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Mary Everest Boole was a revelation in mathematics during the early to mid 19th century. Although she is not as well known as certain mathematicians, like Euler or the Bernoulli brothers, she has been a driving force in many mathematical concepts, including contemporary mathematics to date. As a woman in the mathematics field myself, she serves as an inspiration to me, as well as stood as a prominent figure for many feminists during her time. She made groundbreaking discoveries, such as string art and curve-stitching, which were and still are used to help children understand geometry more concretely (this will be discussed in detail later on), as well as contributed largely to the teaching of mathematics to children. This paper seeks to serve as a tribute to Mary's life and her contributions to the great language of mathematics.

Mary Everest Boole was born in the year 1832 (the exact date is unknown) in the small village of Wickwar, located in South Gloucestershire, England. Mary's uncle was the famous geographer George Everest, of which – although he highly opposed – the famous Mount Everest was named after. She lived in France for the first 11 years of her life, after which she returned to England where she continued out the rest of her life. In the beginning quarter of her life, she discovered her love for mathematics after being taught by a private tutor of the name Monsieur Deplace, in France. Mary's remaining years of learning mathematics was largely self-taught. Subsequently, she ended up marrying another self-taught mathematician George Boole, who aided in her self-discovery and affinity of mathematics.

At the age of 32, Mary's husband and father of their 5 daughters passed away in Cork, Ireland. After her husband's death, she was offered a librarian position at Queen's College in London, the same college her husband once taught mathematics at in Cork. In addition to her position at Queen's College in London, she took interest in tutoring mathematics to students and people of all ages. It was at this point in her life where she truly stumbled upon what her legacy is known as today. In her years of tutoring, she developed the idea of using materials in conjunction with physical activity to encourage a more creative and thorough understanding of mathematical concepts.

As previously mentioned, Mary was an unprecedented individual during her time. She was breaking down barriers that women, and certain men in her field, didn't dare attempt. Upon marrying her husband, who again was a professor of mathematics at Queen's college, she began to contribute to the mathematics industry by advising him in his teaching techniques and attending his classes. Mary's colleague Victoria Welby, another iconic female mathematician, and herself, began to brainstorm ideas that ranged from the pedagogy in teaching mathematics all the way to religious theories revolving around science. At this time, Mary furthered her contributions to the education world.

Mary's remarkable methods in teaching mathematics began to flourish during the time she spent tutoring students. By using natural-made objects like stones and sticks she theorized that using physical manipulations would strengthen the unconscious understanding of materials learned in a classroom setting[1]. Her most prominent contribution to the teaching of mathematics was the concept of curve stitching, otherwise known as string art, as well as the usage of "sewing cards". The combination of mixing learning and amusing games, Mary found, was an encouraging factor to the

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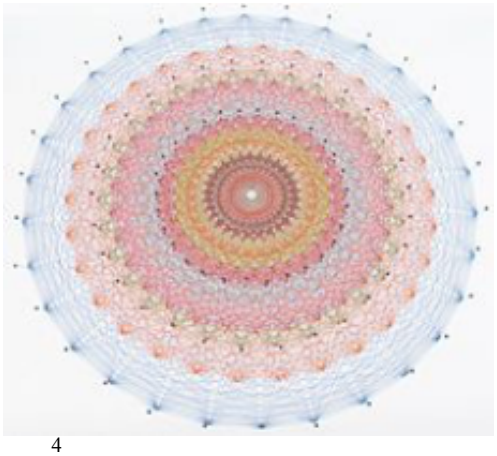
[1] "Mary Everest Boole." *Wikipedia*. Wikimedia Foundation, 8 Mar. 2017. Web. 26 Apr. 2017.

understanding and conceptualizing of somewhat difficult-to-grasp mathematical notions. In addition to her addition of sewing cards and curve stitching to the math world, she also wrote many books meant to explain the logic of math to children, as well as various pedagogies towards teaching.

Mary's contribution of curve-stitching, otherwise known as string art or pin and thread art, is characterized by an arrangement of colored thread strung between points to form geometric patterns or representational designs such as ship's sails, sometimes with other artist material comprising the remainder of the work[2]. Some of the common materials that are used to wind around a grid of nails are wire, string, or thread - although any kinds of material is acceptable as long as it's malleable. The slightly different angles and metric positions at which the strings intersect are meant to give the perception of Bézier curves – used in computer graphics programs– more commonly known as the mathematical concept of the envelope of a family of straight lines[3]. Again, Mary had intentionally created string art to aid in the understanding of confusing geometrical concepts, but it became popularized throughout the 1960's as a decorative craft. The picture featured below on the left is a computerized sample of string art, and the picture on the right is, more or less, how Mary had envisioned string art.



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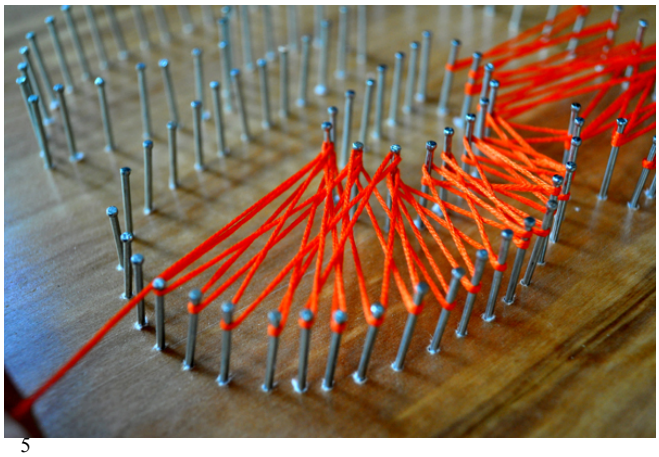

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One of Mary's greatest contributions to the world of mathematics was her book *Philosophy and Fun of Algebra*. This book was written to educate children and aid in the introduction of the complexities of algebra and the depths of logic. In order to describe algebra, Mary talks about a story of how a little girl told her an evening hymn, of which people were fighting over some issue that in reality they did not know the answer to. Mary goes to explain that once these people begin to deal logically with their ignorance on the issue, this method of solving problems by honest confession of one's own ignorance is called Algebra[6]. By using anecdotal language and humorous analogies, Mary is able to translate typically hard-to-understand algebraic concepts, into simple,

[2] "String art." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2017. Web. 26 Apr. 2017.
[3] "String art." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2017. Web. 26 Apr. 2017.
[4] "String art." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2017. Web. 26 Apr. 2017.
[5] "String art." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2017. Web. 26 Apr. 2017.
[6] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 2. London: C.W. Daniel, 1909. Print.

elementary language. In order to really grasp just how elegant and pragmatic Mary is, I have picked out some of my favorite segments from this book.

Mary starts off this book with a chapter titled "The Making of Algebras". Much of the foundation of this book is based off of "Hebrew Algebra", as Mary calls it. However, before Mary dives right into Hebrew Algebra, she makes a few things clear about how to "make an Algebra". Mary describes,

> "We make an Algebra whenever we arrange facts that we know round a centre which is a statement of what it is that we want to know and do not know; and then proceed to deal logically with all the statements, including the statement of our own ignorance. Algebra can be made about anything which any human being wants to know about. Everybody ought to be able to make Algebras; and the sooner we begin the better. It is best to begin before we can talk; because, until we can talk, no one can get us into illogical habits; and it is advisable that good logic should get the start of bad."[7]

Perhaps my favorite example Mary uses to portray what she means by "making an algebra", involves a baby, a tea-pot, and a somewhat dangerous situation. Furthermore, the story Mary describes follows:

> "Sometimes a baby, when it sees a bright metal tea-pot, laughs and crows and wants to play with the baby reflected in the metal. It has learned, by what is called "empirical experience," that tea-pots are nice cool things to handle. Another baby, when it sees a bright tea-pot, turns its head away and screams, and will not be pacified while the tea-pot is near. It has learned, by empirical experience, that tea-pots are nasty boiling hot things which burn one's fingers. Now you will observe that both these babies have learnt by experience. Some people say that experience is the mother of Wisdom; but you see that both babies cannot be right; and, as a matter of fact, both are wrong. If they could talk, they might argue and quarrel for years; and vote; and write in the newspapers; and waste their own time and other people's money; each trying to prove he was right. But there is no wisdom to be got in that way. What a wise baby knows is that he cannot tell, by the mere look of a tea-pot, whether it is hot or cold. The fact that is most prominent in his mind when he sees a tea-pot is the fact that he does not know whether it is hot or cold. He puts that fact along with the other fact:— that he would very much like to play with the picture in the tea-pot supposing it would not burn his fingers; and he deals logically with both these facts; and comes to the wise conclusion that it would be best to go very cautiously and find out whether the tea-pot is hot, by putting his fingers near, but not too near. That baby has begun his mathematical studies; and begun them at the right end. He has made an Algebra for himself."[8]

Mary breaks down the logistics behind algebra in a way that comes across almost humorous to children, but most of all, understandable. Mary emphasizes the importance of imagination in Algebra, even going on to say that using your imagination in the right way will lead to the correct construction of algebra - which present day seems almost odd, since Algebra is so concrete. She then goes on to give a little bit more background on "Hebrew Algebra" – the first Hebrew algebra being called Mosaism, from the name of Moses the Liberator[9] – and how the word "angels" come into play in Algebra. Furthermore, she goes on to say:

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[7] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 4. London: C.W. Daniel, 1909. Print.
[8] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 5. London: C.W. Daniel, 1909. Print.
[9] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 12. London: C.W. Daniel, 1909. Print..

> "The Hebrews called these sensations by a Hebrew word which is translated by the English word "angel," from the Greek "angelos," a messenger. The Hebrews were quite right. The sensations are messengers from the Great Unknown. They bring no information about outside facts…. They [angels] guide us how to frame our *next provisional working hypothesis*, how to choose the particular hypothesis which at our present stage of knowledge and development will be most illuminating for us."[10]

Further in the book, after Mary lays the foundation of how the Hebrews and imagination are vital in learning Algebra, she talks about using sewing cards - which again has been one of the most remembered concepts of her legacy. Mary says that the use of the single sewing cards is to provide children in the kindergarten with the means of finding out the exact nature of the relation between one dimension and two[11]. Again, Mary stresses the importance of understanding math by the use of visual aids, in order to really grasp the confusing concepts. The visualization Mary is aiming towards is as follows:

> "There is another set of sewing cards which is made by laying two cards side by side on the table and pasting a tape over the crack between them. This tape forms a hinge. You can lay one card flat and stand the other edgeways upright, and lace patterns between them from one to the other. The use of this part of the method is to provide girls in the higher forms with a means of learning the relation between two dimensions and three…The use of the books which are signed George Boole or Mary Everest Boole is to provide reasonable people, who have learned the logic of algebra conscientiously, with a means of teaching themselves the relations between n dimensions and n + 1 dimensions, whatever number n may be."[12]

The end of *Philosophy of Fun and Algebra,* deals with concepts in math that have stumped mathematicians for decades. Mary touches on the square root of negative one and infinity, but manages to turn each concept into an amusing story for children. The "square root of minus one", as Mary calls it, is a story of a man at Cambridge who was expected to be Senior Wrangler; but he got thinking about the square root of minus one as if it were a reality, till he lost his sleep and dreamed that he was the square root of minus one and could not extract himself; and he became so ill that he could not go to his examination at all.[13] The story ends with the "angels" and square roots of negative quantities having no existence in three dimensions, and these nonexistent entities are the messengers from the "As-Yet-Unknown", so when the square root of minus one comes around, we (much like the man at Cambridge) must behave reasonably and treat this number logically. Similarly, infinity also comes from that land of the "As-Yet-Unknown" and this particular "angel" (infinity) always comes with a message about a broken link or a loosened chain; it comes, when an hypothesis has been fully worked out, to tell you that you are now free from the bonds of that hypothesis and at liberty to start experimenting on a fresh one[14].

This book was just one of many of Mary's contributions to the education world. Some of Mary's other books include *The Preparation of the Child for Science* (1904), *Symbolic Methods of Study* (1884), *The Message of Psychic Science to the World* (1908),

[10] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 16. London: C.W. Daniel, 1909. Print.
[11] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 21. London: C.W. Daniel, 1909. Print.
[12] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 21. London: C.W. Daniel, 1909. Print.
[13] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 33. London: C.W. Daniel, 1909. Print.
[14] Boole, Mary Everest. *Philosophy & Fun of Algebra*. Page 34. London: C.W. Daniel, 1909. Print.

and *The Forging of Passion Into Power* (1911). Each book tackles its own concept in math or science, but still follows the same anecdotal, light, and easy-to-understand language Mary is notoriously known for. These books, along with Mary's strong belief in cooperative learning, resulted in fun and successful learning of mathematics by children all over the world.

Mary was a spiritualist, a strong believer in the afterlife, and practiced the homeopathic medicine. She grew fond of parapsychology (the field of study concerned with the investigation of paranormal and psychic phenomena which include telepathy, precognition, etc.[15]) and was the first female member of the Society for Psychical Research, which she joined in 1882[16]. Some of the five daughters Mary had with her husband followed in her path of being a groundbreaking woman in traditionally male-oriented fields. Mary passed away in 1916, for unknown reasons, but before doing so, left a significant mark on the mathematics world and forever changed the way in which mathematics has been taught to children.

[15] "Parapsychology." *Wikipedia*. Wikimedia Foundation, 26 Apr. 2017. Web. 26 Apr. 2017.
[16] "Mary Everest Boole." *Wikipedia*. Wikimedia Foundation, 8 Mar. 2017. Web. 26 Apr. 2017.

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Citations

1. Boole, Mary Everest. *Philosophy & Fun of Algebra*. London: C.W. Daniel, 1909. Print.

2. "Mary Everest Boole." *Wikipedia*. Wikimedia Foundation, 8 Mar. 2017. Web. 26 Apr. 2017.

3. Oakley , Patricia . "Philosophy and Fun of Algebra ." *LibriVox* . N.p., 14 July 2006. Web. 26 Apr. 2017.

4. "Parapsychology." *Wikipedia*. Wikimedia Foundation, 26 Apr. 2017. Web. 26 Apr. 2017.

5. "String art." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2017. Web. 26 Apr. 2017.