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Storied Numbers
A Review of Alex Bellos's *Grapes of Math: How Life Reflects Numbers and Numbers Reflect Life*

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Bellos's (2010) *Grapes of Math* is not a book about the history of mathematics, although he includes maths histories. It is not a math textbook, although he leads the reader through a variety of mathematical concepts. It does not follow the life of a great mathematician, scientist, or philosopher, although they make their presence known throughout the book. Rather, *Grapes of Math* it lies at the intersection of these concepts. It is a book of stories, stories of mathematical ideas and the cultures that informed their development. And Bellos is a gifted storyteller.

Situating the Review

Before I delve into my review, it would be of benefit to know my perspective as a reader. I am a mathematics educator and a teacher educator. I have taught at high schools, community colleges, and universities for over a decade, primarily students who do not like math. More recently, I am a faculty member in a secondary teacher preparation program in the United States, where I teach future high school mathematics teachers. And I have a deep appreciation for stories.

Humans use stories to understand the meanings of social acts, of the cultures within which we interact, and of the positioning in our interactions (Harré, 2012). We use stories to understand ourselves, who we are (McAdams, 1985, 2008, 2013) and who we are not (Nelson, 2001). For teachers of mathematics, stories are a pedagogical tool, to challenge students' beliefs about mathematics and their identities as doers of mathematics (Zavala & Hand, 2017). They can be used to embed mathematics in students' lives and their cultures (Gonzales, Andrade, Civil, & Moll, 2001). Finally, stories have a place in teacher

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education (Drake, 2006). This perspective meant that when I began *Grapes of Math*, I did so by settling into a comfortable chair, in front of the fireplace, with a coffee beside me, eager for a good story.

Storied Mathematics

The premise of *Grapes of Math* is straightforward. In each chapter, Bellos tells a story about a mathematical concept or idea. While the focus is on the mathematics, Bellos invokes traditional storytelling techniques to lead the reader down the rabbit hole of ten distinct stories. Each story draws on cultures and history for depth. In Chapter one, Bellos explores the stories of numbers: the mysticism associated with the number one or the number ten; the meanings and emotions attributed to them such as gender, excitability, likability, or lightness. In Chapter two, he explores the frequency of numbers through stories of fraud and wealth inequity, through stories of creationism and of Joyce's love of the word 'I'. He fills each chapter with protagonists and antagonists. In Chapter three, the reader measures the height of the pyramid at Giza with Thales, and the reader embarks on the triangulation of France with Abbé Jean Picard. In Chapter five, the reader is confronted by the hegemony of π and is called to join the revolution, led by τ. Bellos fills each chapter with a deep and beautiful context for his stories, the world of mathematics. Such contexts extend from Benford's Law (Chapter two) to exponential growth (Chapter six) to calculus (see Chapter eight). His stories invite the reader to explore each mathematical landscape alongside mathematicians of old and new. Last, Bellos's use of mathematical images and tables, what mathematics educators call representations, draw the reader into his stories through a shared vision and imagination. They range from representations of more accessible topics like the Game of Life (Chapter ten) to literally imagined numbers (Chapter eight).

Bellos's invitation to each mathematical landscape is, perhaps, the greatest accomplishment of *Grapes of Math*. It is accessible and not in a simplistic sense. His writing and stories speak to a subtle form of scaffolding (Vygotsky, 1978). In each chapter, a mathematical concept is introduced at a preliminary level, and in each chapter, the

concept unfolds and develops. There are concepts I taught in high school. For example, my pre-calculus students, like Galileo and the Marquis Guidobaldo del Monte (pp. 90-91), dipped a ball in paint and rolled it along an inclined plane to explore parabolic motion and curves. Others are more complicated, but Bellos guides the reader through each. Indeed, Bellos models how to take a seemingly simple mathematical concept and make it more challenging, and similarly, how to take a seemingly challenging mathematical concept and make it accessible. In other words, Bellos manipulates the cognitive demand (Stein, Grover, & Henningsen, 1996) for the reader. He does this, I assume, because the target audience is not mathematicians. He invites more casual knowers and doers of mathematics, including those who dislike mathematics or view themselves as 'bad at math', to embark on series of mathematical adventures. While an analysis can be extended to every chapter, I focus on Chapter 7 for this review: The Positive Power of Negative Thinking.

Bellos begins the chapter by discussing negative numbers through practical and historical examples. Negative numbers are an abstract concept for much of mathematics' history. Indeed, Bellos points to 1685, to John Wallis and his "powerful visual interpretation" (p. 172), the number line, before people began having less conceptual difficulties imagining negative values. But even the number line falls short of providing a visual representation of the multiplication of two negative numbers. His discussion serves two purposes. First, it speaks directly against the anxiety many face when learning (and relearning) negative numbers. Second, as I mentioned previously, it scaffolds later, more complex mathematical concepts. He transitions to discussing the exploration of the equation $x^2 = -1$, imaginary numbers, and eventually, Euler's identity, $e^{\pi i} + 1 = 0$. In his story of negative numbers, Bellos lays out a progression of concepts related to negative numbers, from early point of entry, the number line, to significantly more complex concepts like "the most celebrated equation in mathematics" (p. 179), Euler's identity. In education theory, such a progression of "successively more sophisticated ways of thinking about a topic that can follow and build on one another" (National Research Council, 2007, p. 211) is known as a learning trajectory, or in the case of *Grapes of Math*, a storied trajectory.

Bellos does not end with Euler's identity in Chapter seven. He continues to weave in progressively more contemporary mathematics as he explores concepts around negative numbers, eventually introducing iterations, the repetition of an operation, to explore the prisoner set and escapee set of any iteration on the complex plane. As the end of his story nears, the reader is taken to the desk of a mathematician at IBM in 1979. The computer printouts on his desk contained splotches of ink, not printer mistakes but the prisoner set for $z \to z^2 + c$. The desk belonged to Benoit B. Mandelbrot, and the splotches were of the Mandelbrot set, a fractal. Bellos includes a series of striking images of the Seahorse Valley, "the name given to the area between the head and the body of the Mandelbrot set" (p. 198), and he briefly discusses several mathematical stories that the Mandelbrot set informed, currently unfolding with contemporary mathematicians and adventurers. In this, the chapters have a fuzzy ending, a "To Be Continued" of sorts, as the reader is reminded that Bellos's stories are about fields of mathematics that are still evolving.

The Pedagogical Lessons in Stories

I read *Grapes of Math* while I was teaching a mathematics education seminar course, a gateway course that assesses the content knowledge of prospective teachers in their final year of certification before they become high school mathematics teachers. The prospective teachers are concurrently in placements, teaching high school students for the first time under the supervision of a mentor teacher. In other words, it is the semester where they are confronted with the realities of teaching, from lesson plans to classroom management to teaching observations. It was the perfect time to read *Grapes of Math* because I saw in it a number of lessons that would benefit teachers. In other words, Bellos's emphasis on accessibility shifts *Grapes of Math* to become not just a series of stories about mathematics but also a primer for teaching mathematics.

Bellos weaves into his stories the rich history and culture of mathematics, and he brings to life mathematical concepts students sometimes struggle to engage or understand. In this, he shows that mathematics can be fun, engaging, and accessible. Bellos offers prospective and in-service teachers various trajectories of mathematics concepts across

the chapters, illuminating the relationships between simple and more complex concepts. In this, he shows how learning trajectories inform standards-based mathematics curriculums. He offers readers multiple points of entry depending on their prior knowledge of mathematics, modeling the power of scaffolding (Vygotsky, 1978) as he supports the reader's travels through his stories. In short, he shows teachers the power of well-designed, cognitively demanding tasks and problems. As important, Bellos illuminates the interconnectedness of mathematics, troubling the discrete view of mathematics reified by mathematics curriculum in K-12 education. In other words, I see in *Grapes of Math* a variety of resources for teachers of mathematics.

Do I Recommend *Grapes of Math*?

In my early years of teaching, a mentor told me that if I took away one resource from a professional development or course, it should be considered a success. *Grapes of Math* is a fantastic resource for curricular development. The concepts Bellos covers are both broad and relevant, in secondary and postsecondary classrooms. Indeed, as I was reading *Grapes of Math*, I found myself incorporating portions of Bellos's stories, facts, and explorations, particularly from Chapter six, All About *e*, as I was teaching exponential and logarithmic functions.

Grapes of Math is also a fantastic resource for pedagogical development. For teachers and teacher educators, Bellos offers tangible and digestible examples of manipulating cognitive demand, scaffolding (Vygotsky, 1978), mathematical learning trajectories, the effectiveness of multiple representations, and, most important, multiple and accessible entry points to a mathematical concept. *Grapes of Math* will now be included in my curriculum for secondary mathematics teacher preparation. As a teacher educator, I see no greater review of a book than incorporating it into my curriculum for prospective teachers.

I highly recommend *Grapes of Math*, particularly for mathematics educators and mathematics teacher educators. Bellos is not just a gifted storyteller; he is also a master teacher.

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