The geometer's and engineer's workshop: An archaeology of papers, intellectual techniques, and practices of knowledge in Vincenzio Viviani

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Simon Dumas Primbault, *Un galiléen d'encre et de papier. Une histoire matérielle des brouillons de Vincenzio Viviani (1622-1703)*. Paris: Éditions de la Sorbonne, coll. Homme et société, 2024, 320 pp.

Abstract
Moving past traditional intellectualist frameworks that privilege printed treatises as monuments of pure conceptual progress, in *Un galiléen d'encre et de papier* Simon Dumas Primbault undertakes an archaeology of working manuscripts within the *Fondo Galileiano* at the National Central Library of Florence (BNCF). By examining Vincenzio Viviani's rough drafts (*brouillons*), codicological parameters, ink variations, layout grids, and paper management, Primbault aims to demonstrate how physical writing surfaces functioned as active cognitive "paper tools" for theoretical derivation and administrative practice. The review traces three core dimensions of Viviani's intellectual identity: first, his role as Galileo Galilei's "last disciple," curating and editing the master's archive to construct a protective legacy compatible with Medici patronage and Catholic orthodoxy; second, his work as a "divining geometer," deploying mathematical humanism, conjectural reconstruction (*divinatio*), and synthetic geometry directly on the page (*géométrie d'encre*); and third, his active career as Medici First Engineer, where field notebooks, drawing practices (*disegno*), and statecraft intersected with theoretical research. Additionally, the essay contextualizes Viviani's 1692 *Aenigma Florentinum* challenge against Gottfried Wilhelm Leibniz, highlighting a pivotal transition from classical synthetic geometry to infinitesimal calculus.

Keywords
Vincenzo Viviani, Galileian science, engineering, *disegno*, geometry

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1. The archaeology and materiality of science

For much of the twentieth century, the historiography of early modern science operated within an intellectualist framework. Scholars such as Alexandre Koyré and Marshall Clagett viewed the scientific transformations of the seventeenth century primarily as a series of conceptual revolutions. In their analyses, intellectual progress was reconstructed through finished printed treatises, which were treated as complete, self-contained monuments of theoretical reason.[1] The narrative focused on grand conceptual shifts: the mathematization of nature, the formulation of classical mechanics, the concept of universal gravitation, the birth of infinitesimal calculus etc. Within this conceptualist paradigm, the physical media of intellectual work – the sheets of paper, the composition of ink, the physical cutting and pasting of drafts, the structural layout of calculation grids, and the erasures that marked changes in thought – were treated as administrative detritus. Working manuscripts were viewed mostly as physical carriers for pre-existing mental ideas, possessing no independent analytical value for understanding scientific evolution.

Over the past four decades, the history of science has undergone a significant reorientation through what has been termed the material, practical, and spatial turn. Scholars such as Steven Shapin, Simon Schaffer, Mario Biagioli, Lorraine Daston, and Peter Damerow argued that scientific knowledge is fundamentally shaped by physical settings, social codes, instrumental practices, and media technologies.[2] Simon Dumas Primbault's volume, *Un galiléen d'encre et de papier. Une archéologie des brouillons de Vincenzio Viviani (1622-1703)*, applies this material perspective to early modern mathematics and engineering. The study shifts scholarly focus away from published works and toward working manuscripts, moving the analytical axis from the finished textual product to the material process of its development. The subject of inquiry extends beyond the formal mathematical and structural propositions formulated by Vincenzio Viviani to encompass the physical and institutional operations of the scholar's workshop through an investigation of his intellectual techniques.

The primary empirical foundation for Dumas Primbault's study is the extensive collection of manuscript papers held within the *Fondo Galileiano* at the National Central Library of Florence (BNCF). This archive constitutes one of the most comprehensive surviving manuscript records of seventeenth-century scientific activity in Western Europe. Through an examination of rough drafts (*brouillons*), marginal annotations, loose memorandum slips, thematic excerpt notebooks, reading indexes, field registers, and administrative correspondence, Dumas Primbault reconstructs how abstract theoretical formulations were tied to the manipulation of physical media.

1 Koyré, *Études galiléennes*; Koyré, *From the Closed World*; Clagett, *The Science of Mechanics.*
2 Shapin and Shaffer, *Leviathan and the air-pump*; Biagioli, *Galileo, Courtier*; Daston, ed., *Science in the Archives*; Damerow, *Abstraction and Representation.*

The volume draws upon and expands the concept of "paper tools," an analytical category developed by historians of science to describe how physical writing surfaces function as active cognitive spaces rather than passive landing pads for thought.[3] A blank sheet of paper, an open register, or a recycled margin served as a manipulable layout where spatial organization, grid arrangements, variations in ink viscosity, folding patterns, and physical cutting directly influenced the development of formalized ideas. Codicological parameters such as paper formats, chain lines, wire lines, watermarks, iron-gall ink oxidation levels, and scribal trimming habits reveal how the physical page served as a working surface where scholars calculated, diagrammed, organized textual excerpts, and revised proofs.

To carry out this analysis, Dumas Primbault combines codicology, paleography, historical bibliography, reading history, and the sociology of early modern court administration. Through these combined methodologies, Vincenzio Viviani (1622–1703) is re-evaluated outside the boundaries of tradition. Rather than being framed purely through a biographical lens or dismissed as a derivative figure operating in the shadow of Galileo, Viviani emerges as an administrator and technical scholar whose work combined synthetic geometry, manuscript preservation, state engineering, and courtly advancement into a single framework managed through ink and paper.

This methodological framework carries a clear risk of overinterpretation, a limitation that warrants explicit critical attention. When historians analyze working manuscripts through a material lens, there is a persistent temptation to ascribe complex cognitive strategies to physical artifacts that may simply be the result of mundane constraints. A change in ink density, an asymmetrical page layout, a crossed-out line, a dry-point scratch, or a recycled piece of paper may not represent a deliberate epistemological pivot or a calculated heuristic technique. Such features often stem from mundane circumstances: limited paper supplies, deteriorating quills, hasty notes taken under difficult field conditions, routine administrative habits, or unreflected scribbles. By treating every physical mark as a window into the practitioner's cognitive architecture, the material archaeology of science risks over-reading draft physicalities, transforming ordinary workshop habits into complex theoretical choices. Maintaining a distinction between deliberate intellectual methods and routine physical activities remains a key challenge for this analytical approach.

2. The last disciple

Vincenzio Viviani's public standing and professional identity were closely linked to his status as the final disciple of Galileo Galilei. This designation functioned as the primary institutional and social resource around which Viviani built his authority within the Medici court and the broader European republic of letters.

[3] Jardine, "State of the Field: Paper Tools."

Viviani entered Galileo's household at the villa of Il Gioiello in Arcetri in 1639 at the age of seventeen, securing his position through recommendations from Florentine figures including Clemente Settimi and Famiano Michelini. Galileo was by then completely blind, in declining health, and kept under strict papal surveillance following his 1633 condemnation by the Roman Inquisition. He required an amanuensis, reader, and assistant capable of conducting geometric calculations and managing his ongoing correspondence. Viviani resided in Arcetri for nearly three years until Galileo's death in January 1642, sharing his assistant duties with Evangelista Torricelli during the final months of the master's life.[4]

During his time at Arcetri, Viviani acquired foundational skills in mechanics, astronomy, and Euclidean geometry, while adopting the working habits of the Galilean network. He served as the physical hand that drew geometric figures for the blind astronomer and the eyes that read incoming letters and classical texts. This cohabitation created a sense of obligation in Viviani, who viewed himself as responsible for protecting and transmitting the intellectual and material heritage of his master.

Following Galileo's death in 1642, and the subsequent death of Galileo's son Vincenzio in 1649, Viviani took possession of a large, disorganized collection of Galilean papers. This archive contained letters, draft treatises, calculation sheets for projectile trajectories, mechanical notes, geometric diagrams, and laboratory records. Viviani categorized, trimmed, pasted, and rearranged loose sheets, adding his own handwriting to supply missing transitions, re-labeling diagrams, and altering conceptual sequences. His goal was to present a continuous, coherent narrative of Galilean thought that aligned with both Catholic orthodoxy and Grand Ducal interests.[5]

In 1654, Viviani wrote a biographical narrative titled *Racconto istorico della vita del Sig.r Galileo Galilei*, which was published only in 1717. In the *Racconto*, Viviani sought to protect Galileo's historical legacy by muting its theological implications, while simultaneously positioning himself as the primary intellectual heir to the Galilean tradition. This narrative strategy allowed him to consolidate his social standing at the court of Ferdinando II and Cardinal Leopoldo de' Medici.

However, the sustained focus on memory preservation had long-term consequences for Viviani's historical reputation. For centuries, historians viewed Viviani's intellectual work primarily through his connection to Galileo. His efforts to preserve Galileo's legacy ultimately obscured his individual work in synthetic geometry, classical philology, structural architecture, and hydraulic engineering. Dumas Primbault's study examines the individual career behind this historical narrative, pointing out how Viviani operated as an autonomous scholar fully engaged in the technical institutions of his era.

[4] Notable biographical accounts include Favaro, "Amici e corrispondenti di Galileo Galilei. XXIX. Vincenzio Viviani"; Righini Bonelli, "L'ultimo discepolo."

[5] See Favaro, "*Documenti inediti per la Storia dei Manoscritti Galileiani.*"

3. *The divining geometer*

Viviani's mathematical work was grounded in the principles of mathematical humanism. For seventeenth-century geometers working within the classical tradition, mathematical advancement was achieved not by breaking with ancient authority, but by recovering, translating, and restoring the lost geometric texts of classical antiquity.

Within this scholarly environment, the practice of *divinatio*, or conjectural reconstruction, served as a rigorous philological and mathematical methodology. The process relied on a distinct pipeline of empirical and textual inputs: scholars collected surviving fragments, introductory lemmas preserved by later commentators such as Pappus of Alexandria, and partial summaries transmitted through Arabo-Latin manuscript traditions. These diverse textual components were brought together on the working page, where the geometer engaged in conjectural deduction to reconstruct missing propositions and synthesize lost geometric proofs using Euclidean logic. The output of this procedure was a restored classical treatise, which allowed the practitioner to generate advanced mathematical results while presenting them within an ancient framework.

Viviani devoted a significant portion of his research career to two major projects of *divinatio*. The first was the reconstruction of Book V of Apollonius of Perga's *Conics*, a lost work devoted to maximum and minimum lines drawn to conic sections. Viviani worked in secret for years to reconstruct these propositions using synthetic geometric methods, aiming to publish his version before the Arabic text discovered in Florence could be translated by Giovanni Alfonso Borelli. His results were published in 1659 under the title *De maximis et minimis*. His second project was the restoration of the lost books of Aristeus the Elder (*De locis solidis*, completed in 1646, printed in 1673, and published in 1701).

In chapters 1 and 3 of the volume, Dumas Primbault documents the information management techniques Viviani used to handle the textual and mathematical data required for *divinatio*. Viviani organized commonplace books by specific geometric categories, and compiled bibliographical inventories that recorded textual variants, printing histories, and comparative translations across Latin, Greek, and Arabic versions of classical mathematical sources. His working copies of printed books and manuscript drafts feature dense cross-referenced marginalia and layered revisions, where reading a classical text directly prompted the derivation of new proofs.

In Dumas Primbault's reconstruction, Viviani saw geometry as a physical practice carried out on the page (*géométrie d'encre*). Diagrams were not secondary visual aids for completed thoughts, but active working tools through which mathematical relationships were derived. The detailed physical analysis of Viviani's draft sheets shows how the geometer interacted with figures on the page. Galileo's last disciple used inks of different densities and shades to distinguish auxiliary constructions from primary curves, left compass pinholes that preserve the chronological order of drawing steps, and relied on rasures and

cancellations that preserved earlier attempts within a sequence of revisions.

Drawing on these material evidences, Dumas Primbault argues for Viviani's strong theoretical commitment to the synthetic Euclidean and Apollonian traditions, emphasizing how the spatial manipulation of geometric figures using straightedge and compass remained central to the formulation and proof of theoretical proposition. As said, the analytical focus on physical draft details carries a risk of methodological overinterpretation. Interpreting every pinhole, faint guideline, or ink correction as a conscious step in a mathematical derivation can overstate the deliberate nature of standard drawing habits. Physical traces may reflect ordinary drafting practices: re-inking a dry pen, correcting a slipping compass, using available paper efficiently, or fixing an immediate visual error. Attributing systematic cognitive meaning to every physical mark on a manuscript draft risks misinterpreting routine physical adjustments as intentional theoretical choices. Dumas Primbault, however, is always cautious in his analysis.

4. Portrait of the engineer as a conflicted man

Throughout history, scholars have often drawn a strict boundary between theoretical science and practical engineering.[6] Dumas Primbault aims to show that, in Viviani's work, these two domains shared common intellectual and physical roots within the culture of drawing (*disegno*) in seventeenth-century Florence.

Alongside his mathematical studies with Galileo, Viviani received formal instruction in architecture, perspective, and drawing from Baccio del Bianco, a painter, military engineer, and stage designer. Through this training, Viviani entered the tradition of the *Accademia delle Arti del Disegno* in Florence, an institution established by Giorgio Vasari in which artistic practice, architectural design, and applied geometry shared a single analytical foundation. Viviani acquired proficiency in linear perspective, chiaroscuro shading for volume rendering, shadow projection, and land surveying techniques.

A key section (ch. 2) of Dumas Primbault's volume analyzes Viviani's field notebooks (*appunti di sopralluoghi*). When assigned by the Medici administration to inspect river channels, assess military fortifications, or design bridge repairs, the young engineer carried small, portable notebooks designed for field use. These notebooks document the initial recording of engineering data, containing quick freehand sketches of river bends, eroding banks, soil strata, and masonry cracks. Written descriptions, altimetric numbers, water flow measurements, and even records of meetings with landowners were wrapped directly around these drawings.

Dumas Primbault shows that for Viviani, drawing functioned as an analytical tool for ordering complex physical landscapes into structured geometric representations. This pro-

[6] See, in this regard, Schatzberg, *Technology*.

cess unfolded across a structured multi-stage workflow. In the initial field survey stage, the engineer recorded empirical observations in portable octavo or duodecimo notebooks, capturing river morphology, bank erosion, and structural damage alongside altimetric and hydraulic data. During the subsequent studio drafting stage, these field sketches were converted into scale drawings using rulers, compasses, linear perspective, and ink washes to achieve geometric rationalization. Finally, in the administrative stage, these plans were integrated into formal court reports (*relazioni*), where clean-copy drawings accompanied written arguments to guide magistrates and the Grand Duke in technical and financial decision-making.

Beginning in the 1650s and continuing over four decades, Viviani held administrative and technical positions within the government of the Grand Duchy of Tuscany, serving Grand Duke Ferdinando II, Cardinal Leopoldo de' Medici, and Grand Duke Cosimo III. He was appointed First Engineer of the *Magistrato degli Uffiziali dei Fiumi*, the state body responsible for river regulation, soil conservation, and land reclamation across Tuscany. He later served as Architect and Superintendent of Grand Ducal Buildings. These appointments required Viviani to balance his abstract geometric research with the practical demands of civil administration. In chapter 4, Dumas Primbault examines the large body of technical reports (*relazioni*), surveys, and official assessments produced during Viviani's administrative career. His technical duties were divided into two main areas of responsibility: hydraulic management of the territory and structural architecture.[7]

In hydraulic engineering, Viviani developed plans to regulate the Arno River to reduce flood risks in Florence, designed drainage systems for the Val di Chiana, supervised the diversion of mountain streams, and managed riverbank constructions and coastal marshlands. In structural architecture, he performed technical evaluations of major public buildings, most notably conducting an extensive structural assessment of Brunelleschi's dome at Santa Maria del Fiore. In his report on the dome, Viviani mapped structural crack patterns (*screpoli*) and applied geometric principles to analyze vector thrusts and force distributions, ultimately advising against invasive structural alterations and reassuring the court regarding the stability of the building. This heavy administrative workload created continuous tension with his personal research goals. In a manuscript letter written in 1697 to Marquis Salviati, the seventy-five-year-old Viviani expressed deep personal frustration over his professional circumstances. He lamented that his time and energy had been consumed by endless court-ordered assignments, including long journeys through bad weather to inspect broken dikes and settle water-rights disputes between local landowners. He expressed regret over being unable to complete his planned theoretical treatises on Apollonius and Euclid due to these administrative demands. This document, analyzed by Dumas Primbault in chapter 7, illustrates the practical trade-offs required of early modern technical scholars who relied on state employment to support their scientific work.

7 Cf. Barreca, "Between matematici and architetti d'acque."

5. Beyond infinity

Between 1689 and 1690, the elderly Viviani met and corresponded with Gottfried Wilhelm Leibniz during Leibniz's stay in Florence. This meeting brought two distinct mathematical approaches into direct contact. The contrast between these paradigms was fundamental across every dimension of mathematical practice. Synthetic geometry, as practiced by Viviani, relied on Euclidean spatial intuition, proportional ratios between physical magnitudes, and diagrammatic proofs presented in formal Latin or Italian prose, treating geometric curves as static spatial loci. Conversely, the differential calculus developed by Leibniz operated through infinitesimal variables, algorithmic operational rules, and symbolic equations, treating curves as dynamic functional equations.

To demonstrate the capability of synthetic geometry over the new algebraic methods developing in Northern Europe, Viviani issued a public mathematical challenge in 1692, known as the *Aenigma Florentinum*, or *Forma xilographica*. He framed the challenge as an architectural problem, asking how a hemispherical dome could be pierced by four equal openings such that the remaining spherical surface area could be exactly squared using only a straightedge and compass. Mathematically, the problem required calculating the intersection of a hemisphere of radius R with intersecting cylinders of radius R/2, tangent to the central axis. The intersection of these two surfaces forms a space curve known as Viviani's Curve. Viviani proved synthetically that the area of the hemispherical surface remaining after the four openings were removed was equal to four times the square of the sphere's radius, eliminating the transcendental number π from the final expression.

Viviani intended the *Aenigma* to demonstrate that classical synthetic geometry possessed tools capable of solving complex spatial problems without relying on symbolic algebra. However, the outcome ran counter to his expectations. Upon receiving the challenge, Leibniz, Jakob Bernoulli, Johann Bernoulli, the Marquis de l'Hôpital, and John Wallis solved the problem within hours using differential and integral calculus. They used the challenge to publicly demonstrate the efficiency of infinitesimal calculus. Dumas Primbault's examination of Viviani's draft manuscripts in chapter 5 reveals his disappointment at how quickly European mathematicians converted his problem into an application of the new calculus, marking a broader transition in European mathematics away from classical synthetic methods.[8]

All in all, Simon Dumas Primbault's *Un galiléen d'encre et de papier* offers a comprehensive study of early modern scientific practice by examining the material records of Vincenzio Viviani's workshop. By focusing on working drafts, physical notes, administrative records, and drawing practices, the author situates Viviani within the institutional and practical context of seventeenth-century Tuscan science. The volume highlights three key

[8] See Roero, "Leibniz and the Temple of Viviani."

dimensions of early modern intellectual life. First, it documents how scientific work relied on physical media, showing that choices regarding paper, ink, diagram layout, and document organization were directly integrated into the process of theoretical derivation. Second, it presents the Galilean school not as a fixed set of doctrines, but as an evolving tradition that was continually re-interpreted, adapted, and organized by its members. Third, it demonstrates the close connections between practical engineering and theoretical geometry in Viviani's career, showing how visual drawing methods, field surveys, and public administrative duties informed his work on classical texts and his engagement with contemporary European mathematics.

At the same time, the volume highlights the primary methodological vulnerability of the material archaeology of science. In its effort to extract cognitive meaning from every physical feature of a working manuscript, this approach can easily drift into overinterpretation. Historians must maintain a clear distinction between deliberate intellectual strategies and routine physical actions, recognizing that faint guidelines, ink intensity changes, paper folds, or casual notes often reflect ordinary drafting habits or material constraints rather than calculated theoretical choices. While Dumas Primbault successfully eschews the danger of overinterpretation, guarding against this tendency remains essential for maintaining balance in the material history of science.

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