Reading/Rereading

Ludi Matematici by Leon Battista Alberti

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Along with his humanistic interests, Leon Battista Alberti (1404-1472) was attracted to the world of scientific knowledge both during his youth, while studying physics and mathematics, and when he definitively returned to Rome in 1443 following Pope Eugene IV (1383-1447) and started to study these subjects in greater detail [Bertolini 2004, pp. 246, 249]. It was while in Rome, that according to recent studies, historiography would erroneously place at 1450-1452, Alberti composed a manuscript in the vernacular entitled *Ex Ludis Rerum Mathematicarum*, better known as *Ludi Matematici*.

The original text of *Ludi Matematici*, which was lost, was handed down through 13 different copies of the manuscript, now kept in the libraries of Cambridge (n. 2), Florence (n. 6), Genoa, Ravenna, Rome, Rouen and Venice (n. 1 each) [Saletti 2008, pp. 120-122]. The first printed edition with the title *Piacevolezze matematiche (Mathematical Pleasures)* was published in 1568 by the Sienese typographer Francesco Franceschi in the collection *Opuscoli morali di Leon Batista Alberti gentil'huomo fiorentino […]*, translated and partly corrected by Cosimo Bartoli (1503-1572) [Bertolini 2014, p. 131]. For this rereading, in addition to the most recent printed versions published by

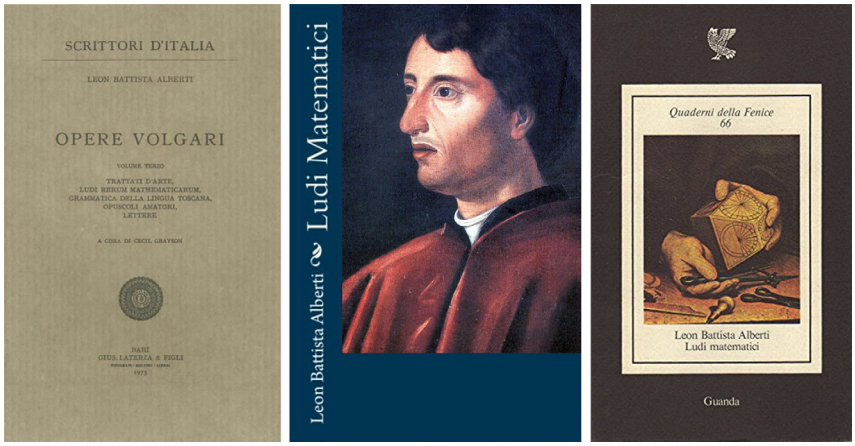

Fig. 1. Covers of the critical editions edited by Cecil Grayson (Laterza 1973 and current commercial version) and Raffaele Rinaldi [Guanda 1980].

Grayson in 1973 and Rinaldi in 1980 (fig. 1), reference was made to two copies of the manuscript currently available online: the first, in 39 sheets, kept at the Houghton Library of Harvard University in Cambridge, Massachusetts [Alberti 1450-1452]; the second, in 36 sheets, at the Bibliothèque municipale de Rouen [Alberti 1401-1500].

Based on recent research, the scholars Francesco Furlan and Pierre Souffrin [Furlan 2006a; Furlan, Souffrin 2001] as well as Beatrice Saletti [Saletti 2008] believe that the dating of the Albertian manuscript must be brought forward to September 1450. Saletti bases the hypothesis on the analysis of the dedication with which the *Ludi* matematici begins. This dedication (*LEONIS BAP. ALB. AD ILLUSTRISSIMUM PRINCIPEM D. MELIADUSIUM MARCHIONEM ESTENSEM. EX LUDIS RERUM MATHEMATICARUM*) is present in most of the manuscripts as well as the printed version (*Allo Illustris. P. Melladusio Marchese d'Este*), while in the manuscript preserved at the Houghton Library it seems to have been deliberately dele-

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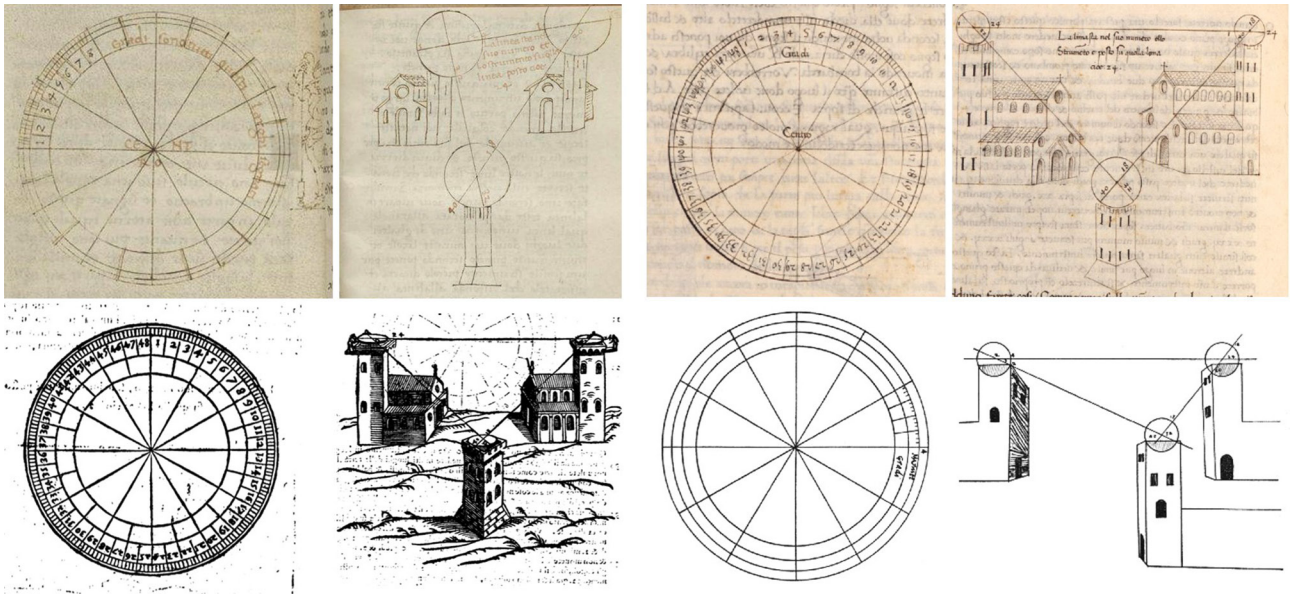
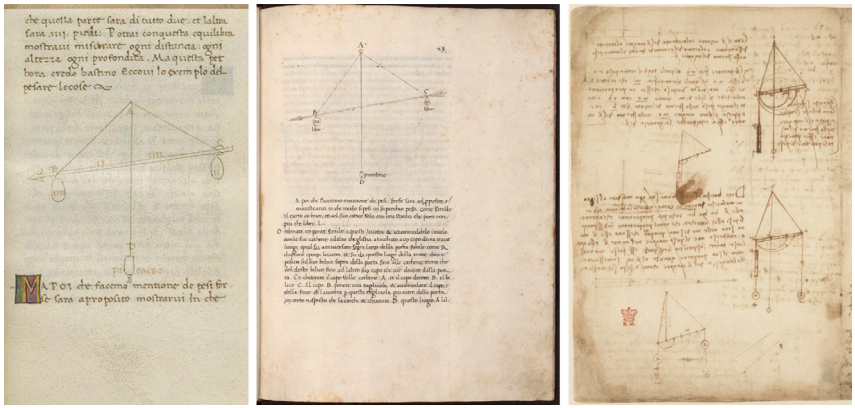
ted. Placing itself in the epochal context affected by the dedication, there is an inaccuracy in its content since Meliaduse d'Este (1406-1452) never held the role of marquis. Meliaduse, the illegitimate son of Nicolò III d'Este, was forced to pursue an ecclesiastical career by his father. Upon becoming commendatory abbot of San Bartolo in 1425, he held the office until he resigned in 1450. On the contrary, his brother Leonello d'Este (1407-1450), equally illegitimate, succeeded his father in 1441 as Marquis of Ferrara until his death when the third brother Borso (1413-1471) took over. At first glance, the dedication formulated by Alberti would reveal a "gaffe" but, thanks to the philological analysis carried out by Saletti [Saletti 2008, pp. 135-136], it is possible to anticipate the dating of the manuscript to September 1450 when, given that was Leonello dying, Alberti hastened to complete the manuscript and, apologizing for the delay, dedicated it to Meliaduse, whose contemporary resignation from the ecclesial office prompted him hastily to consider him as the future Marquis of Ferrara. It is likely that with Leonello's sudden death, the relationship between Alberti and the Este family would have ended and Alberti wanted to ingratiate himself with Meliaduse, believing him to be the future Marquis of Ferrara. Alberti had met Leonello in Ferrara in 1438 during the council and he, known for his cultural patronage, had probably commissioned *De Re Aedificatoria* [Portoghesi 1966, p. XII].
According to Saletti, *Descriptio urbis Romae and De Statue* [Saletti 2008, p. 119] can be both dated to around 1450, the content of which confirms the interest of the essayist in scientific subjects as well as the understanding and use of measuring instruments. During his first stay in Rome (1432-1434) [Bertolini 2004], Alberti had begun to take an interest in the study of architecture through the method of measuring the ruins of the ancient city learned from Filippo Brunelleschi (1377-1446) during his stay in Florence [Grayson, Argan 1960]. Later, these 'measurements' were the object of the short composition *Descriptio urbis Romae* in which Alberti reconstructed the topography of ancient Rome through a system of coordinates that allowed the shape of the city to be graphically restored. Furthermore, the theme of measurement also characterised the Latin work *De*

Fig. 2. "Instrument [to] commensurate the site of a town" in the manuscripts of Cambridge and Rouen and in the printed versions by Bartoli (1568) and Grayson (1973).



Statue [Pfisterer 2007] where, with the help of tools (often of his own invention), Alberti anticipated the culture of 'scientific representation' by determining the proportions of the human body [Collareta 1998].
These works, in addition to dealing with the theme of 'measuring' in the various fields of knowledge and drawing, showed how much Alberti's scientific interest had matured in an epochal context in profound transformation and how much the birth of a new thought linked the mathematical sciences to the humanities, supporting an increasingly operative 'knowledge' [Fabietti 1975]. A position, this of Alberti, which anticipated the relaunching of the cultural season of 'practical geometry', which from the second half of the sixteenth century characterised the production of treatises in the fields of civil and military architecture [Zerlenga 1994, pp. 59-74, 75-100].
In the *Preface* to the re-edition of the *Ludi Matematici* edited by Raffaele Rinaldi [Rinaldi 1980, pp. 7-11], Ludovico Geymonat (1908-1991), a multifaceted figure among the most distinguished of the Italian twentieth century, believes that this work is one of the most representative of the time as "in the fifteenth century, despite the absence of, at the forefront, mathematics underwent one of the most profound transformations in its history; it was in this period that it unquestionably emerged from the medieval phase –in which mathematics like all the sciences was conceived as a secondary speculative activity (secondary to the 'central' problem of the salvation of the soul)– entering a new phase, in which science is interpreted as a fully autonomous activity and mathematics assumes the essential role […] of great mediator between science and technology as well as between science and art" [Rinaldi 1980, pp. 7, 8].
In the *Introduction* to the critical edition of *De re aedificatoria* edited by Giovanni Orlandi, Paolo Portoghesi also believes that "[Alberti's] attitude towards technique is an attitude of lively curiosity and documents not only a prodigious knowledge of classical sources, but also an experience of the artisan tradition, also demonstrated by other writings such as the *Ludi Matematici* or *Descriptio urbis Romae*; an attitude that anticipates, due to the breadth of interests, Leonardo's work "[Portoghesi 1966, p. XXIV].
The fifteenth century is a historical period that passes from a medieval culture, static and contemplative, to a decidedly new one, of dynamic and operational rebirth. Geymonat believes that Leon Battista Alberti, "although not a 'mathematical genius', was undoubtedly one of the main protagonists of the transformation" [Rinaldi 1980, p. 8] so much so that the purpose of *Ludi Matematici* was to "illustrate to the largest number of educated people, the very interesting tasks that mathematics can perform as well as the ingenious tricks that it is able to suggest to us in the most varied concrete situations" [Rinaldi 1980, p. 9]. This was the new spirit that animated the presupposition of an adequate knowledge of this subject of 'measurement' and 'description'. Mathematics was not just speculation but became fundamental for the progress of a nascent new civil society, providing a valuable contribution both as a tool for ingenious technical innovations as well as a tool for the highest artistic creations. Thus, in the scientific panorama of the fifteenth century, Geymonat believes that, better than any other work, "the rereading of the *Ludi*" instils the meaning of this innovation of thought [Rinaldi 1980, p. 11].
The field in which Alberti demonstrates the greatest scientific importance is that of geometry aimed at architectural drawing and art. In the chapter "Geometry in aid of painting" (contained in the trilogy *Storia delle Matematiche*) Gino Loria states that Alberti "was not exclusively a great artist; he was one of the great thinkers of the Renaissance who knew

Fig. 3. Drawing of the "Equilibra to measure every weight" in copies of the manuscript (Cambridge and Rouen) and in the Codex Arundel of Leonardo da Vinci.



how to embrace the whole knowledge" [Loria 1929, p. 445]. Whereas, in *La Geometria nella imagine*, Anna Sgrosso recalls how "Alberti's greatest merit was that of having clearly posed the problem of reducing space to the floor, and of having solved it by means of the *section of the Euclidean visual pyramid*" [Sgrosso 2001, p. 40].

In this context, the experience of Leon Battista Alberti's *Ludi Matematici* anticipates the nascent humanistic position according to which mathematics represented a useful language both for solving practical problems as well as expanding personal culture. Conceived and structured in this way, *Ludi Matematici* has a pedagogical intent and constitutes a collection of problems applied to several fields of human knowledge (civil and military architecture, topography, mechanics, astronomy, navigation, hydraulics) to answer questions relating to the measuring of quantities physical (heights and widths, depths, time, flat surfaces, weight, distances) through the 'practical' knowledge of geometry. In architecture, these problems of applied science concern the rules that Alberti sets out to measure "only by seeing" (or 'at sight'), heights, widths and distances, that would have otherwise been inaccessible such as the height of a tower or the width of a river (for which he applies the Thales theorem and the similarity between triangles through the proportionality of homologous sides) or to "commensurate the site of a town", using "a thread with a plummet" and a sort of horizontal protractor, to be placed on top of towers and/or bell towers and with which to survey a territory or a city with a method, that of polar coordinates, which, according to Luigi Vagnetti, Alberti used before others (fig. 2) [Vagnetti 1972, p. 240].

With the spirit of introducing the reader to a "very delightful game", Alberti also tackles other geometric problems, which concern the measuring of depths (wells, reservoirs) and flat surfaces (rectangular, triangular, curvilinear, irregular straight or mixtilinear). For the latter, in addition to claiming to have referred to the practical geometry of ancient Roman writers (such as Columella) and the more modern ones (such as Fibonacci), Alberti resorts to the construction of a measuring instrument, a square with the shape of a right-angled triangle, which he invented and founded on the application of the Pythagorean theorem.

However, the practical problems dealt with by Alberti are not entirely original. Loria considers the collection of *Ludi Matematici* a testimony of Alberti's interest in pure geometry, while stating that "the rules set out by Alberti were neither exact nor original, but that they authenticated the author's knowledge" [Loria 1929, p. 446] demonstrating his vast scientific culture in the application of rules based on the relationships between similar triangles with which Alberti determines the measuring of inaccessible points. However, as can be read in *Ludi*, Alberti would not only have recourse to the determinations of Thales from Miletus or Pythagoras of Samos but also to a previous culture of 'practical geometry', spread by Leonardo Pisano known as Fibonacci (ca. 1170-1242), Tommaso della Gazzaia (d. 1443), Gaetano da Montepulciano (XV century) and by others who in the XII-I-XIV would have divulged mathematical assumptions as parts of a game. In this sense, according to D'Amore, the title *Ludi* mathematici would find reason when placed in a literary tradition of formulating "mathematical games" to capture the curiosity and attention of the reader towards problems notoriously difficult to learn (such as those of mathematics and geometry), proposed as tempting games [D'Amore 2005, pp. 63, 64]. This tradition persisted even in the sixteenth century so much so that around 1512 the cultured merchant Piero di Niccolò d'Antonio da Filicaia published a manuscript entitled *Giuochi mathematici* with a direct inspiration to the Albertian *Ludi* and in particular with the visual calculation of the height of a tower [Palmarini, Sosnowski 2019].

Another rather significant aspect of the cultural result of *Ludi Matematici* is the use of simple tools, provided by the practical tradition (rods, wax to mark the quotas, darts, ropes, poles, bowls, mirrors) to solve the complex measurement problems, as well as the invention of mechanical devices including the *equilibra*, a pendulum level built with rope and dart [Mercanti, Landra 2007, pp. 39-42]. Due to this attitude to use and invent measuring instruments, Alberti is considered a reference for the sixteenth-century printed treatises dedicated to techniques and instruments for surveying architecture, cities and territories [Stroffolino 1999, p. 16] as well as the precursor of Leonardo da Vinci. Regarding the latter, as can be seen from the consultation of the Madrid Codex (c. II-3r) [Leonardo's Library], in describing the list of books held "in the safe of the monastery" Leonardo also mentions "a measuring book by Bta. Alberti" while in some folios of the Codices Arundel (cc. 31v, 32r, 66r) and Atlanticus (c. 675r) as well as in those preserved at the Institute de France, codices F (c. 82r) and G (c. 54v), we learn that for his studies of mechanics and motion Leonardo repeatedly consulted *Ludi Matematici*, citing the source: "Batista Alberti says

in one of his works entitled *Ex ludis rerum mathematicarum*" [Leonardo's Library, Arundel, c. 66r] or, at times, criticizing their assumptions. This is the case of sheets 31v, 32r, 66r of the Codex Arundel where Leonardo takes up Alberti's description of the *equilibra* to "measure every weight" [Alberti 1450-52, c. 23v], giving his own version: "Batista Alberti says in one of his works given to the noble Malatesta of Rimini how, when the scale *a b c* has the arm *ba* and *bc* in double proportion, it still weighs them attached to it, that they dispose of it in such a proportion, they are in the same proportion that they are the arm; but it is converse that is the greater weight in the minor arm; since experience shows it to be false, but its proposal will succeed when the minor arm is the length of the main arm as shown above" [Library of Leonardo, Arundel, c. 31v]. In the aforementioned sheets, Leonardo discusses the Albertian assumption accompanying his demonstration with several autographed drawings, which clearly refer to the copy of the manuscript he consulted and which are compared here with the copies kept in Cambridge and Rouen (fig. 3) [Alberti 1450-1452, 24r; Alberti 1401-1500, p. 23].

Leaving the comparative study of the assumptions between Alberti and Leonardo to another occasion, in the rereading of the text of the *Ludi Matematici*, the analysis of the drawings that accompany Alberti's manuscripts is of particular interest. It is well-known that the original manuscript by Alberti is currently given as missing and, therefore, it is evident that, like the written text, the drawings were also copied by other writers directly from Alberti's original or from copies, to the point of having different representations of the same subject as, for example, in the

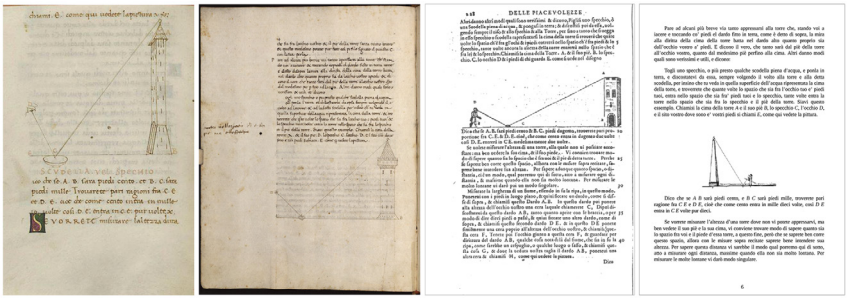


Fig. 4. Comparison of graphic style (writing and drawing) between the Cambridge and Rouen manuscripts and the printed versions by Bartoli (1568) and Grayson (1973).

case of the *equilibra* in the Cambridge and Rouen copies. Furthermore, it is reasonable to believe that the original could have been devoid of drawings since it is well known that Alberti's treatise production is characterized by the presence of only the written text and, according to current historiography, Alberti would have left only very few drawings and sketches to posterity, among which, according to Furlan, those representing a detail of the double volute of the Malatesta Temple in Rimini and the plan of a *thermarum* building [Furlan 2006b, p. 210].

According to Furlan, the relationship between scientific texts and figures would be affected by the epochal context, which established the superiority of writing over drawing. Referring to *Ludi Matematici*, Furlan draws the reader's attention to the punctual precision of Alberti's literal descriptions which, therefore, would not have needed any drawing to be understood but which, on the contrary, would have allowed any reader to gradually follow the description and personally produce some drawings, which would have illustrated the assumption. A sort of instructions for use in written form, whose descriptive precision allowed anyone to independently produce graphic illustrations. The omission of graphic illustrations in the drafting of a scientific text, such as that of *Ludi Matematici*, however, would not have concealed the adherence to a purely ideological question (summarized in 'writing vs drawing') but, according to Furlan, would have found reason in the consistency of *Ludi Matematici*, or in their being a manuscript and non-typographical product and, therefore, subject to considerable risk of error during the copying.

In the comparison made here between the two copies of the manuscript *Ludi Matematici*, consulted online, there are many differences both in the drafting of the drawings as well as in the correspondence of the written text. These differences in writing could be attributed to bad transcription by the copyists or to their attempt to correct some lacuna due to homeoteleuton [Furlan 2006b, p. 203], i.e. by repetition of the same or similar words at the end of different lines or proximity of words of the same termination in the same line of the text. This would lead to the hypothesis that the original copy of

Ludi Matematici could have been produced by Alberti without any graphic illustrations (perhaps since it was intended for private use) as happened for the other works elaborated on the theme of 'measuring', *Descriptio Urbis Romae* and *De Statue,* and, more generally, *De Re Aedificatoria*. This hypothesis is reflected both in Alberti's own exhortations, contained in the work *De Statue* where he invites "the reader – and with him the 'sculptor'– to record the series of data thus collected '*non picturæ modo sed litteris et commentariis*': 'Not with a drawing, but in writing and with annotations'" [Furlan 2006b, p. 208], which in the long-standing research (which has still not given any positive results) for the existence of a possible topographical map of Rome drawn up and attached by Alberti to the *Descriptio Urbis Romae* [Vagnetti 1974], which especially in the method adopted by the author to reduce the description of the city map (scientifically detected through measuring instruments) to a series of coordinates provided in the text only.

Nevertheless, if this is the critical panorama that accompanies the reproduction of the Albertian manuscript of *Ludi matematici* in its many manuscript copies, the one linked to its printed edition appears equally complex. As previously mentioned, in 1568 Cosimo Bartoli printed a collection of works by Leon Battista Alberti, including *Ludi matematici* which, for the occasion, were entitled in the index "Mathematical Pleasures" and, in full, "Of the pleasures of mathematics" [Bartoli 1568, pp. 242-271]. In his work as an erudite philologist, in 1550 Bartoli had already translated "into the Florentine language" and published *De re Aedificatoria* by Alberti [Bartoli 1550]. Aware of land surveying and geometry, in 1564 Bartoli published (again at the Franceschi printing house) a work entitled *Del modo di misurare le distantie, le superficie, i corpi, le piante, le provincie, le prospettive, e tutte le altre cose terrene, che possono occorrere a gli huomini, secondo le vere regole d'Euclide, e de gli altri più lodati scrittori.* Among the writers used by Bartoli, there is also Leon Battista Alberti, to whom he referred in the First Book to describe the indirect measuring of the height of a tower [Bartoli 1564, pp. 1-49]: this is a theme extensively treated by Alberti in his *Ludi*. Bartoli's training in these fields of human knowledge led him to become familiar with *Ludi* matematici and to carry out the first critical operation of passing from a multiplicity of manuscripts to a printed edition. It is not known which manuscript edition (or editions) Bartoli referred to [Bertolini 2014, pp. 133-136]. In the dedication that introduces *Ludi* in *Opuscoli*, Bartoli refers to the "many incorrectnesses" contained in the manuscripts and the "various and varied copies, which, thanks to my friends, have come into my hands" of which, however, he does not quote the sources [Bartoli 1568, p. 224]. It was certain that Bartoli innovated the lexicon in an even more modern version of the Florentine vernacular, returned the iconographic apparatus with the typographic style of the then scientific illustration, replaced the word 'booklet' in the dedication with that of 'operetta' and, as in the handwritten copy kept in Rouen, he omitted Alberti's recommendation to Meliaduse d'Este for his brother Carlo.

Currently, the most recent and authoritative printed edition that divulges Leon Battista Alberti's *Ludi Matematici* is not that by Cosimo Bartoli but rather that of Cecil Grayson (1920-1998), an English scholar of Italian literature who in 1973 reprinted it in a collective work regarding the correct identification and reproduction of the original text and drawings (fig. 4). According to Furlan, the version published by Grayson does not derive from any critical analysis and comparison of the various copies of the manuscript, presenting wide margins of approximation [Furlan 2006b, p. 200]. Saletti states that Grayson was not even aware of the existence of the thirteen copies of the manuscript but of only eleven [Saletti 2008, p. 120].

In this sense, and moving towards some conclusions, the current historiographical framework still leaves open many questions of a purely philological nature on the exegesis of the text as well as on the determination of a method of approach capable of reconstructing a possible 'correct' copy of the original manuscript by Alberti. Therefore, in compliance with the operation of 'rereading' the text, the subject of this contribution seems, rightly so, to ask other questions and ask for the reasons that make, even today, the rereading of the *Ludi Matematici* in areas not strictly of mathematical relevance [Williams, March, Wassell 2010, pp. 9-140]. Compared to the rich and complex epochal context, to which the theme opens, and the variety of events that have taken place, there are numerous answers as well as the points of view from which to observe this rereading. Meanwhile, there seems to be an affinity with the field of architectural and environmental surveying, especially in the context of the indirect determination of the metric measure, such as the height of a tower or the distance from it or from a city. This is an aspect of great interest when considering the critical panorama of the numerous studies carried on architectural surveying methods for the knowledge and protection of towers and/or bell towers through

contemporary criteria, methods and instruments offered by the application of digital photogrammetry and the use of laser scanners and drones for data acquisition [Zerlenga, Iaderosa]. In addition, remaining in this subject area, the central question of drawing as a tool of mental imagination for the illustrated verification of a written text is still relevant. Just as is the role of scientific awareness in the resolution of practical problems for the determination of measuring, which allows to manipulate the use of the tools well and, on the contrary, not to be manipulated by them as Alberti himself demonstrates in *Ludi Matematici* solving problems difficult to measure with the use of simple tools but resorting to determinations of cognitive logic based on the study of geometry. In this regard, it is worth reporting the recommendation that Alberti dedicates to the reader upon opening his 'booklet': "Perhaps I will satisfy you, when in these things *iocundissime* collected here you will take delight in considering again in practicing and using them. I tried to write them very openly; yet I should remind you that these are very subtle matters, and they can be treated badly so slowly that it is not convenient to be careful to recognize them" [Grayson 1973, p. 133]. This clarification also invites to understand the concept of 'measuring' not referable only to the metric dimension but extended to an increasingly multidimensional contemporary thought. Finally, in a world that is running faster and faster, there is the importance of knowledge and the conscious acquisition of one's own disciplinary roots or sources: an assumption that is valid for Alberti, in his time, as well as for every period that wishes to progress.

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