BOOLE, BÉZIER, AND BEAUTY

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Ontario's newest destreamed Grade 9 Mathematics course encourages students to view mathematics from a variety of perspectives. Active learning and inquiry can help students to see the beauty of mathematics from a diversity of perspectives for all learners. Approximating curves by using lines and line segments is fundamental to the understanding of Calculus, yet younger students can explore this concept through perspectives with both historical contexts and modern applications.

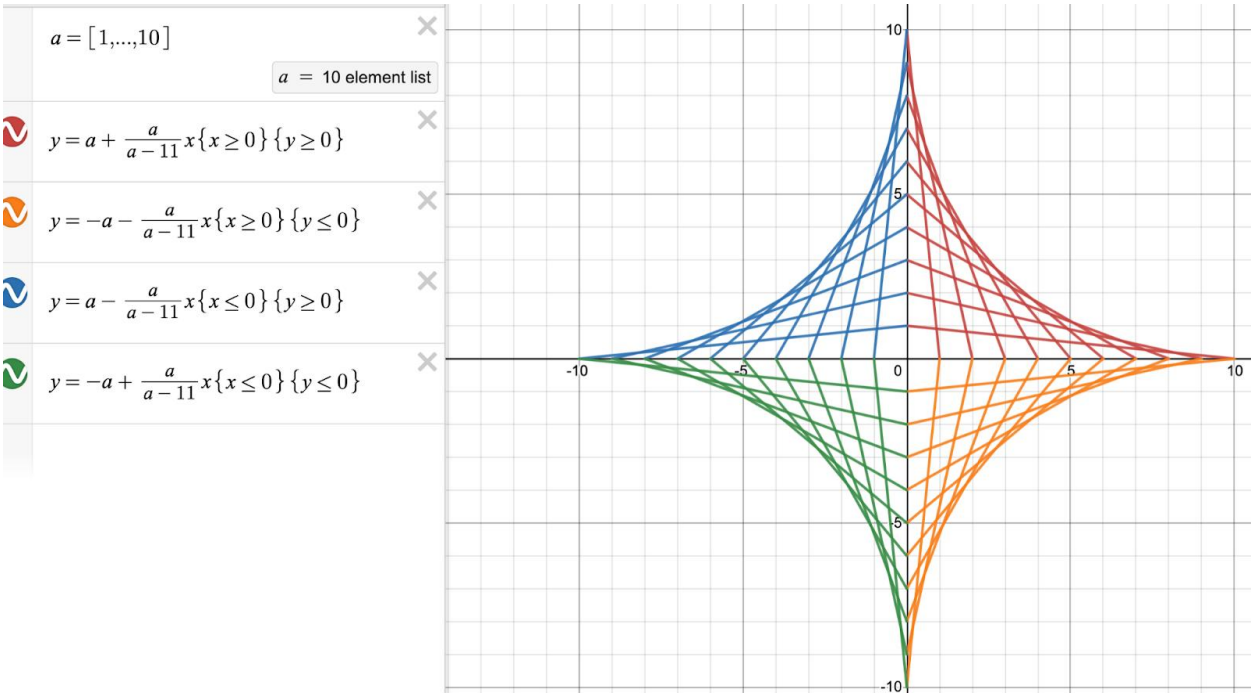
This abstract demonstrates how students from grade 6-12 can first actively build curve approximations with lines, following Mary Everest Boole's sewing cards approach. Using technology, they then extend this to incorporate introductory algebra. Applications include coronal loops, the Zambian Ba-ila settlements, architecture, and computer graphics.

Curve Stitching formally originated with Mary Everest Boole as an elementary application of mathematics for younger children, to create curves with line segments using string and cards. Mary Everest Boole was the wife of the founder of Boolean Algebra, George Boole, and niece of Mount Everest namesake George Everest. She introduced a playful approach to mathematics as a teacher, mother, and librarian (Frost, 2019). As an educator, she incorporated sticks, stones and other natural materials, what we now would call manipulatives, to help students understand mathematical concepts. As a self-taught mathematician, she believed that mathematical thinking arose from interaction with the beautiful natural world.

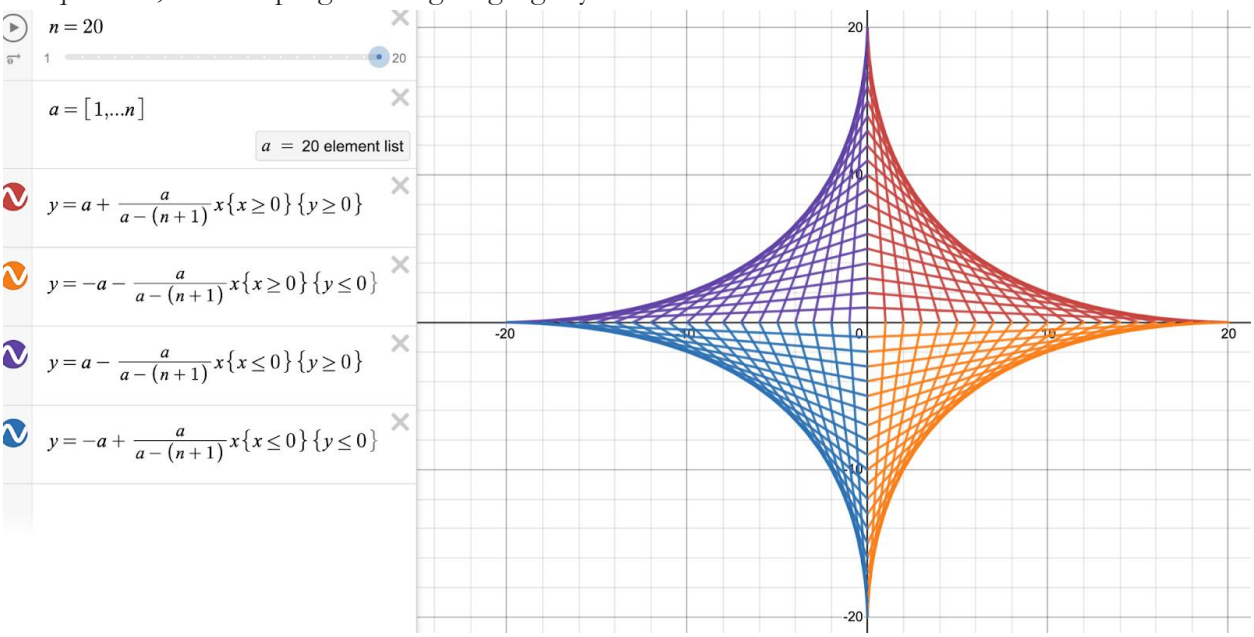
Even though she wrote her educational philosophy in the early 1900s, modern classrooms today still reflect her pedagogical theories. As early as 1904, she proposed cooperative learning and suggested that students create their own formulas and algorithms. Akin to our current understanding of Social Emotional Learning, she sought to reduce "nerve storms" for young children during calculations with discovery, emphasizing beauty and patterning (Valente, 2010). Discovery hands-on lessons, inquiry, and active learning help today's students develop their Social Emotional Learning, reduce their math anxiety, and empower them to think critically and creatively with mathematics.

Students first can use tacks, cardboard, and string, to create a curved shape using straight lines (Poole, 2012). Translating that to graph paper, they slide a right triangle within the first quadrant's axes: creating a line segment joining (0, 10) to (1, 0), then (0, 9) to (2, 0) and so on. Students can use lists on Desmos to generate similar images, implementing changing restrictions and altering signs in

the linear equations and slopes.

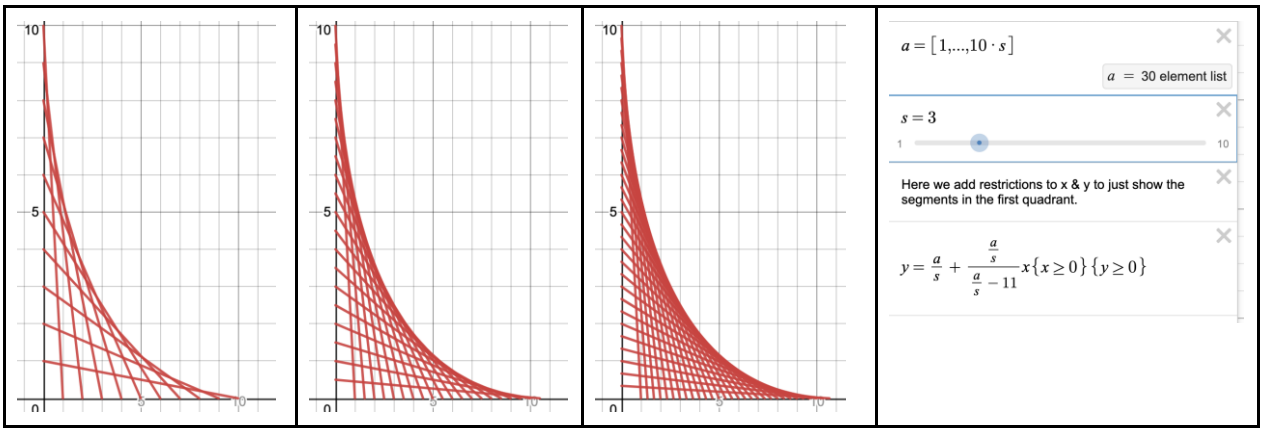


Students draw conclusions about why the coordinate points are where they are, and how changing the slopes and equations can make the curve larger or smaller. By considering how to reflect and rotate the lines, students create a more expansive design. Lists in Desmos provide an alternative to formal programming by demonstrating repeated equations, in an array-like structure within a series of equations, without programming language syntax.



As the next step, students use sliders to explore how subdividing those exterior lines creates a smoother curve. Once they see the changing image by increasing the subdivided sections, learners are curious to adapt their own pre-calculus thinking. Children's unique perspectives also incorporate

abstract art design principles to create their own pieces. Students noted that this helped them to understand the symmetry and more fully explain the algebra of their linear equations while motivating them to explore the beauty of mathematics.



Students explore and model similar examples of curves using straight line segments in design architecture, coronal loops on the sun, and cardioids in the shadows of a coffee cup. French engineer Pierre Bézier actually did not create his namesake curve, but rather developed the consistent notation for it and popularized it in the 1960s for use with Renault automobiles. Bézier curves, simply explained, are smooth curves created with many control points (Davies, 2010, Kamerman, 2022). The Jerusalem Chord Bridge represents a parabolic shape three-dimensionally with a Bezier curve (Gross, 2012). TrueType fonts use quadratic Bézier curves to create letters' smooth curves while SVG graphics use cubic Bézier curves to create smooth shapes. Existing Scratch blocks can also be adjusted for curve stitching and Bézier curves for animation.

Students are fascinated that the mathematical learning that originated for them with cards and string can also model the curves of a car or a bridge or a font or a coronal loop. Integrating high-impact strategies such as activity-based, problem-based, and project-based learning for students has demonstrated how beauty and creativity can cluster expectations while cultivating links between multiple mathematical learning strands.

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