Manoel Ferreira de Araújo Guimarães, the Royal Military Academy of Rio de Janeiro and the definition of a scientific genre in Brazil in the early 19th century[1]

Manoel Ferreira de Araújo Guimarães, a Academia Real Militar do Rio de Janeiro e a definição de um gênero científico no Brasil em inícios do século XIX

Luís Miguel Carolino*

Resumo

Na sequência da transferência da Corte portuguesa para o Rio de Janeiro, em 1807/1808, foi fundada a Academia Real Militar do Rio de Janeiro, em 1810, com o objetivo de formar a elite técnico-científica do Estado joanino. Orientada por tais objetivos educativos, essa escola superior de ensino técnico instituiu, no Brasil, um modelo de ciência e de ensino científico de matriz politécnica. A astronomia foi um exemplo dessa tendência. Num período em que a astronomia esférica se ia tornando crescentemente uma disciplina autônoma, Manoel Ferreira de Araújo Guimarães, professor de astronomia na Academia Real Militar do Rio de Janeiro, decidiu orientar o seu curso para esse ramo aplicado da astronomia e escreveu aquele que viria a tornar-se um dos primeiros manuais de astronomia esférica, um gênero maior da literatura científica do século XIX.

Palavras-chave: Academia Real Militar do Rio de Janeiro; Manoel Ferreira de Araújo Guimarães; astronomia.

Abstract

Following the transfer of the Portuguese court to Rio de Janeiro in 1807-8, the Royal Military Academy of Rio de Janeiro was created in 1810 to train the state's technical and scientific elite. Guided by its educational aims, this higher education technical school institutionalized a polytechnic model of science and science teaching in Brazil. Astronomy is a case in point. In a period when spherical astronomy was becoming an autonomous discipline, Manoel Ferreira de Araújo Guimarães, professor of astronomy at the Royal Military Academy of Rio de Janeiro, decided to orient his course to this applied branch of astronomy and authored what was to become one of the first textbooks on spherical astronomy, a major genre of scientific literature in the nineteenth century.

Keywords: Royal Military Academy of Rio de Janeiro; Manoel Ferreira de Araújo Guimarães; astronomy.

* Researcher, Centro InterUniversitário de História das Ciências e da Tecnologia, UL/UNL and Museu de Ciência da Universidade de Lisboa. Universidade de Lisboa – Faculdade de Ciências. Campo Grande – Edifício C5 – Lisboa – Portugal 1749-016. lm.carolino@gmail.com

On Wednesday, 18 May 1814, *Gazeta do Rio de Janeiro* announced that Royal Press (*Impressão Régia*) had just finished printing the book *Elementos de Astronomia para uso dos alumnos da Academia Real Militar*, by Manoel Ferreira de Araújo Guimarães (1777-1838), at that time sergeant of the Corps of Engineers, professor of the Military Academy of Rio de Janeiro, and editor of the newspaper renowned for its cultural and scientific dissemination *O Patriota*, as well as being responsible for the *Gazeta*.[2] Anyone looking through this manual, which the advertisement added could be found for sale in the *Gazeta do Rio de Janeiro* shop, could not but be surprised with the warning that the author had exceeded the bibliographic indications recommended in the *Carta de Lei* (charter) which created the Royal Military Academy.[3] According to this official document, the professor, who taught the fourth year of the course of 'exact sciences and observation' of the Royal Military Academy of Rio de Janeiro, also having taught spherical and optical trigonometry, was supposed to cover just astronomy, giving a precise indication of the books to be used. According to the *Charter dated* 4 December 1810,

> The professor... shall explain the system of the world; for which many will use the works of la Caille and la Lande, and the celestial mechanics of la Place; though not entering into his sublimes theories, because he will not have time for this: but showing the great results that he so eloquently exposed, and thus explaining all the methods to determine latitudes and longitudes at sea and on land; carrying out all observations with great regularity and showing all the applications convenient to geodesic measures, which once again will include all their breadth.[4]

In writing an astronomy manual which used as a foundation not the recommended works of theoretical astronomy by Pierre Simon Laplace, Joseph-Jérôme de Lalande and Nicolas-Louis de Lacaille, but rather a recently published set of books, such as those by Jean-Batiste Biot and Samuel Vince, Manoel Ferreira de Araújo Guimarães actively participated in the genesis of a new genre of technical and scientific literature, the manual of spherical astronomy. Being accepted as a genre of scientific literature implied that the community of men of science, professors and students, readers and editors, recognized in this genre a set of common and stable characteristics which allowed it to be identified without hesitation or a lack of unanimity.[5] As a genre of technical and scientific literature, the spherical astronomy manual developed during the first decades of the nineteenth century, reaching its apex with

the 1863 publication of the *Manual of Spherical and Practical Astronomy* by William Chauvenet.

By choosing this approach Guimarães, nonetheless, did not infringe the charter which had founded the Royal Military Academy of Rio Janeiro a few years previously. To the contrary, as can be concluded from the excerpt cited, he followed the intentions of the legislator, the Minister of War, d. Rodrigo de Sousa Coutinho (1755-1812) (See also, Biblioteca Nacional do Rio de Janeiro, Ms. I – 28, 32, 13, fl. 2). As had happened with its European contemporaries founded, in accordance with the French model, during the second half of the eighteenth century and the first decades of the nineteenth, the creation of the Royal Military Academy in Rio de Janeiro was intended to educate a technical and scientific elite who would serve as the basis for the development of the *Joanino* state in Brazil.[6] These skilled officers not only included those who guaranteed territorial defense and control, but also the engineers responsible for opening new roads, constructing new bridges and developing all types of infrastructure, in short, politically and economically integrating the vast territory of Brazil. In the education of these technical and scientific specialists the applied component of knowledge was determinant. Hence, in relation to astronomy, the explicit warnings of those who wrote the legislation for the Royal Military Academy not to enter into details about the sublime theories of celestial mechanics, but above all to emphasize its applications, especially in the determination of terrestrial coordinates.

Manoel Ferreira de Araújo Guimarães followed these indications and prepared a course, and later a manual, which most especially emphasized a branch of astronomy which was slowly emancipating itself and conquering space and prestige in nineteenth century academic communities and institutions. Accompanying the tendency for science to specialize in the nineteenth century, marked by the rising autonomization of scientific communities, institutions and disciplines, nineteenth century astronomy gradually divided between theoretical astronomy frequently designated as celestial mechanics in the sequence Pierre Simon Laplace's (1749-1827) foundational work *Traité de Mécanique Céleste*, and spherical astronomy.[7] In the final decades of the century, astrophysics was added to these two branches. Spherical astronomy was particularly taught in military academies and technical schools in Europe and the Americas. The foundation of these types of institutions reinforced the tendency towards disciplinary autonomization.

Manoel Ferreira de Araújo Guimarães and the Royal Academy of Rio de Janeiro were, thus, protagonists in this triple process of the development of a

system of scientific and technical teaching at the university level, disciplinary specialization and the emergence of a genre of scientific literature characteristic of the nineteenth century. Furthermore, this was in a phase that was obviously precocious in a process that indelibly marked a significant number of countries on the European and American continents.

Historiography has recognized the important role that the Royal Military Academy of Rio de Janeiro played in the establishment of the regular teaching of science and engineering at the university level in Brazil. As has already been highlighted, the establishment of this academy occurred in the context of the enlightened policies of Rodrigo de Sousa Coutinho involving the development of state structures in *Joanino* Brazil.[8] However, the contribution of the Academy to the process of disciplinary specialization has been largely ignored. In a relatively recent study it is even stated that "the [Royal Military] Academy, despite having people in its heart who made important contributions to science in Brazil at the time, did not provide a local scientific standard of development" (Oliveira, 2005, p.214). Not being part of academic in relation to the movement towards disciplinary autonomization characteristic of the nineteenth century, it is no wonder that the particularity which constitutes the *Elementos de Astronomia para uso dos alumnos da Academia Real Militar* in the process of affirming a genre of scientific literature has gone unnoticed by historians and historians of science in particular. Maria Beatriz Nizza da Silva has actually already drawn attention to the singularity of this astronomy manual, highlighting the discrepancy existing between the bibliographic recommendations of the academy's statutes and the choice of Manoel Ferreira de Araújo Guimarães to prepare a book based on new bibliographic references (Silva, 1999, p.65-66). However, historians of science continue to repeat the interpretation of Abraão de Morais, prepared in the 1950s, according to which "apart from the ordering of the material, there is nothing original" in *Elementos de Astronomia*.[9]

The explanation for the perpetuation of this interpretation of the somewhat frustrated role of the Royal Military Academy and Manoel de Araújo Guimarães' manual can, to a great extent, be found in the historiographic conception which has guided the historians of science who have studied the academy's initial years. Marked by a concept of the history of science which places the historical investigation of science within a narrative of the supposed linear progression of human rationality in the understanding of this nature, these historians have tended to valorize the role of particular individuals and institutions which, in relation to the proposing and defending of new theories, have been outstanding in the development of science. In its narrative, the

notion of 'centers' of production of scientific knowledge emerges as an evident category, leaving the other historic actors the role of mere receptors and passive translators of the scientific models and theories prepared in these centers. In this context, institutions such as the Rio Military Academy, and scientific activities such as the preparation of manuals, are seen as second line achievements which fulfill nothing other than utilitarian type intentions.

Resulting from a profound historiographic revision in which the category of science has gained new contours, and emerging as a practice and form of specific communication – as proposed by James Secord[10] –, the context of the teaching of science has received increased attention in the recent historiography of science. Historians such as Kathryn Olesko, for example, have demonstrated that there is a close relationship between the teaching of science and the definition of new disciplinary contours in the nineteenth century. Studying the emergence of an seminar of investigation in physics in the University of Königsberg in Prussia in the nineteenth century, Olesko demonstrates that in this institution aimed at the training of teachers and physicists a new conception of physics was affirmed, with the integration of the two previously distinct approaches, mathematics and experimental physics. This type of study also revealed that the division between research and teaching institutions could in some cases be clearly anachronistic.[11] In the context of teaching practices, manuals were prepared to transmit scientific theories and knowledge, but also modes of research. By doing this the scientific manuals of the nineteenth century played a decisive role in the establishment of content and scientific practices in the process of disciplinary autonomization.[12]

Research on the organization, functions and significance of the Royal Military Academy of Rio de Janeiro and the scientific practices carried out in this institution suggests, as I have sought to show in this article, that this institution actively participated, like its European contemporaries, in a process of disciplinary and institutional definition – and occasionally collaborated in the actual creation of scientific communities – which changed the face of nineteenth century science. This disciplinary specialization, which was concomitant with the affirmation of a model of teaching and cultivation of science, materialized in works such as Manoel Ferreira de Araújo's *Elementos de Astronomia*, a work belonging to the first generation of spherical astronomy manuals.

Under the patronage of d. Rodrigo de Sousa Coutinho – the beginnings of Manoel Ferreira de Araújo Guimarães' scientific career

D. Rodrigo de Sousa Coutinho was, as is well known, the central figure in the expansion, at the end of the eighteenth and the beginning of the nineteenth century, of a policy of development based on political economy and science and technology. Diogo Ramada Curto has drawn attention to a peculiarity in the modernizing policy of d. Rodrigo. While, on the one hand, he was an outstanding defender of the rationalization and modernization of the state apparatus, on the other hand, to implement these principles he resorted above all to his personal network of relations and clients and actually strengthened it.[13] Under the *Ancien Regime*, nomination to public positions was granted as a reward with which the sovereign distinguished some of his subjects. Among these positions were those which depended widely on technical knowledge and skill. Since the 1770s, during the rule of d. Maria, as shown by Ronald Raminelli in *Viagens ultramarinas: monarcas, vassalos e governo à distância*, the Portuguese state had converted itself into a patron of scientific knowledge, allowing the social ascension of the men of science involved in the understanding and administrating better the distant colonial possessions. As Minister and Secretary of State of the Navy and Overseas Possessions (1796-1801), president of the Royal Purse and Minister and Secretary of State of Finance (1801-1803) and later Minister of War and Foreign Affairs (1808-1812), d. Rodrigo had the opportunity to reinforce his clientelist network. Very close to d. João, he had the power to influence the monarch in nominations for public positions, especially for the institutions of technical and scientific teaching that he sponsored, collaborating in the promotion of the men of science who participated in his political and scientific project.

The dimension of the political patronage of d. Rodrigo is particularly known in the case of the naturalists. Figures such as José Bonifácio de Andrada e Silva, Manoel Ferreira da Câmara, and Joaquim Veloso de Miranda are frequently associated with Sousa Coutinho's project for discovering more about the natural resources of Brazil and metropolitan Portugal for the economic development of the Portuguese Empire. The support he gave Friar José Mariano da Conceição Veloso in relation to the editorial venture of Arco do Cego is also frequently cited.[14] However, the patronage of intellectuals with backgrounds in the mathematical sciences has received less attention, which to an extent is surprising since these sciences were instrumental for territorial

control and knowledge, a preeminent question in Portugal in the transition from the eighteenth to the nineteenth century.

Manoel Ferreira de Araújo Guimarães was one of the mathematicians, like other professors in the Royal Naval Academy, the Coastguard Academy and the Military Academy of Rio de Janeiro, whose scientific career was tightly linked at its beginning with the support and patronage of d. Rodrigo de Sousa Coutinho.

It was probably in 1799 when d. Rodrigo first received reports about Manoel Ferreira de Araújo Guimarães, a young student in the Royal Naval Academy, born in Bahia in 1777. According to the institution's statues, the best students from the Academy were granted a monetary prize. In 1799 in the information provided by the Academy's professors, nominated for the prize was the young Bahian Manoel de Araújo Guimarães. Once the decision was made, d. Rodrigo de Sousa Coutinho was responsible for sending the order to the Admiralty Council about the awarding of the prize (Arquivo Histórico da Marinha, Cxa. 5-2-8, ordem datada de 22 abr. 1799). It involved a promising student from the Royal Naval Academy whose mathematical and linguistic skills, associated with a very delicate economic situation (Arquivo Histórico da Marinha, Cxa. 5-2-8, Processo de Manoel Ferreira de Araújo Guimarães), made him a particularly favorable candidate to the scientific patronage of Rodrigo de Sousa Coutinho. While still a student of the Academy he had translated the *Elementos de Mathematica* by Abade Marie, for which a commission of professors from the Academy were unsparing in their praise.[15] At this time the then Minister of the Navy and the Overseas Dominions was particularly concerned with establishing the publishing company of Arco do Cego in Lisbon, which was concerned with promoting the translation and the publication of scientific works. Guimarães initially distinguished himself as a translator of mathematical works.[16]

Rodrigo de Sousa Coutinho would once again receive news about Manoel de Araújo Guimarães in June 1801. Guimarães had recently completed the mathematics course in the Royal Naval Academy.[17] That year, due to the need to appoint new professors to the Royal Naval Academy and the Coastguard Academy, Manoel Jacinto Nogueira da Gama, professor of the Royal Naval Academy wrote to d. Rodrigo de Sousa Coutinho with biographical information about possible professors to be appointed to the two naval academies. In relation to Manoel Ferreira de Araújo Guimarães, the enlightened minister was able to read that this candidate:

> had completed the course of mathematics in the Royal Naval Academy, constantly deserving particular contemplation, having received prizes every year and even an extraordinary prize which His Highness ordered to be given to him, an annual pension of 50$000: he is employed in the Royal Observatory of the Navy: in his first year as a pupil he translated the Elements of Mathematics by Abb. Maria which His Highness commanded to be printed and published: he translated the Elements of Algebra by Cousin, which is currently being printed: and is well advanced in the translation of Calculus by Cousin, which he was charged with by order of His Royal Majesty: he is very active and resourceful in his work: has shown himself to be a recommendable genius. His lack of a degree in Mathematics, from the University of Coimbra, should not exclude him from being a Professor in the academies, as it did not exclude Joze Maria Dantas Pereira, *Capitam de Mar e Guerra*, Commander of the Coastguard, and Euzebio Dias Azedo *Sargento Mor* (Sergeant-Major) of Engineering. (Arquivo Histórico da Marinha, Academia Real da Marinha – lentes coletivos, Cxa. 5-4, fl. 467)

Manoel Ferreira de Araújo Guimarães was nominated substitute professor of the Coastguard Academy, where he held the professorship of navigation, equivalent to being a professor for the second and third years. In August 1802 he embarked on the carrack *Princesa da Beira*, where he taught theoretical and practice astronomy (Arquivo Histórico da Marinha, Cxa. 5-2-8, Processo de Manoel Ferreira de Araújo Guimarães; Caixa 3-1, Academia Real da Marinha). According to Abraão de Morais, Araújo Guimarães returned to Brazil with the Conde da Ponte in 1805.[18] A few years later, following the transfer of the Coastguard Academy to Rio de Janeiro, accompanying the Portuguese court who had moved to the city in following the French invasions, Manoel de Araújo Guimarães reclaimed his place as professor of this academy.

Circumstances in Rio de Janeiro allowed Manoel de Araújo Guimarães to strengthen his relations of proximity and dependence on the minister of d. João. As we have seen, in 1810 the Military Academy of Rio de Janeiro was founded under the aegis of d. Rodrigo de Sousa Coutinho, at that time Minister of War and Foreign Affairs (see note 5). In February 1811, Araújo Guimarães moved to this academy. In a description of his work in the Academy, written a few months after the death of d. Rodrigo de Sousa Coutinho, Guimarães made an allusion to the period when he had worked as a dependent of d. Rodrigo. The astronomy professor stated:

> A worthy Minister, who dignified me with the name of friend, leaving in my

> heart an interminable longing, also leaving me with the need to discover how I satisfactorily fulfilled the obligations of my employment, and perhaps his own points of view.[19]

Patronage also justified Manoel de Araújo Guimarães' invoking of the memory of his protector in a poem entitled *Epidecio ao Illustríssimo e Excelentíssimo D. Rodrigo de Sousa Coutinho* (Rio de Janeiro: Impressão Régia, 1812), in which he not only praised the latter`s qualities as a statesman, but also as a man of knowledge: "Still in green years he exhausted / From Science the most sublime arcane / He amazed the Mondego with the talents / of the second Bernoulli" (p4).

The Military Academy of Rio de Janeiro and the definition of a model of science and scientific education

After joining the Royal Military Academy of Rio de Janeiro, Manoel de Araújo Guimarães' scientific activities were largely dependent on (poly)technical based model of science and teaching. According to Bruno Belhoste's proposal (2003, p.164), a model of teaching can be defined as the concrete synthesis of a body of reference knowledge (*savoirs de référence*), educational aims and pedagogical methods. A study oriented towards the analysis of these questions demonstrates that the Royal Military Academy of Rio de Janeiro, based on a tradition of university level technical education developed in the military context in the second half of the eighteenth century had a decisive role in the affirmation of a specific model of scientific teaching in Brazil. This model had direct reflections on the type of scientific and technical production in the period immediately before the independence of Brazil and probably also in the first half of the nineteenth century.

As is explicitly mentioned in the Charter which founded the Military Academy, this institution had the educational aim of providing scientific and technical education to future specialist agents of the state. This question was preeminent in the Portuguese Empire and in Brazil, in particular. The absence of the various types of infrastructures was a hindrance to the affirmation of political power, territorial control, and naturally economic development. As a result the formation of a corps of geographic, topographical and construction engineers was imperative. As stated in the preamble of the Charter of 4

December 1810, with the creation of the academy in Rio de Janeiro it was intended to establish

> a regular course of exact sciences and of observation, such as all those which are used in the military and practical studies which military science in all its difficult and interesting branches, in such a way that from these courses of study Officers of Artillery and Engineering will graduate, and even officers from the class of geographic and topographic engineers, who can have the useful employment of directing administrative objects in mines, roads, gates, canals, bridges, water sources and pavements.

The plan of studies for the Military Academy was organized in two cycles, corresponding to two distinct courses. The curriculum began with a four year cycle dedicated to the generic study of mathematical sciences and 'observation,' followed by a three year cycle of military sciences. This dual scheme had been rehearsed in Portugal in the eighteenth century with the link between the Royal Naval Academy founded in 1779, and the Royal Academy of Fortification, Artillery and Design, created in 1790. In the Royal Naval Academy the future engineers received a wide-ranging education in mathematical sciences, before entering the Royal Academy of Fortification, Artillery and Design to study fortifications, artillery and architecture.[20] A more consistent formulation of this teaching system occurred in France during the Revolution with the creation of the *École Polytechnique* in 1794. This was aimed at providing a general scientific preparation to candidates for specialized schools, the 'applied schools' (*écoles d'application*).

The initial cycle of studies was structured around the principle that mathematics was basilar for the study of other sciences and, above all, for applied sciences such as cartography and military disciplines. Mathematical disciplines emerged associated with other sciences, designated as 'sciences of observation.' This disciplinary organization led to the body of reference knowledge for the Royal Military Academy of Rio de Janeiro and was mirrored in the organization of the curriculum of this institution.

In a synthetic manner, the first year of study basically consisted of an introductory approach to the mathematical sciences; in the second year the content was studied in a more detailed way, and in the final years attention was given to the application of mathematics in other disciplines. In accordance with the initial statutes, in the first year of the Military Academy arithmetic was studied, the study of algebra was started, covering equations until the third

or fourth degree, and then geometry was moved onto, concluding with the study of trigonometry, including the study of basic notions of spherical trigonometry. In the second year, after the revision of contents related to calculus learned in the first year, the study of algebra was completed, especially in relation to equations, moving on to the applications of this discipline in the geometry of lines and curves. In this academic year differential and integral calculus was also studied, as well as their applications to physics, astronomy and differential calculus, with the study plan terminating with descriptive geometry. The third year of the scientific course of the Military Academy was occupied with the study of the principals of mechanics (statics and dynamics) and hydrodynamics (hydrostatics) and ballistics theory. The curriculum of the propedeutic course of the academy ended with a year dedicated to the study of spherical trigonometry and astronomy and their application to geodesics, notions of refractions and reflector, optic, catropric and dioptric instruments, topography and cartography, geography and physics (Carta de Lei, p.236-237).

Mathematics was thus the foundation of the body of reference knowledge of the Royal Military Academy of Rio de Janeiro. As the course progressed its applications in related areas were explored, such as astronomy and physical sciences. What was unprecedented in comparison with eighteenth century Portuguese military academies was the introduction in the second cycle of studies of the disciplines of chemistry, mineralogy and natural history (Carta de Lei, p.237).[21] D. Rodrigo de Sousa Coutinho, after assuming the position of the Navy and Overseas Dominions in 1796, sought to put into action a consistent policy of the exploitation of natural resources, not just in Brazil but also in Portugal. José Bonifácio de Andrada e Silva was associated with this policy. Once the academy had been established in a territory as prosperous and promising as Brazil, the introduction into the plan of studies of the disciplines of chemistry, mineralogy and natural history was an almost obvious decision. Certainly the presence of Carlo Antonio Napione (1756-1814) contributed to this. He was a Piedmontese specialist in mineralogy, chemistry, metallurgy and artillery who Rodrigo de Sousa Coutinho had attracted Portugal, where he arrived in August 1800. In Rio de Janeiro, where he had gone with the Court, Napione became a particularly influential figure, holding the presidency of the Royal Military Academy of Rio de Janeiro. He was also a member of the Council of Justice and was made an inspector of the Military Arsenal and was involved in the establishment of the gunpowder factory in Lagoa de Rodrigo de Freitas and the respective industrial complex which included, amongst

other institutions, two military factories, one of which was dedicated to the casting of bronzes.[22]

The objective of forming an elite of specialists and men of science in a little over six years who would be able to serve the state apparatus naturally had its impacts on the pedagogical methods used in the Rio academy. As in its European contemporaries, in this institution the choice of pedagogical methods was guided by the objective of consolidating a culture of precision and objectivity. An ethos based on cultivation of values such as objectivity was a structuring characteristic of the technical and scientific elite which advanced the modernization policy of nineteenth century states.[23] The uniformization of technical and scientific methods and procedures was, thus, a fundamental task of institutions such as the Royal Military Academy of Rio de Janeiro. This involved a standardization of the content of curricula, evaluation processes, and naturally methods and forms of teaching. One of the most efficient ways to achieve this uniformization was the preparation and publication of manuals. The emergence of this type of scientific literature was to a large extent concomitant with the emergence of linked systems of technical and scientific teaching at the end of the eighteenth century.

Probably inspired by the experience of the University of Coimbra reformed by Marquis Pombal in 1772, in the Military Academy the professors were charged with translating and writing manuals to support their teaching (Carta de Lei, p.234-237). In the Brazilian case the publication of this type of work was facilitated by the establishment in Rio de Janeiro of the *Impressão Régia* (Royal Print) in 1808. The direct support of the monarch – on the frontispiece of each work it was stated that it had been printed 'by order of HRM,' – meant that in the years that followed the foundation of the Academy, a significant set of manuals translated by professors were published. These works covered the subjects taught and were explicitly aimed at the students of the Military Academy. Despite the strong suspicion of Napoleonic France, the influence of French manuals was clear. Following the indications stipulated in the Academy statutes, professors published the translations of Legende's geometry and trigonometry manuals; Lacroix's manuals of arithmetic, algebra, the application of geometry and differential calculus; as well as a translation of Euler's algebra manual, Abade Haüy's physics manual, Francoeur's mechanics, and Lacaille's optics manual.[24] Manoel de Araújo Guimarães was one of the most active translators in the Military Academy, fulfilling the expectations d. Rodrigo de Sousa Coutinho had of him.

The publication of these manuals uniformized the content which the Academy was supposed to teach and determined some of the educational practices of the institution. However, its influence on the paradigm of science and the linkage between the sciences was much greater. The publication policy, strongly subsidizing the plan of studies of a military technical academy, had an underlying concept of science in which mathematics and applied sciences strongly figured. The Military Academy of Rio de Janeiro thus established a very concrete model of science and scientific development. Let us look at the case of astronomy.

The definition of an area and scientific genre: the *Elementos de Astronomia*

When Manoel Ferreira de Araújo Guimarães wrote in Rio de Janeiro his *Elementos de Astronomia para uso dos alumnos da Academia Real Militar*, one of the questions which most mobilized the community of astronomers was the correct determination of the movement of celestial bodies based on the application of Isaac Newton's theory of universal gravitation. Years later, for example, in a book published in London in 1834, it was recognized that "we are still far from having a sufficient knowledge of the movement of both the sun and the stars."[25] Nevertheless, Pierre Simon Laplace (1749-1827), in his work *Traité de Mécanique Céleste* published in five volumes (Paris, 1799-1825), had already given an essential contribution to the study of the question through new techniques for the calculation of the perturbations of the trajectories of celestial bodies. The influence of French astronomy and mathematics was so fundamental that at the beginning of the nineteenth century, celestial mechanics was synonymous with theoretical astronomy. As Araújo Guimarães summarized, after Laplace "astronomy came to be a great problem of mechanics" (Guimarães, 1814, p.52-53).

During the nineteenth century, alongside this branch of astronomy astronomers came to distinguish another autonomous branch of this science, which they called spherical astronomy.[26] As Manoel de Araújo Guimarães himself explained,

> The doctrine of spheres consists in determining the times of the rising and setting of all celestial bodies and finding their position at any given time relative to the horizon or meridian, or the time that has elapsed since these positions; the

> causes of the different lengths of day and night, and the change of seasons. (Guimarães, 1814, p.7)

While theoretical astronomy focused on the movement of celestial bodies, spherical astronomy sought to determine the position and the *directions* of stars based on observation at a temporally specific moment and a concrete space on earth. These observations allowed the rigorous determination of the geographic coordinates of observation points on earth, and for this reason they were vital in dominion of cartography, nautical science and territorial control in general.

This applied component explains Guimarães' choice to orient his course, and consequently his manual, to spherical astronomy. He thereby eschewed the theoretical astronomy works of Laplace, Lalande and Lacaille recommended in the statutes of the Royal Military Academy of Rio de Janeiro. In doing this, he composed the first manual of spherical astronomy in Portuguese (and the first book of astronomy printed in Brazil), but also one of the first works in this new technical and scientific genre.

Even though the preparation of works for didactic purposes goes back to earlier period, only in the nineteenth century, with the generalization of scientific and technical teaching in Europe and the Americas,[27]did teaching manuals emerge as an autonomous genre of technical and scientific literature, in other words, as a type of scientific literature with its own set of common and stable characteristics which allowed its identification by the community of authors, producers and consumers. Not only did men of science and professors from scientific areas start to include the writing of this type of work among their activities, but there also emerged a public avid for these books, mostly consisting of students from universities and technical schools created during the nineteenth century, but also the technical staff of industry and the state apparatus.[28] Being the object of increased demand, the emergence of this type of literary genre was strengthened by the appearance of publishers of scientific manuals.

This process of the affirmation of manuals as a genre of technical and scientific literature did not just occur in astronomy, rather it was common to the various exact and natural sciences. As was the case of spherical astronomy, the emergence of this genre of literature was concomitant with the process of autonomization of scientific disciplines and the definition of the scientific communities and institutions characteristic of the nineteenth century (Cahan, 2003). In the case of Chemistry, for example, which is the most studied, the appearance

of a 'manual' industry was decisive not only in the introduction of new ideas of chemistry in countries such as Portugal, Spain and Greece, but also in the establishment of the actual scientific nomenclature. The appearance of these manuals frequently coincided with the implementation of reforms which sought to modernize university level scientific teaching. An example of this was the publication of the *Elementos de Chimica* by Vicente Coelho Seabra, a work produced in the context of the Pombaline reform of the University of Coimbra, which marked the emergence of modern chemistry in Portugal.[29] In some cases the development of this genre of technical and scientific literature emerged in an intimate relationship with the genesis of scientific communities.

In the case of spherical astronomy, the relationship between the emergence of this type of technical and scientific literature, reforms of technical and scientific teaching, and the formation of local scientific communities is obvious. In fact the need to educate specialists with skill in the area of astronomy demanded a standard study manual which could clearly present the content and the basic practices of this science. Spherical astronomy was thus confirmed as a specific disciplinary area, with the principal genre being the publication of school manuals, being correlated to the institutionalization of technical and scientific systems of education. The French case is a good example. During the French Revolution a national system of technical secondary schools was created, the *écoles centrales*, while astronomy was included on the school curriculum. Given the lack of a study manual, Jean-Baptiste Biot (1774-1862), professor of the College de France and the first student of the *École Polytechnique* to become a member of the Academy of Sciences (Belhoste, 2003, p.89), was charged with writing an astronomy manual, producing a treatise in four volumes which become famous, *Traité Élémentaire d'Astronomie Physique* (Paris, Chez Bernard, 1805. See v.I, p.viii). It was not technically a manual of spherical astronomy. The first volume introduced the student to the basics of astronomy, focusing on topics dear to spherical astronomy such as the observation of the movement of celestial bodies, the figure of the earth, refraction and the calculus of the parallax of celestial bodies. However, the following volumes were concerned with more theoretical themes, with the second volume focusing on the theory of the Sun; the third the volume and theory of the Moon; and the fourth the theory of the planets, their satellites and comets. However, in systematizing the content of astronomy for pedagogical purposes (especially in the first volume) and having achieved notable success in the nineteenth century, it became a very important work in the establishment of this genre of technical and scientific literature.

Another basic manual for spherical astronomy was *The Elements of Astronomy designed for the use of students in the University* (Cambridge, 1801) by Samuel Vince, "Plumian Professor of Astronomy and Experimental Philosophy" at the University of Cambridge. This manual was much closer to the model of what a spherical astronomy manual would become in the nineteenth century. It began with an outline of the definitions used in astronomy, moving on to the determination of celestial coordinates, parallax, refraction, the world system, celestial movements and related aspects, ending with a method of determining longitude on Earth. However, it lacked one topic that would be essential in spherical astronomy manuals, the discussion of the operation and function of astronomical instruments.

Manoel Ferreira de Araújo Guimarães shared with Biot and Vince the necessity to write a manual to be used in astronomy classes. Naturally this function limited the dimensions of *Os Elementos de Astronomia para uso dos alumnos da Academia Real Militar* and imposed a more didactic form of organization. The text, provided with the necessary tables and mathematical formulae, occupied a little more than two hundred pages (219 to be exact), and was complemented by two appendices (with ten and twenty pages respectively), and a set of technical notes which ran for two dozen pages. The work ended with a set of 62 figures and diagrams which supported the main content and to which the text constantly referred.

In deciding to write this foundational work, using for this the Library of the Coastguard Academy, Guimarães had at his disposition a good set of updated astronomical works.[30] The treatises of Biot and Vince, as he acknowledged, were inspirations for him.[31] Like the professors from Paris Cambridge, Araújo Guimarães began the central text of his manual outlining astronomical terms and concepts, including the systems of celestial coordinates, to which was added an introduction to the movement of stars and a description of the figure of the Earth and its consequences in the area of geodesics. This is in the area of spherical astronomy. The analysis of the body of the work corroborates this scientific affiliation. In fact, while the general organization of the book is somewhat conventional, the author chose to formally group the themes into 'Celestial bodies' (book II), 'Planetary movements' (book III) and 'Eclipses' (book IV), a detailed analysis of the content of the work demonstrates that it is not a manual of celestial mechanics. Although the part dedicated to celestial bodies included a brief description of the world system, naturally advocating the heliocentric system (p.46-50), and another part of the work, which was relatively short, in which the theory of the movement of celestial bodies was

discussed (p.149-195), the *Elementos de Astronomia* focused above all on questions of spherical astronomy such as the calculation of parallax and refraction, the application of the apparent movement of the sun to calculate sidereal and solar time, while also resorting to astronomical observations and the consultation of star 'tables' and ephemerides, the prevision of eclipses of the moon and the sun, and theoretical questions with a direct impact on astronomical practice, such as the description of the effects of the precession of equinoxes and Kepler's theory of the orbital ecliptics of celestial bodies. Araújo Guimarães' manual also included a description of the principles and functioning of reflection instruments (p.125-140) and practical exercises to determine the latitude and longitude of concrete points on the Earth's surface (p.221-252). This work was followed by *Elementos de Geodesia para uso dos discipulos da Academia Real Militar desta Corte* (Rio de Janeiro, Impressão Régia, 1815), also written by Manoel de Araújo Guimarães. *Elementos de Astronomia para uso dos alumnos da Academia Real Militar* only had one edition.

Elementos de Astronomia is basically a work of spherical astronomy. However, to what extent is it an original work? We have seen that the historiography of the traditional sciences did not recognize the originality of the *Elementos*, seeing it as a compilation of books by third parties. Being structurally intended for application and basically developed in technical teaching contexts, the originality of a spherical astronomy manual resided largely in the selection of topics covered and, above all, in the discussion. As a result, as happened with Manoel de Araújo Guimarães and his *Elementos de Astronomia*, the authors of nineteenth century spherical astronomy manuals frequently stated that the methods, content and solutions given in their works were taken from other authors. For example, this was the case of George C. Comstock, director of the Washburn Astronomical Observatory in the United States, who in his *Studies in spherical and practical astronomy* acknowledged that the methods he discussed were from other authors.[32] In the choice of these methods, as was recognized not only by the astronomer from Bahia, but also by Dascom Greene, professor of mathematics and astronomy in the Rensselaer Polytechnic Institute, adaptation to the concrete needs of studies beginning in the study of spherical astronomy was vital.[33]

The originality of a work of this nature results to a large extent from the experience of the professor and his capacity to select the topics and methods to be presented. Or, if we want to present the question in other terms, the analysis of the originality of a manual like the *Elementos de Astronomia* involves evaluating whether it translates a specific evaluation of a theoretical

body and reflects a particular practice. Analyzed from this point of view, it cannot be denied that the work of Manoel de Araújo Guimarães is far from being a translation and adaptation of foreign manuals, as has been shown above.

Elementos de Astronomia reflects the practice of Manoel de Araújo Guimarães as an astronomer and professor of nautical astronomy in the Royal Naval Academy in Lisbon, and professor of astronomy and geodesics in Rio de Janeiro. This work was, above all, written from the perspective of an observer based in the Southern Hemisphere – and not the northern, to the contrary of, for example, the manuals of Vince and Biot (see, for example, Guimarães, 1914, p.4 e 247). Moreover, Guimarães appears to have also adapted some of the practices to local conditions. For example in his geodesics manual which complements the *Elementos de Astronomia*, in his presentation of the first steps of primary triangulation, specifically the measurement of the bases of the primary triangle, he mentions that the bases of the triangle have been marked with rods of class, pine, iron and platinum. However, Guimarães recommends that pine rods be used, with care being taken to "boil them for a long period in a gross material and cover them with a thick layer of paint and oil." This care would result in the obtaining of stakes that were insensitive to variation in humidity – and thus particularly useful in a tropical climate – and, consequentially, as reliable as those of metal, but much lighter (Guimarães, 1914, p.81-82).

The teaching and scientific of Araújo Guimarães was also shown in the presentation of the astronomical content. By way of example, let us look at the presentation of the processes of the calculation of terrestrial longitude based on astronomical observations, a central topic in spherical astronomy. At the time, the most used processes were based on the observation of occultations, transits, and also eclipses of the satellite of Jupiter; in the observations of lunar distances, the 'altitudes' of the moon, or the occultation of stars by the moon; in the observation of solar or lunar eclipses; and also in the use of portable chronometers – timekeepers. Of these processes, those which involved the observation of the satellites of Jupiter, even though this was quite reliable on *terra firma*, could not be used satisfactorily at sea, since constant undulations prevented the effective use of a wide-ranging instrument for this type of observation. The lack of eclipses also served to remove this resource from the men of the sea.[34]

Guimarães recognized that when compared with the calculation of latitude longitude is more difficult to determine. In practice, he states "all methods

are reduced to finding the difference in the times between the two meridians" (Guimarães, 1814, p.232). In fact, taking into account that the Earth revolved 360 degrees per day and that 15 degrees thereby correspond to an hour, if the time between the moment what a star passes the reference meridian is compared with the moment with the same star passes another meridian, the difference in time is converted into angular distance and the astronomical longitude of the second meridian is obtained. In relation to the methods proposed by Araújo Guimarães, in the part of his manual dedicated to the calculation of longitude, in addition to referring to the process of obtaining longitude or time difference from 'marine clocks,' he identifies as astronomical processes the observation of the satellites of Jupiter, solar eclipses, occultations of the stars by the Moon and the lunar distance method (Guimarães, 1814, p.233-252). However, after describing these processes, and identifying their vantages and disadvantages, Guimarães is only concerned with presenting the lunar distances method, in his opinion "a method as easy as rapid." "They [the distances of the Moon and Sun or to the stars] are found in the Tables, and knowing the time at which a given distance occurs in a place, the difference between this time, and what is stated at the meridian in the Tables, gives the difference in longitude" (ibid., p.234). A set of problems for students to practice and the professor clarifies his method.

Different reasons can justify the fact that, in his manual, Araújo Guimarães privileges the lunar distance method. He identifies the simplicity, speed and reliability of this method in comparison with the other methods. However, certainly the decisive reason can be found in the familiarity of the author with this method. Before joining the Military Academy, Manoel Araújo Guimarães taught mathematics and astronomy to future members of the navy (and the merchant navy) in the Royal Naval Academy and the Coastguard Academy. In this context the methods of determining longitude on the open sea which he presented was certainly based on lunar distances.

Manoel Araújo Guimarães' practice as a professor and astronomer is thus reflected in his manual. An example of this is the content related to instruments. To measure the angular distances between the Moon and the stars, the basis of the method he adopted to discover longitudes, Guimarães would have to resort, above all, to instruments such as sextants, octants and circulars. We know that these instruments existed in the Royal Naval Observatory in Lisbon, where Guimarães trained.[35] There can be no doubt that he dominated this type of instrument, since when he embarked in August 1802 on the carrack *Princesa da Beira* as a professor, he brought with him for classes and exams two octants,

a sextant, a quintant and two circulars, as well as an azimuthal needle, a needle for marking, two glasses, a timekeeper and two nautical barometers (Arquivo Histórico da Marinha, *Companhia dos Guardas Marinhas e sua Real Academia*, Cxa. 116-1, doc. 99). Unsurprisingly in his *Elementos de Astronomia*, he describes with great detail the instruments he best knows and which were indispensible to the star based localization method he adopted, in other words, reflection instruments such as the octant and the sextant (Guimarães, 1814, p.125-141).

Manoel de Araújo Guimarães' *Elementos de Astronomia*, thus, reflect an original synthesis of the contents of spherical astronomy. The manual is one of the first works in this genre of scientific literature, which underwent great development during the nineteenth century. In the 1860s the spherical astronomy manual reached its modular form with the publication of *A Manual of Spherical and Practical Astronomy* (Philadelphia, 1863) by William Chauvenet (1820-1870). This book is divided into two volumes, with the first being dedicated to the theoretical content of spherical astronomy and the second to the theory and use of astronomical instruments. In relation to the content of this discipline, Chauvenet's book reflects the stabilization of the contents of spherical astronomy. Since the middle of the nineteenth century this branch of astronomy had been concerned with the following content: coordinates (spherical and rectangular) of the celestial sphere; the figure and dimensions of Earth; calculation of solar and sidereal time with resort to star catalogues, ephemerides and interpolations; observation and 'reduction' of the results of the center of the Earth, calculating variables such as parallax and refraction; calculation of time in any place based on astronomical observations; calculation of latitude and longitude through astronomical observations; study of astronomical phenomena such as eclipses, the transits of Venus and Mercury, precession, nutation, aberration and the annual parallax of fixed stars.[36]

Like Manoel Ferreira de Araújo, William Chauvenet was also a professor of a technical and military academy. Before joining the recently founded University of Washington in 1859, Chauvenet was linked to the foundation of the United States Naval Academy, located in Annapolis, where he was a professor.[37] Like the *Elementos de Astronomia*, the *Manual of Spherical and Practical Astronomy* reflects the experience of its author as an astronomer and professor of astronomy.

Final Considerations

With the foundation in 1810 of the Military Academy of Rio de Janeiro, a *polytechnique* based system of scientific teaching was established in Brazil. As in other European and American states, the creation of this type of system of teaching resulted to a great extent from the need to train technical and scientific personnel who would allow the economic development and political consolidation of the state. In the case of the Royal Military Academy of Rio de Janeiro, this institution emerged in close connection with the enlightened policy of the Minister of War, Rodrigo de Sousa Coutinho. Based on the enlightened principle that the state was reserved a central role in the creation of infrastructure which would allow the scientific development of society, the priority aim of the Royal Military Academy of Rio de Janeiro was the formation of a technical and scientific elite to lead the development of the *Joanino* state in the tropics.

Underlying this system of technical teaching was a connection between the sciences and a model of specific scientific development. In the hierarchy of sciences, mathematics stood out, seen as a discipline whose study was propedeutic for the other sciences and instrumental in the education of officers and engineers. The mathematical disciplines occupied a central place in the curricula of the academy in Rio de Janeiro. The aim of the formation of a technocracy also implied that the applied dimension of the other sciences would be valorized, such as, for example, astronomy. In his preparation of the astronomy course in the Military Academy of Rio de Janeiro, Manoel Ferreira de Araújo Guimarães gave clear priority to an area of this science which was at the beginning of a complex process of disciplinary specialization, spherical astronomy. This choice led him to prepare an original manual which contained some of the central characteristics of spherical astronomy manuals, a genre of technical and scientific literature which became consolidated in the middle of the nineteenth century.

The case study of Manoel Ferreira Guimarães and the Royal Military Academy of Rio de Janeiro demonstrates not only the concomitance between the consolidation of systems of technical and scientific education at a national scale, growing disciplinary specialization among the sciences during the nineteenth century and the affirmation of manuals as a genre of determinant scientific literature in the period, but also how this association occurred in Rio de Janeiro in a phase that was obviously precocious in a process which indelibly marked a significant number of countries on the European and American

continents. Far from being an institution which passively received and copied the foreign example, the Military Academy of Rio de Janeiro had a leading role in the process that created a system of technical teaching and disciplinary specialization characteristic of the nineteenth century.

NOTES

[1] The author would like to thank *Fundação para a Ciência e Tecnologia* (Portugal) for the support provided to this study (project HC/0084/2009).

[2] In relation to the activities of Manoel Ferreira de Araújo Guimarães as editor of *O Patriota*, see KURY, Lorelai (Org.). *Iluminismo e Império no Brasil – O Patriota (1813-1814)*. Rio de Janeiro: Ed. Fiocruz, 2007; KURY, L. A ciência útil em *O Patriota* (Rio de Janeiro, 1813-1814). *Revista Brasileira de História da Ciência*, v.4, p.115-124, 2011; and in relation to *Gazeta do Rio de Janeiro*, see, amongst others, SILVA, Maria Beatriz Nizza da. *A Gazeta do Rio de Janeiro (1808-1822)*: cultura e sociedade. Rio de Janeiro: Ed. Uerj, 2007; and MEIRELLES, Juliana Gesuelli. *Imprensa e poder na corte joanina*: a *Gazeta do Rio de Janeiro* (1808-1821). Rio de Janeiro: Arquivo Nacional, 2008.

[3] GUIMARÃES, Manoel Ferreira de Araújo. *Elementos de Astronomia para uso dos alumnos da Academia Real Militar.* Rio de Janeiro: Impressão Régia, 1814. n.p.

[4] Carta de Lei de 4 dez. 1810. In: *Collecção das Leis do Brazil de 1810*. Rio de Janeiro: Imprensa Nacional, 1891. p.236.

[5] BERTOMEU-SANCHEZ, José Ramón; GARCÍA BELMAR, Antonio; LUNDGREN, Anders; PATINIOTIS, Manolis. Introduction: Scientific and technological textbooks in the European periphery. *Science and Education*. Special issue: *Textbooks in the scientific periphery*, v.15, 2006. p.662.

[6] In relation to the connection between the foundation of technical military schools in Europe in the eighteenth and nineteenth centuries and the development of technical specialists for the state, see, amongst others: ARTZ, Frederick B. *The development of technical education in France, 1500-1850*. Cambridge (Mass); London: The MIT Press, 1966; TATON, René (Org.). *Enseignement et diffusion des sciences en France au XVIIIe siècle*. Paris: Hermann, 1986; GREEN, Andy. *Education and State formation*: the rise of educational systems in England, France and the USA. Houndmills & London: The Macmillan Press, 1990; BRET, Patrice. *L'État, l'armée, la science*: l'invention de la recherche publique en France (1763-1830). Rennes: Presses Universitaires de Rennes, 2002; BELHOSTE, Bruno. *La formation d'une technocratie*: l'École Polytecnique et ses élèves de la Révolution au Second Empire. Paris: Belin, 2003; CAROLINO, Luís Miguel. Measuring the heavens to rule the territory: Filipe Folque, the teaching of astronomy at the Lisbon Polytechnic School and the modernization of the State apparatus in nineteenth century Portugal. *Science & Education*, v.21, n.1, p.109-133, 2012.

[7] The process of the autonomization and specialization of sciences during the nineteenth century was studied in detail by CAHAN, David (Org.). *From Natural Philosophy to the Sciences*: writing the History of nineteenth-century science. Chicago & London: The University of Chicago Press, 2003.

[8] The influence of Rodrigo de Sousa Coutinho has been recognized in the historiography about the signing of the Charter on 4 Dec. 1810. See, for example: BARATA, Mário. *Escola Politécnica do Largo de São Francisco*: berço da engenharia brasileira. Rio de Janeiro: Associação dos Antigos Alunos da Politécnica, 1973. p.17 and 46; TELLES, Pedro Carlos da Silva. *História da Engenharia no Brasil*: séculos XVI a XIX. 2.ed. rev. e ampliada. Rio de Janeiro: Clavero, 1994. p.83, 89ss; OLIVEIRA. *D. João VI adorador do Deus das Ciências?* A constituição da cultura científica no Brasil (1808-1821). Rio de Janeiro: e-papers, 2005. p.159. A very detailed study of the first years of the Military Academy of Rio de Janeiro can be found in PONDÉ, Francisco de Paula e Azevedo. A Academia Real Militar. *Anais do Congresso de História da Independência do Brasil*. Rio de Janeiro: Instituto Histórico e Geográfico Brasileiro / Departamento de Imprensa Nacional, 1975. v.6, p.37-85. In addition to the bibliography cited, see: SILVA. *A cultura luso-brasileira*: da reforma da Universidade à independência do Brasil. Lisboa: Ed. Estampa, 1999. p.62-68; and SARAIVA, Luís. The beginnings of the Royal Military Academy of Rio de Janeiro. *Revista Brasileira de História da Matemática*, v.7, fasc. 13, p.19-41, 2007.

[9] MORAIS, Abraão de. A Astronomia no Brasil. In: AZEVEDO, Fernando de (Org.). *As Ciências no Brasil*. 2.ed. v.1. Rio de Janeiro: Ed. UFRJ, 1994. p.128. Abraão de Morais' position, published for the first time in 1955 can be found, for example, in OLIVEIRA, 2005, p.182.

[10] SECORD, James A. Knowledge in transit. *Isis*, v.95, p.654-672, 2004. See also: TOPHAM, Jonathan R. Rethinking the History of Science Popularization/Popular Science. In: PAPANELOPOULOU, Faidra; NIETO-GALAN, Agustí; PERDIGUERO, Enrique (Org.). *Popularizing Science and Technology in the European Periphery, 1800-2000*. Farnham: Ashgate, 2009. p.1-20.

[11] OLESKO, Katheryn M. *Physics as a calling*: discipline and practice in the Königsberg Seminar for physics. Ithaca: Cornell University Press, 1991. A similar theoretical proposal can be found in WARWICK, Andrew. *Masters of theory*: Cambridge and the rise of Mathematical Physics. Chicago & London: The University of Chicago Press, 2003; KAISER, David (Org.). *Pedagogy and the Practice of Science*: historical and contemporary perspectives. Cambridge (Mass) & London: The MIT Press, 2005.

[12] See, for example: BERTOMEU-SANCHEZ et al., 2006, p.657-665; GARCIA-BELMAR, Antonio; BERTOMEU-SÁNCHEZ, José Ramón; BENSAUDE-VINCENT, Bernadette. The power of didactic writings: French chemistry textbooks of the nineteenth century. In: KAISER (Org.), 2005, p.219-251. An innovative study about a spherical astronomy manual in the nineteenth century can be found in HEIZER, Alda. O tratado, o astrônomo e o instrumento. *Revista Brasileira de História da Ciência*, v.1, n.2, p.167-177, 2008.

[13] CURTO, Diogo Ramada. D. Rodrigo de Sousa Coutinho e a Casa Literária do Arco do

Cego. In: CAMPOS, Fernanda Maria Guedes de et al. (Org.). *A Casa Literária do Arco do Cego (1799-1801)*. Lisboa: Imprensa Nacional-Casa da Moeda, 1999. p.32-33.

[14] SIMON, William Joel. *Scientific expeditions in the Portuguese overseas territories (1783-1808) and the role of Lisbon in the intellectual-scientific community of the late eighteenth century*. Lisboa: Instituto de Investigação Científica Tropical, 1983; DOMINGUES, Ângela. *Viagens de exploração geográfica na Amazónia em finais do século XVIII*: política, ciência e aventura. Lisboa: Região Autónoma da Madeira/ Secretaria Regional de Turismo, Cultura e Emigração/ Centro de Estudos de História do Atlântico, 1991; NUNES, Maria de Fátima; BRIGOLA, João Carlos. José Mariano da Conceição Veloso (1742-1811): um frade no universo da natureza. In: CAMPOS (Org.), 1999, p.51-75; PATACA. Ermelinda. *Terra, água e ar nas viagens científicas portuguesas (1755-1808)*. Doctoral Dissertation – Universidade Estadual de Campinas. Campinas (SP), 2006; RAMINELLI, Ronald. *Viagens ultramarinas*: monarcas, vassalos e governo à distância. São Paulo: Alameda, 2008.

[15] However, they believed the first version needed a scientific revision. AHM, Academia Real da Marinha, Cx. 3-1, fls. 174-174v. This work is *Curso elementar e completo de mathematicas puras, ordenado por La Caille, e augmentado por Marie, illustrado por Cheveneau,e traduzido do francez ... por Manoel Ferreira de Araújo.* Lisboa: na Officina Patriarcal de João Procopio Correa da Silva, 1800. According to a report from the *Jornal de Coimbra*, Araújo Guimarães also translated at this time *Explicação da formação e uso das taboas logarithmicas e trigonométricas do Abbade Marie. Traduzida por Manoel Ferreira de Araújo Guimarães. Jornal de Coimbra*, n.12, dez. 1812. Lisboa: Impressão Régia. p.424.

[16] A list of the translations done by Guimarães can be found in: ALMEIDA, Palmira Morais Rocha de. *Dicionário de Autores no Brasil Colonial*. Lisboa: Colibri, 2003. p.218-219.

[17] In the draft certificate of the completion of the second year the content of what had been studied that year was given. This included advanced algebra superior, its application to arithmetic and geometry, studies of conical sections, fluxions, the general principals of mechanics and their application to statics, dynamics, hydrostatics, hydrodynamics, as well as the construction and maneuvering of ships. Arquivo Histórico do Museu de Ciência da Universidade, Cxa. 1846, f.n.n.

[18] MORAIS, 1994, p.127. In the Navy Historical Archive (Cxa. 5-2-8) there is an undated request from Guimarães to be given the position of clerk of "entrance and departure" from customs in Bahia. It is not certain that there is a relationship between this request and his move to Brazil in 1805.

[19] Biblioteca Nacional do Rio de Janeiro, Ms. I – 28, 32, 13, fl. 1. A copy of this document can be found in *Instituto Histórico e Geográfico Brasileiro*, DL 58, 26.

[20] Before the foundation of the Royal Academy of Fortification, Artillery and Design, students of the Royal Naval Academy, once they had passed mathematics, had to attend the so-called 'Engineering Class.' However, as Maria Paula Diogo and Ana Cardoso de Matos have shown, this class never worked properly. See DIOGO, Maria Paula; MATOS, Ana Cardoso de. Aprender a ser ingeniero: la enseñanza de la ingeniería en el Portugal de los

siglos XVIII y XIX. In: LAFUENTE, Antonio; MATOS, Ana Cardoso de; SARAIVA, Tiago (Org.). *Maquinismo ibérico*. Madrid: Ed. Doce Calles, 2007. p.123-145.

[21] In relation to the significance of the Military Academy of Rio de Janeiro in the context of military institutions for technical and scientific education at the end of the eighteenth century and the beginning of the nineteenth, see: CAROLINO, Luís Miguel. The making of an academic tradition: the foundation of the Lisbon Polytechnic School and the development of higher technical education in Portugal (1779-1837). *Paedagogica Historica: International Journal of the History of Education*, v.48, 2012, in print. Available at: www.tandfonline.com/doi/pdf/10.1080/00309230.2011.628322.

[22] A detailed description of the activities of Carlo Napione no Rio de Janeiro before the death of D. Rodrigo can be found in BURDET, Carlo A. M. *Carlo Antonio Napione (1756-1814)*: artigliere e scienziato in Europa e in Brasile, un ritratto. Torino: Celid, 2005. v.2, p.693-751.

[23] Historians have emphasized the importance of the affirmation of a culture of precision and objectivity from the end of the eighteenth and during the nineteenth century in the formation processes of nation states in Europe and the Americas. See, for example: WISE, M. Norton (Org.). *The values of precision*. Princeton (NJ): Princeton University Press, 1995.

[24] *Elementos de Geometria por A. M. Le Gendre traduzidos do francez…* , trad. Manoel Ferreira de Araújo Guimarães (Rio de Janeiro: na Impressão Régia, 1809); *Tratado de Trigonometria por A. M. Legendre* (Rio de Janeiro: na Impressão Régia, 1809). According to Camargo and Moraes this treatise was also probably translated by Araújo Guimarães (CAMARGO, Ana Maria de Almeida, MORAES, Rubens Borba de. *Bibliografia da Impressão Régia do Rio de Janeiro (1808-1822)*. São Paulo: Edusp; Kosmos, 1993. p.37. Lacroix, *Tratado Elementar d'Arithmetica,* trad. Francisco Cordeiro da Silva Torres (Rio de Janeiro: na Impressão Régia, 1810); *Elementos d'Algebra por Mr. La Croix*, trad. Francisco Cordeiro da Silva Torres (Rio de Janeiro: na Impressão Régia, 1811); *Tratado Elementar de Applicação da Algebra á Geometria por Lacroix traduzido do francez…*, trad. José Victorino dos Santos e Souza (Rio de Janeiro: na Impressão Régia, 1812); *Tratado Elementar de Calculo Differencial, e Calculo Integral por Mr. Lacroix*, trad. Francisco Cordeiro da Silva Torres (Rio de Janeiro: na Impressão Régia, 1812); *Compêndio dos Elementos d'Algebra de Lacroix* (Rio de Janeiro: na Impressão Régia, 1813); *Elementos d'Algebra de Leonardo Euler* (Rio de Janeiro: na Impressão Régia, 1811); *Tratado Elementar de Physica pelo Abbade Haüy*, 2v. (Rio de Janeiro: na Impressão Régia, 1810); *Tratado Elementar de Mechanica por Mr. Francoeur*, 4v., trad. José Saturnino da Costa Pereira (Rio de Janeiro: na Impressão Régia, 1812); *Tratado de Optica por La Caille traduzido sobre a nova edição de 1802* (Rio de Janeiro: na Impressão Régia, 1813). This book was probably translated by Pinto (CAMARGO; MORAES, 1993, p.129).

[25] "We are still however far from a sufficient knowledge of the motions either of the sun or stars." *Natural philosophy. Vol. 3: Astronomy. History of astronomy. Mathematical geography.*

Physical geography and navigation. Unabridged facsimile of the 1834 edition by Baldwin and Cradock, Elibron classics, 2006, p.11.

[26] These two branches of astronomy were joined in the 1870s by an area whose emergence and affirmation would change astronomy at the end of the nineteenth century and during the twentieth century, astrophysics. The division of the different dominions of nineteenth century of astronomy can be found, for example, in: BRÜNNOW, Franz. *Spherical astronomy*. London: Asher & co., 1865, p.70; CHAUVENET, William. *A manual of spherical and practical astronomy*. Philadelphia: JB Lippincott Co., 1863. v.I, p.17-18; NEWCOMB, Simon; HOLDEN, Edward S. *Astronomy for high schools and colleges*. 6.ed. rev. New York: Henry Holt & Co., 1889. p.2-3.

[27] BENSAUDE-VINCENT, Bernadette; GARCIA-BELMAR, Antonio; BERTOMEU-SÁNCHEZ, José Ramón. *L'émergence d'une science des manuels*: les livres de chimie en France (1789-1852). Paris: Éd. des Archives Contemporaines, 2003.

[28] LUNDGREN, A. The transfer of chemical knowledge: the case of chemical technology and its textbooks. *Science & Education*, v.15, p.761-778, 2006.

[29] CARNEIRO, Ana; DIOGO, Maria Paula; SIMÕES, Ana. Communicating the new chemistry in 18th-century Portugal. *Science & Education*, v.15, p.671-692, 2006. More case studies in the area of chemistry can be found in: BENSAUDE-VINCENT et al., 2003; BERTOMEU-SÁNCHEZ, José Ramón; GARCIA-BELMAR, Antonio. Pedro Gutiérrez Bueno's textbooks: audiences, teaching practices and chemical revolution. *Science & Education*, v.15, p.693-712, 2006; SELIGARDI, Raffaella. A comparison between two university textbooks in the Bolognese context at the beginning of the 19th century. *Science & Education*, v.15, p.713-737, 2006.

[30] The Coastguard Academy Library included works by authors such as Cassini, Lalande, Lacaille, Delambre, Laplace and Vince. However, apparently it did not have Biot's book, explicitly cited by Guimarães. Cf. "Catalogo da Bibliotheca da Academia dos Guardas Marinhas creada por ordem de S.A.R. na cidade do Rio de Janeiro", Biblioteca Nacional do Rio de Janeiro, Ms. 7, 4, 92, p.10. The first edition of *Traité* de Biot contains the information that book was for sale in Paul Martin's bookshop in Lisbon.

[31] "The Law for this purpose [explaining the system of the world] points to the works of Lacaille, Lallande, and Laplace. Reflecting seriously on the spirit of this Law and combining when possible the applications of Engineering with the Statutes of the University of Coimbra L. 3, P. 2, T. 4, C. 4, I found that that there was nothing better than combining Biot's Astronomical Physics (Paris, 1805) with Vince's *Elementos d'Astronomia* for the use of the students of the University of Cambridge (Cambridge, 1801) choosing from these authors what seemed to me to be most fundamental, adding the results of Delambre and Laplace, and the work of Mackay on longitudes (Aberdeen, 1801), as well as the *Elementos de Navegação* by Bouguer, Bezout, and Rios, extracting the easiest methods, and not discarding Maskelyne's explanation of Requisite Tables (London, 1802), nor the *Ephemerides de Coimbra* by Jozé Monteiro da Rocha", Biblioteca Nacional do Rio de Janeiro, Ms. I – 28, 32, 13, fls. 1-2.

[32] *Bulletin of the University of Wisconsin*, v.1, n.3, 1895. p.57.

[33] *An introduction to Spherical and Practical Astronomy*. Boston: Ginn & Co., 1892. p.iii-iv.

[34] In relation to the history of the methods of calculating longitude and the problems associated with them, see: ANDREWES, William J. H. (Org.). *The quest for longitude*. Cambridge: Collection of Historical Scientific Instruments, 1996. See also, by way of introduction: SOBEL, Dava; ANDREWES, William J. H. *The Illustrated Longitude*. London: Fourth Estate Limited, 1998.

[35] In fact, in March 1801 the Royal Naval Observatory received a set of instruments, including Troughton's circular, Ramsden's circular, two acromatic glasses with a focal distance of three and a half feet, Borda's circular, three sextants, an artificial mercury horizon, a theodolite and a pendulum owned by J. Bullock. REIS, António Estácio dos. *Observatório Real da Marinha, 1798-1874*. Lisboa: CTT Correios de Portugal, 2009. p.35.

[36] CHAUVENET, 1863, v.I; FOLQUE, Filipe. *Elementos d'astronomia coordenados para uso dos alumnus da Eschola* Polytechnica. Lisboa: Litografia da Escola Politécnica, 1840; BRÜNNOW, 1865; MAIN, Robert. *Practical and spherical astronomy.* Cambridge: Deighton, Bell and Co., 1863; LIAIS, Emmanuel. *Traité d'astronomie appliquée a la Géographie et a la Navigation.* Paris: Garnier Frères, 1867; NORTON, William. *Astronomy, Spherical and Physical, with astronomical problems and Solar, Lunar, an other astronomical tables*. 4.ed., revised and expanded. New York: John Wiley & Sons, 1872; COMSTOCK, George C. *A text-book of field astronomy for Engineers*. New York: John Wiley & Sons, 1901; NEWCOMB, Simon. *A Compendium of Spherical Astronomy*. New York: MacMillan, 1906.

[37] MATZ, F. P. Biography: William Chauvenet. *The American Mathematical Monthly*, v.2, n.2, p.33-37, 1895.

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