Introduction

James Wynn and G. Mitchell Reyes

Mathematics has always influenced public culture. Prior to the late twentieth century, however, that influence was rarely felt on a daily basis at the level of the individual citizen. This is not to diminish mathematics' profound influence on everything from religion and music (Pythagoras, Pascal) to warfare and art (Archimedes, Da Vinci) to optics and physics (Newton, Leibniz) but merely to note that these influences could, to some degree, be separated from the everyday circulation of public discourse and the production of public culture. Only in the late twentieth and early twenty-first centuries has such a separation become increasingly difficult to sustain. We see it in the rise of mass media, statistics and probability, computational power, surveillance technologies, and—perhaps in the most immersive, communication-tracking technology thus far—the internet. These are just a few of the phenomena necessary for the emergence of an information society, in which those who can mathematically, algorithmically mine enormous data sets enjoy power heretofore unimagined. While mathematics and algorithms should not be conflated, the increasing cultural influence of mathematics via algorithms and other means has attracted the attention of an interdisciplinary audience of scholars, including rhetoricians.

With a few exceptions, however, scholars and practitioners of rhetoric and mathematics have for the last two millennia been content to let their fields coexist as parallel enterprises, even policing the boundaries between them to reinforce their incompatibility. In *Arguments in Rhetoric Against Quintilian*, for example, sixteenth-century logician and mathematician Peter Ramus wrote, "mathematicians deal with arithmetic and geometry, men of learning and wisdom, not rhetoricians" (683–84). Two centuries later rhetorical scholar George Campbell penned words with a similar sentiment in his *Philosophy of Rhetoric* (1776): "[Demonstration] is solely conversant about number and extension, and

about those other qualities which are measured by these. . . . Here rhetoric it must be acknowledged has little to do" (65). Little changed during the two hundred years following Campbell's declaration of incommensurability, until in the 1980s mathematicians Philip Davis and Ruben Hersh (1987)—who had been invited to participate in a discussion about argumentation in different disciplines—took up the challenge of exploring the possible interrelations between rhetoric and mathematics. In their landmark contribution to the subject, "Rhetoric and Mathematics," they concluded "that mathematics is not really the antithesis of rhetoric, but rather that rhetoric may be sometimes mathematical, and that mathematics may sometimes be rhetorical" (54). Their work, supported by other intellectual undercurrents in rhetoric (discussed in chapter 1), encouraged a few rhetorical scholars to take up the study of mathematics, but these efforts were isolated, uncoordinated, and without designs to make the case for a sustained program of study. They also ran parallel to and without much acknowledgment of scholarship in the fields of history, sociology, philosophy, and mathematics education, each of which dealt with complementary topics. Despite a promising sea change in the perspectives of some researchers about the relationship between rhetoric and mathematics, no coordinated effort to study the intersections of these two fields emerged.

This book aspires to change this state of affairs. Though our chapters touch on myriad topics from a variety of perspectives, the volume is collectively dedicated to the argument that rhetorical scholars can and should make a sustained and coordinated effort to study the rhetorical dimensions of mathematics. For the last two centuries, mathematics has been woven ever more tightly into the social, political, scientific, and economic fabric of our lives. In James Wynn's book *Evolution by the Numbers* (2012), for example, he explored the process by which the study of evolution, variation, and heredity became mathematized starting in the mid-nineteenth century, a process that led to revolutionary new understandings and practices in breeding, medicine, and taxonomy even as it enabled the rise of new kinds of scientists such as biostatisticians (who conduct scientific research into biological phenomena by making it amenable to mathematical analysis). Similarly, scholars such as Theodore Porter (1995) have illustrated how mathematics became increasingly important in political decision-making starting in the nineteenth century because of its capacity to bridge the ethical gap between policy-makers and the nonexpert publics whose behaviors they wished to influence. More recently, the rise of digital technologies and increasing automation has made mathematics even more influential across a

broad spectrum of political, economic, and sociocultural activities. Algorithms flag hate speech and monitor the influence of foreign powers in our political discourse and on our elections. They track the movements of people, money, and disease across the globe. They make forecasts about the future of our climate and estimate who will be the winners and losers in our future economy. As mathematics insinuates itself ever deeper into the social, political, scientific, and economic activities of our lives, the imperative grows for understanding precisely how it influences the values and beliefs with which we assess the world and make decisions, as well as how our values and beliefs influence the kinds of mathematical instruments we construct and accept. This interleaving both opens mathematics up to rhetorical analysis and makes it an important site for rhetorical studies.

The promise of a research space is typically judged by the number and quality of scholars occupying it and by the degree to which these scholars believe the concepts and methods native to their area of expertise can be used productively to produce new insight. To most scholars, rhetoric and mathematics may seem like largely uncharted territory. This impression is understandable given the current state of rhetoric and mathematics scholarship. Much of the work is distributed across academic space and time, appearing in different journals in different fields authored by researchers with few social or intellectual ties with one another. Thus the work of the first two chapters of this volume is primarily synthetic, bringing together the research of scholars interested in topics germane to rhetoric and mathematics and highlighting the intellectual connections between them in order to give some shape and coherence to the transdisciplinary and intradisciplinary conversations about rhetoric and mathematics that have already occurred. Chapter 1, for instance, explores the intellectual dissociation of rhetoric and mathematics that separated the fields for so long, teeing up our discussion later in the chapter on the transdisciplinary conversations that have begun to reassociate them. Building on these transdisciplinary conversations, Edward Schiappa's chapter, "In What Ways Shall We Describe Mathematics as Rhetorical?," examines the *intradisciplinary* discussions in rhetorical studies about mathematics and mathematical discourse. From his synthetic investigation a tripartite configuration emerges, with scholarship clustering around (1) rhetoric *of* mathematics, (2) rhetoric *in* mathematics, and (3) mathematical language *as* rhetorical. Schiappa uses this tripartite taxonomy to both organize and place into dialogue disparate work on the rhetorical dimensions of mathematics, leading ultimately to an examination

of how rhetorical study of math allows scholars to see rhetoric itself in novel and unexpected ways.

While the opening two chapters collect and frame past scholarly conversations on rhetoric and mathematics, the body chapters deepen the exploration of questions such as "To what extent and in what ways does mathematics operate rhetorically" and "What insights can rhetorical scholars offer from its study?" We have organized these chapters into three clusters to help direct readers to particular emphases or interests. The first section deals primarily with the interface between rhetoric and math in public culture, the second with the interplay of rhetoric and math in moments of technical innovation, and the third with the synthesis of rhetoric and mathematics in contexts where experts seek to communicate persuasively to lay audiences.

Rhetoric, Mathematics, and Public Culture

Collectively, the first three body chapters address the power of mathematics to shape both public institutions and public culture. Both Cathy Chaput and Crystal Colombini's chapter and G. Mitchell Reyes's chapter examine how mathematics and mathematical ideas have influenced neoliberal economic orthodoxy and enabled massive economic bubbles like the one that led to the 2008 subprime crisis. Chaput and Colombini explore Adam Smith's metaphor of the "invisible hand" as part of the conceptual underpinnings of neoliberalism, arguing that while the persuasive force of the invisible hand is fundamentally rhetorical (i.e., it resides in the metaphor), this force is focused and directed by the mathematical constructs of neoliberal economics. They explain, "While this metaphor circulates *energeia*—a classical concept revived in recent rhetorical scholarship to discuss the intensity, power, and force that actualizes potentiality—its mathematical formulations crucially direct that power toward the kinds of economic activities that need to be cultivated in a given historical moment." In other words, the mathematics grounds the metaphor in real-world economic activities across shifting temporal contexts, making that metaphor more "real" in the process.

While Colombini and Chaput investigate the complex interrelationship between mathematics and metaphor, G. Mitchell Reyes explores how the commitments and assumptions of mathematical formulae, their "horizons of judgement," operate invisibly but tangibly to influence material practices of public

culture. Using a combination of constitutive theory and Latourian actor-network theory, Reyes traces the rise of a little-known mathematical algorithm called the Li Gaussian copula, which played a crucial role in the growth and spread of subprime mortgages. His analysis unpacks the copula's horizon of judgment as well as the symbolic-material relations that it introduced into the domain of structured finance. These new symbolic-material relations, Reyes argues, fundamentally changed the size of structured finance and the power structures governing it, precipitating the collapse of the subprime mortgage market and the broader global economy in 2008.

Finally, Nathan Crick and Andrew Jones go beyond economics to show how mathematical ideas have shaped forensic investigations in both literature and the real world. Specifically, they trace Edgar Allan Poe's use of mathematically informed analytic logic and its influence on the public's imagination about the potential for a disciplined forensic approach to criminal investigations. Drawing on Peirce's divisions between rhetoric, logic, poetics, and mathematics, the authors describe how Poe's rational detective, Dupin, systematically develops a hypothesis for explaining the murders in the Rue Morgue. Their description highlights the role of mathematical reasoning as an inventional resource for building plausible stories of causality in literary plots, and they illustrate how Poe's detective story ignites the American public's interest in "rational forensic" methods. Jones and Crick conclude the chapter by exploring the real-world consequences of Poe's rational forensics as it was used to "solve" the real-life murder of New Yorker Mary Rogers.

Mathematical Argument and Rhetorical Invention

While it is unsurprising that rhetoric and mathematics comingle in economics and politics where numbers, beliefs, and values collide, it is perhaps unexpected to find rhetoric and math commingling in technical fields like physics. Yet such a commingling is precisely what Joseph Little identifies and traces in his study of Japanese physicist Hantaro Nagaoka's Saturnian analogy to explain spectral emission lines. Little shows that much of the *orthos logos* of Nagaoka's mathematics, the guiding "right reason" for his equations, was entailed by his initial conceptual commitments to a unique Saturnian analogy. His analysis also reveals that analogical mediations can operate natively (that is, without the presence of natural language) within the symbolic system of mathematics

and that these operations can provide the rationale for establishing connections between mathematical concepts and procedures and natural real-world phenomena.

Whereas Little examines the intersections of rhetoric and mathematics in twentieth-century physics, Jeanne Fahnestock explores the gradual entanglement of mathematics and rhetoric in the development of scientific visuals from the sixteenth to the nineteenth century. In "The New Mathematical Arts of Argument: Naturalistic Images and Geometric Diagrams," she shows how Melanchthon—in his effort to create a syncretic art of argument derived from all fields of reasoning including mathematics and rhetoric—introduced a new type of definition argument in *Erotemata dialectices* (1547) that depended both on visualization and on encounters with material objects. This new modality of argument, influenced by the then improved ability to create and reproduce naturalistic images in woodcuts and engravings, was taken up aggressively in ensuing decades by natural philosophers, who increasingly used images to generate arguments that relied on the available conventions of geometrical depiction to manage their scrutiny. By examining the changing features of visual representation in science from the Enlightenment to the nineteenth century, Fahnestock illustrates the interconnectedness of mathematics, scientific visualization, and rhetorical invention.

Mathematical Presentations: Experts and Lay Audiences

While the previous chapters argue collectively that rhetoric and mathematics are deeply connected in both the public and technical spheres and that a rhetorical perspective provides a valuable and necessary vantage point for the study of mathematics, the chapters in this section illustrate the value a rhetorical perspective might have for mathematics professionals. One of the pressing challenges math professionals face is that American students struggle with mathematical proficiency and are rarely drawn into postsecondary programs or careers in mathematics. In *Raising Public Awareness of Mathematics* (2012), contributor Reinhard Laubenbacher of the Society of Applied and Industrial Mathematics describes the challenges facing the mathematics community this way:

> In the end, the imperative for the mathematical sciences community to raise awareness of mathematics among the general public is clear: we want

> to recruit the next generation of mathematicians; we want our university administrators to value mathematics. . . . We want the general public and elected representatives to support mathematics and provide adequate funding for the agencies that promote our research; we want our funding agencies to view mathematics as the central enabling technology for much of scientific progress. . . . We want our K-12 educational system to train students adequately. (53)

The fundamental question Laubenbacher poses but does not ask directly is "How?" How can mathematicians and their institutions persuade the public to embrace mathematics while at the same time training them to succeed in the field?

Because the study of rhetoric is in part the study of persuasion, there might be something to gain for mathematics professionals from an examination of mathematics from a rhetorical perspective, if only to increase the effectiveness of their communication. Our final two chapters address these exact issues. James Wynn's chapter explores efforts by Danica McKellar, an actress with a bachelor of science in mathematics, to persuade middle school girls to identify with mathematical study and consider math careers. He also examines the challenges her female-centered accommodation strategies faced in public discussions. Assessments of McKellar's efforts and the public response to them provide useful information about audiences important to the mathematical community and the challenges that may need to be addressed in engaging them.

Extending Wynn's focus on audience, Michael Dreher assesses efforts by mathematics professionals to reach lay audiences within the context of changing K-12 math curricula. Dreher's chapter thus necessarily engages with issues surrounding the management of mathematical education, exploring the challenges math educators face when they try to persuade the public to adopt new and unfamiliar methodologies for teaching mathematics. Understanding these challenges from a socially informed and audience-centered perspective, Dreher argues, is a useful point of view from which to understand the many rhetorical exigencies associated with mathematics education and, as a result, imagine the kinds of solutions, rhetorical or otherwise, that might be devised to address those exigencies.

Collectively, the chapters in this volume seek to expand our understanding of the many ways rhetoric and math increasingly intersect in contemporary culture. These intersections have been studied independently for decades by

scholars in mathematics, politics, philosophy, linguistics, history, sociology, education, and rhetoric. By identifying and connecting these mostly independent nodes of transdisciplinary scholarship, we hope to illuminate the contours of a transdisciplinary conversation in the making and offer inspiration to students, established scholars, and anyone inside or outside of rhetorical studies who might be interested in exploring the intersections between rhetoric and mathematics—intersections that are reshaping public culture in increasingly consequential ways and call in a rising chorus for a critical account.

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