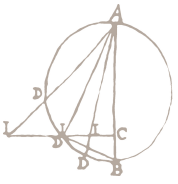

Matteo Valleriani

Forms and Functions of Codification of Knowledge
An Example from the Work of Joseph Furttenbach

The stage

At the occasion of the marriage between Cosimo II and Maria Magdalena of Austria in 1608, the play *Il giudizio di Paride* was performed in the Uffizi Theatre of Florence. The acts of the play were enriched with intermezzi, as usual in the court theatre of the period. The scenery and, in particular, the theatrical machinery of these intermezzi were completed by the Florentine engineer Giulio Parigi. The fourth *intermezzo*, which the argument of the present work begins with, celebrated the figure and discoveries of Amerigo Vespucci in heroic manners:

[...] the scene transformed into a peaceful and calm sea. Its shores appeared to be covered by trees unknown to us and, among them, one could see dwellings made of palm trees and reeds and some of earth and others were in the trees. On other sites, there were enclosures of reed and beds of mesh tied to the trees. The air was full of parrots and similar varieties of birds. Below there were naked men, as common in the West Indies. In this sea a big sail ship appeared, with a Lion at the bow. Because of the lilies on the trees and on the sails it was possible to recognize the Florentine Amerigo Vespucci, who sat at the stern, armed, dressed with a greatcoat according to the customs from his homeland, an Astrolabe in his hand. The ship's wheel had the shape of a chained dolphin and was governed by the Nautical Science, which was a woman dressed in cerulean colors, with anchors, a compass, and other maritime instruments. Hope, Daring and Fortitude, all dressed with their marking signs, were at bow among the soldiers and the sailors. When they saw land, they all shouted[...].[1]

[1] » [...] la Scena si fece Mare placido, e quieto, e le sue rive apparuero vescice d'alberi incognici à noi, e fra essi vedevansi qua, e là sparse case fatte di palme, e di canne, alcune in cerra, altre su gli alberi: altrove ricinti d'incannucciate, e letti di rete le gati a gli alberi: l´aria ,piena di Pappagalli, e simil variecta d'uccelli, e per terra huomini nudi, come costuman nell´Indie Occidentali. In questo mare comparve a vela una nave grande, con un Leon in prua, e gigli sopra gli alberi, e nelle vele, dà tali contrassegni, si riconobbe Amerigo Vespucci Fiorentino, che sedeva in poppa armato, con sopravvesta all'uso della patria, e l'Astrolabio in mano. II Timone era in figura di Delfino incatenato, e lo governava la Scienza Nautica, donna vestita di color ceruleo, con ancore, e bussola, e alrri strumenti di marineria: la Speranza, l'Ardire, la Fortezza, vestite de'propro contrassegni, erano in prua, fra li soldati, e marinari. Scoperto terra, levaron tutti un grido [...] .« [Camillo Rinuccini], *Descrizione delle feste fatte nelle reali nozze de' Serenissimi Principi di Toscana D. Cosimo de' Medici, e Maria Maddalena Arciduchessa d'Austria,* Firenze: Giunti, 1608, p. 40. For an overview of the entire intermezzo, its meaning and historical as well contemporary sources, and its contextualization in the frame of early modern history, see Viktoria Tkaczyk, *Himmels-Falten. Zur 7heatralitdt des Fliegen in der Frühen Neuzeit*, Paderborn: Fink, 2011.

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The »Nautical Science« was the personification that represented one of the most dramatic changes in the culture of the early modern period: it meant recognizing the unexpected great size of the planet and discovering unanticipated different beings, though human. The era of the journeys of exploration had already begun a long time before the performance of 1608 but it had not yet stopped delivering new material to be assembled and integrated into the old Western culture. Epistemically, the phenomenon of the journeys of explorations imposed the recognition that the sciences that were called »mixed« during the Middle Ages, that is, those mathematical sciences, that could find an application in the real world and were in turn generated by such applications, were way more relevant than what had been supposed for many centuries. Amerigo Vespucci was depicted as a strong man who carried weapons but at the same time he also carried an astrolabe and was onboard of a ship piloted by »Nautical Science«. The latter was a mixture of basic mathematical astronomy, metric geography and practice of mathematical and observational instruments that, from the second half of the sixteenth century onward, could no more be replaced by simply having ‚experience on the seas«. The power of science was transformed into action by means of the ship, which, considered with actors's category, was nothing else than a machine, that is, a device that allowed to accomplish an action by a smaller number of men (less force) and in shorter time. A ship or a fortress were in principle considered, for instance, like a machine to lift up weights, or to saw trunks or to mill wheat. Treatises codifying the practical knowledge of the machine-makers quickly increased in numbers during this time.[2] Such texts were furnishing what we would nowadays call »empirical material« to one of the most recents frontiers of the science of the time, the science of machines. This science had been systematized, at least concerning static considerations, by Guidobaldo del Monte a

[2] Bert S. Hall, »Der Meister soll auch kennen schreiben und lesen: Writings about Technology ca. 1400 - ca. 1600 A. D. and their Cultural Implications«, in: *Early Technologies,* ed. by DeniseSchmandt-Besserat, Malibu: Undena Publications, 1979, p. 47-58.

few decades earlier.[3] It encompassed any real machine like a compound machine and any compound machine as a combination of simple machines. These in turn were only five - the lever, the pulley, the wheel, the wedge and the screw – and the functioning of all of them could be explained by means of the principle of the lever.[4]

Ships, however, were particularly elaborated compound machines. The young science of machines was not yet developed to the extent that the functioning of all components of the ships could be described in clear terms. For instance, the debate concerned with the functioning of the oars and the way they power the movement of the ship was very relevant at the time of the performance and the same Galileo Galilei remained involved in an enquiry of the Collegio della Militia da Mar of Venice at the end of the sixteenth century. [5]

Ships were therefore a topic in the culture of the early modern period. They symbolized the exploration, domination and power by means of force and science and, because of their importance, they also represented a challenge: they had to be improved, to become bigger, faster, more effective, safer, more aggressive and no state had enough of them. The ship and the imagery around it became a myth that was able to provoke interest and emotion in many social groups and on many levels, from science and technology[6] to literature and theatre.

The representation of the ship in the framework of theatrical scenery, finally, was itself a further issue of mechanical nature that, also because of its cultural

[3] Guidobaldo del Monte, *Guidiubaldo e Marchionibus Montis Mechanicorum Liber*, Pisauri 1577; Guidobaldo del Monte and Filippo Pigafetta, *Le Mechaniche dell´Illustrissimo Sig. Guido Ubaldo De'Marchesi del Monte*, Venetia: Concordia, 1581.

[4] Matteo Valleriani, *Galileo Engineer* (Boston Studies in the Philosophy of Science, vol. 29), Dordrecht: Springer, 2010, p. 91-104. Guidobaldo's systematization, as usual during the early modern period, resulted from the attempt to face contemporary issues also by means of selective appropriation and transformation of ancient science. On the role of ancient science and the mechanisms through which it was approbated, see Matteo Valleriani, »Appropriation and Transformation of Ancient Science«, in: *Nuncius* 29 (2014), p. 1-8.

[5] Valleriani, *Galileo* (as note 4), p. 117-154.

[6] During the early modern period, the scientific debate concerning the functioning of the ships first focused on some aspects of their propulsion mechanisms. In particular, the debate could emerge on the basis of the re-appropriation of the ancient text of the *Mechanical Questions*, which contains four Questions related to nautical issues. New knowledge was first codified in form of scientific commentaries to the *Mechanical Questions*. The earliest example in this respect is represented by the work of Pedro Nuñes published in 1566. For more information, see Jürgen Renn and Matteo Valleriani, »Galileo and the Challenge of the Arsenal«, m. *Nuncius* 16 (2001), p. 481-503; Henrique Leitáo, *O comentário de Pedro Nunes á Navegaçáo a Ramos*, Lisboa: Edifil-Publicações económicas Lda., 2002; Matteo Valleriani, »The Transformation of Aristotle's ›Mechanical Questions‹ : A Bridge Between the Italian Renaissance Architects and Galileo's First New Science«, in: *Annals of Science 66* (2009), p. 183-208.

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relevance, increasingly attracted the attention of professionals of the mechanical arts during the same period. It is difficult to quantify the relevance of the topic »ship « in early modern theatre. It is known, however, that nineteen years before the recital of Il giudizio di Paride something similar had been represented in Florence already. At the occasion of the marriage between the Grand Duke Ferdinando de Medici and Christina of Lorraine in 1589, great and solemn ceremonies took indeed place in Florence. The most relevant among these events, according to contemporary sources, was the representation of six intermezzi during the recital of the comedy La pellegrina on May 2 . The engineer in charge to realize the theatrical machinery at this time was Bernardo Buontalenti, who also acted as a master for Giulio Parigi. As it is known from Barthold von Gadenstedt, who accomplished a trip to Italy after his studies between 1587 and 1589, during the fifth act, the scene was transformed into a sea, which in turn appeared as if the wind were moving it by means of a mechanical device. As soon as the inevitable sirens disappeared, a ship came into the stage. The ship was equipped with masts and sails as a real one. Also the ship moved together with the water and the impression was realistic so chat it seemed that the waves were moving it.[7] In the following the sources at disposal chat describe the theatrical machinery used in the fourth intermezzo of the recital of Il giudizio di Paride will be investigated. On the basis of chis analysis, then, the path will be explored, along which mechanical knowledge related to theatrical machinery entered the field of the theoretical mechanics, as this was emerging during the seventeenth century.

The sources

Thanks to the work of the tireless engineer Joseph Furttenbach (1591 - 1667), it is possible co approach the detailed knowledge regarding the technical contrivances used during the intermezzo devoted to Amerigo Vespucci. In particular, the available sources allow the exploration of different forms of codification of the same knowledge concerned with the construction and functioning of the scenic ship.

The sources considered here are, first, Furttenbach's sketchbook Codex iconographicw

[7] Werner Friedrich Kümmel, »Ein Deutscher Bericht über die Florentinischen Intermedien des Jahres 1589«, in: *Studien zur Italienisch-Deutschen Musikgeschichte 7* (1970), p. 1-19. Because of a series of striking similarities, it is plausible to believe chat the machinery used for the intermezzi in 1589 were then in face re-used in 1608. For more information, see Sara Mamone's contribution in chis volume and Tkaczyk (as note 1), P. 88.

The sources considered here are, first, Furttenbach's sketchbook *Codex iconographicus 40r*[8] and, second, his own late publication of 1663.[9] The first historical source discusses the ship constructed at the occasion of the performance of *Il giudizio di Paride* while the second, clearly conceived on the basis of the first, discusses a ship designed for a performance in Ulm. After his commercial education, Joseph Furttenbach embarked on a ten years' journey to Italy, as was common at the time, to gain the international profile needed for chat particular career. During this time, however, he also increasingly devoted his attention to mathematical, architectural and mechanical issues and became one of the most relevant educated engineers of the first half of the seventeenth century.[10] For chis reason, after having spent several years in the city of Genua, Furttenbach moved to Florence and was able to enter among the pupils of Giulio Parigi 's workshop. At that rime, Giulio Parigi was intensively occupied with the conception and construction of theatrical machineries and, in particular, was responsible for the realization of the *intemezzi* of the recital.[11] It is not by chance therefore chat the same Furttenbach might have seen such intermezzi at the Uffizi theatre originally built by Bernardo Buontalenti and, in general, looked at the contrivances behind the scenes. The *Codex iconographicus 40I*, recently ascribed co Furttenbach by Hole Rößler, contains the private notes of a practical mathematician already well-versed in the mechanical arts who was learning contrivances apt to theatrical machineries. The ship machinery is sketched in Figure I (Fig. 1).

8 Joseph Furttenbach, *Beschreibung und Illustration von Festaufzügen zu Florenz gehalten unter Cosimo II., Großherzog der Toskana I608 - I6I7*, Bayerische Staatsbibliothek Munich, *Codex Iconographicus 40I.*

9 Joseph Furttenbach, *Mannhaffter Kunst-Spiegel, oder Continuatio und Fortsetzung allerhand mathematisch- und mechanisch hochnutzlich- sowohl auch sehr erfrölichen Delectationen* , Augsburg: Schultes, 1663

10 Margot Berthold, »Joseph Furttenbach von Leutkirch, Architekt und Ratsherr im Ulm«, in: *Ulm und Oberschwaben* 33 (1953), p. 119-192. As is well known, it is not concerned with mechanics and practical mathematics during the early modern period. All categories such as artist, architect, engineer, and even scientist might apply to the same historical actor. The fundamental work that opened this discussion on a histographical level is Edgar Zilsel, *The Social Original of Modern Science,* Heidelberg, New York and Dordrecht: Springer, 2000.

11 Tkaczyk (as note I), p. 255-258.

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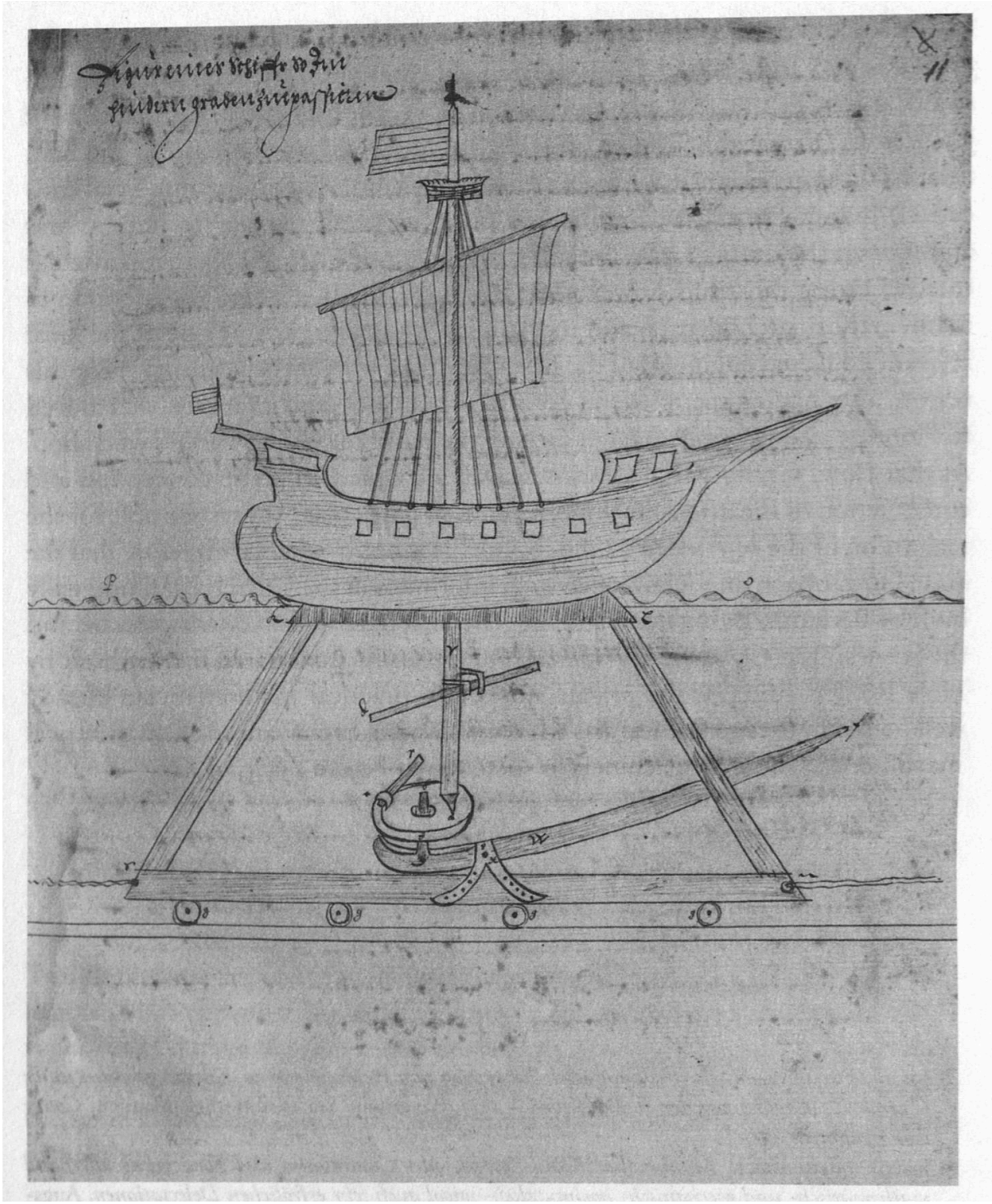

Fig.I : Sketch by Joseph Furttenbach of the scenic ship used in the intermezzo of the recital Il giudizio di Paride, in Florence in 1608. From Joseph Furttenbach, *Codex iconographicus 40r*. Beschreibung und Illustration von Festaufzügen zu Florenz gehalten unter Cosimo II., Großherzog der Toskana 1608-1617, Bayerische Staatsbibliothek, 1608-1617, pag. 79 (fol. II).

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Furttenbach's accompanying text of reads as follows:

P O is the level of the stage. The ship is placed on a framework k l s n with four legs standing on four wheels, marked g. There are round bars in n and m. Using ropes and a winch, the framework and ship can be drawn wherever one desires. i is a round disk with its center in b, connected to the beam W at point y. X is an iron fitting which has a pin at c, which allows beam W to move [up and down]. Vis a beam which is inserted into the [bottom of the] ship. At a it has an iron point which rests on one side of the disk. The bar r inserts into an iron ring ate [on the disk]. At d there is another bar. If the rope n is pulled, the ship moves straight ahead. If a man pushes the pole W down at f, the ship's prow will dip down. If he pushes up and down on f, the ship will sway as if it is in a stormy sea. If the bar r is turned, the side of the ship rocks to the side it is turned. To turn the ship around so that its bowsprit faces the spectators, the bar d can be turned around, and so on: Thus, the ship can perform all actions as if it were afloat at sea. Furthermore, the land at the shore is simply painted on the telari, and between these, even more telari of wilderness and rocks can be quickly pushed forth.[12]

At first view, a detailed analysis of the description shows some imprecisions. The relation between text and image remains unclear in places; for instance, when Furttenbach describes the mechanism that allows the ships to be moved on the sides. However, it would be wrong to focus the attention on the fact that an external reader could not apprehend some of the details. As a matter of fact, this text was absolutely comprehensible and rich enough for all those versed in the discipline and experienced in the activity. Any equivalent of Furttenbach would have perfectly understood how to re-build the same mechanical device. Furttenbach 's notes are comparable to the notes that fill a sketchbook preserved at the Library of Congress and that, according to the analysis of Hole Rößler (personally communicated), is a direct product of Giulio Parigi 's school of the same period and therefore most probably of a pupil, as Joseph Furttenbach himself was (Fig. 2).[13]

[12] Furttenbach, *Beschreibung und Illustration*, pag. 78 (fol. 9v) . Translated by Ashley Elrod and Hole Rößler.

[13] »Sketchbook on military art, including geometry, fortifications, artillery, mechanics, and pyrothechnis «, Library of Congress, Lessing J. Rosenwald Collection. MS 27. 17th century. This manuscript was first found by Daniela Lamberini. For more information, see Daniela Lamberini, *Two Projects: A Sketchbook on Molitary Architecture and the Frederick Hartt Papers,* Washington: National Gallery of Art. Center for Advanced Study in the Visual Art, 2004.

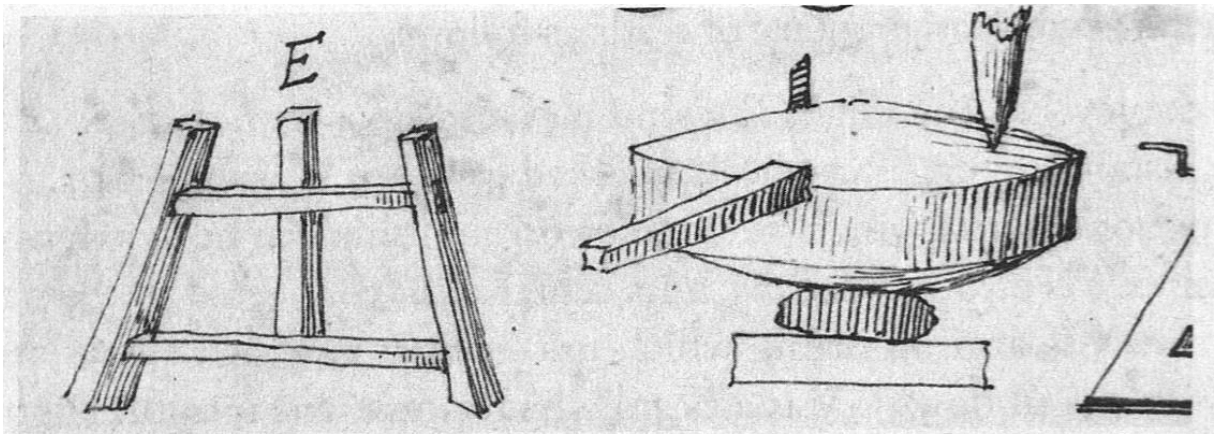

Fig. 2 : Mechanical devices used for the construction of the scenic ship. From Sketchbook on military art, including geometry, fortifications, artillery, mechanics, and pyrotechnics, Library of Congress, Lessing J. Rosenwald Collection, MS 27, 17th century, fol. 277' (detail).

The text, the images and their relation to each other show also in this case that these were notes made for those who were able to build such mechanisms and for whom, therefor~, these pieces of information represented a complete workflow. A very different historical source on the same subject in the section dedicated to the description of the scenic ship in the last of Furttenbach's works, was published in 1663 (Fig. 3).[14] The image of the ship in this work is particularly significant because Furttenbach decided to keep the entire mechanism hidden. This is mentioned in the text but more from the perspective of the spectator . The author also mentions possible variants so to achieve different effects. He finally refers to the »erfahrener Mechanicus« (the expert mechanician), in case someone were to have the idea to have those contrivances really built. What is more relevant in reference to this source, is the place assigned by Furttenbach to the description of the scenic ship. As mentioned this description was inserted in the chapter on »Perspective «. This chapter follows one on nautical techniques and is followed by one on the general character on mechanics, specifically on the science of machines. The book in its entireness is a monumental work on practical mathematics, the summa of Furttenbach's experience and knowledge. Already its title suggests Furttenbach's agenda: [...] *Continuatio und Fortsetzung allerhand mathematisch- und mechanisch-hochnützlich- sowohl auch sehr erfröhlichen Delectationen* ([. ..] prosecution about all mathematical and mechanical, very useful and also very amusing contrivances). Furttenbach focusses on the ancient association of mechanics and amusement, fundamentally renovated under the impulse, among others, of the glorious early modern theatre tradition and habit. He begins according to the typical structure of such texts with an introduction into arithmetic and geometry. The next six chapters function as a general introduction

[14] Furttenbach *Mannhaffter Kunst-Spiegel* (s note 9), p .136-137.

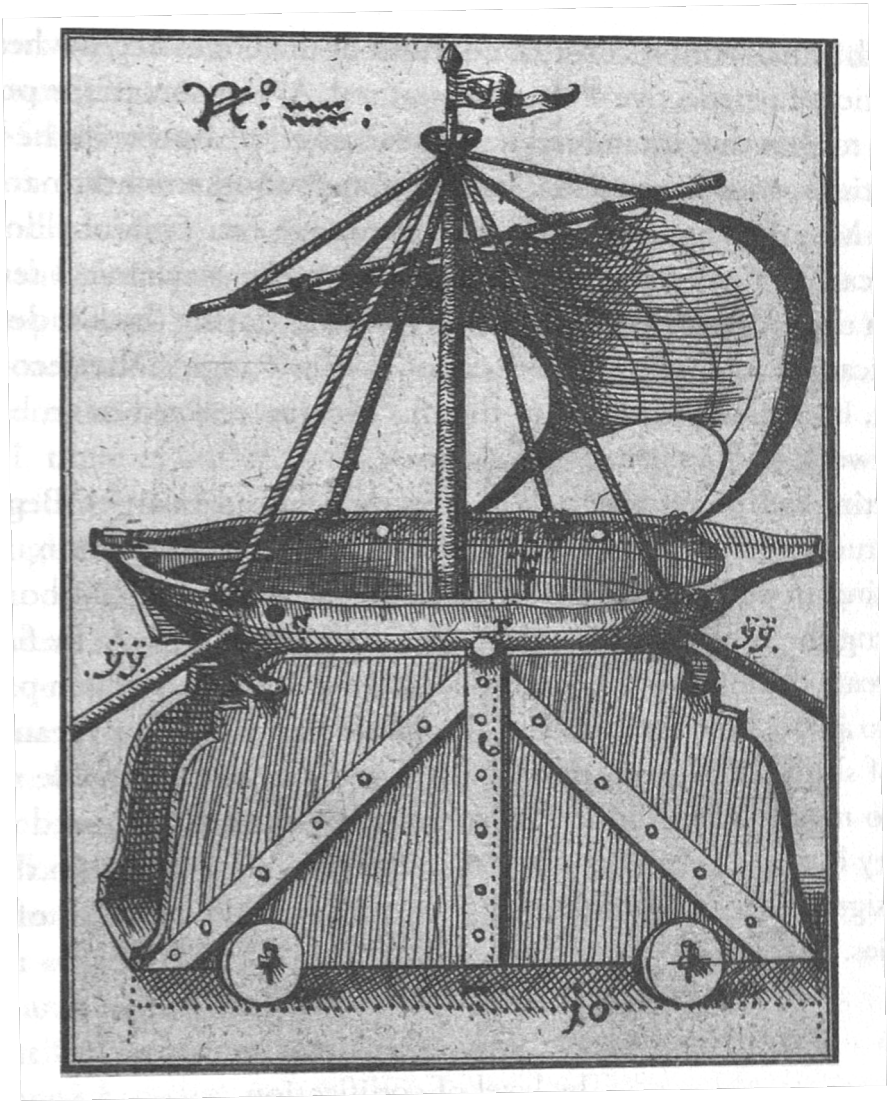

Fig. 3: From Joseph Furttenbach, *Joseph Furttenbachs des Aeltern Mannhaffter Kunst-Spiegel, oder Continuatio und Fortsetzung allerhand mathematisch- und mechanischhochnützlich- sowohl auch sehr erfröhlichen Delectationen,* Augsburg: Schultes 1663, p. 124, Tab . 13 (detail) .

to corresponding activities: planimetry, geography, astronomy, and the already mentioned navigation techniques, prospective, and mechanics. The next eight chapters are more specific, though still approached in general terms: the grottos' works, water pipes, pyrotechnics, cannon production, military, civil, naval and isle architecture. The last source that needs to be taken into consideration is the *Pratica di fabricar scene, e machine ne'teatri* by Nicola Sabbattini published in 1637/1638.[15] Sabbattini's work is entirely dedicated to the instructions on how to build theatrical machineries. The first edition contained only the first of the two books,

[15] Nicola Sabbattini, *Pratica di fabricar scene, e machine ne'teatri,* Ravenna: de' Paoli & Giovannelli, 1638.

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of which the final work is constituted. Both of the books begin where the entire mathematics of perspective is already acquired. As the note of the printer clearly states, the readers that intend to know the theoretical aspects in the background of Sabbattini's work have to first work through another work, namely Guidobaldo del Monte's *Perspective*.[16] Sabbattini was in fact Guidobaldo's pupil and his work can be finally read as a clear rendering in mechanical terms of what he Italian theatre tradition had put into practice during the last decades before this publication, including the works of Guilio Parigi.[17] The second book, in particular, is explicitly devoted to the machineries realized or to be realized in the framework of *intermezzi*.

Sabbattini composed his work in a very Euclidean manner. Beginning with the construction of the stage and with useful further instruction, for instance, constructing in such a way that men could be hidden at the bottom, before introducing the subject of the scenic ship in the second book, he first described how to create the effect of the sea in several manners. Around ten pages are then devoted to all possible scenic effects that could be achieved by means of different models of ships.[18] The work of Sabbattini was destined to a wide audience but was by no means an introduction to mechanics. It only focussed on theatrical machinery but in a very exhaustive manner. As will be shown in the following, it is the sign of an emerging process that brought the creation of disciplinary boundaries.

The level of codification

Mechanics was one of the first disciplinary areas that, together with its related practical activities, pioneered within the process of emerging of new sciences during the early modern period. The same term »new science«, used innumerable times by the early modern actors, was not at all rhetorically constructed, as it is often stated. It clearly denoted the awareness of the time that practical activities

and w~rkfl.ows were becoming increasingly and more intimately linked with

[16] Guidobaldo del Monte, *Guidiubaldi e' Marchionibus Montis Perspectivae libri sex*, Pesaro: Concordia 1600; Sabbattini (as note 15), p. 11. For an investigation concerned with the fundamental role played by Guidobaldo del Monte's Perspective in the creation of, first, a mathematical concept of illusory space and, second, the conditions to use such concept in the practice of theatrical machineries, see Livia Tirittico, »La nuova teoria prospettica nei ‚Perspectivae libri sex‚: II primato dell'architettura e della pittura nell'opera di Guidobaldo del Monte e in particolare nel, ›De scenis‹ «, in: *Guidobaldo del Monte (I545 - I607). Theory and Practice of the Mathematical Disciplines from Urbino to Europe*, ed. by Antonio Becchi, Domenico Bertoloni Meli, and Enrico Gamba, Berlin: Edition Open Access, 2013.

[17] Tkaczyk (as note 1), p. 80-90.

[18] Sabbattini (as note 15), p. 113-122.

and workflows were becoming increasingly and more intimately linked with theoretical knowledge.[19]
The case of the intermezzo and its ship, analyzed on the basis of the sources at disposal, can be used to explore how this approaching process between practical and theoretical knowledge took place. In particular, the sources can be analyzed according to the level of abstraction and, therefore, the form of codification they achieve and represent. The term ›codification‹ is used here to focus on the activity that allowed early modern professionals to reflect and codify both in textual and in graphic form their own activities.
First of all, there is the proper activity of Giulio Parigi, when he built the theatrical machinery of the intermezzo. He made use of his own practical knowledge. Although the result, that is, the final product of his work can be seen as the result of a codification process, this is not really how the term is used here. The final product is an external representation of Parigi's practical knowledge but was no intended to disseminate his knowledge. As external representation, it can. nevertheless be used to produce knowledge, for instance by another professional by means of reverse engineering.
Codification begins, when reflecting knowledge begins. Parigi had a workshop with pupils. The work in this workshop can be seen as the first level of codification of practical knowledge. One of the aims of the workshop was the education of a small number of people and the codification, in form of discussion or of notes, was meant as an integration to the most relevant part of the educational process, which is identified by the method of learning by doing. It is at this level that Furttenbach took his notes concerning the scenic ship as in the *Codex iconographicus 40I.* These notes represent the minimal necessary amount of information needed by an experienced professional to rebuild the same machine. Codification processes of practical knowledge are relevant for the formation of new sciences during the early modern period because codified knowledge became mobile and could, depending on the external circumstances, be acquired by other figures, who were not experts of the particular activity and discipline, but who, because of different interests, might have eventually connected this knowledge with other heterogenous aspects of knowledge. At the level of the notes of the *Codex iconographicus 40I*, however, this effect 1s hardly 1magmable. Notes could indeed circulate to a greater extent than the real artifact, and the

[19] The first among the most famous examples of early modern »new science« is Nicolo Tartaglia's attempt toward the foundation of mathematical ballistics. For a modern edition of translation of the entire *Nova Scientia* of Tartaglia, see Matteo Valleriani, *Metallurgy, Ballistics and Epistemic Instruments. The ›Nova Scientia‹ of Nicolò Tartaglia. A New Edition,* Berlin: Edition Open Access, 2013.

presence of the sketchbook preserved at the Library of Congress shows this very clearly. Nevertheless, such notes were not useful to non-experts in the field. Furttenbach's publication of 1663 is a completely different case. Here, it is not someone else, who integrated the regional workshop knowledge into a wider knowledge system by choosing a more abstract level of codification. It is the same Furttenbach, however at the end of his career as a consequence of his decision to write down the entire mechanical knowledge that he acquired during his life according to the principle of harmonious unity of the mechanical arts. The mechanics of the scenic ship is inserted in the broader frame of mechanics in general. This work is not only intended for professionals anymore but for educated people who wanted to reach a certain level of knowledge in mechanics according to the general cultural tendencies of the time. This work allowed an easy connection of mechanics to several further disciplinary areas, ranging from theoretical mechanics to expertise in contemporary theatre. This was a kind of work that contributed to the general increase of the level of the shared scientific knowledge in many social groups. Its readers could range from engineers and pharmacologists to courtly philosophers and tutors. The goal of this work was not constitutional concerning the science of mechanics. Its goal could rather be defined as didactical.

In the frame of mechanics, the early modern production of treatises could be taxonomically grouped into three different categories. The treatises with a constitutional aim in the mechanical science, which will be discussed below; treatises written by and for engineers only, like the so called machine theaters and the treatises written for didactical reasons. The machine theaters were collections of machine drawings accompanied by textual descriptions usually very short. Their aims was to describe combinations of simple machines so to allow all possible transformations of movement, such as, from a horizontal one, to a vertical or a circular. A famous example is the *Novo teatro di machine et edificii* by Vittorio Zonca, published in 1607.[20] Treatises with didactical purpose where somehow between the constitutional ones and the machine theatres. The late work of Furttenbach belongs to this category and before it, a well established tradition had already emerged especially associated to the activity of military engineering. The 16th century experienced a sensational evolution of this specific skill so to reach a level of codification of knowledge that tended to embrace all possible aspects of knowledge needed not only to build and maintain fortresses

[20] Vittorio Zonca, *Novo teatro di machine et edificii*, Padova: Bertelli, 1607. Another well known treatise of this sort is Agostino Ramelli, *Le diverse et artificiose machine del Capitano Agostino Ramelli dal Ponte Della Tresia Ingegniero del Christianissimo Re di Francia et di pollonia: nelle quali si contengono uarij et industriosi Mouimenti, degni digrandißima speculatione, per cauarne beneficio infinito in ogni sorte d'operatione*, Parigi: Autore 1588.

but also to rule them in phases of peace and phases of war. Therefore they also all contain chapters dedicated to mechanics and especially dedicated to machines, as these were needed in many frameworks related to fortresses: from its construction to the preparation of the artillery onto the wagons, everything was accomplished in a fortress by means of machines. The corresponding treatises, such as *Le fortificationi* of Bonaiuto Lorini, published in 1609[21], were therefore encyclopedic summae of mechanical knowledge that shaped the genre of these treatises. Furttenbach's work is a late appearance of a treatise that belongs to an already roo old tradition of texts. A constitutional role concerning the science of mechanics, finally, was exclusively played by the works of engineer-scientists, whose mathematical education was very advanced, linguistic skills broad enough to engage with Latin works, and possessed an education that let them enter the workshops, too. The foundational works in this example are therefore only those written by Guidobaldo del Monte. From this perspective, finally, Sabbattini's work can also be analyzed.

The readership of Sabbattini's work was more limited than Furttenbach's work from 1663. His readers were mathematically educated engineers who wanted to specialize in theatrical machinery or had to realize a project in that framework. This does not mean that the readers of Sabbattini's work would have been able to realize those machines without having acquired a solid experience in the field. Placing this work on a long term perspective, however, it emerges that this is a kind of work already belongs to a new generation and a new era. On the one side, the ideal readers were more specialized because of their mathematical education, on the other they were also more uniform because of the fact that they all had the same mathematical education and relied less and less on the artistic creativity and ingenuity of single professionals like Giulio Parigi. Sabbattini could already make use not only of his education and of his experience but also on many other works of didactical nature, like the 1663 work of Furttenbach, to summarize the discipline of theatrical machinery and subsume it onto the more gernal label of theoretical mechanics, that is, mathematics. Although Sabbattini`s project could not be completely successful at his time, it nevertheless is an early example of the creation of new science which then fully established itself at the turn of the following century.

[21] Buonaiuto Lorini, *Le Fortificazioni,* Venetia: Rampazetro, 1609.