mathematicians. This book has a chapter on Brahmagupta along with other prominent Indian mathematicians. In the chapter where it talks about Brahmagupta, it primarily focuses on Brahmagupta's main book, the Brahmasphutasiddhanta. It then focuses on his second major book, the Khandakhadyaka which was a book on astronomy. I learned that as well as being an important mathematician, Brahmagupta was also a skilled astronomer. This book was useful to me as I had never known that Brahmagupta was also an astronomer.

Rooney, A. (2013). The History of Mathematics. New York: Rosen Pub.

This book helped me decide what my topic was going to be as it has a short comprehensive history of mathematics. I knew I wanted my topic to be involved in mathematics but I did not know what I wanted to do. This book talked about the history of zero which is what got me started on my project and gave me ideas on what I should do. It talks about Greek mathematicians mainly and gives a good timeline of events and talks about important mathematical breakthroughs such as the invention of the numeral zero.

Seife, C., & Zimet, M. (2014). *Zero: The Biography of a Dangerous Idea*. NY, NY, U.S.A.: Penguin Books.

This was a great book which provided me with lots of information on zero being used in Europe. This book mainly talks about how the Greeks and Romans had banned zero because they were skeptical about Arabic ideas such as zero. In Europe, medieval church leaders had also banned zero because they viewed zero as satanic as god was everything that existed when nothing was viewed as satanic. I have used a Charles Seife quote on my website. Overall, this was a very useful book towards my research.

Videos:

BBC Four-YouTube. https://www.youtube.com/watch?v=LQEuywkWa2U&feature=youtu.be. Accessed 7 Feb. 2020.

This video was a great source which I have used on my website. This video talks about the history of zero. It is debated on whether zero was brought into India by Chinese merchants with their counting books or if zero was invented in India. India's number system was ranked as the one of the greatest innovations of all time as those 9 numbers were the foundations of the current number system we use today. If you look at those numbers, you can see some similarities. The Indians were the first to introduce zero as a number into the world. An inscription on a temple wall was one of the first recorded inscriptions of zero as a numeral. Zero had been in use in other cultures but only as a placeholder. The Indians were the first to explain zero as a number in its own right. These definitions revolutionized mathematics. With 10 numbers, it was now possible to describe astronomically large numbers in an incredibly efficient way. I have used a clip of this video on my website.

Carnegie Mellon University-YouTube. https://www.youtube.com/watch?v=USl2Vv7kmpI. Accessed 18 Feb. 2020.

This video talks about the significance of zero, and the significance of the Hindu-Arabic Numeral system. The development of higher mathematics became possible due to the invention of zero. At first, the Roman Numeral system was the only number system used by the Europeans and was very inefficient. Then, through Arab traders, the idea of the Hindu-Arabic Numeral system came to Europe. It then developed into the number system that we currently use today.

Ehow-YouTube. https://www.youtube.com/watch?v=A_e5jspsNsM. Accessed 18 Feb. 2020.

This video talks about who invented zero and some of the history of zero. What I learned was at first, European leaders had originally dismissed zero as a number, but when European mathematicians had started to use negative numbers, there needed to be a "middleman" between positive and negative numbers to differentiate the two. This is one of the reasons why zero had been accepted as a number in Europe.

/Mystery-YouTube. https://www.youtube.com/watch?v=qx_I6gs7fEg&feature=youtu.be. Accessed 8 Feb. 2020.

This video gives an overview about the history of zero. One thing I learned from this video was that even though people had understood the concept of nothing or having nothing, the concept of zero is relatively new. Before then, mathematicians struggled to do even the simplest of calculations. The first evidence of zero was from the Sumerian culture in Mesopotamia around 5,000 years ago. It then spread to Babylon and then India. Algebra, algorithms and calculus(the three pillars of modern mathematics) are all the result from zero. Mathematics is a science of invisible entities which we can only understand by writing it down. By adding zero to the positional number system, unleashed the true power of numbers advancing mathematics from infancy to adolescence and from rudimentary to its current sophistication.

Royal Institution of London-YouTube.

https://www.youtube.com/watch?v=9Y7gAzTMdMA&feature=youtu.be. Accessed 7 Feb. 2020.

This video was a great video for explaining the history of zero and zero's importance. Some things that I learned from the video was that one of the reasons which zero was banned was that the Romans were against the Arabic numbers(which included zero) so they dismissed the notion. Zero had formed the foundation for modern computing and still does. I have used clips of this video on my website.

Science Museum-YouTube. https://www.youtube.com/watch?v=D-oxsEknIIc&feature=youtu.be. Accessed 8 Feb. 2020.

This was a great video which gave me information on the Bakshali Manuscript and some history of zero. I had learned that one of the most important things that zero had given to us was that the common person was able to do mathematics. Before, calculations were done on an abacus which was hard to record. This meant that mathematics was only in the power and use of the "authorities' ' who were able to do mathematics. Zero first appeared in the Indian subcontinent. The Bakshali manuscript is now the latest description of zero. The Bakshali manuscript is a complicated document which involves many pieces written over many centuries.

TED-Ed-YouTube. https://www.youtube.com/watch?v=cZH0YnFpjwU&feature=youtu.be. Accessed 8 Feb. 2020.

This video was extremely helpful in providing me information about other cultures and civilizations number systems. What I've learned from this video was that numbers have been a factor of life throughout history. As the complexity of life increased, current systems used by people were not sufficient. Civilizations created their own counting

systems. A lot of counting systems are just extensions of tally marks representing a value. Roman numerals had an interesting approach but it was still a hassle to express large numbers. By the 8th century, Ancient Indian mathematicians had perfected the number system and over the next several centuries, Arab scholars, traders, and conquerors began to spread it into Europe. Zero had then come into play and the understanding of zero as both a value and a placeholder made for reliable and consistent notation(there were problems describing an absence of a number). This was a great video which helped me establish a timeline so I could organize my website.

Unique Brain- YouTube. https://www.youtube.com/watch?v=369PedGlySo. Accessed 18 Feb. 2020.

This video provided me with great information on zeros uses and why zero is important. Without zero, we wouldn't have calculus, financial mathematics, algebra, modern day computers, and the ability to do calculations quickly. Brahmagupta was the first to define zero as a number. The idea later on went to the Middle East. After that, the idea spread to Europe by the famous Italian mathematician Fibonacci. He learned zero after taking trips to the Middle East.

Way Back-YouTube. https://www.youtube.com/watch?v=iUW7Iz6NHZg&feature=youtu.be. Accessed 17 Feb. 2020.

This video is a video of Robert Kaplan who is the author of a book about zero. He is talking about his book, "Nothing That Is: A Natural History of Zero. Here, Robert Kaplan explains his book and talks about some of the history of zero and some history of mathematics. This video was useful to me as I used some of the quotes which Robert Kaplan states in this video, on my website.

Pictures:

Dark mathematical background-10553742-close-up-of-mathematical-background.jpg

This was my main background which I used throughout my website. Since my topic is about math, I wanted to have a background somewhat related to math. I really liked the dark color of the background and it helped me think of the color scheme that I use.

Mathematical Background-1000_F_134371185_9fcm39FcAcLJUrgnjC6kFgr57GUGWkHW.jpg

This was my secondary background. Same as above, I wanted my background to be somewhat related to math and I found one. It matches with the dark background and color scheme.

Articles:

Aczel, Amir. “The Origin of the Number Zero.” *Smithsonian Magazine*, https://www.smithsonianmag.com/history/origin-number-zero-180953392/. Accessed 17 Feb. 2020.

This was one of the first articles I had discovered and had helped form the basis of my website’s information. This article talks about some of the origins and history of zero. One thing I learned was that zero was introduced in the West in the 13th century, after the Italian mathematician Leonardo of Pisa; better known as Fibonacci, introduced the numerals to Europeans. He’d learned them from Arab traders, who presumably adopted them during travels to the Indian subcontinent.

American Mathematical Society- “Feature Column from the AMS.”, http://www.ams.org/publicoutreach/feature-column/fcarc-india-zero. Accessed 12 Mar. 2020.

This site was useful to me as it gave me information on one of the first ever recorded uses of zero as a number. This article from the American Mathematical Society talks

about the history of zero and the Indian ideas of zero. This is an inscription on a temple in Gwalior, India. What is most surprising about this is that the numbers are very similar to the same numbers we use today. This site also provided me with numerous pictures of the inscription which I considered putting on my website.

Ayoub, Ayoub B. "*Generalizations of Ptolemy and Brahmagupta Theorems.*" Mathematics and Computer Education, vol. 41, no. 1, 2007, pp. 30–36. https://eric.ed.gov/?id=EJ769623

This site raised a lot of questions. The site mainly talks about two mathematicians, Ptolemy and Brahmagupta and the generalization of their theorems. What I learned from this site was that Brahmagupta's formula for the area of a cyclic quadrilateral was described as remarkable. I wonder why. Was it because it was a work of genius? Or was it important? If it mattered about the importance, wouldn't Brahmagupta's work on zero be more important?

BBC -Ward, Mariellen. *India's Impressive Concept about Nothing*. http://www.bbc.com/travel/story/20180807-how-india-gave-us-the-zero Accessed 12 Mar. 2020.

This was a great website which has provided me with pictures, information, and quotes. I have paraphrased some of the ideas and information from this website and have used it on my website. This article talks about the history of zero. Some of my information in my website has been paraphrased from the ideas of this website. A very important thing that I had learned from this website was that major IT hubs all around the world would not have been possible without zero and binary code. All of our computers and electronic devices would not have been possible without India's invention of nothing.

Brahmagupta (598-670). *Saint Andrews University, Scotland* http://mathshistory.st-andrews.ac.uk/Biographies/Brahmagupta.html.

Accessed 22 Nov. 2019.

This website gave me great information about Brahmagupta's main book, the Brahmasphutasiddhanta. I have used some of the ideas and information from this website and have used them on my website. This site overall talks about Brahmagupta's books. I also found out that there was a possibility that he could've gotten the estimation of the solar year from Aryabhata. He also gave rules for summing series. It talks about the mathematicians Aryabhata and Brahmagupta and talks about how Aryabhata used the number but Brahmagupta actually treated the numeral zero as a number and developed rules for the numeral zero. One of his rules stating that zero divided by zero is incorrect. This site also gave me great quotes which I have used on my website.

"Brahmagupta | Indian Astronomer." *Britannica*, https://www.britannica.com/biography/Brahmagupta. Accessed 19 Feb. 2020.

This website talks about Brahmagupta's life and some of his accomplishments. This site was useful to me as it talked a lot about Brahmagupta's accomplishments as an astronomer and not just a mathematician. Some things that I learned were that Brahmagupta's work on astronomy had a direct influence on later Islamic and Byzantine astronomy. The most important thing that I learned on this site was that Brahmagupta often criticized mathematicians from other religions and was heavily influenced by his Hindu religious views.

Canadian Museum of History-Civilization.ca - Mystery of the Maya - Mathematics. https://www.historymuseum.ca/cmc/exhibitions/civil/maya/mmc05eng.html*. Accessed 27 Mar. 2020.*

This was a very useful website which I used for information and pictures. This website was especially useful in my "Zero in the Americas" section. I found a picture of the

Mayan counting system which I have used on my website. I have also used some of the ideas and information on this website and have paraphrased those ideas and information onto my website. This was overall a good website which provided me with good information about the Mayan's counting system and a good picture.

CSS Rounded Corners. https://www.w3schools.com/css/css3_borders.asp. Accessed 17 Mar. 2020.

This site was useful to me as it provided me code so I could make certain boxes on my website have rounded corners. I used the CSS code which I got from this website on my website to create rounded corners on boxes.

Class Blog for Math 3010- fall 2014, *University of Utah*. "Counting Rods https://3010tangents.wordpress.com/tag/counting-rods - Accessed 1 Jan. 2020

This site provided me with lots of information about ancient Chinese mathematics and furthermore gave me information about the Chinese-Rod Numeral System. I have used some of the information from this site and have paraphrased the information onto my "East Asia: Where Zero Became A Number" section of my website. Some things I've learned from this website was that like the Indian system, the Chinese-Rod Numeral System uses the base ten numeral system. In around 200 BCE, they used something called "rod numerals". The counting system included 9 more digits and to represent zero they just used a blank space. In the Chinese Rod Numeral system, it contained a decimal system. It also allowed them to use fractions, where they had one number on top of the other, just like we do today.

Dola RC - Ancient History Encyclopedia. https://www.ancient.eu/user/dolaraic/. Accessed 24 Mar. 2020.

This article was a great reference which provided me with lots of facts. I have used some of the ideas and a quote from the author on my website. This article mainly talks about the Gupta Dynasty. Brahmagupta was born in the Gupta Dynasty era so I wanted to have some information about the time period. What I had learned was that the Gupta Dynasty was a time period of great advances in arts, sciences, architecture and more. I have used a quote from the author, Dola RC on my website stating what the Gupta Dynasty overall was. Overall, this was a great source which really helped me understand the Gupta Dynasty.

Fry, Hannah. *We Couldn't Live without 'Zero' – but We Once Had To*. https://www.bbc.com/future/article/20161206-we-couldnt-live-without-zero-but-we-once-had-to. Accessed 1 Jan. 2020.

This was one of the best websites I had found on the history of zero. I have found a lot of information from this site and have paraphrased some of the information onto my website; especially in my "History of Zero" sections and my "Significance of Zero" section. This site mainly talks about the history of zero and some things that rely on zero. This site was especially useful to me as the site provided me with some quotes from the author which I have used numerous times throughout my website. Some of the things that I learned were that in 1299 in Florence, Italy, zero was banned along with all Arabic numbers. It seemed really strange to me that someone would ban numbers. They said that Arabic numbers would encourage fraud, but after I looked into more I also found out that countries in Europe were also xenophobic towards countries in the east which is another reason why they banned the numbers. It wasn't until the 15th century that zero and the other Arabic numbers were finally accepted. Calculus is a branch of math which studies continuous change. Without zero, calculus would not have been invented as

zero offered a precision with numbers that was revolutionary. We could now use decimal numbers by putting a zero or multiple zeros. For example, the number (.01) would not have been possible without zero. Our modern mathematics relies heavily on zero.

History Staff. "Who Invented the Zero?" HISTORY.com, Jan 22, 2014, https://www.history.com/news/who-invented-the-zero. Accessed 22 Nov. 2019.

This site provided me with facts about Brahmagupta as well as facts about other famous mathematicians such as Isaac Newton and Gottfried Leibniz. I further mention these two mathematicians on my website using some of the information which I have gotten from this site. This article gives some information about the history of zero. It mentions how Brahmagupta invented a placeholder for zero. I learned about the Arabic mathematician Mohammed ibn-Musa al-Khowarizmi who had learned of the numeral zero and synthesized Indian arithmetic and showed how zero could be used in algebraic equations. The invention of zero then traveled to Europe where famous mathematician Rene Descartes had used the numeral zero and along with the mathematicians Isaac Newton and Gottfried Leibniz's ideas and the invention of calculus.

"Home."- ZerOrigIndia, https://www.zerorigindia.org/. Accessed 21 Nov. 2019. (Organization)

This is the site of an organization that is looking for evidence on where zero was created and hopes to learn a better understanding of 0. What I learned from this site was that the true inventor of the number zero is not 100% known. Bramgupta was the first to treat zero as a number, but it is unknown whether he took the idea from another person or created the numeral zero himself. This shows that there is some controversy regarding who created the number zero. We also see how most scholars agree that zero was invented in India, but they are not 100% sure either. I had later undertaken an interview

with the secretary of the organization, Mr. Peter Gobets who had provided me with several sources of information to use which were valuable to me.

“How Zero Works.” HowStuffWorks, 4 May 2011, https://science.howstuffworks.com/math-concepts/zero.html.

This website talks about the history of zero. This website was useful as it gave a more in-depth talk about the idea of zero in different cultures. I had learned that the ancient Sumerians used diagonal parallel lines to denote the absence of a number. Then, thousands of years after the parallel lines were introduced in Sumer, zero as a placeholder, symbolizing nothingness, became more standardized in nearby Babylon around 300 B.C. with the advent of the abacus, which gives us our conception of numeral places that we use today.

H Rodrigues, Dakota Duffy-Brahmagupta-*Scholarly Resources for the Study of Hinduism* | Maghavidya. -March 10, 2015 http://www.mahavidya.ca/2015/03/10/brahmagupta/. Accessed 29 Nov. 2019.

This was a useful site which provided me with information on Brahmagupta’s life and his book the Brahmasphutasiddhanta. I have used a quote from the writer, Dakota Duffy on my website. Brahmagupta was influenced by his religious beliefs and opposed other viewpoints. Brahmagupta refuted Aryabhata’s idea that the earth was a spinning sphere. Brahmagupta’s main work was the Brahmasphutasiddhanta which made invaluable contributions to geometry, arithmetic, algebra, astronomy, and more. The book had a big impact in India. Since Brahmagupta was the first to do addition, subtraction, multiplication, and division with zero, Brahmagupta is credited with the discovery of zero. Unfortunately, most of Brahmagupta’s contributions to geometry were ignored as credit was often given to Europeans due to Europe's dominant attitude.

Image Hovering with CSS-w3schools.com-CSS Coding

https://www.w3schools.com/howto/howto_css_zoom_hover.asp.

Accessed 18 Mar. 2020.

This was a great site which provided me with the CSS and HTML code to make my images zoom in when someone would move their cursor over the image. This site contains the code which I used to make my images zoom in. I have used the code from this website on my website. I feel that the addition of the image zoom to my website would really help the audience.

“Illuminating India Events Programme.” *Science Museum Blog*, London

https://blog.sciencemuseum.org.uk/illuminating-india-events-programme/. Accessed 12 Feb. 2020.

This was a great website which introduced me to zero's unique history. This was one of the first websites I had found and it was a great source. The site talks about the Bakshali Manuscript and provides many useful pictures. The Bakshali Manuscript is an ancient manuscript which contains 70 leaves of birch bark. The Bakshali Manuscript shows all 10 decimal digits which included the number zero. The reason the Bakshali Manuscript is so important is that it has the earliest ever recorded use of zero as a number. This article helped me learn about the Bakshali Manuscript and its importance.

Importance of Binary Numbers in Computing - GHacks Tech News.

https://www.ghacks.net/2011/08/12/the-importance-of-binary-numbers-in-computing/.

Accessed 11 Feb. 2020.

This website was useful in my “Significance of Zero” and “The Barriers Broken” sections of my website as the site provided me with information on how zero is used in binary code and its importance. This website talks about the importance of binary code in

computing. Binary numbers consist of only two digits, 0 and 1. This seems very inefficient and simple for us humans who are used to working in base 10, but for a computer base 2, or binary, is the perfect numbering system. This is because all calculations in a computer are based on millions of transistors that are either in an on position, or an off position. So there we have it, 0 for off, and 1 for on. Before binary code, a simple processor would need an entire building of space, not just a small square just a few centimeters across, and these big computers were very low powered in comparison, perhaps only capable of a mere 70 thousand instructions per second back in the 1970's, but now, modern computers can handle trillions of instructions today. But at the end of the day, all this is done with billions of tiny switches, off and on, 0 and 1. This shows how binary code has really helped our online technology evolve.

Is Calculus Necessary?-Harvard University-

http://people.math.harvard.edu/~knill/pedagogy/use/index.html. Accessed 9 Feb. 2020. This website was useful in providing me information about calculus, which I talk about on my website. I have used some of the information from this website on my website. This website talks about why calculus is important. Calculus is extremely important and is involved in things like google earth, autonomous driving, artificial intelligence, computer games, and social networks. Calculus is essential for our survival as we need to develop and understand climate or population growth models, creating cures for diseases and mechanisms to resolve conflicts or deal with economic and financial crises. This just reaffirms how zero has led to important things. Calculus would not have been invented without zero.

Jessie Szalay- "Who Invented Zero?" LiveScience.com, September 18, 2017

https://www.livescience.com/27853-who-invented-zero.html/

Accessed 20 November 2019

This website was one of the best sites I had found on the history of zero in Europe. I have used some of the information from this site and have paraphrased some of the information onto my website. This article talks about the history of zero, where it began, where it traveled throughout history and its effect on the world. I learned that the invention of 0 is widely seen as one of the greatest innovations in human history and I agree as this forms the basis of everyday engineering and running computers to advanced calculus. Zero was independently created in numerous civilizations around the globe. For example, the Mayans developed a placeholder for zero and used it in their calendar systems. When zero traveled to Italy from Arabia, the Italian government banned the use and number zero. Imagine banning a number! But zero was still used in secret. Medieval religious leaders in Europe did not support zero, saying that the number was satanic.

J J O'Connor and E F Robertson-Brahmagupta (598-670). - *University of St. Andrews* http://www-groups.dcs.st-and.ac.uk/history/Biographies/Brahmagupta.html- Accessed 30 Nov. 2019.

This site talks mainly about Brahmagupta's books. The site also shows a lot of the rules that Brahmagupta had invented. For example, a fortune (positive number) minus zero is a fortune. What I learned from this site was some of the rules that he invented. I also found out that there was a possibility that he could've gotten the estimation of the solar year from Aryabhata. This was big because it is unsure where Brahmagupta's mathematics were derived so he could have stolen them. Some historians claim that Brahmagupta's famous formula for cyclic quadrilaterals was an error while others claim he clearly meant the rules to apply to cyclic quadrilaterals.

Katz Brigit. “Carbon Dating Reveals the History of Zero Is Older Than Previously Thought” *Smithsonian.com,* 14 August 2017, https://www.smithsonianmag.com/smart-news/dating-ancient-indian-text-gives-new-timeline-history-zero-180964896/#lwz1eq3JrmYV2gpY.99/

This was a great site which provided me some information about zeros importance. This article focused on the discovered Bakhshali manuscripts and the impact of the number zero. I learned how the invention of the number zero has led to the rise of calculus, the vacuum of the notion in quantum physics, and binary code which is the basis of the digital world we live in. The Bakshali manuscript is a mathematical text consisting of 70 pages of birch bark. What makes the Bakshali manuscripts so valuable is that when scientists had examined the manuscript, they found that the manuscript has the oldest representation of the number zero, which was first thought to be believed in a temple in Gwalior, Madhya Pradesh India.e

Math Forum- National Council of Teachers of Mathematics - NCTM http://mathforum.org/library/drmath/view/64378.html. Accessed 9 Feb. 2020.

This site answers an important question: What if there was no zero? We see how without the concept of zero, algebra would have stagnated at the stage it reached at 800 AD meaning that algebra would not have been expanded as much as it has now. There isn’t really a need for zero until you reach algebra, but once you reach algebra, you will find a need for zero and negative numbers. Without zero, algebra, calculus, and beyond would have remained too difficult to learn, apply, and build on.

Massachusetts Institute of Technology-1.2 What Is Calculus and Why Do We Study It? http://www-math.mit.edu/~djk/calculus_beginners/chapter00/section02.html. Accessed 8 Mar. 2020.

This website mainly talks about what is calculus and why calculus is important. This site was especially useful to me as I was still unsure why calculus was important. The main thing I learned from this website was that the development of calculus and its applications to physics and engineering is probably the most significant factor in the development of modern science. This development caused the Industrial Revolution and everything that followed from it.

"Ancient Text Reveals New Clues to the Origin of Zero." *National Geographic News*, 16 Sept. https://www.nationalgeographic.com/news/2017/09/origin-zero-bakhshali-manuscript-vi/ Accessed 3 March 2020:

This was a great site which provided lots of information about the Bakshali Manuscript and other old inscriptions of zero. The main thing I learned was that before the Bakshali Manuscript, the oldest representation of zero as a number at the time was found in a temple in Gwalior, India, in a temple. This knowledge was useful to me as I was not aware that there was another old inscription.

Nils-Bertil Wallin-YaleGlobal- The History of Zero | YaleGlobal Online. November 19, 2002, https://yaleglobal.yale.edu/history-zero. Accessed 22 Nov. 2019.

This website overall was very useful to me. I have used the information on my website and have paraphrased them on my website. The article mentions a good history of the numeral zero, but this article is more comprehensive. For example, the invention of the number zero led to calculus which then led to physics, engineering, and economics and finance. I found out the mathematician Rene Descartes who founded the Cartesian coordinate system made the origin of a coordinate system 0,0. We still use this concept today. I found that it was hard to make big or even simple transactions as there was no

100 you had to represent 100 with a number. That would be very confusing! This website was also helpful because I found pictures which I could use on my website.

“Nothingness: Zero, the Number They Tried to Ban.” New Scientist, Webb, Richard https://www.newscientist.com/article/mg21228390-500-nothingness-zero-the-number-they-tried-to-ban/. Accessed 10 Mar. 2020.

This article was one of the best sites for information as it talks about how the number zero was banned in Italy along with other Arabic numbers. At first I thought this was misinformation but after further research, the statement above was true as for a long time, merchants had to secretly use zero. I had also learned that medieval leaders in Europe had viewed zero as satanic as they believed that God was everything that was, and nothing was viewed as satanic. When zero was introduced in Europe, the idea was originally viewed as satanic. This was really interesting to me because I knew that zero had faced opposition in Europe, but I didn’t know that it was labeled as satanic. I used some information from this site on my website.

Numbers Is a Positive Number-San Jose State University http://www.sjsu.edu/faculty/watkins/brahmagupta.htm. Accessed 24 Nov. 2019.

This article helped me find some more information about Brahmagupta, which was what I first did as I was trying to research Brahmagupta’s accomplishments. This article mainly talks about Brahmagupta’s accomplishment of finding that the product of two negative numbers is a positive number and we still use this rule today. This article also talks about Brahmagupta’s life and provides proof of why the product of two negatives would be positive. We see that Brahmagupta did not provide proof for his answer so it is unknown where his answer was truly derived from(like a lot of his ideas) but nonetheless still impressive. It goes on to explain why the rule is correct.

“Papyrus Collection.” *Lund University Library*, 4 July 2014. Accessed 10 May 2020 https://www.ub.lu.se/en/the-papyrus-collection.

This was a great site which provided me with hundreds of Greek papyrus papers. I had used a picture of one of their pieces on my website. This was a useful source because it provided me with lots of pictures which I could use.

Positive Side of Zero (U.S. National Park Service). https://www.nps.gov/articles/the-positive-side-of-zero.htm. Accessed 9 Feb. 2020.

This site talks about the history of zero, and how zero is used in data collection and citizen science monitoring. Zero was first introduced to the Western mathematics with the Italian mathematician Fibonacci brought zero back from a trip to Northern Africa. Many other cultures continued to resist the idea of zero for centuries because of superstitions and the dark magic that surrounded it.

Resnick, Brian- “The Mind-Bendy Weirdness of the Number Zero, Explained.” Vox, 5 July 2018, https://www.vox.com/science-and-health/2018/7/5/17500782/zero-number-math-explained

This was a great site which provided me with information on why zero is important and we cannot live without it. I have used some of the information from this site, and have paraphrased it onto my website. This site talks about the effect of zero, what is zero, what is zero’s use, and how zero is so important. The main thing I learned on this website was how zero led to the invention of calculus and our electronic technology. Binary code is based off of 1s and 0s. Without zero, we would have no online technology. Furthermore the important mathematical idea of calculus relies heavily on zero. Without zero, Sir Isaac Newton and Gottfried Lebniz who were the inventors of calculus, would not have had the precision to discover the revolutionary branch of math

now known as calculus. Without a doubt, we can tell that without zero, much of our modern world would literally fall apart. I used this saying on my website.

"Resisting a New Concept: The Discovery of Zero." *BBC Science Focus Magazine*, https://www.sciencefocus.com/science/resisting-a-new-concept-the-discovery-of-zero/. Accessed 16 Feb. 2020.

This article talks about the history of zero and some of its uses. Since civilizations such as the ancient Egyptians and the Romans used a counting system, they didn't need to use zero as they could describe large numbers. But if the civilization had used a place value system, you would find the need for a symbol to represent large numbers. This was one of the reasons that different civilizations around the world used a symbol or placeholder to determine an absence of a number.

Special Numbers-*Wichita State University*- Accessed 19 Feb 2020 http://www.math.wichita.edu/history/Topics/snumbers.html#zero.

This site was useful in providing me information about zero in the Middle East and its use in Europe. I have used some information from this site and have paraphrased some of the ideas. Another reason why zero was originally not accepted into Europe was that people were used to Roman Numerals and did not want to learn another way. It took time but eventually Arabic Numerals were used on coins and were frequently used in Europe.

Stetson University, Deland, Florida- Brahmagupta- https://www2.stetson.edu/~efriedma/periodictable/html/Pb.html. Accessed 19 Feb. 2020.

This site talks about Brahmagupta's life, his accomplishments, and provides some rules which Brahmagupta had created. This website was useful as it gave me information which I used on my website. For example, on this website I learned that at the time of

Brahmagupta, Ujjain India, was the foremost mathematical center in India at the time which I did not know. I had also learned that Brahmagupta's main work, the Brahmasphutasiddhanta, is made up of two parts. The first 10 chapters are his first version when the last 15 chapters are his second version. He created the Brahmasphutasiddhanta by combining the two.

Syamal K. Sen, Ravi P. Agarwal.- "*Brahmagupta - an Overview"* | *ScienceDirect Topics*. https://www.sciencedirect.com/topics/mathematics/brahmagupta. Accessed 21 Nov. 2019

This article talks about Brahmagupta and some other prominent Indian mathematicians. The most valuable thing on this site for me was the list of all the ancient documents which reference zero. For example, the 94 CE. Sankheda charter on copper contains the numeral zero. We see how the Indian mathematician Bhaskara II credited Brahmagupta and other prominent Indian mathematicians for their algebraical work.

*Uni*versity of Baltimore- http://home.ubalt.edu/ntsbarsh/zero/ZERO.HTM. Accessed 28 Mar. 2020.

This was an amazing source which provided me with over 30 pages of knowledge of number systems and zero. The pages were full with information and quotes which I have used on my website. I have used the information from this website and have paraphrased some of the information on my website. I had also found out some more information about the importance of numbers and some information about zero.

University of Toronto Canada- Question Corner -- Why You Can't Divide Nine By Zero. https://www.math.toronto.edu/mathnet/questionCorner/nineoverzero.html. Accessed 28 Mar. 2020.

This website was useful in learning why we cannot divide zero by zero. I had received this question multiple times from people and I still struggled to answer the question even when researching this topic multiple times. This website from the University of Toronto helped me understand why zero can not be divided zero completely. The reason why zero cannot be divided by zero is that there is no way to define the answer in any reasonable or consistent manner.

Utah University-Why Can't We Divide by Zero?- https://www.math.utah.edu/~pa/math/0by0.html. Accessed 8Mar. 2020.

This website is from the University of Utah and talks about why we cannot divide by zero. This website was extremely important as I never knew why we cannot divide by zero. The reason we cannot divide by zero is that you run into contradictions whenever we try to divide by zero. To simplify, we label zero divided by zero as undefined.

"What Is the Origin of Zero? How Did We Indicate Nothingness Before Zero?" Scientific American, https://www.scientificamerican.com/article/what-is-the-origin-of-zer/. Accessed 9 Feb. 2020.

This site provided me information about the beginnings of zero. I have used some of the information from this site onto my website. This site talks about the origin of zero. The first evidence we have of zero is in the Sumerian culture in Mesopotamia about 5,000 years ago. Then, it made its way to Babylon and then to India. Arab merchants brought the zero with them and then gave it to the West. After many adventures and much opposition, the symbol we use was accepted and the concept flourished, as zero took on much more than a positional meaning. Since then, it has played a vital role in mathematizing the world.

“Why Zero Is So Ridiculously Important.” IFLScience, https://www.iflscience.com/editors-blog/what-zero-and-why-it-so-important/. Accessed 7 Feb. 2020.

This site explains zero and how it’s important. It was only until the 7th century that zero was explicitly called a number. This was because mathematicians in Europe had originally dismissed the idea. As human thought progressed, mathematics became more of an abstract process. This is where zero came in and it was found to be an extremely useful tool. At the time, zero was only used to denote the absence of a number but when mathematicians looked into this, they discovered zero’s usefulness.

Words from Arabic - Word Origins - Word Lover’s Blog - *Collins Dictionary*. https://www.collinsdictionary.com/word-lovers-blog/word-origins/words-from-arabic,8,HCB.html. Accessed 22 May 2020.

This site provided me with a picture and information on “sifr”, the Arabic symbol for zero. I have used some of the information from this site and have paraphrased the info. What I learned was that to represent the symbol, mathematicians used a little diamond and called it sifr. Overall, this site was useful as the site also provided me with a picture.

“Zig-Zagging History Of The Number Zero.” *NPR.Org*, https://www.npr.org/2015/01/03/374737120/the-zig-zagging-history-of-the-number-zero. Accessed 20 Feb 2020.

This was a good source which provided some information about the controversy of zero. This site has a transcript of an interview which was between an author who wrote on zero and an NPR host. The controversy was that some historians believed that zero did not come from India and had in fact come from the West. Other mathematicians believed the opposite. It took many years but there is now lots of evidence pertaining to the notion

of zero being invented in India. This was an interesting site which provided me with information that I had not thought about.