

A VIEW ON GALILEO'S *RICORDI AUTOGRAFI* GALILEO PRACTITIONER IN PADUA*

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Abstract

After Favaro's reconstruction, Galileo's *Ricordi Autografi* represents what we would call a multi-column register nowadays. Galileo wrote them down during the Padua years, also adding short explanations to most of the entries. Relations between the *Ricordi* and letters enclosed in the Galilean correspondence can also be found. An analysis of these documents allows us to take a look at Galileo's household. The workshop where he and Master Marc'Antonio Mazzoleni made military compasses, and the subjects of private lessons, often given to his guests, are only two of the interesting subjects we can study. Focusing on the military compass and the private lessons I will give a general view of Galileo's *Ricordi*.

Introduction

When Galileo was in Padua, he gained significant theoretical results on the isochronisms of the pendulum, the theory of motion and the theory of solid bodies. And so, it is generally acknowledged that this is the period in which

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he achieved many of his most important theoretical discoveries. In this paper are presented the first results of research done in the context of a Dissertation that focuses on this period of Galileo's life but on different aspects.

We have many documents that allow us to throw light on Galileo's work in Padua. One of the most important documents is certainly the famous letter to Paolo Sarpi of 14th of October 1604. This letter and the one to Guidobaldo del Monte from 1602, as well as the great theoretical results achieved in this period, evoke the image of Galileo sitting down, alone, with the hand put on his forehead, in a quiet room, pondering on his ambitious new theory of motion.

On the other hand there are details of his life that do not fit in with this image. Consider, for instance, his request for a patent for a lifting water machine, for the building of whose model he borrowed money from Niccolò Contarini in 1601. Also, thanks to the statements of his contemporaries, we know about his special skill in polishing lenses for telescopes, in the latest period of his stay in Padua. Furthermore, we know from the first sentence of the *Discorsi* that he often visited the Arsenal in Venice. There, he became aware of the practical problems related to shipbuilding, which constituted the normal agenda of the work at the Arsenal. In fact, the *Proti*, foremen of the Arsenal, necessarily faced the problem, later at the core of one of Galileo's two new sciences, namely that of the strength of materials, and this because of the need to change some aspects of the design of the "large galleys", exactly in those years when Galileo was in Padua. The two letters between Galileo and the then *Provveditore* at the Arsenal, Giacomo Contarini, are, in fact, related to some of these problems.¹

These details suggest that it makes sense to investigate the context in which Galileo was working during his time in Padua. Some points of this context are well known, but they are often considered to be marginal with respect to his major achievements. In order to reconstruct this context more extensively the first step is to analyze the environment in which he was working and, therefore, also the work in his house. Although some details of this environment are well known, a general and quantitative view of his work at home has not been given.

Manuscript

The text called *Ricordi Autografi* represents what we would call a multi-column register for Galileo's household.

¹ For the relations between the first of Galileo's new sciences, that of the strength of materials, and the practical knowledge of the foremen of the Venetian Arsenal, see Renn J., Valeriani M., "Galileo and the challenge of the Arsenal", *Lecture Galileiane*, Florence, March 21st, 2001. To be published in *Nunciatus*.



Figure 1. Mss. Gal. 26, 13r, Biblioteca Nazionale Centrale of Florence.

The *Ricordi Autografi* are the result of a reconstruction made by Antonio Favaro, whereas the real manuscripts, Manuscripts number 26 and 49, from which the *Ricordi* were taken out, include also many calculations for Medici satellites and some notes on Motion. Moreover, the entries are ordered in groups and normally in chronological order, whereas these groups are scattered on the original pages often without any order. Most of the entries refer to the Paduan time and especially to the first years of the XVIIth century. However, since there are similar entries for the earlier and later periods, until 1620, one can suppose that a large section of these entries went lost.

The analysis of the *Ricordi Autografi* allows us to describe the two main activities at Galileo's house - the workshop and the private lessons. I concentrate here on the period between 1602 and 1604, as delimited by the letter to Del Monte (November 29th, 1602) about the isochronisms of the pendulum, and that to Paolo Sarpi (October 16th, 1604), where signs of the construction of the theory of motion are present. We know that this is also the period in which Galileo extensively worked on the folios constituting the now famous Manuscript 72 on Mechanics.²

Taking a glance at the Manuscript 26 in a general way, the first remarkable information concerns the number of persons who were living there, the quantity of work which was being done and the great amount of money circulating at Galileo's house. All of this is documented by a large amount of entries regarding the general administration of the house.

Workshop

Galileo's house also comprised a workshop. There Messer Marcantonio Mazzoleni, who lived in the house together with his family, worked as a smith. With Galileo's words of July 5th, 1599:

Memory that, on the mentioned day, Mess. Marcantonio Mazzoleni, came to live in my house, in order to work mathematical instruments for me and on my charge; and having obliged myself to make all the expenditures for him, his wife, and his daughter, and, moreover to give him 6 *ducati* a year, the money that he will receive from me will be annotated here.³

² Galilei G., Mss. Gal, Ms. Gal. 72, Florence, B. N. C. F., 1602-1637. For the electronic representation of the manuscript, see Galilei G., Biblioteca Nazionale Centrale of Florence, Istituto e Museo di Storia della Scienza of Florence, Max Planck Institute for the History of Science in Berlin (eds.), Galileo Galilei's Notes on Motion: Ms. Gal. 72; Folios 33 to 196; Electronic Representation of the Manuscript, Max Planck Institute for the History of Science, www.mpiwg-berlin.mpg.de/Galileo_Prototype/MAIN-HTML, and the Istituto e Museo di Storia della Scienza of Florence, <http://galileo.imss.firenze.it/ms72>.

³ Galilei, G., "Ricordi Autografi", in Favaro, A. (ed.), *Le Opere di Galileo Galilei*, XIX, G. Barbèra, Firenze, p. 131: "Memoria come a di detto è venuto a stare in casa mia Mess. Mar-

Studying how this and other workshops functioned, it is possible to learn not only about the practical method used to manufacture instruments, but also about the *shared knowledge* that also made Galileo's realization of experiments possible.⁴

In the workshop, Galileo achieved a quite systematic production of military and surveying compasses of different kinds. The military compasses differed from each other with respect to their materials, their size and their functionality. The workshop fabricated three kinds of military compasses: a simple one with two points, one with four points and the military compass with four bent points. Ordered from the lowest to the highest quality, the materials used were basin brass, Italian brass, German brass and silver. Points were of steel. In reference to the size the military compasses are registered either as normal or as big. Normally Messer Marcantonio and Galileo purchased the materials themselves. But sometimes also friends or relatives did so. The material was ordinarily bought in form of plates and then sent to a foundry. Once the pieces came back in the proper shapes and sizes, Mazzoleni completed them by refining and assembling them. Unfortunately it is not clear who normally marked them because only one entry of the *Ricordi* is concerned with it. Often Galileo registered payments for finished compasses. From his letter of the November 11th, 1605 to Cristina di Lorena, to whom two military compasses of silver had been promised, we know that Galileo was waiting for silver blocks in order to mark them personally, whereas Messer Mazzoleni probably marked them normally:

I am waiting that the two instruments of silver are sent to me, in order to be able to mark them and to send them perfect back.⁵

In the period taken into account here, 23 compasses were produced, of which one of silver and two big. Most of them were sold to his private students. Besides military compasses the workshop was producing also surveying compasses. But in this case it is documented that not only Mazzoleni in the workshop was manufacturing them but also that Galileo purchased them in Venice and in Florence. Surveying compasses were mostly sold to his private students as well. Finally, the workshop also produced iron tools and parts of tools like screws, perpetual screws and clamps.

cantonio Mazzoleni, per lavorare per me et a mie spese strumenti matematici; et essendomi io obligato di far le spese a lui, sua donna et alla sua puttina, et di più darli 6 ducati l'anno, qui a presso saranno notati i danari che da me haverà ricevuti”.

⁴ For an extensive discussion about the concept of shared knowledge, see the article of Büttner J., Damerow, P., and Renn, J. in this volume. Concerning Galileo's skill in making instruments, see also Settle T. B., *Galileo's Experimental Research*, 1996. Preprint n. 52, Max Planck Institute for the History of Science, Berlin.

⁵ Galilei, G., “Corrispondenza”, in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, X, G. Barbèra, Firenze, p. 149: “Io sto aspettando che mi siano mandati li due strumenti d'argento, per poterli segnare et rimandare perfetti.”

Private lessons: students

The workshop with its variety of products was not an isolated commercial activity, independent from Galileo's intellectual pursuits. In fact, the instruments produced and sold in Galileo's household were only useful together with the knowledge of how to operate them. The transmission of this knowledge was, therefore, another essential activity, going on in Galileo's household and intimately related to the workshop. Private lessons were Galileo's way of transmitting this knowledge.

Private students who were also roomers	Other private students
Schweinitz G. (+2) Lazocski (+1) Lentowicz M. Bucau B. (+1) Buc Plesch M. ? Giovanni - from Lithuania Ferrante (+1) Ricques D. Zator G. (+8) Lesniowolski R. Soell G. C. Het B. Montalban A. (+2) Morelli Andrea (+1) Caietano Giulio Cesare (+1)	Allfeldt (von) C. Filippo d'Assia Vinciguerra Coll'Alto Reisener B. Luzimburg Noailles (de) F. Batavilla Reigesberg G Dietrichstein (de) P. +3 students whose names are unknown
Total: 33 person	Total students: 28

Figure 2. Private students from November 29th, 1602 to October 16th, 1604. In brackets there is the number of their friends and/or servants.

Galileo gave private lessons on a variety of themes. Their overarching topic was, as it turns out, fortification.

His students were often young persons from distinguished or, anyhow, rich families who wanted to complete the curriculum at the University of Padua before starting their military career as officers. At the time, taking private lessons was quite normal. They offered the student the possibility of improving his knowledge of special topics in comparison with what could be learned from attending the University lectures alone. In this sense, it was perfectly normal that a student destined for a military career took private

lessons on Fortifications. Accordingly, fortifications and military Architecture formed a part of the *shared knowledge* of many Engineers and Architects.

During this short period of two years, as many as 28 private students are registered in the *Ricordi*, sixteen of whom also lived in his house as roomers either for the whole period or part of it. At least one servant or friend also accompanied most of his roomers, so that the total number of roomers documented during that period even increases to 33.

By going through the Manuscript, it is easy to reconstruct that at least ten roomers were simultaneously living in Galileo's house all the time. Taking servants and workers into account, there were at least fifteen persons in Galileo's house permanently. Now, by considering also the presence of the workshop and of all these students and roomers, it becomes immediately clear that the image of Galileo, the lonely thinker, sitting down, alone, in a quiet room is probably wrong.

Private lessons: topics

Entries regarding private lessons are, as a rule, labeled according to their topic. These topics are: Geodesy, Mechanics, the Sphere, Perspective, Euclid, Arithmetic, Fortifications, and Use of the Military Compass. Although lessons specifically labeled as Fortifications are only one type among many others, a comparison with a traditional and most used treatises on Fortifications of that time, for example, with that of Boniauto Lorini of 1609⁶, suggests that all registered topics, taken together, constitute a rather typical treatise on fortification for that time.

Four of these different kinds of lessons were based on the treatises known as *Le mecaniche*⁷, *La Sfera ovvero Cosmografia*⁸, *Le Fortificazioni*⁹ and *L'Uso del Compasso Militare*¹⁰ and the entries for these lessons are registered exactly under these names. Furthermore, in 1603 a copyist, Messer Silvestro, was also working at Galileo's house providing the private students with handwritten copies of the treatises:

⁶ Lorini B., *Le Fortificazioni*, Venetia, presso Francesco Rampazetto, 1609.

⁷ Galilei G., "Le Mecaniche", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, II, G. Barbèra, Firenze, pp. 155-191.

⁸ Galilei G., "Trattato della sfera ovvero Cosmografia", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, II, G. Barbèra, Firenze, pp. 211-255.

⁹ Galilei G., "Breve Instruzione all'Architettura militare, Trattato di fortificazione", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, II, G. Barbèra, Firenze, pp. 17-146.

¹⁰ Galilei G., "Del compasso geometrico e militare", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, II, G. Barbèra, Firenze, pp. 343-424.

Nota delle scritture haute da Mess. Silvestro:
 Fortificazioni, copie 2, per il S. Giovanui Svainitz et S. Lerbac
 Item, copie 1 al S. Bucau
 Item, copie 1 al S. Alfelt
 Item, copie 1 al S. Staislao
 Item, copie 1 al S. Niccolò Beatavil
 Per una copia dell'Uso del Compasso, data al S. Staislao
 Per una copia dell'Uso del Compasso, data al S. Beatavilla
 Per una copia del detto Uso, data all'Ill.mo et Ecc.mo S. Langravio
 Per una delle dette copie, data ad un gentil'homo todesco
 Per una data al S. di Noaglies...¹¹

Although we have entries regarding handwritten copies of treatises only concerned with Mess. Silvestro in 1603, there is nevertheless no reason to exclude that this was a normal procedure in Galileo's house. Moreover, as we know from Favaro's analyses of four handwritten copies of Galileo's *Trattato della Sfera*, Galileo's students were able to copy for themselves Galileo's treatises. This is the case, for instance, for Abbot Giugni's copy of this treatise. In 1604 Galileo writes:

On October 28th, Lord Abbot Giugni came with a priest and a servant of him.¹²

If the hypothesis that Galileo's teaching was characterized by an encompassing curriculum of fortification is true, the most significant difference that distinguishes Galileo's curriculum concerns the long and detailed explanation of the uses of mathematical instruments like the compass for military purposes.

Reconstructing the curriculum of the course offered by Galileo, by means of the *Ricordi Autografi*, it becomes clear, in particular, that almost all of the students were taking lessons on the *Uso del Compasso Militare*.

The possibility of obtaining such an instrument together with its instructions was not easy at the time and, since in Galileo's house it was also possible to obtain both the instrument and private instructions on its use, this must have been a great opportunity for a student of Fortifications, who could also obtain a horoscope from Galileo into the bargain.

¹¹ Galilei G., "Ricordi Autografi", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, XIX, G. Barbèra, Firenze, pp. 166-167.

¹² Galilei G., "Ricordi Autografi", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, XIX, G. Barbèra, Firenze, p. 163: "A dì 28 di Ottobre è venuto il S. Abate Giugni, con suo prete et servitore". Cf. also Favaro A., "Avvertimento al Trattato della Sfera", in Favaro A. (ed.), *Le Opere di Galileo Galilei*, II, G. Barbèra, Firenze, p. 206; letters n. 119, *Alessandro Sertini to Galileo*, April 16th 1609, n. 121, *Galileo to Niccolò Giugni*, June 11th, 1605, n. 134, *Vincenzo Giugni to Galileo*, January 21st, 1606 in Galilei G., "Corrispondenza", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, X, G. Barbèra, Firenze.

Most of the students alternated these lessons on the military compass with those specifically based on the treatise called *Le Fortificazioni*, like, for instance, Lord Alfelt, who in 1602:

On December 10th has began again Fortifications and Instrument.¹³

Before these lessons many students took others on different topics. As mentioned above, Galileo called one of these kinds of lessons *Le Mecaniche*¹⁴. In fact many contemporary treatises on fortification, such as that of Lorini, have a section dedicated to the same topic. It thus becomes clear that Galileo's treatise *Le Mecaniche*, usually only considered in the context of

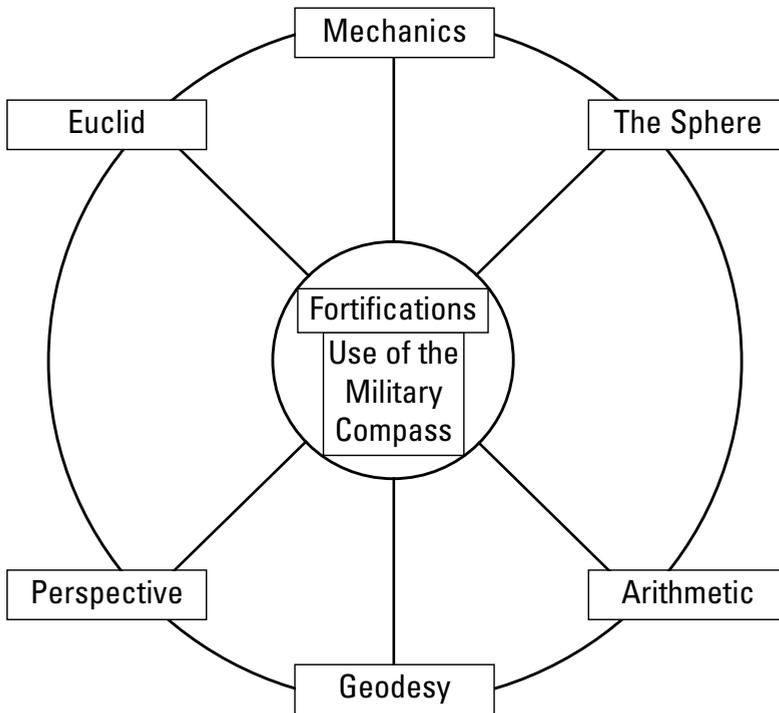


Figure 3. Galileo's private lessons: the core was represented by courses in Fortifications and Use of the Military Compass. The students could take classes in one or more propaedeutic topics (those along the circumference).

¹³ Galilei G., "Ricordi Autografi", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, XIX, G. Barbèra, Firenze, p. 152: "A dì X di Xmbre ha ricominciato fortificazione et lo strumento il S. Alfelt".

¹⁴ A paradigmatic entry in the *Ricordi Autografi* for the lessons called "mecaniche" is the following: in 1602, "A dì 5 di Marzo cominciò le mecaniche il S. Marco pollacco, et il maiordomo del' Ill.mo S. Lencischi et S. Donec"; in Galilei G., "Ricordi Autografi", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, XIX, G. Baebèra, Firenze, p. 151.

Galileo's emerging science of motion, was actually part of a curriculum on fortification.¹⁵

The topics of the other lessons are compatible with this interpretation. Galileo's reading of Euclid and Perspective, for instance, was oriented towards the practical needs of a military man faced with challenges such as designing fortresses, aiming a cannon, and surveying a terrain. Like every other treatise on fortification, Galileo's taught how to divide lines and angles, how to draw geometric figures, and how to apply some useful geometric theorems, and this also referring to Albrecht Dürer.¹⁶

Another topic taught by Galileo was the Sphere. For these lessons there are many entries in the *Ricordi*. Most of the students of the Sphere were taking these lessons after Mechanics and before starting Fortifications and Use of the Compass and some of them are registered only for this topic.

Finally we have one entry regarding lessons in Geodesy and one for Arithmetics.

For the way the topics of the lessons are labeled and, more concretely, for the way in which students learned, it is possible to conclude that all topics, apart from the main lessons in Fortifications and Use of the Military Compass, were propaedeutic to the latter.

To sum up, Galileo's course was organized around Fortifications and the Use of the Military Compass. These lessons were based on the treatises *L'Uso del Compasso Militare* and *Le Fortificazioni*. Other topics were offered to the student probably in form of propaedeutic lessons such as those on Mechanics, Euclid, Perspective, Arithmetics, the Sphere and Geodesy. On some of these subjects, students could buy treatises in form of handwritten copies or copy Galileo's original treatises for themselves.

Obviously the teaching of these subjects must have been combined with and supported by an introduction into the usage of the mathematical instruments produced and sold by Galileo's workshop. The fact that the students could learn all of this while staying in Galileo's household was certainly an advantage and effectively made this household resemble more a boarding school for future officers than a scholarly studio.

Conclusion

In conclusion, it is clear that the two main activities at Galileo's home –the workshop and the private lessons– were absorbing a great amount of his

¹⁵ Problems related to the dating of the Manuscript *Le Meccaniche* and that reveal the link between this Manuscript and Galileo's course on Fortifications are described in Gatto R., "Sull'edizione critica de *Le Meccaniche* di Galileo", in this volume.

¹⁶ Galilei G., "Breve Instruzione all'Architettura militare", in Favaro. A. (ed.), *Le Opere di Galileo Galilei*, II, G. Baebèra, Firenze, p. 20.

time and this already without counting the general administration of the household. Furthermore, the presence of the workshop finds a full explanation only if related to the large number of private students on Fortifications. What is more important is that the four treatises –*Le Meccaniche*, *Trattato della sfera*, *Le Fortificazioni* and *L'Uso del Compasso Militare*– are related to each other as parts of a complete course, where only the last of those, the one on the Military Compass, represents something new in comparison with common treatises on Fortification of the time. In other words, the subjects of *Le Meccaniche*, *Trattato della Sfera*, and *Le Fortificazioni* perfectly fit in the shared knowledge of military Architects of the time.

Finally, all this suggests that the image of Galileo, the lonely theoretician in Padua, is probably not adequate and must be complemented by that of Galileo *Ingegnere*.

