



Practical mathematical knowledge in early modern Verona: Feliciano, Tartaglia and interdisciplinary exchange

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Abstract

This article examines how practical mathematical knowledge was shaped through interactions between abbaco mathematicians and other expert practitioners in early sixteenth-century Verona. During the 1520s and 1530s, the Veronese abbaco masters, Francesco Feliciano and Niccolò Tartaglia both taught practical mathematics, undertook consultancy, and developed successful printed works while working in the city. Through comparing their practices, publications, and professional networks, I argue that the differing communities they engaged with shaped not only the problems they addressed, but also the values they promoted. Feliciano's surveying activities fostered process-based forms of knowledge directed toward reliability, fairness, and practical competency, while Tartaglia's engagement with military practitioners encouraged ambitious approaches to motion and theory, with a focus on ingenuity and innovation. Their frontispieces similarly show both a shared image of mathematical expertise and a divergent reach in epistemic ambition. In this way, I show that exchange across professional worlds was not incidental, but integral to the production of abbaco knowledge.

Keywords

practical mathematics, Niccolò Tartaglia, Francesco Feliciano

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Introduction

Recent scholarship on Renaissance and early modern science has increasingly emphasised the role of practice, material engagement, and social interaction in the formation of knowledge. Rather than treating knowledge as separate from practice, historians have shown how it evolved through use, in turn shaped by the routines of work, the demands of specific tasks, and exchanges between practitioners working across different social and professional settings. This approach has been particularly productive for the study of early modern mathematics, where attention to practical calculation and geometric visualisation has revealed the central epistemic role of artisans and non-elite experts.¹ More recently, scholars have emphasised the importance of reconstructing practical knowledge as it moved from lived experience into written form, as embodied techniques were stabilised and reformulated in procedures, diagrams, and printed texts.²

This article examines these processes through a focused study of practical mathematical knowledge in early sixteenth-century Verona, integrating social history, intellectual history, and material culture. During the 1500s, Verona was a key city in the *terraferma*, or mainland territories, of the Venetian Republic. As an important centre of trade, grain production, and military defence, it depended on increasingly sophisticated forms of commercial and practical mathematics. In the cities of central and northern Italy, such skills were cultivated through the *abbaco* tradition, whose history extended to the early 13th century works of Leonardo Fibonacci. In popularising Hindu-Arabic arithmetic and mathematical problem solving, particularly in the merchant world, Fibonacci helped launch a long-standing program of practical mathematical education throughout the Italian peninsula.³ By the early sixteenth century, commercial mathematics was taught in a network of public and private schools, where children of merchants, landowners, and artisans learned calculation, bookkeeping, and applied problem-solving, often alongside basic literacy. These schools were led by *maestri d'abbaco*, who rarely confined their activities to teaching alone. In addition to instruction, *abbaco* teachers often competed in mathematical contests, delivered public lectures, and acted as consultants on problems of trade, valuation, measurement, surveying, and other practical affairs.⁴ As a result, these non-university educated practitioners occupied an unusual social position. Able to move between multiple professional worlds, they were well placed to translate practical and embodied forms of expertise into more stable textual and visual forms.

¹ Cormack, “The Role of Mathematical Practitioners”; Cormack et al., *Mathematical Practitioners and the Transformation of Natural Knowledge*, vol. 45; Lefèvre et al., *The Power of Images in Early Modern Science*.

² Smith, *From Lived Experience to the Written Word*; Jardine, “The Book as Instrument.”

³ For more on Fibonacci and the commercial revolution of the 13th and 14th centuries, see Danna, “Leonardo Fibonacci”; Danna, “The Spread of Hindu-Arabic Numerals,” 61–66.

⁴ Høystrup, *The World of the Abbaco*; Grendler, *Schooling in Renaissance Italy*.

In the 1520s and 1530s, Verona's two main schools of practical mathematics were led by Francesco Feliciano (c.1470–1542) and Niccolò Tartaglia (c.1499–1557). Both were recognisably formed within standard *abbaco* practice. Each taught practical mathematics, cultivated their reputations through mathematical competition, worked beyond the classroom as consultants, and drew on their practical mathematical expertise in print. Yet neither was wholly typical of the profession at large. At the more ambitious edge of *abbaco* culture, they both became well known for their consultancy work and achieved an unusual degree of success in publication. While Tartaglia's works, including *Nova scientia* (1537) and *Quesiti et inventioni diverse* (1546), have attracted sustained attention from historians of science, Feliciano's more conventionally *abbaco*-oriented texts, the *Libro de abbacho* (1517) and *Scala Grimaldelli* (1526), have received far less scrutiny, despite their considerable success over an extended period.

This article is divided into two main parts. The first situates Verona within the Venetian Republic in the early sixteenth century, outlining the city's economic and military significance and the role of *abbaco* mathematics within its educational and professional landscape. It also introduces Feliciano and Tartaglia as coexisting practitioners in Verona between approximately 1517 and 1534. The second part turns to a comparative analysis of their practices, examining their interactions with different expert communities, their printed texts, and the contrasting epistemic ambitions embedded within their work. While Feliciano and Tartaglia worked alongside one another as Veronese *abbaco* masters for well over a decade, their surviving texts articulate notably different forms of practical mathematical knowledge. I propose these differences were shaped not simply by individual ability or intellectual ambition, but by sustained interaction with different practitioner communities in the period prior to their publication.

Feliciano's consultancy work involved quantity and land surveying, during which he interacted primarily with merchants and landholders. While this work involved variable measures and the need for expert judgement, it also depended on recognised procedures, and authority largely rested on reliability, fairness, and practical competence. In contrast, Tartaglia's first publication emerged from his engagement with practitioners in the rapidly developing world of the military arts. The different communities they engaged with prove important in at least three ways. Military interaction exposed Tartaglia to problems of motion that were less easily contained within the regular procedures of *abbaco* mathematics, brought him into contact with practitioners interested in pursuing more abstract mathematical analysis, and opened up a broader horizon of advancement, including drawing the attention of military elites and powerful patrons. Perhaps most importantly, the military arts provided a context in which speculative ingenuity and mathematical novelty were more readily treated as virtues. In a field being transformed by technological innovation and the increasingly elite status of military leaders, mathematical novelty was less likely to be viewed as a departure from practical usefulness, but as a mark of superior expertise.

At the same time, Feliciano and Tartaglia did not develop their ideas in isolation from each other. Working in the same city, they encountered overlapping communities of practitioners and participated in a shared abbaco culture. While direct evidence for their close relationship remains limited, I suggest Tartaglia's recounting of multiple exchanges with Feliciano, in which he refers to him as "my maestro,"⁵ as well as notable affinities in the ways they envisioned the value of mathematics, suggests a stronger relationship than has usually been recognised. In this way, the works of Tartaglia and Feliciano register both similarity and divergence, revealing how a shared abbaco environment could be developed in markedly different directions. In this sense, mathematical knowledge in use was not simply adapted to social settings after the fact, it was constituted through them, taking different shape as it moved across mercantile, agricultural and military worlds.

Part 1. Verona and practical mathematics

In the sixteenth century, Verona occupied a significant position within the terraferma of the Venetian Republic. Nearing 50,000 inhabitants, the city's population almost matched that of Florence, and it had become critical to trade, food supply and the defence of Venice itself.⁶ Since the late fifteenth century, maintaining these functions required increasingly sophisticated techniques of calculation, measurement, and technical problem-solving, which, in turn, raised the profile of practical and commercial mathematics.⁷ One domain in which these demands were deeply embedded was commerce. Located on major overland routes linking Venice with Milan and northern Europe, Verona's importance to the Venetian Republic was closely tied to its position as a corridor for the movement of goods, money, and information.⁸ By the late fifteenth century, this position supported an active merchant community whose activities connected rural producers with urban markets and long-distance trade in agricultural goods and textiles such as woollen cloth and, increasingly, silk textiles. Commercial practice in this setting involved a wide range of mathematical tasks, including currency conversion, partnership accounting, credit management, pricing, and profit calculation. As trade expanded and transactions became more complex, demand grew for expert practitioners able to apply mathematical techniques across different commercial contexts.

Trade and commerce were closely connected to Verona's role in agricultural administration. The city of Venice lacked arable land and depended increasingly on mainland

⁵ Tartaglia, *Quesiti et inventioni diverse*, bk. 9 qn. 9, "Mo maestro."

⁶ Knapton, "The Terraferma State," 88; Farrell, "Connections and Community," 4.

⁷ For more on the spread of abbaco beyond commerce, see Danna, "The Spread of Hindu-Arabic Numerals," 66–68.

⁸ Black, *Early Modern Italy*, 37.

territories for food supplies, including Veronese grain.⁹ This dependence placed pressure on cities such as Verona to organise production, oversee estates, and manage irrigation to regulate water distribution across cultivated land.¹⁰ The planning, construction, and maintenance associated with these systems required skills in mathematically-based problem solving. At the same time, a large share of Venetian state revenue came from land-based taxes assessed on agricultural output.¹¹ Managing both food supply and state income required systematic measurement, as land needed to be surveyed and divided, harvests estimated, and storage and transport capacities calculated, making mathematical expertise increasingly central to the effective functioning of Verona's agricultural systems.

Perhaps most dramatic was the increased demand for specialist mathematical skills generated by Verona's importance to Venetian military efforts. The War of the League of Cambrai (1508–1516) exposed deficiencies in Venetian defences, particularly during the period when Verona fell out of Venetian control. After the city was recovered, Venice invested heavily in fortifications across the *terraferma*, and Verona became a central site for military planning and construction. The city's *castelvecchio* served as a base for the training and lodging of troops as the Venetian republic developed a standing army that was to become one of the strongest across Italy.¹² These local projects coincided with rapid changes in European artillery, as the development of mobile cannonry opened new possibilities for attack and increased firepower proved too strong for standard fortifications.¹³ Designing more effective defensive structures required careful measurement, geometrical planning, and proportional calculation, making mathematical skills an increasingly essential component of military practice.¹⁴ As Brioiist has put it, "military expertise had never been so precious and warfare so technical."¹⁵ Like changes in other early modern cities, Verona's growing importance to Venice in trade, agricultural administration, and military defence intensified requirement for specialised knowledge in commercial and practical mathematics and elevated mathematical expertise from a routine skill to a valued form of professional competence.¹⁶ These demands were met within an already developed educational landscape. By the late fifteenth-century, Verona supported an established culture of *abbaco* teaching directed toward transmitting the skills needed for trade and practical affairs, as well as consultants able to provide expert mathematical advice when required. It was within this local environment that Feliciano and Tartaglia worked, and in turn, produced some of their most influential texts.

⁹ Alfani and Di Tullio, "The Venetian Fiscal System," 28.

¹⁰ See, for example Knapton, "The Terraferma State," 101.

¹¹ Alfani and Di Tullio, "The Venetian Fiscal System," 22–28.

¹² Knapton, "The Terraferma State," 97.

¹³ Black, *Early Modern Italy*, 8.

¹⁴ Cf. Bennett and Johnston, *The Geometry of War 1500–1750*.

¹⁵ Brioiist, "Familiar Demonstrations in Geometry," 2.

¹⁶ Cf. Cormack, "Introduction: Practical Mathematics..."

Abbaco mathematics in Verona

In Verona, the development of practical mathematical expertise was centred primarily in the city's *scuole d'abbaco*. As recent work by Francesca Masiero has shown, abbaco teaching in Verona formed part of a long-established and publicly supported civic education system. The city had promoted abbaco instruction from at least the thirteenth century, and by the fifteenth century its importance was evident in the generous salaries paid to abbaco masters and the provision of free teaching spaces in prominent locations, including Piazza delle Erbe and the Palazzo della Ragione.¹⁷ Like abbaco schools elsewhere in Italy, these institutions trained pupils from mercantile, artisanal, and other practically oriented backgrounds in arithmetic, geometry, and applied problem-solving.¹⁸ Yet the Veronese schools also reflected the northern Italian tradition, which differed from the Florentine model which focused almost exclusively on calculation. In Verona, pupils began by learning reading and writing, before moving through arithmetic, geometry, accounting, surveying and algebra.¹⁹

Masiero's analysis of surviving Veronese abbaco manuscripts further highlights the local character and wider standing of the city's abbaco tradition. Written in the Veronese dialect, the treatises show that the city's abbaco teaching was adapted to regional needs, with problems directed toward locally important trades, such as wool and silk, and with descriptions of land surveying according to local methods, including the use of the rod known as the *perticha*. At the same time, the manuscripts circulated well beyond Verona, suggesting that the city's abbaco teaching was well regarded more broadly.²⁰ By the early sixteenth century, abbaco schools were also attracting students from higher-status mercantile families, a shift that reflected both the limitations of traditional Latin schooling and the growing practical and social prestige of mathematical expertise.²¹

The work of Veronese abbaco masters also extended beyond teaching. Like their counterparts elsewhere on the Italian peninsula, they often participated in mathematical challenges intended to show their skill and increase their reputation, as well as consulting on matters of calculation, measurement, and practical advice.²² In his later works, Tartaglia recalled a series of challenges posed to him during his years in Verona, many of them by

¹⁷ Masiero, *Literacy and Learning*, 126–131.

¹⁸ For good overviews of standard abbaco teaching, see Ulivi, "Masters, Questions and Challenges in the Abacus Schools"; Danna, "The Spread of Hindu-Arabic Numerals."

¹⁹ Grendler, *Schooling in Renaissance Italy*, pp.

²⁰ Masiero, *Literacy and Learning*, 148.

²¹ Cf. Grendler, *Schooling in Renaissance Italy*; Høyrup, *The World of the Abbaco*.

²² For more on abbaco masters commonly engaging in mathematical contests and consultancy see, for example, Ulivi, "Masters, Questions and Challenges in the Abacus Schools"; Goldthwaite, "Schools and Teachers of Commercial Arithmetic."

maestro Feliciano, as well as masters from Brescia, Venice, and Florence.²³ Evidence of a tradition of consultancy can likewise be found for other abbaco teachers in the city, with Masiero showing that Giovanni Maria Phanice di Rovigo and maestro Battista also worked as surveyors while teaching in Verona.²⁴

As Feliciano and Tartaglia worked side by side as Verona's two principal maestri d'abbaco during the 1520s and 1530s, they pursued activities typical of the tradition. Feliciano's career, in particular, closely matches the traditional profile. His school was located in the Palazzo della Ragione, in which – according to his nephew – Feliciano constructed his teaching space “out of boards and beams at his own expense.” There he taught “reading, writing, addition, subtraction, all kinds of accounting of every kind and everything related to mathematics,” activities Feliciano's nephew described as “a useful and essential resource for a city.”²⁵ As well as teaching and engaging in mathematical challenges, Feliciano also became well known as a master surveyor, being called on for the measurement of land, produce, and water levels, as well as consultation on commercial partnerships and exchange.

During his Veronese years, Tartaglia also operated in remarkably similar ways. Tartaglia taught abbaco in the nearby Palazzo Mazzanti in Piazza delle Erbe and consulted on practical mathematical concerns.²⁶ Evidence of his consultancy is found both in Tartaglia's later works, and in the archival record. For example, in his *General trattato*, Tartaglia describes how, during a period of famine in Verona, he was asked by the city bakers to make a mathematical table so they could determine “how much bread to make with respect to the price of wheat.” The prices had risen to such a degree that the old table, “anciently made” was no longer applicable and so the bakers turned to Tartaglia to extend it. However, to “do this rightly” Tartaglia did not follow a simple arithmetic rule, but rather sought out specific practical information, including the amount of taxes the bakers were required to pay, and the limits imposed by the city on the bakers wages.²⁷ Further evidence is shown in a testimonial disposition by Tartaglia, found by Favaro in the municipal archives of Verona. According to his testimony, Tartaglia was brought in to determine the value of a number of gold and silver items described in a goldsmith's bill of exchange, and to resolve a subsequent dispute.²⁸

²³ References to Feliciano can be found in Tartaglia, *Quesiti et inventioni diverse*, bk. 9 qns 1, 8, 9, 13. Further references to Verona can be found in Tartaglia, *General trattato di numeri et misure*, pt. 1, f. 254v. “as you will understand from the following problem, which was put to me toward the end of 1532 in Verona”; f. 277v. “This other problem, similar to the preceding one but somewhat more difficult, was put to me in Verona in the year 1533 by a Genoese man.”

²⁴ Masiero, *Literacy and Learning*, 143–144.

²⁵ Quoted in Gallozzi, “Francesco Feliciano,” 54.

²⁶ Masotti, “Tartaglia, Niccolò,” 259.

²⁷ Tartaglia, *General trattato di numeri et misure*, pt. 1, ff. 171–172.

²⁸ Favaro, “Per la biografia di Niccolò Tartaglia,” 352–353.

Another indication of Tartaglia's close engagement with Verona's practical mathematical culture can be found in his discussions of local customs in relation to trade, construction, and agriculture long after he had left the city. In his last major work, the *General trattato*, Tartaglia provides extensive detail of Verona's customs in matters as varied as the measurement of land, cloth, wheat, wine, and ruins.²⁹ Introducing land measurement as "a most commonly useful and necessary thing," Tartaglia remarked that "almost every city has a certain particular order or custom, not only in the buying and selling of lands, but also in the material ways they use to measure them." He explained his focus on the customs of Verona was due to its location as his "homeland." Although he had been born in Brescia, Verona was the first place in which his career had been sustained, and he was "lovingly nourished ... and honoured for about 15 years."³⁰ Together, this evidence suggests that during their time in Verona, both Feliciano and Tartaglia operated not only as schoolmasters and participants in mathematical contests, but also as regular providers of practical quantitative expertise.

Practical mathematics in print

At the same time, during their years in Verona, neither Feliciano nor Tartaglia was wholly representative of abbaco practitioners more generally. Rather, both followed the mathematician Luca Pacioli, a major figure in the abbaco tradition, in achieving an unusual degree of success through print. They are therefore best understood not as average practitioners, but as locally-rooted exponents who developed recently opened opportunities in especially ambitious ways. These new opportunities arose through broader changes in the circulation of practical mathematical knowledge. Abbaco knowledge had previously circulated mainly through oral instruction and manuscript. However, from the late fifteenth century, a new tradition of printed abbaco treatises greatly expanded their reach. As Angela Nuovo has shown, these printed manuals emerged in close connection with the urban educational cultures of northern Italy, especially in major commercial centres such as Venice and Milan, where dense school networks and expanding economic activity created a reliable market for instructional works.³¹

Abbaco books were typically structured around problems, ostensibly drawn from trade, measurement, and everyday calculation, and served students, merchants, and other practitioners seeking practical problem-solving rather than scholastic theory. They were often written by especially enterprising abbaco masters, who drew on their teaching and consultancy experience to produce books that could both supplement in-

²⁹ Tartaglia, *General trattato di numeri et misure*, pt. 3.

³⁰ Ibid., pt. 3, bk. 2, f. 7.

³¹ Nuovo, "Abacus Manuals, Schools and Urban Readers," 312–316.

come and enhance professional standing.³² Such works were part of a broader shift in which practical knowledge of all types was increasingly valued and instructional texts became highly sought after. The publishing activity of the Venetian calligrapher and woodblock cutter Giovanni Antonio Tagliente provides a striking example. His successful publications included not only his *Libro de abaco* (1515), written by his relative Girolamo Tagliente, but also guides to needlework, accounting, and the art of writing.³³

Beyond this broader development in the printing of practical manuals, the publications of the abbaco-trained friar Luca Pacioli stand out for the way they expanded the scope, aspirations and status of practical mathematics. His *Summa*, printed in Venice in 1494, brought together commercial and more scholarly mathematical traditions into a single, wide-ranging synthesis, presenting abbaco mathematics as a serious field of knowledge.³⁴ In doing so, it helped raise the standing of practical mathematics within Renaissance culture. This ambition became still clearer in the *Divina proportione* (1509), in which Pacioli presented the study of geometry as a privileged route to order, harmony, and higher knowledge of creation, incorporating illustrations by Leonardo da Vinci. In a culture in which the greatest prestige was often accorded to humanistic learning, Pacioli asserted the centrality of mathematical knowledge, not merely as useful, but as a sign of intellectual authority in its own right. His works helped open the way for later abbaco authors, including Feliciano and Tartaglia, to both perceive and present their practical expertise in more expansive and ambitious terms.³⁵

The Venetian terraferma also provided a strong base for abbaco publication. As Francesca Masiero has shown, the region was among the most active centres of abbaco publishing in Italy, responsible for five of the first six printed abbaco manuals, with presses in the terraferma continuing to produce more abbaco editions than any other region well into the sixteenth century.³⁶ Within this regional context, Verona provided a particularly fertile setting for the production of abbaco knowledge. Long before Feliciano's publications, the city already held a manuscript tradition of practical mathematical writing, including treatises focused on land measurement, currency exchange, and local commercial procedures. Feliciano's *Libro de Abbacho* and *Scala Grimaldelli* can therefore be read as particularly successful printed extensions of this local tradition. They similarly

³² Ibid., 2.

³³ Rivali, "Tagliente, Giovanni Antonio"; De Luca and Nuovo, "Libri d'abaco e strumenti didattici tra Venezia e Milano nella prima età moderna," 257–259.

³⁴ Pacioli, *Summa de arithmetica geometria proportioni*.

³⁵ Sangster et al., "The Market for Luca Pacioli's *Summa Arithmetica*," 120–121.

³⁶ Masiero, *Literacy and Learning*, 148; The first six printed abbaco books in chronological order are commonly identified as Anon, *L'arte de l'abbacho* (Treviso Arithmetic); Borghi, *Qui comenza la nobel opera de arithmetica*; Calandri, *Libro d'arithmetica*; Sfortunati, *Luminario de arimetica*; Tagliente and Tagliente, *Libro de abaco*; Feliciano, *Libro de abbacho*.

offered structured treatments of calculation, proportion, and applied problem-solving grounded in everyday economic and agricultural needs. Their repeated reprinting and long afterlife further suggest that Feliciano's works addressed enduring demands within urban and rural economies.³⁷

Although also grounded in Verona's abbaco culture, Tartaglia's published work aligned more closely with Pacioli's broader intellectual ambitions. Even as he later produced texts addressing familiar concerns of commercial measurement and calculation, Tartaglia's first publication diverged sharply from traditional abbaco terrain.³⁸ With *Nova scientia*, Tartaglia did not set out to produce an instructional manual codifying established techniques, but to articulate a genuinely new science centred on his original mathematical analysis of projectile motion. The origins of this project can be directly traced to Tartaglia's interactions with highly experienced and mathematically curious military practitioners operating in and around Verona. However, there was also local precedent for the printing of technical military literature. As early as 1472, Verona had seen the production of Roberto Valturio's *De re militari*, the earliest work to combine technical and military knowledge with print and illustration. Taken together, the publications of Feliciano and Tartaglia show how the same Veronese abbaco culture could generate markedly different textual responses to distinct professional environments. In Feliciano's case, durable manuals of practical procedure and in Tartaglia's, a mathematically ambitious science of motion. The coexistence of Feliciano and Tartaglia in Verona thus offers a distinctive opportunity to examine how practical mathematical knowledge was shaped through interaction with different practitioner communities.

Part 2. Feliciano and Tartaglia compared

Francesco Feliciano and the surveying arts

Francesco Feliciano was a professional maestro d'abbaco and mathematical consultant whose career was centred in Verona, though his reach extended across northern and central Italy. Originally from Lazise, Feliciano moved to Verona around the age of ten and by his mid-twenties was already working in the city as an abbaco master. Alongside teaching at his school in the Palazzo della Ragione, he supplemented his income through consultancy, particularly in the surveying arts. Such work brought him into sustained contact with landowners, merchants, and other technical practitioners, and

³⁷ Gallozzi, "Francesco Feliciano," 56–58.

³⁸ His much later work, Tartaglia, *General trattato di numeri et misure* shows far more affinities to the traditional structure of Feliciano's work. Thank you to the anonymous reviewer who pointed out a comparison to this later work of Tartaglia's may also prove insightful.

helped establish his reputation as an expert *misuratore*. Feliciano's writings are particularly revealing of the range of knowledge expected of an abbaco consultant, in which he combines foundational mathematical knowledge with their application to mercantile, artisanal, and agricultural problems, including accountancy, valuation, estimation, and, above all, surveying and measurement.

In his works, Feliciano repeatedly emphasised the geographical reach and the practical variety of his work. In the preface to the *Scala Grimaldelli*, he provided a sense of the scope of his professional activity, asserting his authority by recalling the three decades he had spent working as a surveyor "almost throughout the whole of Italy." Acting alone as well as in collaboration with other surveyors, Feliciano measured such diverse things as "lands, cattle, oats, wines, walls, woods, marshes, [and] drainage waters."³⁹ This kind of work often required translating irregular parcels of land into computable figures and the use of proportional reasoning where direct measurement was impractical or impossible. Therefore, the authority of such measurements rested not only on exactness, but on competence in recognised procedures grounded in a long-established practical tradition.

Feliciano consistently foregrounded instruments and embodied practice in his discussions of measurement. A key instance concerned the use of the surveyor's level, which he described as essential in situations where "the true measurer has the burden of carrying water from one place to another, to create fountains or to water meadows or fields."⁴⁰ The accompanying image depicts a simple but effective device consisting of a vertical post supporting a flat plank. From the plank hangs a plumb bob to ensure it is level and small uprights at either end with holes to provide a straight line of sight (Figure 1). Explaining its use, Feliciano offered a worked example in which a surveyor seeks to determine whether a particular location lies higher or lower than "a stream at the foot of a mountain." He goes on to describe how the measurer must progressively move the level so that, looking through the holes, "one can just make out" a mark placed on a stick at the previous location. By repeating this procedure across the terrain, the surveyor can determine the difference in height over the given expanse.⁴¹

³⁹ Feliciano, *Scala Grimaldelli*, "quasi per tutta l'Italia a misurare in compagnia, e senza compagnia de' misuratori, terre, feni, biave, vini, muri, boschi, paludi, & livelar acque, e simil cose . . .," f. n.p.

⁴⁰ Gallozzi, "Francesco Feliciano," 70.

⁴¹ Feliciano, *Scala Grimaldelli*, f. 79.

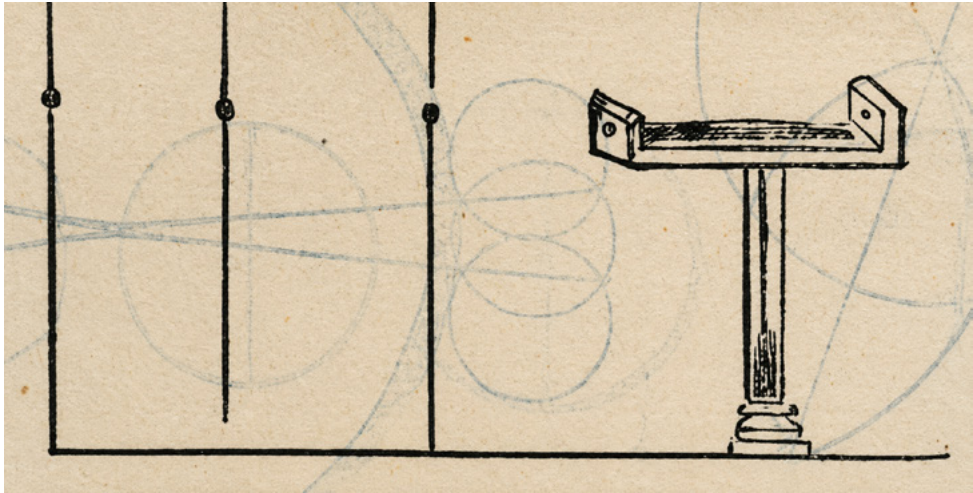


Fig. 1 – Feliciano's sketch of a surveyor's level to determine differences in height, Scala Grimaldelli (1526).

Along with this attention to instruments, Feliciano expressed concern for their proper use. Remarking on “the difficulty of the art of measuring,” Feliciano noted that growing demand for surveying services across Italy had led him to observe that “many follow this art, but few are capable.”⁴² In 1526, he became the first author to publish an account of the surveyor's cross, an instrument consisting of a horizontal disc with pairs of cross-pieces at right angles, designed to improve the accuracy of land measurement. While acknowledging its value, he warned that “there are some who work well with the surveyor's cross,” whereas “others still carry the cross knowing little or nothing about its usage.” Drawing on his own experience “measuring lands, fences, fields,” Feliciano explained that he wished to show correct procedure not only through words, but also through images (Figure 2). His aim was not only to help inexperienced practitioners, but also those who employed surveyors, so that they may also judge “who will do well and who will do badly.”⁴³ In Feliciano's account, measurement is depicted as a highly skilled form of expertise requiring experience, judgement, and disciplined practice.

⁴² Ibid., f. 65.

⁴³ Ibid., ff. 64–65.

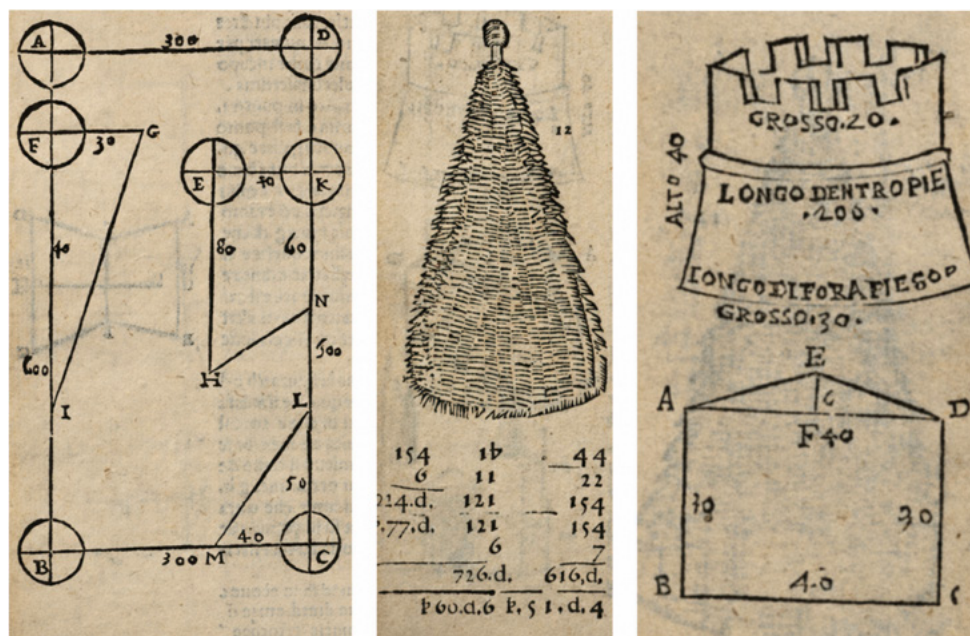


Fig. 2 – Some of Feliciano's images of measurement problems, *Scala Grimaldelli* (1526).

Feliciano extended the proper qualities of the consultant surveyor to encompass a moral and ethical dimension. While describing the difficulties involved in measuring the amount of hay in a wagon, Feliciano emphasised that the expert measurer should be “a good man” who, above all else, possessed a “good conscience.” To do the job fairly, a surveyor must avoid empty words, ground claims in facts, and maintain fairness between clients, “because he cannot serve one while displeasing another.”⁴⁴ In this way, Feliciano insisted that expertise in measuring was inseparable from ethical responsibility.

Feliciano's written works translated his expertise in teaching and consultancy into printed form within the same local context as Tartaglia. Feliciano's *Libro di abbaco*, first published in 1517, appeared around the same period Tartaglia arrived in Verona.⁴⁵ Nearly a decade later, after years of professional overlap in the city, Feliciano published the more ambitious *Scala Grimaldelli* (1526). The reception of Feliciano's books attests to their practical value and enduring influence.⁴⁶ The *Libro di abbaco* was reprinted in 1519 and

⁴⁴ Feliciano, *Scala Grimaldelli*, f. 76; Gallozzi, “Francesco Feliciano,” 69–70.

⁴⁵ Masotti, “Tartaglia, Niccolò” tell us Tartaglia most likely moved to Verona between 1516 and 1518.

⁴⁶ Grendler, *Schooling in Renaissance Italy*, 308.

1525, followed by a revised and expanded edition prepared by the author in 1532 and published posthumously in 1550. The *Scala Grimaldelli* enjoyed even greater success, first appearing in 1526 and then being reissued eight times over the following forty-four years, before being expanded in the seventeenth century by the Veronese accountant Filippo Macario, and reprinted repeatedly well into the seventeenth century.⁴⁷ The available evidence suggests that books such as Feliciano's appealed not only to those first learning abbaco mathematics, but also to readers with prior training. In his study of the readership of Florentine abbaco texts, Goldthwaite found that many owners were merchants already schooled in the tradition, drawn not only to the practical utility of such works but also to the intellectual appeal of their problems, whose working-out could provide "its own satisfaction."⁴⁸ In combining technical instruction, mathematical problem-solving and explicit ethical guidance, Feliciano's works gave durable form to a vision of practical mathematical knowledge grounded in skilled measurement, practical experience, and professional responsibility.

Niccolò Tartaglia and the military arts

Niccolò Tartaglia was nearly thirty years younger than Feliciano, and his route into abbaco mathematics was less conventional. Born into a modest family in Brescia, a terraferma city repeatedly contested during the Italian Wars, he was left in poverty after the death of his father when he was still a child.⁴⁹ The War of the League of Cambrai marked his early life in especially traumatic ways. During the sacking of Brescia in 1512, he suffered severe head and jaw wounds that left him struggling to recover his speech. For this, he earned the mocking nickname Tartaglia, "the stammerer," which he later adopted permanently "in memory of my misfortune."⁵⁰ Too poor to receive even basic abbaco schooling, he taught himself to write and pursued learning largely outside formal institutions. In later life, he recalled turning seriously to abbaco mathematics at around the age of fourteen, developing a particular aptitude for algebra.⁵¹ This background did not place him outside abbaco culture, but it seems to have encouraged an unusually self-reliant intellectual style, grounded in intensive textual study and a willingness to seek knowledge beyond customary pathways.

Around the age of seventeen, Tartaglia left Brescia, itself recently returned to Venetian control after years of French occupation and moved to Verona. There, as we have seen, he engaged in the range of professional activities typical of the abbaco master, teaching practical mathematics, offering private instruction, and serving as a consultant on problems of

⁴⁷ Gallozzi, "Francesco Feliciano," 71.

⁴⁸ Goldthwaite, "Schools and Teachers of Commercial Arithmetic," 432.

⁴⁹ For more detail on the timeline of Tartaglia's life see Pizzamiglio, "Niccolò Tartaglia," 37–40.

⁵⁰ Tartaglia, *Quesiti et inventioni diverse*, bk. 6 qn. 9.

⁵¹ Favaro, "Per la biografia di Niccolò Tartaglia," 345.

calculation, measurement, valuation, and accounting. Yet, despite this conventional profile, Tartaglia's first publication departed strikingly from both Feliciano's works and usual forms of *abbaco* writing. In contrast to problems of bookkeeping or surveying, Tartaglia's *Nova scientia* announced itself as a "new science" devoted to the mathematical analysis of gunnery. Described by its author as a "newly found invention" containing results "never heard or thought of by any other person, ancient or modern," the treatise centred on the geometrical treatment of cannon fire (Figure 3).⁵² It introduced abstract representations of projectile trajectories and included a full-scale template for constructing a gunner's quadrant, marking a significant expansion of the epistemic ambitions typically associated with *abbaco* mathematics.

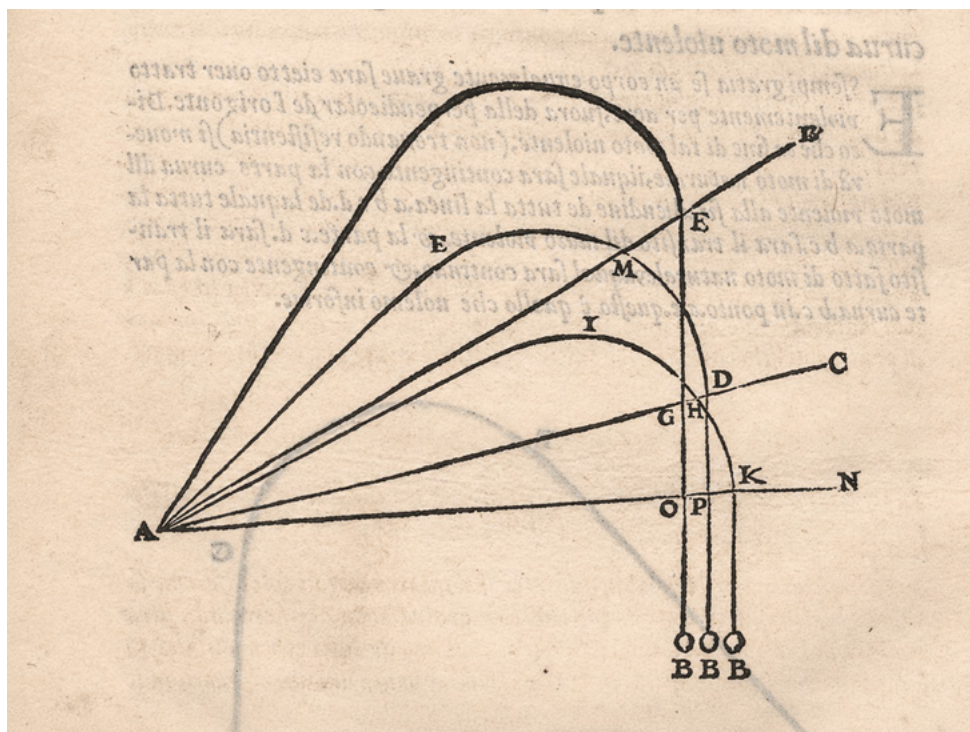


Fig. 3 – Tartaglia's geometric analysis of projectile motion, *Nova scientia* (1537).

I propose that Tartaglia's striking divergence from the subject matter and conventions of standard *abbaco* writing can best be understood through his interactions with expert military practitioners in Verona. These exchanges introduced him to a class of problems

⁵² Tartaglia, *Nova scientia*, ii, Epistle.

less readily managed through the usual routines of abbaco practice, brought him into contact with practitioners who appear to have been unusually receptive to mathematically ambitious and speculative inquiry, and opened access to a wider social horizon in which his expertise could be directed toward elite military leaders and potential patrons as well as technical practitioners.

In the dedicatory epistle to *Nova scientia*, Tartaglia explains that he first took up the problem of gunnery in 1531 after a skilled bombardier stationed at Verona's Castelvechio, described as a "close and kind friend," posed a speculative question, at what angle would a cannon shot travel the greatest distance?⁵³ Drawing on his abbaco expertise, Tartaglia concluded that the optimal elevation was forty-five degrees. This result satisfied his bombardier friend after it "was verified by means of certain specific experiments."⁵⁴ However, the inquiry did not end there. A year later, Tartaglia's conclusion was challenged by the chief bombardier of Padua, who argued that a lower angle would yield a greater range. To resolve the dispute, the Paduan bombardier arranged a field experiment against one of Tartaglia's defenders, Sir Leonardo Iustiniano, chief bombardier of Verona. As Tartaglia explained:

A certain quantity of money was bet on this [question] and they finally arrived at the experiment. A culverin of twenty [libra] was brought to the countryside around Santa Lucia. Each of them shot according to what they suggested and without any difference in reference to the ball and to the charge. The one who shot according to our conclusion reached 1972 perches...the other, who shot two points lower, reached only 1872 perches. For this reason, all the bombardiers and the other persons recognised the truth of our conclusion, although before the experiment they had doubted it and most of them had been of the contrary opinion as it seemed to them that the piece was elevated too much.⁵⁵

Although later commentators have emphasised the practical military inspiration of *Nova scientia*, Tartaglia's own account points instead to the largely theoretical character of the bombardiers' interest. As indicated by the illustrations within the treatise, the high angles under discussion were not typically employed in combat, since their use required substantial excavation behind the gun emplacement (Figure 4). The question was therefore not one of immediate tactical advantage, but a speculative puzzle pursued by technically sophisticated practitioners interested in understanding the behaviour of artillery beyond the constraints of everyday use. Tartaglia himself emphasised this orientation in the dedication of *Nova scientia*, presenting his new science as especially valuable for "speculative

⁵³ Tartaglia and Valleriani, *The Nova scientia of Nicolò Tartaglia. A New Edition*, 67.

⁵⁴ Ibid.

⁵⁵ Ibid., 71.

Mathematical Bombardiers.”⁵⁶ In this respect, Tartaglia’s military practitioners appear not simply as practical men of war, but as participants in a more reflective culture of quantitative inquiry.

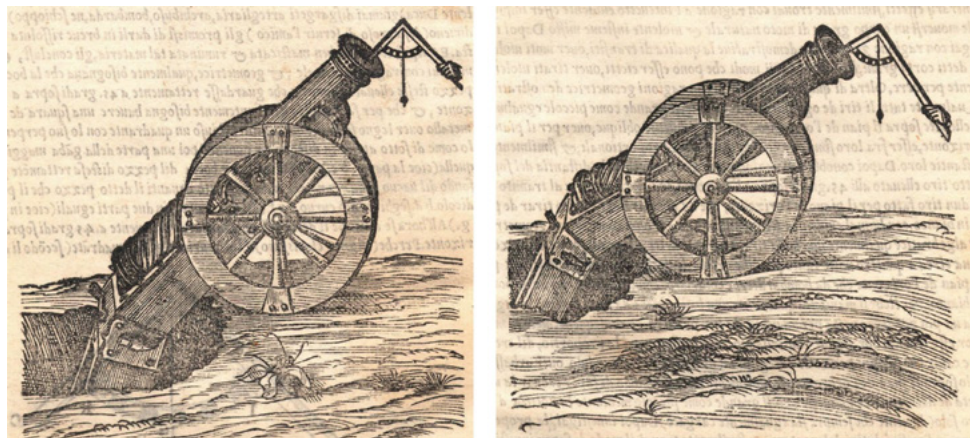


Fig. 4 – Tartaglia’s illustrations of the bombardier’s experiment, *Nova scientia* (1537).

This episode is revealing in several respects. Most obviously, it presented Tartaglia with a different problem than those more commonly posed in surveying, valuation, or book-keeping. Although those fields also involved uncertainty, judgement, and changing conditions, projectile motion confronted him with relations of movement that were harder to stabilise through the ordinary procedures of *abbaco* mathematics. Yet the episode suggests something more than the novelty of the problem itself. The bombardiers involved were not merely seeking a practical rule. They were willing to pursue a speculative question, to test competing conclusions experimentally, and to treat mathematical argument as a meaningful way of adjudicating between them. By taking on their questions as his own, Tartaglia’s engagement with these theoretically-minded gunners encouraged him to extend practical mathematics into a more explicitly analytical and demonstrative form. The military world offered not only a new class of problem, but also a community in which more ambitious mathematical treatment was recognised and valued.

Examining the problem more deeply led Tartaglia to a further methodological innovation. Projectile motion could not be adequately captured through the ordinary resources of Euclidean geometry alone. Seeking a theory capable of accounting for motion, Tartaglia turned to Aristotle, incorporating concepts from natural philosophy into his mathematical analysis. This move was highly unusual for an *abbaco* master, as Aristotelian philos-

⁵⁶ Tartaglia, *Nova scientia*, Incipit, [f. 1v], ii, “speculativo Mathematico Bombardiero.”

ophy was an elite discipline typically reserved for university-trained Latin scholars. Yet Tartaglia's move into this new terrain can still be understood, at least in part, as an extension of abbaco problem-solving practice, in which practitioners often showed a pragmatic willingness to draw on whatever bodies of knowledge proved useful, regardless of their traditional disciplinary or institutional location.⁵⁷ The expanding book trade in northern Italy also facilitated such movement by making scholarly materials more accessible beyond university settings. Through sustained interaction with theoretically inclined bombardiers, a background in abbaco problem solving and access to newly available forms of knowledge, Tartaglia forged a mode of inquiry that bridged practical experience, applied and speculative mathematics, and natural philosophy.

The military arts mattered in a third way as well. They offered Tartaglia access to a social and epistemic horizon that differed from that available through the more ordinary commercial work of the abbaco master. Surveying, valuation, and land measurement were indispensable to civic administration and economic life, but they were usually tied to practical service and private clients. By contrast, the military arts were bound up with territorial defence, state survival, noble command, and elite authority. Artillery expertise in particular could therefore be addressed upward, not only to working practitioners, but also to rulers, captains, and military leaders. This wider horizon is visible in Tartaglia's dedication of *Nova scientia* to the Duke of Urbino, Francesco Maria della Rovere, who was both a noted patron of mathematicians, including Luca Pacioli, and a major military leader, having served as captain general of the Venetian forces and later as supreme commander of the Holy League.⁵⁸ In presenting his work as a *scientia* rather than as an extension of ordinary abbaco practice, Tartaglia was responding not only to the nature of the problem, but also to the elevated audience and patronage possibilities that military mathematics made available.

Unlike Feliciano's surveying-focused works, which have remained largely outside histories of early modern science, *Nova scientia* has long been recognised as a pioneering contribution to the science of ballistics.⁵⁹ It has also been seen as a foundational effort to integrate practical mathematics with natural-philosophical reflection on projectile motion, a line of inquiry later pursued most famously by Galileo, also trained in the abbaco tradition.⁶⁰ Seen in this light, Tartaglia's later prominence marks not a major departure from abbaco culture, but one of its most ambitious and historically consequential exten-

⁵⁷ For more on this feature of the abbaco tradition see Ekholm, "Tartaglia's *Ragioni*," 181.

⁵⁸ Brioiist, "Familiar Demonstrations in Geometry," 2–4.

⁵⁹ Tartaglia and Valleriani, *The Nova scientia of Nicolò Tartaglia. A New Edition*; Lefèvre, "Gun-nery," sect. 4.5; Bennett, "The Mechanical Arts," 691–692.

⁶⁰ Indeed, in a letter to Cesare Marsili in 1632, Galileo wrote that his "primary intention when I started speculating about motion was to find just such a trajectory." Translation from Frova and Marenzana, *Thus Spoke Galileo*, 83.

sions. Like Pacioli before him, Tartaglia did not abandon *abbaco* culture so much as extend some of its central habits, such as practical problem-solving, quantitative reasoning, and responsiveness to expert practitioners, into a more ambitious register. The result was a work that recast practical mathematics for a higher-status audience, presenting it not as a set of procedures for particular tasks, but as a general science grounded in military experience and directed toward broader theoretical claims.

Practitioner interactions and knowledge in use

Although Francesco Feliciano and Niccolò Tartaglia shared many features of occupational life, the expertise they developed diverged in important ways. Their interactions with different practitioner communities shaped their work in three key ways. First, Feliciano's consultancy generally required the stabilisation of variable quantities through recognised procedures, whereas Tartaglia's gunnery problem demanded the analysis of motion and relations not readily captured by established *abbaco* techniques. The former therefore placed greater emphasis on the reliable application of established techniques, while the latter pressed more insistently towards abstraction and the formulation of general relations.

Second, the two figures foregrounded different epistemic and moral virtues. Feliciano emphasised honesty, fairness, and professional responsibility, insisting that the expert measurer must ground claims in fact and avoid favouring one client over another. These virtues were well suited to a consultancy world in which trust, repeatability, and social credibility were paramount. Tartaglia, while also concerned with practical effectiveness, highlighted somewhat different values, including mathematical ingenuity, invention, and the demonstration of truth through challenge and experiment. His accounts of public disputes and trials underscore a conception of expertise in which authority was established not only by reliable service, but by extending knowledge into previously uncharted territory.

Third, their printed works differed in their social and political orientation. Feliciano's books were designed for sustained use by expert practitioners operating within the economic life of the *terraferma*, such as farmers, merchants, surveyors, and technicians, for whom mathematical competence functioned primarily as a practical resource, even as it could be enjoyed for its own satisfaction. Their longevity reflects their success in codifying techniques that remained interesting and applicable across generations. In contrast, *Nova scientia* did not simply transmit established methods but proposed a new way of understanding a dynamic class of phenomena. Tartaglia addressed the work both to expert practitioners, the "speculative Mathematical Bombardiers" whose questions had prompted it, and to the Duke of Urbino, a prominent military patron. While Feliciano's works circulated chiefly within professional networks concerned with land, trade, and measurement, Tartaglia's treatise positioned mathematical analysis within a domain that offered more

direct access to military command, noble patronage, and the political stakes of war. The contrast is therefore not simply between a ‘practical’ Feliciano and a more ‘theoretical’ Tartaglia. Their mathematics differed in the problems they sought to stabilise, the virtues through which expertise was claimed, and the social worlds toward which mathematical authority was directed.

Parallel visions of knowledge

Beyond their differing professional trajectories, Feliciano and Tartaglia appear to have articulated overlapping yet distinct visions of mathematical knowledge. These visions emerged within a shared world of *abbaco* and were shaped by prolonged professional co-existence in Verona. The surviving evidence also suggests a closer relationship between the two men than has generally been recognised. In his later work, Tartaglia recalls a series of questions put to him by Feliciano, describing him as “mo maestro Feliciano.”⁶¹ A comparison of their frontispieces provides further suggestive evidence of their closeness (Figure 5). Read together, the frontispieces of the two authors reveal a significant degree of shared conceptual ground, even as they also bring into focus the more expansive epistemic claims advanced by Tartaglia.

Although the content of Feliciano’s works remained more conventionally *abbaco* than that of Tartaglia’s *Nova scientia*, comparison of their frontispieces reveals overlap in imagery, ethos and an insistence on the centrality of mathematics to knowledge. In the frontispiece to Feliciano’s *Scala Grimaldelli*, the title’s meaning is explicitly figured through the image of a ladder and key. In the opening sonnet, Feliciano declares that “whoever wishes to open a strong iron lock / at the top of a tower or castle / must have the ladder and the [correct mathematical] tools.” His text promises to show “in a gentle way” how each tool is to be understood and applied, while warning that without such preparation the seeker’s efforts “will end short.”⁶² In this way, Feliciano presents knowledge as a fortified structure, accessible only through disciplined mastery of mathematical techniques. The imagery of towers, gates, and ladders indicates that the pursuit of knowledge requires effort and order and proceeds by stages toward ascent. Yet while insisting that there are no shortcuts, Feliciano also invites the reader in, presenting mathematical understanding as, in principle, open to all who are willing to learn. In his preface, he reiterates this point, explaining that his “little book” teaches forms of measurement that are “necessary for all human beings to understand,” using clear examples to demonstrate the relevant methods and practices.⁶³

⁶¹ Tartaglia, *Quesiti et inventioni diverse*, bk. 9 qn. 9.

⁶² Feliciano, *Scala Grimaldelli*, frontispiece.

⁶³ *Ibid.*, preface.

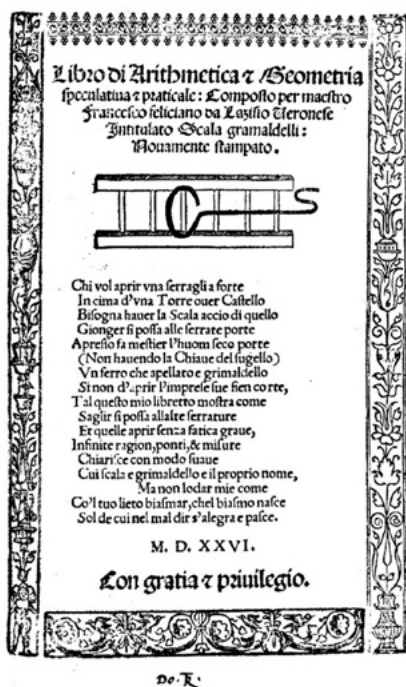


Fig. 5 – Frontispieces to Feliciano's *Scala Grimaldelli* (1526) and Tartaglia's *Nova scientia* (1537).

Tartaglia's well-known frontispiece to *Nova scientia* displays remarkable similarities in both imagery and meaning. Like Feliciano, he represents the path to knowledge through towers, gates, and ladders. He likewise presents mathematical training as the necessary first step, with the figure of Euclid indicating that entry to knowledge begins with geometry and the mathematical disciplines. He also insists that there are no shortcuts, showing a figure attempting to bypass Euclid as failing because his ladder is too short to reach the gate (Figure 5). The inscription at the base of the image similarly aligns with Feliciano's earlier frontispiece, telling the reader that "if you wish to know the causes of things" you must first learn the mathematical disciplines. Echoing Feliciano's insistence that such knowledge is learnable, Tartaglia likewise declares that "this one path is open to all."⁶⁴

Alongside these multiple affinities, however, Tartaglia's frontispiece diverges from Feliciano's in articulating a more ambitious epistemic vision. Beyond the acquisition of mathematical principles and their application to material and practical domains, Tartaglia

⁶⁴ Tartaglia, *Nova scientia*. "Disciplinæ Mathematicæ loquuntur. Qui cupitis Rerum varias cognoscere causas / Discite nos, cunctis hac patet una uia." Translatable as: The mathematical disciplines speak. If you wish to know the causes of things / Learn from us: This one path is open to all.

extends the path of knowledge all the way to the elite realm of causal and philosophical understanding. In his image, once the seeker has learned from Euclid, those principles are applied to worldly phenomena, including traditional abbaco domains such as perspective and architecture, but also scholarly fields such as astronomy and music, as well as Tartaglia's own "new science" of gunnery. From there, the seeker may be guided by Aristotle and Plato into the highest realm of philosophy. Tartaglia thus expands the scope of the abbaco master's vision beyond practical and artisanal mathematics, incorporating the elite world of natural philosophy within a single epistemic framework. These higher ambitions are reinforced in the upper section of the image. Addressing a more elevated audience than Feliciano, Tartaglia includes the shield of his dedicatee, the Duke of Urbino, Francesco Maria I della Rovere, alongside that of his wife Eleonora Gonzaga. He further surrounds the shields with a Latin inscription, directly taken from the introduction to Pacioli's *Divina Proportione*, which confidently asserts that "as gold is revealed by fire, ingenuity shows itself through mathematics."⁶⁵

In this way, comparison with his fellow Veronese abbaco master highlights both a shared commitment to mathematics as an organising principle of knowledge, and a difference in the scope and ambition of that commitment. Where Feliciano emphasised the reliable ordering of the world through measurement, instruction, and ethical practice, Tartaglia advanced a vision in which mathematics unified practical expertise and speculative reasoning into a pathway toward ultimate metaphysical explanation. The frontispieces therefore complicate any simple account of divergence. Even as Tartaglia's frontispiece showed greater ambition, his epistemic vision remained visibly articulated through imagery and assumptions shared with his older Veronese colleague.

Conclusions

In sixteenth-century Verona, practical mathematics did not develop only in the school-room or on the page. Rather, it also took shape through continued exchanges between abbaco masters and the wider communities who sought out their expertise. By looking more closely at these interactions, the contrast between Feliciano's work with landholders and Tartaglia's with bombardiers reveals something important. These relationships signify not merely different locations in which abbaco mathematics was performed, but an intrinsic part of the process through which it took form. In particular, they shaped not only the kinds of problems these abbaco masters encountered, but also the values they went on to promote in their published works. In Feliciano's case, his texts codified process-based, cumulative forms of mercantile and surveying knowledge, highlighting values of expert

⁶⁵ Tartaglia, *Nova scientia*. "AVE PROBATVR IGNI, ET INGENIUM MATHEMATICIS"; Pacioli, *De divina proportione*, 14.

practice, fairness and practical adequacy. In Tartaglia's case, engagement with theoretically inclined military practitioners exposed him to less readily stabilised questions of motion and drew him into a social world more receptive to abstract and innovative treatment, as well as broader possibilities for patronage and advancement. Engagement with an unsolved problem of dynamics, along with the opportunities present in the elevated military world, in turn encouraged Tartaglia to make ambitious claims, culminating in his 'new science' of gunnery. In this way, the comparison suggests that interdisciplinary exchange did not merely shape the application of practical mathematics, it helped determine what kinds of mathematical claims could be made, how far they could be extended, and the extent to which theory and innovation appeared as liabilities or virtues within different worlds of practice.

The comparison further shows that these interactions shaped not only professional trajectories but also distinctive visions of knowledge. As explored in the analysis of their frontispieces, Feliciano and Tartaglia articulated overlapping, yet different epistemic ideals. Feliciano presented mathematical problem-solving techniques as a set of keys to be learnt in order to provide access to higher level of knowledge, while Tartaglia advanced a more expansive vision in which mathematics unified practical expertise and speculative reasoning into a pathway toward metaphysical philosophical understanding. These parallel visions did not emerge in abstraction. They were forged through ongoing engagement with each other, as well as with practitioners, tools, and texts that allowed them to explore what mathematics could be applied to and what it could plausibly explain.

The comparison also highlights the flexible social and epistemic position of *abbaco* masters in Renaissance Italy. *Abbaco* practitioners were able to move between the worlds of the educator, artisan, technician, merchant, printer and, on occasion, scholar and nobleman. This mobility provided them with the tools and opportunities to translate embodied forms of expertise into more stable mathematical procedures, texts, and visual representations. *Abbaco* mathematics was therefore not merely a medium for transmitting knowledge between social worlds. It was itself an important site of knowledge production, in which solving problems of trade, measurement, surveying, and war could be reworked into communicable rules, printed books, and broader claims about the scope and authority of mathematics. Together, Feliciano and Tartaglia reveal *abacus* mathematics as an adaptable epistemic domain, capable of supporting both practical problem-solving and speculative inquiry.

More broadly, this study underscores the importance of attending to personal and professional relationships in the history of science. While historians have increasingly recognised the role of practice, material culture, and institutions in the production of early modern knowledge, face-to-face interactions between practitioners, especially those operating across different traditions and social hierarchies, remain underexplored as sites of knowledge production. The cases of Feliciano and Tartaglia show the value of treating

these relationships as objects of historical investigation in their own right. As Kapil Raj has argued, science is produced, in large part, “through the encounter and interaction between heterogeneous specialist communities of diverse origins.”⁶⁶ By foregrounding such encounters, this article contributes to a growing body of work that treats knowledge not as a static collection of techniques or theories, but as something continually produced through interpersonal exchange. Attending to these interactions allows us to see more clearly how relations between practitioners from different social and occupational worlds opened new possibilities, generated new motivations, and contributed to the production of innovative knowledge in early modern science.

⁶⁶ Raj, “Beyond Postcolonialism ... and Postpositivism,” 343.

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