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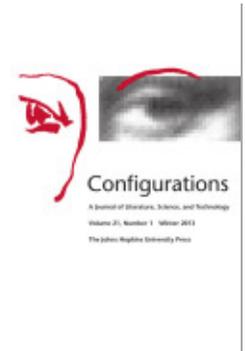
The Dialogue of Early Modern Mathematical Subjectivity

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# The Dialogue of Early Modern Mathematical Subjectivity

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ABSTRACT: Mid-sixteenth-century dialogues by Robert Recorde teach basic mathematics and allow a reader partially to construct and inhabit a mathematical identity—a subject position—appropriate to advanced work in mathematics through reorganization of the reader's mind directed by an engagement with, absorption of, and finally independence from the instructing dialogues. This essay explains the mechanism used by the dialogues to accomplish this, and shows that Recorde's deployments of eloquence, the ethos of the active life, and pedagogical conveniences conflict with mathematical rigor, almost resulting in the collapse of the project. The conclusion considers ways in which the mathematical reader may still benefit from Recorde's efforts despite the indecorous intrusion of his personal difficulties into the dialogues.

. . . he mastered there a double spirit  
Of teaching and of learning instantly.

—William Shakespeare, *1 Henry IV*<sup>1</sup>

Renaissance mathematics was a discourse in flux. Printing, humanism, and new technology and science greatly extended the reach of mathematics. Mathematics quickly outgrew the structures of the *quadrivium*. New or newly invigorated forms of mathematics, notably algebra, joined arithmetic and geometry as new writing

1. William Shakespeare, *1 Henry IV* (5.2.63–64).

practices (notation, for example), techniques (logarithms, decimal fractions), and mathematical objects (curves not generated solely with compass and straight edge, negative and imaginary numbers, infinitesimals) proliferated. Likewise, the character and identity of those who pursued mathematics underwent profound change. In the middle decades of the sixteenth century, polymath and pedagogue Robert Recorde (ca.1510–1558) composed a series of texts that provided English mathematics with its first native expression.<sup>2</sup> Several of his texts took the form of dialogues between a fictional master and scholar. These dialogues provide an opportunity not only to study how early modern mathematics redefined itself as a system of thought during a period of rapid reorganization for all intellectual activity, but also to study the literary form of dialogue in contact with a topic that would at first appear to be uncongenial to its form and conventions. I shall argue that, in addition to teaching basic mathematical skills, these dialogues also require a reader to construct and then inhabit an ethos appropriate to mathematical activity in its eloquent fittingness with the rhetorical aims of mathematics as a cultural and social practice. I will adopt the concept of “mathematical subjectivity” as a means of properly orienting a reorganization of the reader’s mind directed by an engagement with, absorption of, and finally independence from the instructing dialogues. “Subjectivity” is the appropriate term here because it acknowledges that the classical ethos, although traditionally perceived as entirely the construction of the orator or author, is, in fact, also subject to the influence of intersecting overt and implicit power relationships that determine the full social and cultural nature of the “individual.” Recorde’s tribulations as an author and as the model for his mathematics master will bear this out. Recorde attended both Oxford and Cambridge and trained as a physician. He is best known for his mathematical writings, which are heavily identified with the nonacademic environment of London despite nominal settings in the universities. Recorde was also a minor civil servant, with responsibility for various government minting and mining enterprises in England and Ireland. It is in connection with these activities that Recorde’s own lives—the active and contemplative—came into appar-

2. English-language mathematics prior to Recorde appeared as either English translations of Latin texts, Anglo-Latin treatises, or printed English translations of Dutch and French arithmetic books. See Robert Steele, ed., *The Earliest Arithmetics in English*, Early English Text Society, Extra Series 118 (London: Oxford University Press, 1922); Cuthbert Tunstall, *De arte supputandi libri quattuor* (London: Richard Pynson, 1522); and Travis D. Williams, “The Earliest English Printed Arithmetic Books,” *The Library*, 7th series, 13:2 (2012): 164–184.

ently irreconcilable conflict largely due to his impolitic challenges of higher-ranking court officials, leading to personal legal distresses that have some mirror in the dialogues themselves, and that must inform our reading of them.

The dialogues reposition classical authority as a heuristic for intellectual work and subordinate it to rigor, arrived at by independent reasoning. "Rigor" in this argument encompasses methodological strictness, necessity, and demonstrative proof, as exemplified in particular by Euclidean geometry and the associated traditions of Aristotelian logic.<sup>3</sup> Dialogue was crucial to this process because it did not only argue that rigor was a necessary component of mathematical activity, but also provided a mechanism to make rigor a characteristic of mathematical subjectivity. Dialogue permitted a reader not merely to understand the importance of rigor, but to make rigor a part of his identity as a mathematical subject as he pursued further mathematics in the contingent realm of human affairs, the *vita activa*. By the end of Recorde's project, however, it becomes apparent that the paradoxical interaction of dialogue with mathematical rigor contains from the start the likelihood of its failure, suggesting limits for dialogue as a viable form for mathematics.

The *vitae*, active and contemplative, were a central concern of humanism. Textual humanism developed editing, philology, and rhetoric to reacquaint Europe with the classical tradition, and to make it newly functional within a Christianized contemporary moment that prized the ideal of the highly educated person who lived a life in service of the commonwealth—civic humanism. Application of knowledge was key, as Victoria Kahn remarks in her study of Coluccio Salutati: "Knowledge for Salutati is not a goal itself; rather it must always be applied, and this insistence on application affects the concept or structure of the knowledge which is *to be applied*."<sup>4</sup> Despite some opposition (see below), mathematics met this requirement easily. Advocates for mathematics promoted its study and development due to its obvious applications in many areas, such as warfare, navigation, economics, and trade. Even the contemplative side of mathematics—those aspects that developed mathematics for its own sake, subject to its own internal priorities—was not automatically

3. For discussion of the confluence of Euclidean demonstration and Aristotelian logic in early modern mathematics, see Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995), pp. 41–43.

4. Victoria Kahn, "Coluccio Salutati on the Active and Contemplative Lives," in *Arbeit Musse Meditation: Betrachtungen zur Vita activa und Vita contemplativa*, ed. Brian Vickers (Zürich: Verlag der Fachvereine, 1985), p. 155 (emphasis in original).

dismissed, for as Kahn argues, in the Renaissance, “contemplation is a form of action and has the same epistemological status as does action.”<sup>5</sup> It was when the two *vitae* came into contact with each other that mathematics faced a conundrum. Just as Renaissance logic and rhetoric became less distinguishable, the *vitae* were distinct as ideals, but interpenetrated each other in practice. Practitioners had to make ethical decisions about how to manage the roles. Recorde’s mathematical dialogues present one such attempt to understand and enact a relationship between the active and contemplative lives.

Recorde’s use of dialogue makes the reader a performer: it encourages the reader to inhabit the roles and enact the dialogues in order to transform textual experience into civic act. Our task is to understand how the reader negotiates dialogic instruction in a rigorous discipline within the performance of a factitious intellectual drama played on the prudential stage of civic responsibility. The dialogue form is particularly resonant for topics of civic responsibility, but less so for the presentation of mathematical rigor. There is evidence that neither Recorde nor his textual persona as Master is fully aware of this discontinuity—a lack of realization that manifests itself in moments where the dialogic narrative shows the Master needing to abandon his studies to face trials (literally) in the world.

My argument will move among the intention, result, and consequences of reading these dialogues in a mode of criticism modeled by dialogue itself: a literary and rhetorical form that attends to how reading experiences incorporate themselves into a reader and reform him. The first section of this essay presents the stakes of aligning mathematics with rhetoric and eloquence. Section 2 critiques the standard models of dialogue dominated by categorization; it departs from them in favor of analysis of conversational and pedagogical dynamics—with parallel examples from Plato and Galileo—including the justly famous Copernican passage in *The Castle of Knowledge*. The result is an explication of the mechanism by which mathematical subjectivity is formed, emphasizing what dialogue creates rather than how it is categorized. Section 3 expands on the textual humanism pursued by the dialogues, the strategies of which lead to a dissociation of mathematical rigor and eloquence and finally the collapse of the dialogues into a melodramatic closet drama that nearly cancels earlier civic humanist achievements. The conclusion considers the ways in which Recorde’s project, although compromised in certain respects, need not be futile from the mathematical reader’s point of view.

5. Ibid., p. 157.

### Eloquent Mathematics in the Active Life

Recorde's mathematics curriculum allowed non-Latinate readers to follow a series of guided lessons in all the areas of basic mathematics as it was understood in the period, a mixture of topics from the *quadrivium* (arithmetic, geometry, and astronomy, but not music) with newly developing topics (algebra).<sup>6</sup> The historical progression of Recorde's titles suggests that his curriculum takes the form of an allegorical journey through mathematical knowledge. First, the reader laid *The Ground of Arts* in 1543 to learn basic arithmetic.<sup>7</sup> Along this ground, the reader then followed *The Pathway to Knowledge* in 1551 to learn basic geometry in Euclidean terms.<sup>8</sup> He then arrived at *The Castle of Knowledge* in 1556 to learn the rudiments of astronomy and cosmology,<sup>9</sup> and finally acquired *The Whetstone of Wit* in 1557 in the form of basic algebra.<sup>10</sup>

Recorde uses prefaces and dedications to argue for the importance of mathematics to the *vita activa*, the active life lived in virtuous service of one's nation, prince, friends, and family. Although these arguments initiate a tension apparent across the entire breadth of the mathematical project of how to place mathematics between the

6. On the *quadrivium* and its changing relationship with the *trivium*, see Walter J. Ong, *Ramus, Method, and the Decay of Dialogue: From the Art of Discourse to the Art of Reason* (Cambridge, MA: Harvard University Press, 1958), p. 138; and Timothy J. Reiss, *Knowledge, Discovery and Imagination in Early Modern Europe: The Rise of Aesthetic Rationalism* (Cambridge: Cambridge University Press, 1997).

7. Robert Recorde, *The ground of artes teachyng the worke and practise of Arithmetike, moch necessary for all states of men. After a more easyer & exacter sorte, then any lyke hath hytherto ben set forth: with dyuers newe additions, as by the table doth partly appeare* (London: Reynard Wolfe, 1543) (hereafter GA 1543). Four more editions of *The Ground of Arts* appeared during Recorde's lifetime (1549, 1551, 1552, and 1558), one of which (1552) is an important authorial revision. In total, there were forty-two editions of *The Ground of Arts* through the end of the seventeenth century, making it one of the most popular mathematics books in early modern England.

8. Robert Recorde, *The pathway to knowledg, containing the first principles of Geometrie, as they may moste aptly be applied vnto practise, bothe for vse of instrumentes Geometricall, and astronomicall and also for proiection of plattes in euery kind, and therefore much necessary for all sortes of men* (London: Reynold Wolfe, 1551) (hereafter PK). Later editions appeared in 1574 and 1602. *The Pathway to Knowledge* is not a dialogue, a distinction I will address below.

9. Robert Recorde, *The Castle of Knowledge* (London: Reginalde Wolfe, 1556) (hereafter CK). A second edition appeared in 1594.

10. Robert Recorde, *The whetstone of witte, whiche is the seconde parte of Arithmetike: containyng the extraction of Rootes: The Cossike practise, with the rule of Equation: and the workes of Surde Numbers* (London: Jhon Kyngstone, 1557) (hereafter WW). Recorde's fifth surviving text is a medical text (not in dialogue), *The Urinal of Physick* (London: Reynolde Wolfe, 1547). There were seven more editions.

*vita activa* and its counterpart, the *vita contemplativa* (lived in service of learning and ideas), Recorde admits no uncertainty. His forceful appeal to Edward VI on behalf of the social utility of mathematics places him among the “commonwealth men,” who pushed for reform during the young king’s reign.<sup>11</sup> In his most confident statement of the case, Recorde rededicates *The Ground of Arts* in 1552 to the king,<sup>12</sup> quoting a lengthy section of Cicero’s *De Inventione Rhetorica* (1.2.2). Recorde presents the original Latin, acknowledges “how far the grace of Tully’s eloquence doth excel any Englishman’s tongue,” then proceeds to translate for the benefit of “my mere English countrymen.” Cicero’s story recounts a wild and bestial humanity, devoid of reason and prey to its brute physical urges. Eventually, a ruler appears who combines power, wisdom, and eloquence and is thereby able to reform the human animal into a civilized being: “This man with persuasion of reason . . . bringing them into one common society, did trade [*sic*] them to all such things, as either were profitable or honest. . . . yet at length through reason and persuasion of words they obeyed him more diligently, and so of a wild and cruel people, he made them courteous and gentle.”<sup>13</sup>

Recorde takes the trouble to cite these views as Cicero’s not just to impress and flatter the king, but also to encourage the educated reader to recall the context for this passage in Cicero’s text, his larger discussion of the birth of eloquence (glanced at obliquely by Recorde’s own studied worry over translation), which, according to

11. On “commonwealth men” in the reign of Edward VI, see David Landreth, *The Face of Mammon: The Matter of Money in English Renaissance Literature* (Oxford: Oxford University Press, 2012), p. 23. Henry Turner provides a wide-ranging discussion of the artisanal, mechanical, and practical readers of mathematical treatises by Recorde and others in *The English Renaissance Stage: Geometry, Poetics, and the Practical Arts, 1580–1630* (Oxford: Oxford University Press, 2006), esp. p. 61.

12. Recorde originally dedicated *The Ground of Arts*, in 1543, to Master Richard Whalley. In 1552, this dedication became a preface addressed to the “Loving Reader” and Recorde composed a new dedication to the king. Whalley was tried and confessed to a variety of misdemeanors in 1552, the same year that Somerset fell and was executed. In this light, Recorde’s rededication of *The Ground of Arts* to the king in the same year was a prudential decision. On Whalley, see Alan Bryson, “Richard Whalley (1498/9–1583),” *Oxford Dictionary of National Biography*. <http://www.oxforddnb.com/view/article/29161>.

13. Robert Recorde, *The Ground of Artes Teachyng the worke and practise of Arithmetike. Both in whole numbres and fractions, After a more easer and exacter sorte, than any lyke hath been sette forth: with divers new additions, as by the table doeth partely appeere* (London: Reynold Wolff, 1552), sig. A4r–v (hereafter GA 1552). Quotations from Recorde’s works have modernized spelling and punctuation and hereafter will be cited parenthetically by signature.

Cicero, is the indispensable skill that can mold wisdom into something useful for society: "wisdom without eloquence does too little for the good of states, but that eloquence without wisdom is generally highly disadvantageous and is never helpful."<sup>14</sup> Eloquence allows wisdom to be useful to the commonwealth, and wisdom legitimates the practice of eloquence. Placing this myth at the head of his arithmetic book, *Recorde* casts mathematics as a form of wisdom that can also benefit from the shaping hand of eloquence and thereby do its proper work in the commonwealth.<sup>15</sup> These identifications are both powerful and risky. Rhetorical strategies leading to eloquence provide a "voice" for mathematics that is commensurable with the *trivium*-heavy education standard in sixteenth-century England. But as expressed through dialogue, the same rhetorical strategies create a potential rift between the subject matter of mathematics and *Recorde*'s chosen pedagogical form.

In addition to the Ciceronian impetus for making mathematics a foundational part of the active life, *Recorde*'s project also resists contemporaneous negative assessments of mathematics as especially unsociable. Juan Luis Vives "warned against too much study of the *quadrivium* . . . because mathematical abstractions 'withdraw the mind from practical concerns of life, and render it less fit to face concrete and mundane realities.'"<sup>16</sup> Roger Ascham, although he was a mathematical lecturer at Cambridge from 1539 to 1541, writes similarly: "Marke all Mathematicall heades, which be onely and wholly bent to those sciences, how solitarie they be the[m]selues, how vnfit to liue with others, & how vnapte to serue in the world."<sup>17</sup> Robert Burton, musing on the effects of imagination and day-dreaming, won-

14. Marcus Tullius Cicero, *De Inventione*, trans. H. M. Hubbell, Loeb Classical Library (Cambridge, MA: Harvard University Press, 1949), 1.1.1.

15. Cuthbert Tunstall was the first English mathematical writer to consider eloquence a worthy goal in mathematical writing. In his dedication of *De arte supputandi* to Thomas More, he stated that "many points often arose which seemed to offer no scope either for Latin style or for eloquence. . . . More than once I reflected that, even though I were not able to realize to the full my hope that everything should glitter with more or less brilliance, it would not be without use to render some matters less uncouth which, in their rude state, lay neglected." The English translation from the original Latin is in Charles Sturge, *Cuthbert Tunstal: Churchman, Scholar, Statesman, Administrator* (London: Longmans, Green, 1938), pp. 71–78.

16. Brian Vickers, *In Defence of Rhetoric* (Oxford: Clarendon Press, 1988), p. 182.

17. Roger Ascham, *The Scholemaster* (London: John Daye, 1570), sig. D2v. Long-s has been modernized. For Ascham as a mathematics lecturer, see Paul Lawrence Rose, "Erasmians and Mathematicians at Cambridge in the Early Sixteenth Century," *Sixteenth Century Journal* 8:2 (1977): 46–59.

dered “how many Chimæras, Anticks, golden mountains and Castles in the Aire doe they build unto themselves? I appeale to Painters, Mechanicians, Mathematicians.”<sup>18</sup> In *Othello*, Iago abuses Cassio’s qualifications to be Othello’s lieutenant, sarcastically calling Cassio a “great arithmetician” and “counter-caster” whose “bookish theoretic” contrasts poorly—“mere prattle without practice”—with practical military experience: Cassio “never set a squadron in the field / Nor the division of a battle knows / More than a spinster.”<sup>19</sup> Many literary, rhetorical, and philosophical writers of the period make similar statements. Even positions complimentary of mathematics are often unwilling to grant it dignified autonomy, let alone utility to the commonwealth. Quintilian’s view is typical and was influential in the Renaissance: “But it is considered that the value of geometry resides in the process of learning, and not as with other sciences in the knowledge thus acquired.”<sup>20</sup> Thus Francis Bacon recommends mathematics, but for instrumental reasons: “if one be bird-witted, that is, easily distracted and unable to keep his attention as long as he should, Mathematics provides a remedy; for in them if the mind be caught away but a moment, the demonstration has to be commenced anew.”<sup>21</sup>

18. Robert Burton, *The Anatomy of Melancholy*, ed. Thomas C. Faulkner (Oxford: Oxford University Press, 1989), 1.2.3.2. See also Vickers, *In Defence of Rhetoric* (above, n. 16), pp. 182–183.

19. William Shakespeare, *Othello*, ed. E. A. J. Honigmann, Arden 3 (London: Arden Shakespeare, 1996), 1.1.7–32. On *Othello*, see especially Patricia Parker, “Cassio, Cash, and the ‘Infidel 0’: Arithmetic, Double-entry Bookkeeping, and *Othello’s* Unfaithful Accounts,” in *A Companion to the Global Renaissance: English Literature and Culture in the Era of Expansion*, ed. Jyotsna G. Singh (n.p.: Wiley-Blackwell, 2009), pp. 223–241. Although my primary critical focus in this essay is on scholarly literature concerned with the dialogue as an ethical form, I wish to acknowledge my debt to the wider field of scholarship on the role of mathematics in culture. Work on mathematics in connection with English literature has exploded in recent decades; see especially books and articles by David Bady, Amanda Bailey, Paula Blank, Michael Booth, Patricia Cahill, Mary Thomas Crane, Kenneth Knoespel, Natasha Korda, Carla Mazzio, Eugene Ostashevsky, Helen Ostovich, Patricia Parker, Mary Poovey, Shankar Raman, and Henry Turner. See also the recent studies in the history of ideas, history of mathematics as a cultural practice, and art history by Amir Alexander, James Elkins, and Timothy Reiss, and older scholarship by Michael Baxandall, Natalie Zemon Davis, Ernst Gombrich, David Eugene Smith, and Frank Swetz. Mario Biagioli is expert on the social and ethical positionings of early modern mathematical practitioners, while Reviel Netz (working on classical mathematics) has produced the most important theorizations of mathematics as text.

20. Marcus Fabius Quintilianus, *Institutio Oratoria*, trans. H. E. Butler, 4 vols., Loeb Classical Library (London: William Heinemann, 1920–22), 1.10.34.

21. See *De Augmentis Scientiarum* (6.4) in Francis Bacon, *The Philosophical Works of Francis Bacon*, ed. John M. Robertson (London: Routledge, 1905), p. 560.

According to the Ciceronian model, in order to transform mathematics from technical procedure into civic practice, its wisdom had to be mediated by eloquence and this required unabashed dependence on rhetoric. Therefore mathematics must accommodate the characteristics of rhetoric and rhetoricized logic that became increasingly prominent in early modern reorganizations of those subjects. By opening the door to eloquence, *Recorde* allows in decorum, prudence, practical reasoning, probable arguments, and ethics. These concepts interact, and sometimes conflict, with the wisdom of mathematical content, which has traditionally presented itself as rigorous, theoretical, demonstrative, and generally impervious to the predations of rhetorical presentation. In the most general sense, this required the "rhetoricization" of mathematics, "the skill of 'accommodating' one's language and *ethos* to appeal to a particular audience,"<sup>22</sup> a task that might damage the rigorous *ethos* already characteristic of mathematics.

### Models and Mechanisms

Plato's *Meno* is the *locus classicus* for mathematical and scientific dialogue. During a geometrical demonstration, the *Meno* departs from even the lopsided conversation that Socrates usually allows his partner. Socrates seeks to prove that knowledge is latent within our minds, and only needs to be activated through the mental activity of disputation. One example concerns whether the square on a given line is doubled or quadrupled when the given line is doubled.<sup>23</sup> A slave boy—produced from among the servants in Meno's household for this purpose—gives the answers that technically prove Socrates' thesis. The boy's responses are as brief as necessary to express the required information. Socrates employs leading questions for which the boy's answers are almost vestigial; he does little more than affirm each statement. If we were to remove the boy's responses and turn each of Socrates' questions into a declarative statement, the dialogue would be transformed into something approaching a monologic geometric proof. So uneven are the intellectual capacities of Socrates and the boy (despite Socrates' insistence that knowledge is innate) that no real dialogue can occur. To be more precise, there may be a dialogue, but no dialectic, no sifting of positions with well-matched, opposing points of view. Such rote responses are a vestige

22. Virginia Cox, *The Renaissance Dialogue: Literary Dialogue in Its Social and Political Contexts, Castiglione to Galileo* (Cambridge: Cambridge University Press, 1992), p. 57.

23. See *Meno* in Plato, *The Dialogues of Plato*, trans. Benjamin Jowett, vol. 2 (New York: Oxford University Press, 1892), pp. 42–43.

of purely oral pedagogy; they reappear in medieval mathematical instruction. *The Art of Nombryng*, an English translation of John of Holywood's (Sacrobosco's) Latin verse arithmetic primer *De Arte Numerandi*, begins with a remnant of oral rote learning: "Boys seying in the beginning of his Arsemetrike." *The Crafte of Nombrynge* also adopts a question-and-answer form for part of its lesson: "Questio. ¶ Why ten fyguris of Inde? Solucio. For as I haue sayd afore þai were fonde first in Inde of a kynge of þat Cuntre, þat was called Algor."<sup>24</sup> There is extensive critical agreement that such "dreary" dialogues, recording questions and answers between a master and a scholar, are not real dialogues at all, but merely catechisms.<sup>25</sup>

What makes a dialogue "real" rather than, presumably, "imaginary" is a matter that has occupied much scholarship on dialogue. Such categories and divisions proliferate remarkably, without always providing the critical clarity one would hope for from such industry. There are categories based on historical archetypes: Platonic/Socratic, where one voice dominates the others; Ciceronian, in which harmony among voices marks the discussion; and Lucianic, marked by discord between voices.<sup>26</sup> To this tripartite division some critics add the symposium as a model of true *in utramque partem* ("on all sides") discussion.<sup>27</sup> Then there are categories concerned with the purpose of dialogue.<sup>28</sup> Expository dialogues demonstrate preexisting material

24. Portions, respectively, of British Library MS Ashmole 396 and British Library MS Egerton 2622, both from the fifteenth century, transcribed in Steele, ed., *The Earliest Arithmetics in English* (above, n. 2), pp. 33, 3.

25. J. Christopher Warner, "Thomas More's *Utopia* and the Problem of Writing a Literary History of English Renaissance Dialogue," in *Printed Voices: The Renaissance Culture of Dialogue*, ed. Dorothea Heitsch and Jean-François Vallée (Toronto: University of Toronto Press, 2004), p. 66. See also Luc Borot, "Hobbes, Rhetoric, and the Art of the Dialogue," in *Printed Voices*, p. 175; Cox, *The Renaissance Dialogue* (above, n. 22), p. 113; and Stanton J. Linden, "'Wand'ring Thoughts, and Notions Vain': *Paradise Lost* and the Scientific Dialogue," *ANQ* 12:2 (1999): 20. On catechism, see Peter Burke, "The Renaissance Dialogue," *Renaissance Studies* 3:1 (1989): 3.

26. Eva Kushner, "The Renaissance Dialogue and Its Zero-Degree Fictionality," in *Fiction Updated: Theories of Fictionality, Narratology, and Poetics*, ed. Calin-Andrei Mihailescu and Walid Hamameh (Toronto: University of Toronto Press, 1996), p. 172.

27. See, for example, David Marsh, *The Quattrocento Dialogue: Classical Tradition and Humanist Innovation* (Cambridge, MA: Harvard University Press, 1980), p. 8.

28. Roger Deakins, "The Tudor Prose Dialogue: Genre and Anti-Genre," *SEL* 20:1 (1980): 9; Burke, "The Renaissance Dialogue" (above, n. 25), p. 3; Donald Gilman, "The Reconstruction of a Genre: Carolus Segonius and the Theorization of Renaissance Dialogue," in *Acta Conventus Neo-Latini Torontonensis*, ed. Alexander Dalzell et al. (Binghamton, NY: Center for Medieval and Early Renaissance Studies, 1991), p. 353; Gilman,

and are often cast for master and pupil. Investigative dialogues address themselves to the discovery of new knowledge. Investigative dialogues are further subdivided: *obstetric* (also *maieutic*) dialogues emphasize competition over the knowledge produced and are often cast for an objector and an answerer, while *tentative* (also *peirastic*) dialogues subordinate competition to the search for knowledge. In some respects though not all, obstetric and tentative dialogues are parallel to Platonic and Ciceronian dialogues, respectively. Other systems gauge the fidelity of dialogue to truth. Virginia Cox distinguishes between “‘true’ dialogues and ‘false’ ones: dialogues which are genuinely dialectical and those which are monologues in disguise.”<sup>29</sup> A parallel system distinguishes open dialogues from closed. Closed dialogues are *didactic* (which returns us to the expository form), while open dialogues are *skeptical*, which is somewhat akin to the tentative form.<sup>30</sup> One of the more useful classifications contrasts *magistral* from *probative* (or *initiative*) discourses, as developed by Bacon to describe two ways of conveying knowledge (although Bacon was not talking specifically about dialogue). “Initiative methods,” Lisa Jardine explains, “are those which display the stages by which the author’s conclusions were reached, so that the reader may both check that he would have reached the same conclusions on the same evidence, and pursue the investigation further if he so chooses. . . . Magistral methods to a greater or lesser extent try to impose their conclusions on the reader.”<sup>31</sup> In Cox’s further formulation, “a ‘magistral’ mode of trans-

“A Meeting of Minds: Bakhtin, Renaissance Humanism, and the Dynamics of Dialogue,” in *Recapturing the Renaissance: New Perspectives on Humanism, Dialogue and Texts*, ed. Diane S. Wood and Paul Allen Miller (Knoxville, TN: New Paradigm Press, 1996), p. 23; and Warner, “Thomas More’s *Utopia*” (above, n. 25), p. 64.

29. Cox, *The Renaissance Dialogue* (above, n. 22), p. 2; see also Olga Zorzi Pugliese, “Sperone Speroni and the Labyrinthine Discourse of Renaissance Dialogue,” in *Imagining Culture: Essays in Early Modern History and Literature*, ed. Jonathan Hart (New York: Garland Publishing, 1996), p. 61.

30. Burke, “The Renaissance Dialogue” (above, n. 25), p. 3; see also Pugliese, “Sperone Speroni” (above, n. 29), p. 63.

31. Lisa A. Jardine, *Francis Bacon: Discovery and the Art of Discourse* (Cambridge: Cambridge University Press, 1974), pp. 174–175. The relevant passage in Bacon is *The Advancement of Learning*, in *The Philosophical Works of Francis Bacon* (above, n. 21), 2.17.2–4. See also Stanley Fish’s excellent discussion in *Self-Consuming Artifacts: The Experience of Seventeenth-Century Literature* (Berkeley: University of California Press, 1972), esp. pp. 83–90. He shows that Bacon’s subtle use of both methods alters the reader’s evaluative capacity through the process of reading. It is also worth noting that, in *The Advancement of Learning*, Bacon singles out mathematics as perhaps the only subject that appears to employ a probative delivery: “Of which kind of delivery the method of the mathematics, in that subject, hath some shadow” (2.17.4).

mission . . . presents a set of conclusions in a form which demands a simple consensus, and an 'initiative' mode [lays] bare the stages by which those conclusions were reached, [and] offers the reader a 'thread' on which to spin an original network of knowledge."<sup>32</sup>

All of these categories are useful to a certain extent, but in every case the category is compromised by the always mixed form of an actual dialogue. Any theory of dialogue must account for the control of conversation and differentiate carefully between who is in control and who appears to be in control, as well as for the changing nature of the reader's relationship to the represented discourse. Consider Cicero's *De Oratore*, a favorite model for Renaissance dialogue. Crassus and Brutus present quite opposed approaches to the acquisition and exercise of eloquence by an orator. Each also rhetorically deprecates his own views and praises those of his interlocutor. Through self-deprecation, the discussants seem only to arrive at contingent truth, which is the goal of Ciceronian dialogue and one of its attractions as a model for the Renaissance.<sup>33</sup> This makes *De Oratore* a true and open dialogue. But there is also no doubt that a reader also considers the position of Cicero, the *author* of both points of view, who would insist on the necessity of both theory (the approach of Crassus) and practice (the approach of Brutus). Hence *De Oratore* is false and closed. Recorde's arithmetic, astronomy, and algebra texts are well-developed dialogues between a master and a scholar. He writes in most of the styles enumerated above (all except the Lucianic, because its combative quality renders it inapt for the topic, and so indecorous) because the nature of the subject requires him to do so. Various topics will require different modes of delivery. The critical task is therefore not to decide which mode a dialogue uses, but how a dialogue manages an inevitable variety of modes. Our goal must be to understand how mathematics complicates a mixed form, and how a mixed form affects mathematics. Given the potential difficulties of mixing mathematics with a form like dialogue, mathematics is perhaps a limit case for the examination of dialogue and how it accomplishes its special form of intellectual work.

Recorde's justification of dialogue as his form immediately upsets the ideal models of the form: "I have written [my book] in the form of a dialogue, because I judge that to be the easiest way of instruc-

32. Cox, *The Renaissance Dialogue* (above, n. 22), p. 59. The image of a thread is Bacon's.

33. David Marsh, "Dialogue and Discussion in the Renaissance," in *The Cambridge History of Literary Criticism*, vol. 3: *The Renaissance* (Cambridge: Cambridge University Press, 1999), p. 265.

tion, when the scholar may ask every doubt orderly, and the master may answer his question plainly" (*GA* 1543,  $\pi$ 6v). No catechism this, if the Scholar will be asking some of the questions. Although *The Ground of Arts*, in fact, begins with the Master firmly in control, it is the Scholar who speaks first and seems to require the Master to defend the discipline:

The *Scholar* speaketh: Sir, such is your authority in mine estimation, that I am content to consent to your saying, and to receive it as truth, though I see none other reason that doth lead me thereunto: whereas else in mine own conceit it appeareth but vain, to bestow any time privately in learning of this thing.

. . .

*Master*. Lo, this is the fashion and chance of all them that seek to defend their blind ignorance, that when they think they have made strong reason for themselves, then have they proved quite contrary. (*GA* 1543, A1r–2r)

The Master maneuvers the Scholar into a number of humbling retreats as he is forced to recognize the importance of mathematics and its influence on all other activities. The Master pummels the Scholar with the most basic questions: "How many years old art thou? . . . How many days in a week? How many weeks in a year? What lands hath thy father? How many men doth he keep? How long is it sith you came from him to me?" The Scholar can only make the dumb reply "Mum" (*GA* 1543, A2r). It is the function of the dialogue to build the Scholar up again from this annihilation, and as I shall show, the reader makes a similar journey.<sup>34</sup> The goal of a dialogue determines the behavior of its discussants, which is another reason why Recorde's lessons could never take the form of a simple master/scholar interchange. The Master recalls questioning "children and idiots" to elicit information that will solve complicated mathematical riddles (*GA* 1552, X6v), just as Socrates did with the slave boy. Obviously, the Master's treatment of children and idiots would be quite different from what we see take place with the Scholar, for precisely the reason that the dialogue of Master with child or idiot would be entirely unproductive of the mathematical subjectivity that the dialogue of Master with Scholar is meant to create in the reader.

34. Compare Fish's opening thesis: "A dialectical presentation . . . is disturbing, for it requires of its readers a searching and rigorous scrutiny of everything they believe in and live by. It is didactic in a special sense; it does not preach the truth, but asks that its readers discover truth for themselves, and this discovery is often made at the expense not only of a reader's opinions and values, but of his self-esteem. . . . the experience of a dialectical form is humiliating" (see *Self-Consuming Artifacts* [above, n. 31], pp. 1–2).

An early exchange in *The Ground of Arts* shows how dialogue can function to make rigorous mathematical method an internal imperative rather than an external imposition. The Scholar is learning to add large numbers, and he ventures on an example of his own: “[Suppose] [t]here came through Cheapside. ii. droves of cattle, in the first was 848 sheep. And in the second was 186 other beasts. Those two sums I must write as you taught me.”<sup>35</sup> When the Scholar adds the numerals 8 and 6, instead of writing the numeral 4 under the addition bar and carrying the 1 (or, as the text puts it, “keep[ing] [it] in your mind”), he writes the number 14 under the bar. Immediately, the Scholar stumbles, in part because he was allowed to stumble by the Master, and the error is twofold, as the master now points out:

here are you twice deceived first in going about to add together ii. sums of sundry things, which you ought not to do, except you seek only the number of them, & care not for the things. For the sum that should result of that addition, should be a sum neither of sheep, nor other beasts, but a confused sum of both. . . . [Y]ou were deceived in another point, and that was in writing 14, which came of 6 and 8, under 6 & 8, which is impossible: For how can two figures of two places, be written under one figure, and one place?”

Not only is the fault corrected, but the Scholar’s error becomes the impetus for a lesson on carrying in addition, a subject that would have to be dealt with sooner or later. Here, it seems to arise naturally as a result of conversation. After the Master explains the rules for carrying in addition, the Scholar responds with an understanding grounded in his own experience: “Now do I perceive you, and the reason of this is (as I understand) because that no one place can contain above 9, which is the greatest figure that is” (*GA* 1543, C2v–3v), and he works through the rest of the problem with rather exhausting deliberation. This episode demonstrates that pace is one of the most important benefits of dialogue. Dialogue allows for genuine uncertainty about the nature of the next intervention. When the speaker changes and begins with “But . . .” or some similar conversational formula, there is no way to anticipate if the statement will be an overt contradiction, a clarification, or an incorrect statement. Such uncertainty rarely occurs in a monologic treatise, except in the service of patent artificiality.

So, dialogue allows for a pace and intellectual uncertainty that closely models the development of real thought. Dialogue is more obviously a pedagogic form. The novice works through the problem

35. In Recorde’s texts, Roman numerals function as words (grammatical objects), while Hindu-Arabic numerals function as objects that will undergo mathematical manipulation.

at his own pace. The Scholar has the opportunity to commit errors and have them corrected, and it is precisely the sequence of question, answer, error, and correction that provides an opportunity for a novice reader to understand the textual exchange as a simulacrum of his own educational journey. As a result, he acquires a small measure of prudence: practical reasoning addressed to the particular circumstances of a situation, which can then be applied to yet another set of circumstances. Moreover, the dialogue allows for commission, detection, and rectification of error that if presented in monologue would undoubtedly seem stilted and contrived.

Although the previous example represents a relatively simple case of the activation of independent reasoning through dialogue, it is also undeniable that the topic (beasts in Cheapside) is hardly controversial. The nature of the mathematical situation means that there can be no real debate for the dialogue to present; the dialogue does not make basic facts available for discussion or debate. Whether or not  $2 + 2 = 4$  is a question the dialogue does not ask. Likewise, ontological considerations are absent from Recorde's dialogues: *why*  $2 + 2 = 4$  is also a question the dialogue does not ask or answer. A real test of the dialogue's abilities appears when Recorde broaches a controversial theory like the Copernican hypothesis, a topic that can sustain a real debate.<sup>36</sup> The discussion of the Copernican hypothesis in *The Castle of Knowledge* seems to be the first treatment of it in the English language in a printed book, and it is mentioned by nearly every modern commentator on Recorde, although none has analyzed the passage to discern why it is so compelling.<sup>37</sup> As in the extended passage on the problem of the beasts in Cheapside, what turns out to be the main topic of conversation arises as if by accident from other concerns. The Scholar makes similar leaps of intellectual confidence; the Master must correct him, and uses the occasion to drive home a lesson, although here the stakes are higher because the Scholar's error concerns reasoning and authority themselves, not just mathematical procedure. In the end, even the newly realized authority of reasoning must give way to the proof that the Master is willing to provide in support of his views—the Master is no hypocrite.

36. Dialogue as a safety device in delicate or controversial matters is well-attested: see Burke, "The Renaissance Dialogue" (above, n. 25), p. 8; Marsh, *The Quattrocento Dialogue* (above, n. 27), p. 15; and Thomas Smith, *A Discourse of the Commonweal of This Realm of England*, ed. Mary Dewar (Charlottesville: University Press of Virginia, 1969), p. xxiv.

37. No copies of Copernicus's *De Revolutionibus* (1543) have Recorde in their provenance; see Owen Gingerich, *An Annotated Census of Copernicus' De Revolutionibus (Nuremberg, 1543 and Basel, 1566)* (Leiden: Brill, 2002), pp. 60–61.

An earlier discussion of Ptolemy's proofs in his cosmology (the default system taught in *The Castle of Knowledge*) establishes the tone of the Master's nuanced approach to Copernicanism:

*Scholar.* [A]ll learned men say, Ptolemy is the father of that art, and proveth all his words by strong and invincible reasons.

*Master.* No man can worthily praise Ptolemy, his travail being so great, his diligence so exact in observations, and conference with all nations, and all ages, and his seasonal examination of all opinions, with demonstrable confirmation of his own assertion, yet must you and all men take heed, that both in him and in all men's works, you be not abused by their authority, but evermore attend to their reasons, and examine them well, ever regarding more what is said, and how it is proved, than who sayeth it, for authority often times deceiveth many men. (*CK*, L3v–4r)

According to the Master, an authority can only hold that status if independent reasoning validates its "reasons," or proofs. Discussion of the Copernican hypothesis arises out of an appropriately Ptolemaic discussion of the reasons why the Earth sits motionless at the center of the world:<sup>38</sup> "*Master.* But as for the quietness of the Earth I need not to spend any time in proving of it, sith that opinion is so firmly fixed in most men's heads, that they accompt it mere madness to bring the question in doubt. And therefore it is . . . much folly to travail to prove that which no man denieth" (*CK*, O4v). The studied irony of this passage makes it a highly disingenuous declaration. By the time of this exchange, the scholar has made substantial progress through the curriculum, mastering arithmetic and, it is assumed, the monologic lessons of geometry in *The Pathway to Knowledge*. The Scholar has already learned enough at his Master's knee to note that the worth of a scientific opinion is not based on how many men believe in it:

*Scholar.* Yet sometime it chanceth, that the opinion most generally received, is not most true.

*Master.* And so do some men judge of this matter, for not only Eraclides Ponticus, a great Philosopher, and two great clerks of Pythagoras school, Philolaus and Ecphantus, were of the contrary opinion, but also Nicias Syracusius, and Aristarchus Samius, seem with strong arguments to approve it: but the reasons are too difficult for this first Introduction, and therefore I will omit them till another time. And so will I do the reasons that Ptolemy, Theon and others do allege, to prove the Earth to be without motion: and the rather because those

38. In early modern English, "world" often means (as here) "universe" rather than "Earth."

reasons do not proceed so demonstrably, but they may be answered fully, of him that holdeth the contrary. (CK, O4v)

Clearly, the Master has set a kind of trap by adopting a facetious tone and opinions inconsistent with his previous views. The Scholar momentarily becomes the spokesman for the importance of independent reasoning, and only then does the Master launch into what seems to be his real opinion. The Master appears to oppose authority to authority, an argumentative gambit that he criticizes elsewhere as unproductive, since it still maintains the authority without subjecting it to examination (CK, P3r–v). In accordance with the general practice of *The Castle of Knowledge*, the Master declines to provide rigorous reasons or proof for either opinion, but indicates that Ptolemy's arguments could be refuted by those of the opposing camp. This stance is little changed from the beginning of the Master's speech, but there is the crucial difference that the Master is opposing proof against proof rather than authority against authority. Nevertheless, the Scholar is eager to apply his recent learning: "I perceive it well: for as if the Earth were always out of the center of the world, those former absurdities would at all times appear: so if at any time the Earth should move out of his place, those inconveniences would then appear" (CK, O4v–5r).<sup>39</sup>

Perhaps as a result of his growing confidence, the Scholar has reached beyond his abilities, not heeding sufficiently the Master's assertion that these competing theories are still beyond the scope of this treatise, and hence beyond the Scholar:

*Master.* That is truly to be gathered, how be it, Copernicus a man of great learning, of much experience, and of wonderful diligence in observation, hath renewed the opinion of Aristarchus Samius, and affirmeth that the Earth not only moveth circularly about his own center, but also may be, yea is, continually out of the precise center of the world 38 hundred thousand miles: but because the understanding of that controversy dependeth of profounder knowledge than in this Introduction may be uttered conveniently, I will let it pass till some other time. (CK, O5r)<sup>40</sup>

39. The Scholar distinguishes between two cosmological systems, the first in which the Earth moves in circular motion about the center of the world though never passes through it; and the second in which the Earth moves in some path that passes momentarily through the center of the world. The "inconveniences" are all the supposed astronomical absurdities, adduced earlier in the discussion, that would result if the Earth were not always at the center of the world.

40. In other words, Copernicus hypothesizes that the Earth both moves in an orbit around the center of the world (occupied by the sun) and experiences diurnal motion on its own axis.

The Master bolsters the Copernican hypothesis in two ways. First, he praises Copernicus in the only way that can prove the worth of any authority in the eyes of the Master according to everything we encounter in Recorde's works (terms not much different from the praise of Ptolemy, above): Copernicus is "a man of great learning, of much experience," and perhaps most important, "of wonderful diligence in observation." Second, the Master lays another trap by indicating that Copernicus revives the opinion of a classical writer, one of the authorities whom he had mentioned a few lines above; the careful reader or scholar would know from experience not to take this as certain proof that Copernicus has anything worthy to say. The Scholar is not so careful: "Nay sir in good faith, I desire not to hear such vain fantasies, so far against common reason, and repugnant to the consent of all the learned multitude of Writers, and therefore let it pass for ever, and a day longer" (CK, O5r).

Here, the Scholar has put his faith in exactly the kind of proofs that are questioned throughout *The Castle of Knowledge* and earlier works, and by his own insight just a few speeches previously when he recognized that the most general opinion is not always the worthiest. The Master's preemptory response alludes to the Scholar's age and inexperience in a way reminiscent of the early exchanges in *The Ground of Arts*:

You are too young to be a good judge in so great a matter: it passeth far your learning, and theirs also that are much better learned than you, to improve his supposition by good arguments, and therefore you were best to condemn no thing that you do not well understand: but another time, as I said, I will so declare his supposition, that you shall not only wonder to hear it, but also peradventure be as earnest then to credit it, as you are now to condemn it. (CK, O5r)<sup>41</sup>

The Master, however, maintains his humanist composure, not descending into Lucianic invective or anything like it. Since he will not now provide rigorous proof, he does not require the Scholar to do more than suspend his opinion. The time will come when the Scholar will allow his own reasoning and observation to decide what

41. "Improve" here has the now archaic sense of "refute" or "disprove"; see *Oxford English Dictionary*, s.v. "improve," v<sup>1</sup> (<http://0-www.oed.com.helin.uri.edu/>). "Supposition" is roughly equivalent to "hypothesis," which is how Copernicus's beliefs were portrayed due to Andreas Osiander's unsigned introduction to *De Revolutionibus*, which "claimed that the book only proposed a mathematical hypothesis and made no physical claims." See Diederick Raven, "Elizabeth Eisenstein and the Impact of Printing," *European Review of History* 6:2 (1999): 230n35; and *Oxford English Dictionary*, s.v. "supposition," 1–3a.

is plausible and “peradventure” will change his mind. Throughout the passage, the Master (and hence Recorde) carefully avoids discarding authority simply because it is authority; instead, he seeks a more subtle role for authority, as he does throughout the dialogues. Rather than accepting authority for its own sake because of its age or the fame of an attached name, authority becomes one of several tools available in the new humanist approach to knowledge. Authority ceases to be an a priori legitimizer of knowledge because it is transformed into a heuristic in the investigation and testing of observation and reasoning that themselves lead to the acquisition of knowledge.

These examples show not only that it is unnecessary to limit Recorde’s dialogues to a single ideal form, but that it is detrimental to try. In both examples, at least two fully formed dialogic modes are operating simultaneously: a didactic mode teaching undisputable mathematical or astronomical fact is imbricated with a more philosophical discussion about the nature of knowledge, when and how to use it, and the standards appropriate to judging it. This mixed form suggests that the Scholar and the reader are both being groomed for intellectual discovery beyond the pages of the dialogues. The various dialogic modes are analogous to different ethical relationships between Master and Scholar and between the reader and the author, perhaps more usefully understood as a relationship between the reader and the text. These relationships must be dynamic if the mixed form is to be fully effective, so it becomes imperative to understand how the unequal power dynamic between Master and Scholar evolves into the independent mathematical subjectivity of the reader.

By positing a series of intellectual transformations, we can understand how the reader’s internalization of the roles of the dialogue allow him to acquire the mathematical independence that is also the ostensible goal of the Scholar within the dialogic fiction. Taking full advantage of the quasi-dramatic form of the lessons, the reader insinuates himself into the intellectual dynamic represented by the dialogue in order “to pursue the quest it had begun” beyond the pages of the book.<sup>42</sup> These transformations are achieved because the exchanges within the dialogue are homologous with the reader’s relationship to the text.<sup>43</sup> Initially, the Master relates to the Scholar

42. Cox, *The Renaissance Dialogue* (above, n. 22), p. xii. Cox also suggests that “the dialogue itself is conceived of as a *provocatio*, spurring the learned reader on to join the continuing quest” (p. 62).

43. Compare *ibid.*, p. 5.

as the text relates to the reader. The progress of Master and Scholar through the dialogue both prompts and mimics a self-tutorial in the reader as he experiences difficulty and finds the resources to answer questions and correct errors.<sup>44</sup> The chatty, conversational, and informal tone of the dialogue gives the reader's mind time to digest information and create his own auto-dialogue of question, answer, error, and correction. Nearly sixty years later, a similar process occurs in Galileo's dialogues, for which the internal interlocutors Salviati, Sagredo, and Simplicio each have their counterparts outside the text: Galileo the "professional" scientist; the reasonable amateur scientist; and the unreformed reactionary upon whom reason, evidence, and experiment have no effect. "It was a regular practice of Galileo," Alexandre Koyré argues, "to make the reader trace the phases of his own [Galileo's] thought, fall into the same errors that he himself had fallen into [that is, the role of Simplicio], and then free him from them. Sagredo is always allotted the intermediate phase, and Salviati the final."<sup>45</sup> In the course of reading Recorde's dialogues, the reader should undergo a similar psychomachia as Master and Scholar take on different aspects of the same intellect and politely spar for control. The Master wins, of course. Although initial exchanges may seem brutal from the Scholar's point of view, as the initial passages of *The Ground of Arts* demonstrate, the relationship eventually settles down with a healthy respect on one side and gentle forbearance on the other. Only occasionally does the Master revert to stringent censure of the Scholar's unlearned opinions (as in the Copernican discussion). As the Scholar moves closer to the Master's position and acquires more of his intellectual abilities and judgment, a corresponding change occurs in the reader, who also acquires the judgment of the Master and, implicitly, of the author. The reader as master instructs the reader as scholar.

Eventually, these identifications are further transformed so that the reader engages in a dialogue with himself: the self-who-learns instructed by the self-who-teaches, a relationship that can sustain itself *away* from the textual dialogue. The dialogues thus show the action of humanist self-fashioning in process, and how a reader is trans-

44. See Michel Ruch on similar strategies in Cicero's dialogues: "l'action extérieure 'mime' presque toujours l'action intérieure"; in *Le Préambule dans les œuvres philosophiques de Cicéron: Essai sur la genèse et l'art du dialogue*, Publications de la Faculté des Lettres de l'Université de Strasbourg 136 (Paris: Les Belles Lettres, 1958), p. 378, qtd. in K. J. Wilson, *Incomplete Fictions: The Formation of English Renaissance Dialogue* (Washington, DC: Catholic University of America Press, 1985), p. 15.

45. Alexandre Koyré, *Metaphysics and Measurement: Essays in Scientific Revolution* (London: Chapman and Hall, 1968), p. 55n3.

formed by the process due to his encounter with the text.<sup>46</sup> If the mere transmission of knowledge by rote were all that was desired, a monologic treatise would undoubtedly work well, and certainly more efficiently than dialogue. Dialogue facilitates the transmission of mathematical facts, as well as the establishment of functional mathematical reasoning and judgment in the reader. While a monologic treatise could exhort the reader to exercise reasoning and judgment, the dialogue provides a natural mode for the reader to make reasoning and judgment his own; reasoning and judging for himself become internalized as fundamental components of his identity because he has actively used them in the dialogic formation of his own mathematical subjectivity. For the reader, there is an unmistakable movement from persuasion from without (by the book) to reasoning (with himself) from within.<sup>47</sup> Once the reader becomes active in the exercise of reasoning, he possesses the ability to judge autonomously the participants in a dialogue, as each is “tested out in good faith to establish whether he *might* have a case.”<sup>48</sup> Reasoning allows a practitioner to transcend the specifics of his education; this contrasts obliquely with rote learning, and by implication the authoritative, didactic methods of instruction that employ it: “*Master*. Yea but you

46. Stephen Greenblatt, in reference to Thomas Wyatt’s poetry, provides one of the most important and influential accounts of this phenomenon: “the distance between reader and text is effaced and . . . the reader is virtually created by the text he absorbs.” He makes a similar argument about Edmund Spenser’s poetry, as does Richard Waswo in reference to the “Letter to Raleigh,” which states that the purpose of *The Faerie Queene* is “to fashion a gentleman or noble person in virtuous and gentle discipline”: “The ‘gentleman’ is at the same time both character (Arthur and the eponymous heroes of the six books) and the reader: we are made to share their moral formation.” See Greenblatt, *Renaissance Self-Fashioning: From More to Shakespeare* (Chicago: University of Chicago Press, 1980), pp. 119–120; and Richard Waswo, *Language and Meaning in the Renaissance* (Princeton: Princeton University Press, 1987), pp. 230–231. See also Kahn: “Unlike the reading of an abstract argument, reading poetry and history involves an ‘applicatio mentis’ . . . , a pleasurable activity, exercise or praxis, which educates us in the very act of reading at the same time that it moves us to the application of prudence in human affairs” (“Coluccio Salutati” [above, n. 4], p. 171 [emphasis in original]).

47. Steven Shapin remarks that “[c]onceptions of an invigilating god and requirements for an invigilating interior dialogue between ‘me and myself’ were, of course, widely distributed in Protestant culture”; see *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994), p. 160. Recorder seems to have been a committed Protestant. See his anti-clerical defense of vernacular learning in *The Urinal of Physick* (above, n. 10), B5r–6r; and Jack Williams, *Robert Recorde: Tudor Polymath, Expositor and Practitioner of Computation* (London: Springer, 2011), pp. 255–259.

48. David Simpson, “Hume’s Intimate Voices and the Method of Dialogue,” *Texas Studies in Literature and Language* 21:1 (1979): 70 (emphasis in original).

must prove your self to do some things that you were never taught, or else you shall not be able to do any more than you were taught, [and] that were rather to learn by rote (as they call it) than by reason" (GA 1543, F7v). With Erasmian aplomb, the Scholar appreciates the importance of transcending rote learning: "But for every matter to require aid, and never to travail my own wit, it might seem mere dastardliness. And so were it plain babishness, to covet every morsel, to be chewed before hand, and put into my mouth" (WW, Y3r-v).<sup>49</sup>

The dialogues "persuade the reader not to any specific action, but to the exercising of the prudential judgment that is required for all actions," and the reader begins to persuade himself in the full realm of mathematical and human affairs.<sup>50</sup> The unequal power relationship of Master and Scholar is no longer a stumbling block because it has been fully internalized by the independent mathematical subject. Hence the reader has acquired, as suggested in my epigraph, Prince Hal's "double spirit of teaching and of learning instantly."

Further confirmation of the Scholar's intellectual growth appears in *The Whetstone of Wit*, when he takes on the role of a junior master, even entering into the debate of authorities (see, for example, WW, P3v). The formal device for such moments is what might be called "pedagogical exclusion": the Master deliberately withholds an answer, technique, or complication precisely so that the Scholar can stumble upon it himself (perhaps through error, as in the case of carrying in addition). The Scholar exhibits intellectual development by demonstrating an ability to extend the lesson. And yet the obvious artificiality of this mechanism gestures towards those aspects of dialogue that may make it unsuitable for real, rather than mimed discovery in a discipline like mathematics. Even Galileo acknowledged that dialogue was not bound by the rigor of mathematics: "I thought it would be very appropriate to explain these ideas in dialogue form; for it is not restricted to the rigorous observation of mathematical laws, and so it also allows digressions which are sometimes no less interesting than the main topic."<sup>51</sup> Dialogue may not be bound by

49. Compare Erasmus, who argues that a proper pedagogy in any subject will strive to reach a point when "it will be sufficient to supply the bare subject of the exercise, and no longer necessary, as with infants, to be constantly putting predigested food into their mouths"; see *De Ratione Studii*, trans. Brian McGregor, ed. Craig R. Thompson, in *Collected Works of Erasmus*, vol. 24 (Toronto: University of Toronto Press, 1978), p. 681.

50. Victoria Kahn, *Rhetoric, Prudence, and Skepticism in the Renaissance* (Ithaca, NY: Cornell University Press, 1985), pp. 38–39.

51. Galileo Galilei, *Galileo on the World Systems*, trans. Maurice A. Finocchiaro (Berkeley: University of California Press, 1997), p. 81.

mathematical rigor, but does it follow that dialogue is therefore incapable of it? If so, where does that leave Recorde's project? These questions ask for attention to invention, judgment, and discovery, three of the most important early modern modes of organizing knowledge and its expression.

### Compromise and Collapse

Invention and judgment—the selection and arrangement of material for discourse—are ancient components of rhetoric and were widely taught during the Renaissance. The function and relationship of invention and judgment underwent significant alteration as early modern humanists reorganized rhetoric and dialectic. Whether or not cast into *grands récits* such as the “Scientific Revolution,” the vanguard of early modern thought placed pressure on these classical modes as not being sufficiently effective in the discovery of new knowledge. Despite residual beliefs that some techniques of invention and judgment, such as Erasmian *copia*, could create new knowledge, they were increasingly perceived as merely rearranging what was already known. Discovery required an entirely new mode of thought, which meant an entirely new approach to the use of language. One of the most important results was a divergence in the rhetorical strategies of teaching or presentation (the preserve of invention and judgment) from those of discovery. In extreme cases, such as the methodological writings of Francis Bacon, traditional rhetoric was eschewed as detrimental to scientific discovery.<sup>52</sup> In a dialogue that employs pedagogical exclusion, what might appear at first glance to be discovery is really just invention and judgment, a clever rhetorical arrangement of preexisting knowledge deployed here for a specific pedagogical goal. Although learning techniques of carrying in addition may be new to the Scholar, it hardly qualifies as discovery of new mathematical knowledge.

This is not to suggest that Recorde's talent for invention and judgment, especially in the form of textual humanism, is not extremely powerful; indeed, he provides important mid-century “textbook” examples of textual humanist methods. In one of the most developed cases, the Master undertakes a familiar humanist exercise of translation, re-translation, and textual editing when confronted by a difficult passage in Strabo quoted in *The Castle of Knowledge*. First, he quotes the medieval Latin text and declares that it is “so evil expressed, that no sentence in it importeth any sense: wherefore as

52. For a thorough and influential study of early modern reorganizations of invention, judgment, and discovery, see Jardine, *Francis Bacon* (above, n. 31).

well for the commodity of you as of other, I will somewhat amend that place, wishing them that have leisure and learning to help to amend many other faults of that good book and other like." His amendment begins by quoting the original Greek, which is "full of perfect, sensible and pleasant sentences," and detailing two errors in the Greek. Then the Master translates the Greek into Latin, which differs significantly from the original Latin, and clarifies Strabo's point immediately. Finally, Recorde's vernacular impulse asserts itself and the Master provides an English translation (*CK*, P2v–3r). The effect of this exercise on the Scholar's scientific understanding is immediate. He comments perceptively on the rhetorical subtleties uncovered by the corrected translation (*CK*, P3r), thereby validating the Master's (and Recorde's) emphasis on linguistic and textual scholarship. The episode concludes with the Scholar's demonstration of sophisticated knowledge of the subtleties of rhetoric and composition. Similar textual scholarship even makes itself relevant to the arguments for the social importance of mathematics that are never far in the dialogues. In the Master's discussion of the assize, for example, he mentions statute books in three languages, one "an ancient copy of 200 years old (which I have)" as evidence for his argument on the need to reform the assize (*GA* 1552, T1r). Concerning the measurement of land, the rates are corrupt "not only in the English books of statutes, commonly printed, but also in the Latin books, and in the French also, for I have read of each sort, and conferred them diligently" (*GA* 1552, T3v). Antiquarian research, translation, philology, etymology, and editing thus have their place in mathematics and its civic applications, but the claim to discovery is still tenuous. Resurrecting Strabo's original text is an important accomplishment—even necessary, since no subject can progress without reliable texts—but it is still just a highly developed example of invention and judgment. As a method for discovery, textual humanism clearly has the capacity to reveal knowledge, but recapturing knowledge that had been hidden under the encrustations of poor translation and wayward textual transmission is still not the same as discovery made through mathematical induction and demonstrative rigor.

Recorde's devotion to textual humanism suggests that we consider his project as a means to buttress the necessity of mathematical rigor, but not actually constitutive of it. The fact that *The Pathway to Knowledge*, his geometry book, is not a dialogue provides some suggestive support for this claim. The book presents Euclidean geometry, although with some crucial omissions, as we shall see. As such, *The Pathway to Knowledge* presents the gold standard for early modern mathematical rigor, but without a critique of Euclid, the

historical persona of that rigor's authority. The book does not pursue two of the most important investigations that characterize Recorde's mathematical dialogues: development of mathematical subjectivity and the critique of authority. Moreover, reliable Greek and Latin texts of the *Elements* were widely available, and the *Elements* would achieve a reliable English translation in 1570. The *Elements* was not in the need of the same kind of textual overhaul that is the third specialty of Recorde's dialogues. To the extent that dialogue is the privileged form for these tasks, *The Pathway to Knowledge* cannot make use of it.<sup>53</sup>

*The Pathway to Knowledge* reproduces Euclid's sequence of propositions (with a few exceptions), but omits the proofs. Recorde defends this practice as pedagogical: "to the end that the simple reader might not justly complain of hardness or obscurity . . . are the demonstrations and just proofs omitted, until a more convenient time" (*PK*, a1r). What Recorde states outright in his monologic geometry draws our attention to similar strategies and statements in the dialogues, and to their consequences for the goals we have already established as central to Recorde's project. As we saw in the Copernican episodes, formal, rigorous proofs are necessary for the mathematical sciences to be complete, and indeed the Master does not move beyond speculative consideration of Copernican theories precisely because he chooses not to present relevant proofs. But in that episode, we must remember, the Master omits proofs because they are too sophisticated for that treatise, which is another way of saying that the proofs are too advanced for the Scholar and the reader at that stage of study. This concession is quite different from one that Recorde and his Master frequently make elsewhere: the omission of proofs not because they are too advanced for the state of the current discussion, but because they are harder for the Scholar to understand than pedagogically formulated examples. The Master outlines a pedagogy that begins with discrete examples, "first by some brief precepts to instruct a learner somewhat in the use of the art," and then turns to "reasons" (proofs or demonstrations): "then may you afterward more sooner make him to perceive the reasons" (*GA* 1543, E1v–2r). Again and again, the Master (or Recorde) promises proofs at a "more convenient time" that never comes. Instruction by convenient precept that trumps rigorous proof produces an effect that "appeareth . . . to

53. The economics of printing may also have militated against geometrical dialogue in the early modern period. In Recorde's dialogues of arithmetic, an example will be reprinted again and again as the explanations of the conversation require the presence of a new numeral. Similar repetition of a geometric diagram at each alteration would have been prohibitively expensive.

be of greater force" (G6v). This suggests the division of eloquence, and persuasion by rhetoric generally, from rigorous and certain approaches to mathematics. In every direction, the goals and gains of Recorde's project undo themselves.

Even the claims for a civically useful mathematics undergo strain. Recorde presents a mathematics (geometry especially) that "may most aptly be applied unto practice" (*PK*, ¶1r). With hints of Iago five decades later, "Practic conclusions" applied to "handy works" are preferred to "theorics (which are only mind works)," and the result is a preference for practice that is pedagogically rather than theoretically founded (*PK*, a1r, A1r). There is a divergence in the desired degree of precision between cosmology and "handy works" that was not accounted for in Recorde's overarching conception of mathematics as a unified art to be employed by all ranks for all purposes. Just as clearly, the application of mathematics does not preclude theoretical rigor, but it does indicate that the form of presentation and pedagogy chosen by Recorde cannot accommodate both with the same finesse. It is this divergence that points to the greatest crisis in Recorde's dialogic project.

Dialogue as the form for eloquent, civically useful mathematics draws attention to the social nature of conversation and the social cohesion that was a goal for early modern humanism. At several points in the project, Recorde thinks of the dialogues as closet dramas and introduces details that heighten their mimetic charm. *The Castle of Knowledge* enacts the construction of celestial spheres, globes, and other astronomical instruments and even posits ideas of physical space and movement for the two discussants. At the opening of the fourth treatise, the Scholar begins to speak before he is in company with the Master, trying to balance his desire to learn with the Master's probable desire for privacy:

*Scholar.* [H]is gentleness is such that he seeketh more the profit of other than his own pleasure or peculiar commodity, and therefore will I boldly enter his house. Are you at home sir?

*Master.* I am always at home for my friends, if I be not with them from home, yet sometimes I cannot be at home for myself. (*CK*, I1r)

Much more interesting than these details, and much more consequential for Recorde's project, is a series of moments that dramatizes the increasingly dire personal difficulties of the Master, starting as early as *The Ground of Arts*, when the Scholar says, "I perceive your manifold business doth so occupy or rather oppress you, that you can not as yet completely end that treatise of fractions Arithmeti-

cal" (GA 1552, P5r). *The Castle of Knowledge* ends in a way that can only be described as a cliffhanger when the Master exclaims, "I am driven to omit teaching of Astronomy, and must of force go learn some law" (CK, &4v). *The Whetstone of Wit* expands this threat of legal problems, which enters fully into the dramatic aspects of the dialogue: "But as for the works of *Proportions*, I will omit them till another time: considering . . . the troublesome condition, of my unquiet estate" (WW, C2r). The pattern that emerges from these examples is one in which attention to mathematics and astronomy is delayed or disrupted by concerns of daily life and the outside world. *The Whetstone of Wit* completes the pattern with a stunning conclusion. It departs from mathematics completely in order to devote the full dramatic possibilities of dialogue to the Master's misfortunes, including a third presence on the "stage" during a discussion of the extraction of roots:

*Master.* But hark what meaneth that hasty knocking at the door?

*Scholar.* It is a messenger.

*Master.* What is the message? Tell me in mine ear. Yea sir is that the matter? Then is there no remedy, but that I must neglect all studies, and teaching, for to withstand those dangers. My fortune is not so good, to have quiet time to teach. . . . If I might have been quietly permitted, to rest but a little while longer, I had determined not to have ceased, till I had ended all these things at large. But now farewell. . . . And if I may get any quietness reasonable, I will not forget to perform my promise with an augmentation.

*Scholar.* I will pray, with all them that love honest knowledge, that God of his mercy, will soon end your troubles, and grant you such rest, as your travail doeth merit. And all that love learning: say thereto Amen.

*Master.* Amen, and Amen. (WW, Rr4r-v)

There are many ways to interpret this extraordinary moment and they need not be mutually exclusive. This dramatic flourish could be a convenient way to mark an appropriate place to stop. Whatever else the Master might say about a certain kind of polynomial root, the mathematical conversation as it stands is complete, ending on a point of notation rather than technique or theory. This ending and its early warnings may be a dramatized plea to protect learning from the dangers of the world, which would also emphasize an incompatibility, perhaps insufficiently perceived by Recorde, of mathematics with the *vita activa*. And yet the thrust of these episodes is to draw the Master into an active life in which he seems incapable of implementing his own lessons about civically useful mathematics. The

Master's distress is in no way made relevant to the mathematical topics being discussed, nor do his problems seem open to the application of mathematical assistance within the *vita activa*. As such, there is no coherent motivation for the dialogue to take this turn.

Recorde was both a mathematician and civil servant. He was given responsibility for various English mining and minting activities in both England and Ireland under Henry VIII and Edward VI. I suggest that in these moments of textual distress, the identity of the Master and his author have collapsed into one: when we read of the Master's distress, we are reading Recorde himself writing about his own life. He was not a successful Surveyor of the Mines in Ireland during the early 1550s. His accusers (whose biases we must recognize) detail many occasions when Recorde allegedly failed to fulfill his duties, could not get along with his associates, withheld the funds necessary for legitimate expenses, or engaged in profiteering. They accused him of "affirming that he had more knowledge than all they" and said that "the myners are not com hethir to learne of Mr. Recorde." Then, in the middle of the decade, Recorde was imprudent enough to accuse William Herbert, Earl of Pembroke, of theft and embezzlement from mining operations for which Recorde was the responsible authority. Herbert sued for libel and was awarded £1,000 in damages. Recorde could not pay and was sent for debt to the King's Bench Prison, where he died. It is suggestive that the Recorde who was surveyor seems not to have done well in the active life, in which one's ability to act prudently in relation to other men is key. And, if the miners' complaints are to be believed, he was even a bit of a pedant who chose to delay decisions and "teach" the men their jobs rather than manage everyone to get the job done.<sup>54</sup>

Personal disgrace and suffering are not antithetical to dialogue—far from it. Socrates, Cicero, Boethius, and Thomas More deployed dialogue as an "organizing form for thought and language" in times of danger and distress.<sup>55</sup> Similarly, dramatic details in dialogue traditionally either fade from view or become explicitly relevant to the

54. On these elements of Recorde's biography, see Frances Marguerite Clarke, "New Light on Robert Recorde," *Isis* 8:1 (1926): 50–70 (for the miners' quoted speech, see pp. 60, 65); and Williams, *Robert Recorde* (above, n. 47), pp. 15–52. Recorde may also not have endeared himself to government officials for drawing repeated attention in *The Ground of Arts* to the debasement of English coinage during the reign of Henry VIII. See C. E. Challis, *The Tudor Coinage* (Manchester: Manchester University Press, 1978), p. 82; Stephen Deng, *Coinage and State Formation in Early Modern English Literature* (New York: Palgrave Macmillan, 2011), p. 90; and Landreth, *The Face of Mammon* (above, n. 11), p. 16.

55. Wilson, *Incomplete Fictions* (above, n. 44), p. 151.

subject under discussion.<sup>56</sup> In Castiglione's *Il Cortegiano*, the courtliness of the setting and behavior of the discussants is just as important as what they say about the perfect courtier. In Cicero's *De Oratore*, the discussion of eloquence is reinforced by the urbanity ("humanitatem") of Crassus as host.<sup>57</sup> In Thomas Smith's *A Discourse of the Commonweal of This Realm of England*, the setting in an inn includes the quaint detail of a "pasty of venison" shared among the speakers for dinner, which is symbolic of the unified commonwealth sought by interlocutors of widely different social ranks.<sup>58</sup> In Recorde's dialogues, the setting does not recede, but overwhelms the discussion of mathematics. Whereas dialogue traditionally occurs in a place apart, a *locus amoenus* or place of *otium*, Recorde's dialogues move toward the world of *negotium*.

Recorde's dialogues become a dramatic representation of a particular mathematician within a social context. Not only is the repeatedly promised and repeatedly deferred theory abandoned, but so also is the entire mathematical discourse. These intrusions are a violation of decorum and thus of the eloquential mode adopted at the beginning of the project. The master's lament also betrays the fact that the entire project of mathematics pursued for use in the active life has been an elaborate hypothesis conducted within the contemplative life. The result is the abandonment of mathematics; certainly, there is no attempt to make mathematics useful to the solution of the Master's problems in the world of the active life. Elements of the final exchange suggest that mathematical activity cannot be located entirely within the active life. Opposed to the Master's new need to "withstand . . . dangers" (presumably in the public law courts) are the "quiet time to teach," the "quietness reasonable," and the chance to "rest" in "quiet"—all redolent of a contemplative life.

What is supposed to be a generalizable dialogue for the intellectual formation of a mathematical subject becomes more circumstantial as, simultaneously, the Master gets drawn further into the active life and Recorde gets further drawn into the dialogue.<sup>59</sup> The probable identity of the distressed Master becomes particularized to the point of arresting the gains made by the reader in achieving autonomous mathematical subjectivity. The special power of Recorde's dialogues

56. *Ibid.*, pp. 141–146; Simpson, "Hume's Intimate Voices" (above, n. 48), p. 71.

57. Marcus Tullius Cicero, *De Oratore*, trans. E. W. Sutton and H. Rackham, 2 vols., Loeb Classical Library (London: William Heinemann, 1942), 1.7.27.

58. Smith, *A Discourse of the Commonweal* (above, n. 36), p. 16.

59. Rather, the dialogist's self-effacement is more traditional; Cicero, Castiglione, and Smith state that they were not present at the dialogues they report.

is achieved because the author purposely displaces his direct relationship with the reader onto the fictional relationship of the Master and Scholar. If the primary goal of the dialogues is realized because Recorde has effectively removed his own identity from them, then the goal is severely compromised when the dialogue turns out not to be fictional, but very autobiographical in quite distressing ways. The dialogue metamorphoses into a bathetic entertainment about Recorde rather than an intellectual template upon which the reader may pattern himself and thus detracts from the development of mathematics as the foundational discipline of the *vita activa*. Recorde presents himself as a living example that could be construed as proof of the impossibility of his entire project.

### Conclusion

How does the reader interpret Recorde's textualized stumbling over himself within the context of the kinds of reasoning that had previously been the goal of the dialogue? I have described the lack of demonstrative rigor (or Recorde's repeated deferral of it) and the sudden shifts into autobiographical drama as if they were flaws. They may indeed be flaws from Recorde's point of view, given his position on the importance of mathematics to the *vita activa*. The drama represents a particular *vita activa* and the view it offers is a pessimistic one. The dialogues unwittingly suggest that mathematics, in its fullest realization, is not appropriate to the public role of the *vita activa*, but is instead better suited to the privacy of the *vita contemplativa*. But what might be a failure for the Master and Recorde may not be futile for the reader, who from the start is supposed to be capable of exercising reasoning and certainly should have developed the ability over the course of three dialogues.<sup>60</sup> There is no need to pretend that the reader is a hypothetical construct trapped within Recorde's dialogic system and bound to suffer its failures. The reader, if he has acquired some measure of independent mathematical subjectivity through reading the dialogues, should be able to pick through the debris of the autobiographical collapse and come to his own conclusions about where best to draw a distinction between the pursuit of mathematics for itself and its pursuit in an active life. We are the reader, and we can read the breakdown of mathematical dialogue as

60. Kahn argues that "[i]n early humanism, dialogue and other instances of deliberative rhetoric are encomia of the will: the very fact of written debate is taken to be evidence of the reader's ability to respond, and thus of the existence of free will and the genuine possibility of rhetorical persuasion"; see *Rhetoric, Prudence, and Skepticism* (above, n. 50), p. 20.

a constructive failure teaching lessons about the function of mathematics within the *vitae*.

The real challenge faced by Recorde and his dialogues was a culture that so identified eloquence and prudence with the *vita activa* that it had a hard time conceiving of an alliance of eloquence with the contemplative aspects of mathematics—namely, rigor and demonstration. Kahn argues that in the early modern period, eloquence was “conceived of not only as the cause and effect of prudence, but as a form of prudence itself,” which, in turn, directs life in the world: “The central assumption of the humanist rhetorical tradition,” she continues, “is that reading is a form of prudence . . . and that a text is valuable insofar as it engages the reader in an activity of discrimination and thereby educates the faculty of practical reason or prudential judgment which is essential to the active life.”<sup>61</sup>

Recorde was hardly the only early modern scientific and mathematical writer who had difficulty negotiating the *vitae*; the examples of Galileo and Giordano Bruno still speak eloquently across the centuries. Recorde’s dialogues certainly argue effectively for mathematics in the civic realm and for rigor in mathematics. It is in the implementation of these beliefs that dialogue seems to fail him. To resolve this dilemma, we need to theorize the possibility of a divided subjectivity, generated by different eloquential forms, that can satisfy the requirements of application in the *vita activa* and the demands of rigor in the *vita contemplativa*. It is a commonplace of classical and Renaissance rhetoric that a good orator and a good man are one and the same, but insofar as mathematics and eloquence are allied, what could it mean for a good man to be a good mathematician? When the subject matter’s rigor becomes the primary objective, where do the reader’s prudence, ethics, and reasoning reside? One possibility is to redefine the prudential and ethical virtues inherent in the discourse. For mathematics as the instrumental tool of the *vita activa*, virtue resides in the life that uses it, but for mathematics as an independent subject (the vocation of a *vita contemplativa*), virtue should be located in the discipline itself, in the integrity of rigor and proof that constitutes and generates mathematics. Such division and redefinition means that dialogue, as understood and practiced in the early modern period, could not be all-sufficient. Recorde’s project reaches “the limits of the convention,” pointing “away from itself to something its forms cannot capture.”<sup>62</sup> As mathematics continued its rigorous

61. *Ibid.*, pp. 10–11; see also Ong, *Ramus, Method, and the Decay of Dialogue* (above, n. 6), p. 125.

62. Jardine, *Francis Bacon* (above, n. 31), p. 172; Fish, *Self-Consuming Artifacts* (above, n. 31), p. 4 (emphasis in original).

development, new forms would need to be found to supplement the capacities of dialogue; they call on modern scholarship to interpret their engagements with rhetoric, eloquence, and ethics.<sup>63</sup>

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63. Mikhail Bakhtin's theories of speech genres are one promising avenue for investigating the development of new forms for the creation of rigorous mathematical subjectivity. Inasmuch as mathematics was evolving swiftly during the Renaissance, the changing demands of the mathematical community, in Bakhtinian terms, would elicit genres that could respond appropriately. In this model, the entire mathematical culture is a dialogue writ large. On Bakhtin and dialogue, see James S. Bauman, "Dialogue and *Controversia* in English Renaissance Literature: Historicizing the Reader's Response," *Publications of the Missouri Philological Association* 19 (1994): 1–20; and Gilman, "A Meeting of Minds" (above, n. 28).