



Modern science in Portugal: the 'sphere lesson' in Colégio de Santo Antão

Natália Cristina de Oliveira*, Célio Juvenal Costa and Sezinando Luís Menezes

Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá, Paraná, Brasil. *Autor para correspondência. E-mail: natdeoliveira@gmail.com

ABSTRACT. With the arrival of the Society of Jesus to Portugal in 1540, Jesuit schools were created by the Crown. The College of St. Antão, in Lisbon, was the first Jesuit educational institution, created in 1553. We propose a discussion of the main objectives, characteristics and difficulties of the Jesuit religious order in the Portuguese territory, as well as a presentation of one of the most important classes of this College: the 'Class of the Sphere'. The priests considered fundamental to teach issues related to mathematics and astronomy, because, through these disciplines, they addressed the theory and practice of items and concepts, such as the telescope, logarithms, equations, geometry and others. The curriculum of this college included, in addition to science and mathematics, subjects such as: Latin, Grammar, Humanities, Rhetoric, and Introduction to Moral Theology, Dogmatic Theology and Philosophy, considered only to teaching in the Portuguese context. Studying the College of St. Antão helps us to understand how these innovations were considered in teaching, in the Jesuit case, in the temporal context of Portugal in the 16th century. We understand that the College, mainly by innovations, was essential to the development of science.

Keywords: Society of Jesus, history of science, jesuit science, 16th-century Portugal.

Ciência moderna em Portugal: a 'aula da esfera' no colégio de Santo Antão

RESUMO. Com a chegada da Companhia de Jesus a Portugal, em 1540, passam a ser criados pela Coroa os colégios jesuítas. O Colégio de Santo Antão, em Lisboa, foi a primeira instituição educacional dos jesuítas, criado em 1553. Propomos uma discussão dos principais objetivos, das características e das dificuldades da ordem religiosa jesuítica no território português, bem como uma apresentação de uma das aulas mais importantes desse Colégio: a 'Aula da Esfera'. Os padres consideravam fundamental o ensino naquele Colégio de questões relacionadas à matemática e à astronomia, pois, por meio dessas disciplinas, abordavam a teoria e a prática de itens e de conceitos, como o telescópio, os logaritmos, as equações, a geometria, entre outras. As grades curriculares desse centro de ensino incluíam, além das Ciências e Matemática, disciplinas como: Latim, Gramática, Humanidades, Retórica e introduções à Teologia Moral, à Teologia Dogmática e à Filosofia, consideradas únicas ao ensino no contexto português. Estudar o Colégio de Santo Antão ajuda-nos também a compreender como eram consideradas essas inovações no ensino, no caso jesuítico, na conjuntura temporal de Portugal no século XVI. Entendemos que o Colégio, principalmente pelas inovações, foi essencial para o desenvolvimento da ciência portuguesa.

Palavras-chave: Companhia de Jesus, história da ciência, ciência jesuítica, Portugal do século XVI.

Ciencia moderna en Portugal: 'aula da esfera' en el colegio de Santo Antão

RESUMEN. Con la llegada de la Compañía de Jesús a Portugal, en 1540, pasan a ser creados, por la Corona, los colegios jesuítas. El Colegio de Santo Antão, en Lisboa, fue la primera institución educacional de los jesuitas, creado en 1553. Proponemos una discusión de los principales objetivos, de las características y de las dificultades de la orden religiosa jesuítica en el territorio portugués, así como una presentación de una de las clases más importantes de este Colegio: 'Aula da Esfera'. Los padres consideraban fundamental la enseñanza, en aquel Colegio, de cuestiones relacionadas a las matemáticas y a la astronomía, pues, por medio de estas asignaturas, trataban de la teoría y la práctica de ítems y de conceptos, como el telescopio, los logaritmos, las ecuaciones, la geometría, entre otras. Los programas escolares de este centro de enseñanza incluían, además de las Ciencias y Matemáticas, asignaturas como: Latín, Gramática, Humanidades, Retórica e introducciones a la Teología Moral, la Teología Dogmática y la Filosofía, consideradas únicas a la enseñanza en el contexto portugués. Estudiar el Colegio de Santo Antão nos ayuda también a comprender cómo eran consideradas esas innovaciones en la enseñanza, en el caso jesuítico, en la coyuntura temporal de Portugal en el siglo XVI. Entendemos que el Colegio, principalmente por las

innovaciones, fue esencial para el desarrollo de la ciencia portuguesa.

Palabras clave: Compañía de Jesús, historia de la ciencia, ciencia jesuítica, Portugal del siglo XVI.

Introduction

In this article, we analyze the insertion of the mathematical sciences in the curriculum of Colégio de Santo Antão, the first Jesuit public education center in Portugal. The genesis of the implantation of these classes was promoted by D. Henrique, brother of King João III (1521-1557) and later reinforced and supported by Philip I of Portugal (1580-1598), in continuity of construction of the School of Santo Antão-o-Novo.

There are affirmations, on the part of the scholars of this theme, that the classes on modern science in the School of Santo Antão existed since its implantation; however, it was only in 1590, and later with the Ratio Studiorum of 1599, that the regular course of mathematics was instituted and regularized; Its permanence occurred until the expulsion of the Jesuits of Portugal, by Marquês de Pombal, in 1759.

The main frame of the math course was the 'Classroom of the Sphere'. And to discuss the role and importance of this class in the College of Santo Antão, we must first present what is meant by science in the sixteenth and seventeenth centuries.

Throughout the twentieth century, in the historiographical studies, an approach that dealt with the emergence of modern science as a 'Scientific Revolution' prevailed. The use of the concept of 'revolution' for the analysis of the new knowledge about nature produced from the sixteenth century implies viewing the studies of Nicholas Copernicus, Galileo Galilei, Bacon and Isaac Newton, among others, as a break with existing knowledge until and that remained only in the chief exponents of the Church. Thus, historiography established an opposition between the prior knowledge and the new knowledge of the Renaissance.

Current studies have sought to show that the production of the modern sciences was not a linear process, it involved advances and retreats, and the rupture with the knowledge emanating from the sages of Christianity did not actually take place in that period (Menezes, 2015).

On one hand, thinkers such as Galileo Galilei and Isaac Newton have resorted greatly to the observation of natural phenomena as to the study of the sacred texts of the Church, and, on the other hand, the Church has not been completely averse to new knowledge produced from empirical observation; On the contrary, at various times it stimulated it and, in this sense, the Company of

Jesus stood out (Menezes, 2015).

Studies on the Roman College and on the dissemination of modern science by the Jesuits in the East have already demonstrated in an incisive way the importance of the Jesuits in the production and diffusion of this knowledge (Leitão, 2007).

The insertion of mathematical innovations in the curriculum of the schools administered by this religious order, starting with Santo Antão, propelled the scientific advances in all the places that covered the Portuguese Patronage.

Although the priests, up to then, have had as the main line of their courses the humanistic content, science has had an essential participation in its institutions. The scientific disciplines consisted mainly of mathematical teachings that delineated geometric, physical, astronomical, and astrological questions. When these analyzes are done, we do not exempt the Society of Jesus from interests, even for mercantile purposes, for including modern science in its schools was a valuable instrument for spreading the Catholic faith, since it would attract more interested in their studies and still make Investment by the Crown.

The priests, wherever they went, by the association that made teaching with their improvements, were able to raise funds from Christians who took over much of the maintenance of the colleges, especially by entrusting them with the education of young members of the Society with the immediate return of having there also the Education of their children (O'Malley, 2004).

Between the middle of the sixteenth and seventeenth centuries, this institution was responsible for all the training of science technicians in the Lusitanian kingdom. Although with great loss due to the burning of the documents of the school, with the expulsion of the Company of Jesus, documents were left that, prove such affirmation, as notes of classes, manuscripts, printed texts, among others, that aid in the development of researches.

Some conceptions about science in the sixteenth century

Since the 'Class of the Sphere' is considered a scientific subject, we see the need to work out some questions about this concept. In his study of Jesuit education and science in the sixteenth century, Storer Di Piero (2008) states that with Ratio Studiorum, scientific and mathematical studies in Jesuit colleges were valued. With them, the teaching

of physics, mathematics, Elements of Euclid, geography and 'sphere' were regulated. In this context,

The science considered modern, seems from the same assumption of the Greek *episteme* - there would be an order in the universe that could be apprehended by the man. However, if for the Greek philosopher the apprehension of reality would be mediated by the contemplation of this reality, for the modern scientist beyond contemplation there will be theorization, explanatory modeling, experimentation and, above all, action and transformation of nature (Storer Di Piero, 2008, 29)¹.

Storer Di Piero (2008) also warns that modern science was not only limited to theorizing, but went beyond these assumptions and advanced to practice, to the transformation of what was studied. The author believes that modern science was constructed both by theoretical science and by the practical tradition, whether it was the artisan or the artist who developed it.

In re-dimensioning the view of some thinkers about such a definition, Koyré (apud Oliveira, 1997) states that, in the rebirth, science and technique were kept in a spaced, distant way; The technique consisted in practice, science invested in philosophical, abstract and isolated knowledge of manual labor. Saraiva (2000) reinforces this definition when he positions himself, affirming that, in the sixteenth century, technical (practical) advances did not result in scientific (theoretical) advances.

Contrary to these definitions, Oliveira (1997) considers that science is a junction of technique and experimental doing. In this same vein, Garin (1992) reports that the science presented today (the author refers to the twentieth century) is very different four centuries ago. Science, in the sixteenth century was sometimes associated with magic, was shrouded in mysteries and associated with the devilish, sinful; Yet from the 'Five Hundred' it became a daily necessity.

The scientific innovations that were transforming modern Portuguese society followed the path of experimentation and, according to Paiva (2006, p.6), "Man desires to be freed from the prevailing theological vision and, while believing In God, it distinguishes itself from it, affirming itself

capable and autonomous (Humanism)"². It was in this context that the Society of Jesus, with its colleges, held the dialogues between faith and science. The beginning of teaching took place in the Roman College³, where philosophy, science and theology were taught with equal importance.

Because the Society of Jesus is a religious order and does not have scientific teaching, let alone the diffusion of science, as the focus of its works, it is wrong to conclude that it did not contribute to the emergence of modern science. The Jesuits defended philosophical-theological questions as a principle of teaching and fought against the dissemination of certain scientific works (see the censorship of books put into Jesuit documents). However, those priests were not bound either to Aristotle or to scientific knowledge; they created their own vision at that juncture.

Leitão (2007) affirms that some researchers do not consider the participation of priests and teachers of the 'Class of the Sphere' in modern science considerably and question the quality of these classes. However, we corroborate with the same author when he states that these scholars:

[...] should reflect a little more [...], there are no criticisms at the scientific level of Santo Antão by other Portuguese personalities or institutions [...], neither the Cosmographer's Classroom nor the University of Coimbra, That is, neither cosmographers nor university professors criticized the teaching of the Sphere Classroom (Leitão, 2007, page 43, emphasis added)⁴.

Thus, in the sixteenth century, priests saw the possibility of working science along with faith, for, according to Manso (2005), the Society of Jesus is the fruit of the period in which it lived and, as it promoted scientific advancement, maintain its orthodox Catholic Christian tradition. In a century in which the contents of university curricula and colleges were linked to philosophy and theology, the Jesuits developed technical teachings, not just theoretical ones, but Also practical; the lessons were put on paper and disseminated through the lessons.

¹ In the original: A ciência considerada moderna, parece partir do mesmo pressuposto da *episteme* grega - haveria uma ordem no universo que poderia ser apreendida pelo homem. Contudo, se para o filósofo grego a apreensão da realidade seria mediada pela contemplação dessa realidade, para o cientista moderno além de contemplação vai haver teorização, modelagem explicativa, experimentação e, mais que tudo, ação e transformação da natureza (Storer Di Piero, 2008, p. 2).

² In the original: Paiva (2006, p. 6), "[...] O Homem se quer liberto da visão teológica antes dominante e, embora crendo em Deus, dele se distingue, afirmando-se capaz e autônomo (Humanismo)".

³ Ignatius de Loyola wished that he was a model in Jesuit studies, such as the Characteristics of Education of the Society of Jesus (1987), it is clearly stated that the Roman College was the most outstanding of all Jesuit institutions. In time, he later became a university: Gregorian University; So much so that, in the first elaboration of what would become the future Ratio, Loyola requests that the "Rules of the Roman College" be described principally in that document, since it should be taken as a model.

⁴ In the original: [...] deveriam reflectir um pouco mais [...], não se conhecem críticas ao nível científico de Santo Antão por outras personalidades ou instituições portuguesas [...], nem a Aula de Cosmógrafo, nem a Universidade de Coimbra, isto é, nem cosmógrafos nem professores universitários criticaram o ensino da 'Aula da Esfera' (Leitão, 2007, p. 43, grifo do autor).

According to Leitão (2004), in his study on the scientific book in the fifteenth and sixteenth⁵ centuries, a study sponsored by the National Library of Portugal (BN) in 2004, the period of launching of scientific activities in Europe, Scientific Revolution 'in the Modern Age coincided with the culture of the printed text in Western societies, and with this, scientific contents and works referring to mathematics, astronomy and even astrology were valued.

The mathematical sciences in Santo Antão: on the 'Class of the Sphere'

The 'Class of the Sphere' is considered the main class developed in the School of Santo de Antão, especially after the construction of Santo Antão-o-Novo. It has this name, most likely, and, according to scholars such as Henrique Leitão and Luís de Albuquerque⁶, by the Sphere Treaty, by João de Sacrobosco, elaborated in the thirteenth century, but with influence throughout Europe until the eighteenth century. Due to the works and manuscripts left by teachers of that school, we believe that the name of the classes resulted from this document.

This lesson was fundamental to the innovations and scientific innovations of Portugal in the modern era. Its beginning, in such College, was what guaranteed the entrance of instruments of studies like, for example, the telescope and its construction. Through the 'Sphere Class', the College of Santo Antão, as a pre-university⁷ teaching center, was responsible for the modernization and institutionalization of astronomy, creating the first observatory of Portugal in the 18th century; In addition, it maintained a very close dialogue with the debates of the Academy of Clávio, of the Roman College.

Until the 1570s had only hints of mathematics classes in the Jesuit schools, and yet only by the Jesuit students of those institutions. Later, at the request of D. Henrique, it was that the 'Classes of the Sphere' had its applicability. In Portuguese territory, they were initiated in 1593, in the College

of Santo Antão-o-Novo, and were until 1759, with the expulsion of the Jesuits.

The 'Sphere Classroom' was, for many decades, the most important Portuguese nautical teaching institution and all the techniques associated with navigation. He was also one of the most important institutions of teaching of architecture and military engineering, of perspective and scenography (Leitão, 2007, page 22, emphasis added)⁸.

One of the factors that we believe to have reinforced the maintenance of these classes in the institution was the formation of the Cosmographer-mor. Pedro Nunes occupied this position in the Crown, being officially named in 1547 like representative of the kingdom. In order to be able to practice this profession, it was required, in the regiment of the Cosmographer of 1592, that the candidate had mastery over the 'Mathematical Lessons', as an obligation for someone to take that position.

Therefore, the fact described can explain the demand of the high nobility for enrollments in the College of Santo Antão, since the noble population, with the teachings of that school of education, could serve the king in navigations overseas: "[...] the chief cosmographer, by a clause recorded in the regiment, was already bound to read to pilots, cartographers, nautical instrument makers, and seamen" (Albuquerque, 1972, p. 9)⁹.

As we looked at some of the early CVs of the School of Santo Antão, we noticed that he was very close to the demands made in the regiment of the Cosmographer. Luís de Albuquerque (1972) reports that the classes dedicated to the art of sailing, by Father Francisco Costa, were very similar to what he was charged for the position.

For Albuquerque (1972), with the manuscripts and documents of that period, it is clear that the 'Class of the Sphere' was not elaborated with many practical instruments. Most of the reports show that it had a theoretical and descriptive nature, so much so that there are letters from parents¹⁰ requesting materials for the proper development of this activity.

It should be noted that, according to the curricula, it is possible to observe that the discussions of the 'Sphere Class' and the other disciplines of Santo Antão, in their philosophical and

⁵ Professor Henrique Leitão presents in this work a study of the circulation of printed books in the fifteenth and sixteenth centuries. It is based on the collection of books found in the National Library of Lisbon. It considers to be a representative sample of the scientific literature of Portugal in those centuries. As an appendix to the book, is the catalog, with more than 300 pages, containing lists of everything available on the physical-mathematical sciences and their applications.

⁶ Luís de Albuquerque was responsible for two editions of materials, works and manuscripts left by Father Francisco da Costa (a respected intellectual and one of the main teachers of the 'Sphere Classroom'). Albuquerque's goal was to address subjects about cosmography classes and related subjects taught at the Colégio de Santo Antão.

⁷ We have by reference, in the sixteenth century, pre-university education a form of teaching that was given in the college, in the case of Santo Antão, which preceded the entrance to the Universities. In the case of the institution in question, in addition to mathematics and physics classes, students also learned to learn a variety of languages, not only from Latin or Portuguese (Oliveira, 2015).

⁸ In the original: A 'Aula da Esfera' foi, durante muitas décadas, a mais importante instituição portuguesa de ensino de náutica e todas as técnicas associadas à navegação. Foi também uma das mais importantes instituições de ensino de arquitetura e engenharia militar, de perspectiva e cenografia (Leitão, 2007, p. 22, grifo do autor).

⁹ In the original: "[...] o cosmógrafo-mor, por cláusula registrada no regimento, já então era decerto obrigado a ler aos pilotos, cartógrafos, construtores de instrumentos náuticos e homens do mar" (Albuquerque, 1972, p. 09).

¹⁰ Fr. João König (or João dos Reis), a Jesuit who goes to Portugal in the second half of the seventeenth century to teach and occupy a chair of mathematics at the University of Coimbra, writes that he should send materials such as: earth globes, glasses, compasses Etc., as it aimed to teach with practical classes (Albuquerque, 1972).

theological aspects, were intertwined with the events that occurred at that moment in the Lusitanian Crown, or, to controversial subjects that happened in Europe. Besides that, it showed the opinion of the Society of Jesus regarding the themes.

We did not find, through documents or authors' books that refer to this subject, how to prove the bureaucratic and preparatory procedures that led these classes to function in the College. However, it is possible to suppose how they would have happened when the Jesuits were prepared to attend to the interests of the Crown, specifically those of D. Henrique.

[...] the Jesuits will have sought a suitable teacher, selected among his most competent, and taking care that he acquired an advanced mathematical training, a formation that could not be obtained at the time in the country. We do not know exactly what happened, but it is known that the name of João Delgado [...] does not appear in the Portuguese catalogs between 1576 and 1585 (Leitão, 2007, 46).¹¹

In the catalogs, we can see that later, in the year 1586, there are already accounts of João Delgado as a professor of mathematics, although for small groups of Jesuit students. This may explain why he may have been in Rome at the Academy of Clavus to better prepare and teach mathematics later in Portuguese colleges. Finally, in the year 1590, we have documents of the teacher in full exercise, in the 'Classrooms of the Sphere' in the College of Santo Antão.

The Portuguese Jesuit João Delgado is considered the founder of mathematical studies in Portugal. According to Carolino (2006), mathematicians resorted to that priest's demonstrations to carry out his research and his work. In the Santo Antão class, Father Delgado focused his discussions on proving that mathematics also proceeded by its own 'true' causes and 'principles', as well as other sciences (Carolino, 2006). In this way, he contributed to the discussions of that century, principally by considering the core issues of the philosophy of mathematics and maintaining a close link with the innovations coming from the Roman College.

Leitão (2007) states that the possible reason that the 'Sphere Classroom' took so long to be accomplished and started in the College was due to the need for time for the formation of a specific Jesuit or the transition between one institution and

another, Change of the College of Santo Antão (Coleginho or Little Scholl) to the Colégio de Santo Antão-o-Novo.

With the mathematics classes at Jesuit College, the Crown had new perspectives and expectations regarding science. Thus, in 1592, there was a project to map and perform the geography of the Portuguese territory. So,

[...] made the General of the Jesuits, Claudio Acquaviva, to send the famous Christopher Clávio to Lisbon to head this great enterprise. [...] until the mid-seventeenth century, scientific and mathematical subjects were taught at the College of Santo Antão with a special emphasis on issues related to nautical and cosmography, which was undoubtedly determined by the needs of the country and Not only to fulfill in detail the pedagogical demands of the Order itself (Leitão, 2007, 47)¹².

As we said before, the College of St. Antão was public, that is, open to all interested in its classes, and not only to those who wanted to pursue a church career. One of the main proofs about the participation of lay students in scientific classes at the College of Santo Antão is the annotations in Portuguese and not only in Latin, as were done by the students who wanted to be part of the order. This is what we consider a modern differential in the College of Santo Antão, that is, the public diffusion of knowledge to those who did not intend, for example, to become Jesuits.

Regarding teachers, Rodrigues (1917) clarifies that the Jesuits were not alien to the study of mathematics and science, but rather valued the practice of these questions, especially in Coimbra, Évora, Lisbon and China.

In the researches carried out by scholars of this subject, information that the pre-university teaching center of Santo Antão also considered it essential to learn a variety of languages, not only Latin or Portuguese. In addition to the philosophical-astronomical teachings, each student was given classes, specifically, of the territory to which the Padroado de misamões Portuguese would send him (Leitão, 2007).

The 'Sphere Class' had, above all, a pioneering character in Portuguese territory, whose themes dealing with mathematics, observatory astronomy, Astronomy, theoretical, nautical, cosmography, calendar theory, hydraulics, optics, static, nautical

¹¹ In the original: [...] os jesuítas terão procurado um professor idôneo, seleccionado entre os seus um dos mais competentes, e cuidando em que adquirisse uma formação matemática avançada, formação essa que não se conseguiria obter na altura no país. Não sabemos exactamente o que sucedeu, mas sabe-se que o nome de João Delgado [...] não aparece nos catálogos portugueses entre 1576 e 1585 [...] (Leitão, 2007, p. 46).

¹² In the original: [...] fizeram ao Geral dos jesuítas, Claudio Acquaviva, para que enviasse para Lisboa o famoso Cristóvão Clávio a fim de chefiar esse grandioso empreendimento. [...] até meados do século XVII, as matérias científicas e matemáticas foram ensinadas no Colégio de Santo Antão com uma tónica especial nas questões relacionadas com a náutica e a cosmografia, o que, sem dúvida, era determinado pelas necessidades do país e não apenas para cumprir detalhadamente as exigências pedagógicas da própria Ordem (Leitão, 2007, p. 47).

subjects, and many other subjects, we understand that the institution of Santo Antão, through that class, opened the door to modern science, In the so-called 'Scientific Revolution'. This class at the Colégio de Santo Antão was

[...] the gateway to Portugal of many scientific novelties, from the use of logarithms to the use of Mercator projection, through the construction of scientific instruments, by the first known texts of theoretical static, etc. It was still the first site, and for many decades only, in which the scientific statute of mathematics was proclaimed in a way that could be called modern [8-10]. And it also was the place where Galileo, the telescope and the cosmological debate spread in our country (Leitão, 2010, p.20)¹³.

Mathematics classes, as we have already mentioned, were not considered important only for the Lisbon College, but also for the whole conquest of the Portuguese patronage. A missionary from the Company of Jesus on the missions in China, for example, presented the experiments carried out with telescopes as well as an image of Saturn, seen by Galileo, a subject that gave credibility to the Chinese to trust their fathers. Then, we understand that Santo Antão was the first European institution where students had contact with the construction of telescopes and prepared them for the dissemination of these ideas (Leitão, 2010).

Astronomy, present in the 'Classroom of the Sphere' and taught by Portuguese teachers and foreigners, as we shall see below, has made Lisbon the scene of great circulation of intellectuals and scientists. The departure of the Jesus Company to the Far East, especially China, caused many mathematicians and astronomers to pass through Portugal to carry on and carry out the missions. These priests brought not only knowledge but also works, instruments of analysis, books, scientific subjects, and unveiled polemics about the 'Astronomical Revolution'.

Some másters of the 'Sphere Classroom' and their contributions

João Delgado, according to Leitão (2007) and Rodrigues (1917), was one of the first teachers of this class and did not leave a specific work about this transition or its beginning. What is in the Portuguese archives and others are reports in the

student notebooks and in the works of other priests who affirmed about such information. With notes from Professor Delgado, we can say that:

[...] as well as an introduction to cosmography, taught astronomy much more than merely introductory. He devoted careful attention to topics of theoretical astronomy, in what was called then "theoretician of the planets". [...] like other teachers of the Sphere Classroom, also devoted some time to the study of Astrology (Leitão, 2007, p. 47)¹⁴.

As we have already said, we do not know for sure whether the delay in the systematization of the classes had to do with the construction of the new building or the formation of what one needed to have through one of its members of the religious order. But we suppose that, in view of his preparation, Joao Delgado took care of the formation of Father Francisco da Costa, who replaced him (Rodrigues, 1917).

In the years in which no reports of Professor Joao Delgado are found, there are those of Professor Francisco Costa (1567-1604) who, in turn, although he taught in the 'Sphere Class', had a greater dedication to nautical matters. Leitão (2007) states that Father Francisco Costa was one of the most important authors on nautical texts in the 16th and 17th centuries.

We consider once again that there is no way we can speak of the teaching of mathematics unless we treat the Jesuits at that time. The Roman College, as we have seen, was the most prominent of all institutions; But others, such as La Fleche, of France, who had as students Descartes and Mersenne; Like Ingolstadt, where Christoph Scheiner worked for much of his career; Or Würzburg, with Athanasius Kircher and Gaspar Schott, are also extremely important and with a great participation in the history of modern science, above all in Europe.

The Jesuits in Rome followed the discoveries and made direct contact with the priests of St. Antão. The questions brought by Galileo Galilei are examples of these events. In April 1611, Cardinal Roberto Bellarmino (1542-1621) addressed the mathematical priests of that religious order and questioned them about some questions of the observations in the telescope he had heard so far. The five questions were:

1 - If it is true that you observe with the telescope multitudes of new stars; 2 - if Saturn is surrounded

¹³ In the original: [...] porta de entrada em Portugal de muitas novidades científicas desde o uso de logaritmos ao emprego da projecção de Mercator, passando pela construção de instrumentos científicos, pelos primeiros textos conhecidos de estática teórica, etc. Foi ainda o primeiro local, e durante muitas décadas o único, em que o estatuto científico da matemática foi proclamado em moldes que se poderiam chamar modernos [8-10]. E foi também o local por onde Galileu, o telescópio e o debate cosmológico se difundiram no nosso país (Leitão, 2010, p. 20).

¹⁴ In the original: [...] além de uma introdução à cosmografia, ensinava astronomia a um nível muito superior ao meramente introdutório. Dedicava uma atenção cuidada a tópicos de astronomia teórica, naquilo que então se apelidava de "teórica dos planetas". [...] como outros professores da Aula da Esfera, dedicou também algum tempo ao estudo da Astrologia (Leitão, 2007, p. 47).

by two smaller planets; 3 - if Venus has phases; 4 - if the Moon has an irregular appearance; 5 - if Jupiter has satellites (Leitão, 2008, p. 31)¹⁵.

A few days later, the priests of the Societa Iesus answered, affirming positively the five questions and confirming, consequently, all the affirmations made by Galileo. This document, with the answers, was signed by the Jesuits Cristóvão Clávio, Cristopher Grienberger, Odo van Maelcote and Giovanni Paolo Lembo.

At the end of the sixteenth century, the religious realized the evolution that would manifest in the field of sciences and reorganized what had already been under construction for a long time: *Ratio Studiorum*, a document that gave importance to the teaching of mathematics. One of the main influencers was Father Cristóvão Clávio, or Clavius, who used ideas from Aristotle himself to validate the mathematical science project.

Giuseppe Biancani (Blancanus) published a work in 1615, grouping and commenting on all texts in which Aristotle referred to mathematics, stating in his study that the Greek philosopher did not reject exact science. In a time immersed in innovations, especially with the emergence of the telescope and the microscope, the experimental boundaries for the Jesuits have become increasingly wide. The Company did not invent modern science, but gave vent to the maturation of this theory in Portuguese territory (Lopes, 1988).

The *Ratio Studiorum* regulated the scientific questions in the Jesuit curriculum, which were also held in the Roman College and offered merit to the teaching of the sciences, so much that it founded in its place of education 'Academy of Mathematics'. As we have already emphasized, this college later served as a model for Santo Antão to have a significant leap in the development of science.

Lisbon was in one of the centers of communication between the West and the East. In the College, classes that assisted in the deepening of cosmology were held, for example. The professors of that institution were in contact with those of the Roman College and other scientific centers, for they could not fail to keep abreast of cosmological innovations.

From then on, the Galilean novelties emerged and the question of the problematic involved with the possibility that the Jesuits were relatively pioneers to Galileo¹⁶. Father Cristóvão Clávio

(1537-1612) defended, importantly, mathematics in colleges. It is possible to relate that the impact of the Jesuit tradition in that century was fundamental and, beyond this member of the order, it is possible to mention other names that were great supporters of this teaching, such as:

[...] Gregoire de Saint-Vincent (1584-1667), Rudjer Boskovich (1711-1787), Cristoph Scheiner (1575-1650), Honoré Fabri (1607-1688), Francesco Grimaldi (1613-1663), Francesco Lana-Terzi (1631-1687), Giam-battista Riccioli (1598-1671), Paul Guldin (1577-1643), Ignace Gaston Pardies (1636-1673), Gaspar Schott (1608-1666), Francis Line (1595-1654), François 'Aguilon (1546-1617), Athanasius Kirck (1602-1680), Niccolò Cabeo (1586-1650), among many others (Leitão, 2007, p. 42-43)¹⁷.

The institution of Santo Antão, in its over than a century and a half of operation, has had as lenses about three dozen teachers, of which at least one third were from other countries. In the year 1615, almost all teachers were foreigners, and no Portuguese institution approached this number and this situation.

The presence of so many international professors is explained by the absence of qualified and prepared national team. The dissemination, through these teachers, was so great that teachers taught in Portugal such as:

[...] Cristoph Grienberger (1564-1636), one of the most renowned mathematicians in Europe at that time, who was to succeed Christopher Columbus at the head of the Academy of Mathematics of the Roman Collegio, or Giovanni Paolo Lembo (c. 1570-1618), Probably the most competent telescope builder after Galileo himself, or even Cristóvão Borri (1583-1632), a central personality in the cosmological debates of the first decades of the seventeenth century (Leitão, 2007, 24)¹⁸.

Also attended were illustrious masters like Jan Ciermans (1602-1648) or Heinrich Uvens (1618-

iliséteponers?; Previously, Peter Dear had already analyzed it in the American journal *Studies in history and philosophy of science*, with the title *Jesuit mathematical science and the reconstitution of experience in early seventeenth century*. That is, there are researchers who are concerned that the Society of Jesus, through Portugal, has become interested in the experimental sciences, especially mathematics, in the cultural tradition, considering that, at that juncture, the next one to value it would be Galileo Galilei.

¹⁷ In the original: [...] Gregoire de Saint-Vincent (1584-1667), Rudjer Boskovich (1711-1787), Cristoph Scheiner (1575-1650), Honoré Fabri (1607-1688), Francesco Grimaldi (1613-1663), Francesco Lana-Terzi (1631-1687), Giam-battista Riccioli (1598-1671), Paul Guldin (1577-1643), Ignace Gaston Pardies (1636-1673), Gaspar Schott (1608-1666), Francis Line (1595-1654), François d'Aguilon (1546-1617), Athanasius Kirckher (1602-1680), Niccolò Cabeo (1586-1650), entre muitos outros (Leitão, 2007, p. 42-43).

¹⁸ In the original [...] Cristoph Grienberger (1564-1636), um dos mais reputados matemáticos da Europa de então, que haveria de suceder a Cristóvão Clávio na chefia da Academia de Matemática do Collegio Romano, ou Giovanni Paolo Lembo (ca. 1570-1618), seguramente o mais competente construtor de telescópios depois do próprio Galileu, ou ainda Cristóvão Borri (1583-1632), uma personalidade central nos debates cosmológicos das primeiras décadas do século XVII (Leitão, 2007, p. 24).

¹⁵ In the original: 1 - Se é verdade que se observam com o telescópio multidões de novas estrelas; 2 - se Saturno está rodeado por dois planetas mais pequenos; 3 - se Vênus tem fases; 4 - se a Lua tem uma aparência irregular; 5 - se Júpiter tem satélites (Leitão, 2008, p. 31).

¹⁶ António Lopes (1988) writes an article, in the journal *Broteria*, in analysis to the text published in *The Recherche*, by Pierre Thuillier, entitled: *Les Jésuites ont-*

1667), who were trained in mathematical colleges. Their ideas had an impact and the accomplishment performed by them in Portugal was of great importance (Rodrigues, 1917).

The participation and role of all those who in one way or another made sense to the science of that College did not make him safe from problems. In 1599, due mainly to the shortage of professors, Austrian mathematician Christoph Grienberger was called to give lessons, which later replaced Clávio at the head of the Roman College. Grienberger was disappointed with the scientific level of both the College and the students; After a few years, he returned to Rome.

Leitão (2007, page 48, emphasis added) calls into question that some criticism of this lesson happened:

In of teachers, that is, the possibility of teachers of other nations coming to Lisbon to teach; Secondly, the emergence of a measure - even if informal - comparing the 'Class of the Sphere' not with other Portuguese institutions (against which it would always stand out) but with the best scientific institutions in Europe¹⁹.

With the departure of Grienberger and his return to Rome, Portuguese teachers once again acted as classroom lenses. Both Joao Delgado and Francisco da Costa also occupied the functions of the Company's architects, which took too much time and prevented them from dedicating themselves exclusively to these classes.

In relation to the dissemination of what these masters did in Portugal for the international community, it is worth mentioning the observations of a comet by the Jesuit Valentim Estancel (1621-1705) in Brazil, and referred to by Newton in his *Principia*, and others made in Lisbon by Giovanni Battista Carbone (1694-1750), Domenico Capassi (1694-1736) and published in the *Philosophical Transactions*, *Acta Eruditorum* and *Commentarii*, Academy of St. Petersburg.

Henrique Leitão (2007) classifies the teachers of the teaching center of the sixteenth century and the middle of the seventeenth in the following order and date: João Delgado (1590-1593); João Delgado (1595-1597); António Leitão (1597-1598); João Delgado (1598-1599); Cristoph Grienberger (1599-1602); Francisco da Costa (1602-1602); Francisco Machado (1604-1605); João Delgado (1605-1608);

Sebastião Dias (1610-1614); G. Paolo Lembo (1615-1617); Dionísio Lopes (1617-1619); J. Chrysostomus Gall (1620-1625); Cristoforo Borri (1627-1628); Ignace Stafford (1630-1636); Simon Fallon (1638-1641); Jan Cierman (1641-1642); Hendrick Uwens (1642-1646); Thomas Barton (1648-1649); John Riston (1651-1652); João da Costa (1654-1655); And Bartolomeu Duarte (1655-1658).

Luís de Albuquerque (1972) relates them in a somewhat divergent way in some chronological periods. We will then present the order in which he lists, as well as significant works that should contribute to those researchers who have deeper interests in this area. Some of the lenses at the school left contributions from the classes given. We present a survey of some of these writings.

Albuquerque (1972) claims to be Francisco da Costa (1595-1602) one of the first teachers of the 'Class of the Sphere'. Born of Pinhel, Father Costa, who was born in 1567 and taught in the College until his death in 1604, presented a course with teaching of astrology, art of sailing, geography, hydrography (description of the seas), treatise of the sphere (cosmography) and construction And use of astronomical globes (separated the globe into 'Earth Globe and Celestial Globe').

Cristoph Grienberger (1599-1602)²⁰ was Costa's substitute, also master of arts in Coimbra, and there are no records of his lessons. João Delgado (1600-1612) is considered the third responsible for the classes; Rodrigues (1917) and Albuquerque (1972) affirm that Delgado was successor of Grienberger.

Many documents diverge as to the dates of these teachers, as there are only clear references to the death of each one; Except for this, there is no record. From the works of Delgado, what is most known are his classes dedicated to astrology, a course planned for three years with subjects divided as follows: Astrological course, which began with notions about the sphere of the world, and Judicial Compendium or practical astrology, Which dealt with the principles of astrology and meteorology.

Following the order, we have Francisco Machado, who, according to Albuquerque (1972) and Rodrigues (1917), was a teacher from 1605 until about 1614, but there are no notes from his classes. Then, Sebastião Dias, priest admitted to the Company in 1599, taught a date unknown until 1617, the year of his death.

¹⁹ In the original: Em primeiro lugar, a circulação internacional de professores, isto é, a possibilidade de mestres de outras nações virem até Lisboa para leccionar; em segundo lugar o aparecimento de uma aferição - mesmo que informal - comparando a 'Aula da Esfera' não com outras instituições portuguesas (contra as quais ela sempre se destacaria) mas com as melhores instituições científicas da Europa (Leitão, 2007, p. 48)

²⁰ Regarding the dates on which the priests of the religious order were present and responsible for the 'Aula da Esfera' at the College of Santo Antão, we may find them here in the text at different times. As we have already clarified, the periodizations of Albuquerque (1972), Leitão (2007) and Rodrigues (1917) are somewhat different. There are also time slots where more than two teachers remain in charge of the class, so we find masters with concomitant dates.

Christopher Galo (1619-1627) was a very dedicated German teacher who had his classes assembled in the year 1625, who are entitled as *Treatise on the material, celestial and natural sphere*. It was one of the priests who Distinguished from the others for having eliminated astrology from its course.

After Cristopher Galo, we have Cristoforo Borri (1627-1628), also known as Christopher Bruno or Borro, whose course was divided into two parts, one destined for the 'Art of sailing' and the other for 'New Astronomy'.

The first part of the lessons of Fr. Bruno is perhaps the most valuable contribution of a professor of Santo Antão to nautics. The astronomical part of the course was sourced in Latin and published still in the life of the Author. It should be pointed out that the structure of the program adopted by Fr. Bruno is absolutely unique in the series of courses adopted by his companions (Albuquerque, 1972, p.17)²¹.

Carolino (2009) analyzes the theory of priest and astronomer Borri regarding the empyrean sky. This is one of the only theories advocated by practically all clergy. Borri, author of *Collecta astronomical exdoctrina*, published in Lisbon in 1631, defended the division of the sky and always ordered and articulated his thoughts with divine dictates. In the same work he wrote to his students in the 'Classroom of the Sphere': "[...] a qual [água] depois condensado Deos, e engrosando parte dellafes esta agoa Elemental que temos, e condensado ainda muito mais outras partes ueiodella e produsir todos os corpos celsestes das estrelas e planetas" (apud Carolino, 2009, p. 263).

In order to give continuity and coherence to the plans taught at the Jesuit colleges, Borri followed the instructions established in the *Ratio Studiorum* of 1599, and structured his classes, addressing philosophical themes such as *De caelo*, Of Aristotle (Carolino, 2009).

Master Ignace Stafford, or Inácio Staffor (1630-1635), in 1634 produced a book of *Mathematical Elements*, which may have been the book of his lessons.

Then Simon Fallon (1635-1642), or Father Fallon, who, besides teaching mathematics in Santo Antão, was in charge of D. João IV to take care of the reconstruction of the fortresses of the country, having the title of Engineer- The first, *Mathematical Matters* (subjects on Euclidean geometry), containing astronomy (description of constellations and stellar observations), practical

astrology, centrometry (new matters for the 'Class of the Sphere') and dealt with The theory of the planets; In the second book, practically reproduced the speculative *Compendium of the artificial, sublunar and celestial spheres*, by Cristóvão Galo, elaborated some 20 or 30 years before.

In the historical sequence, we have as teacher of the 'Class of the Sphere' HendrickUwens, or Henrique Uwens (1642-1646). This Flemish priest spent little time in Santo Antão and left for the missions of the East, and there were no reports of any of his writings.

After Uwens, we have: the Englishman John Riston, or John Roston (1651-1652), who left the work *Mathematical course*; The Englishman João da Costa (1654-1655) and the Portuguese Bartolomeu Duarte (1655-1658). The three priests mentioned passed very fast by the seats of Santo Antão, they occupied their places of 1654 to 1660.

Valentim Estancel, a native of Bohemia, went to Portugal after 1650, taught before in Évora and then in Lisbon; His lessons from "Sphere" were from 1660 to 1663. After that date, he left for Brazil (San Salvador), where he died in 1715. The priest left a work with the title *Tipus Lusitano* or new nautical regiment, which taught about "[...] alturas, descobrir os meridianos e desmarcar as variações da agulha a qualquer hora do dia ou da noite" (Albuquerque, 1742, p. 19). The priest was concerned with astronomical navigation. Before going to Santo Antão, he had already published in Evora, in 1658, the *Orbe affonsinosive horoscopo universal*, which consisted of the description of a universal clock and that was dedicated to D. Afonso VI.

Jesuit advances in science

The late sixteenth century and especially the early 17th century were marked by advances in scientific theory. The Jesuits, following all the steps of these (re) evolutions and advances, received, in 1611, Galileo Galilei in the Roman College. Cristóvão Clávio, who was the main astronomer at that institution, warned other Jesuit astronomers to be cautious about the publication and dissemination of theoretically controversial theories and arguments. And in this sense, even in that same year, through research and studies, the Jesuit astronomers confirmed many of the Galilean hypotheses and gradually followed them (Leitão, 2010).

Giovanni Paolo Lembo²², who was professor of the Sphere Classroom in the College of Santo Antão

²¹ In the original: A primeira parte das lições do P. Bruno constitui, talvez, o contributo mais valioso de um professor de Santo Antão para a náutica. A parte astronômica do curso foi vertida em latim e publicada ainda em vida do Autor. Assinale-se que a estrutura do programa adoptado pelo P. Bruno é absolutamente singular no conjunto dos cursos adoptados pelos seus companheiros (Albuquerque, 1972, p. 17).

²² According to manuscripts of the students of Santo Antão, the main discussions in Lembo's lectures were about the discoveries made by Galileo with the telescope.

from 1615 to 1617, according to the order presented by Leitão (2007), was one of the main organizers of telescope constructions and observations Astronomical in all this religious order. This Jesuit was responsible for one of the main works / documents of the entire history of Santo Antão, perhaps of the history of science in Portugal.

The Lembo course, in Santo Antão, because it is one of the most important documents in the history of science in Portugal, was registered with the notes prepared by the students and, in addition to being in a good state of preservation, they are written in Portuguese, Which confirms, once again, that he taught public classes and for the whole community (Leitão, 2010).

Father Lembo held one of the most important debates in the College of St. Anthony: the constructions and considerations about the telescope. His courses, in the teaching center, were fundamental to the innovations started in that place. He wrote, surely, one of the first references to the Portuguese telescope.

Leitão (2007) reports having found notes, student's manuscripts, written in Portuguese and in excellent condition; There are still figures, astronomical and mathematical diagrams. This shows a huge range of information. There are 140 pages of "[...] a set of subjects, which include notions of trigonometry, an introduction to Euclid's geometry, and notions about ecclesiastical computation. [...] The most interesting part, of course, is that devoted to astronomy" (Leitão, 2007, p. 53)²³.

In this manuscript, for the author, it is possible to affirm that, at the beginning of the 17th century, telescopes were already being built in Portugal, since, besides Lembo being one of the greatest constructors of such an instrument, there were many drawings in the notes made by the student.

There is no reason to suppose that Portugal did not know the exceptional cosmological novelties discovered by Galileo and the debates that they gave rise to. On the contrary, the place where these innovations entered the country, where they were known and discussed, was precisely the College of the Jesuits in Lisbon (Leitão, 2007, 56)²⁴.

At the Colegio de Santo Antão, teachers were not the only ones involved in scientific issues and debates. In those years, there were many other

European Jesuits who knew cosmological debates. Most of the teachers who passed through the place were in transit because they were going to China. These professors used to teach courses, even if of short duration, to the students of the place. One of the main and best known, for being one of the promoters of the 'new astronomy', was Cristóvão Borri (1583-1632), already mentioned above.

It is necessary to consider that discussions on other scientific problems were intensified with the 'Class of the Sphere'. Astronomical and mathematical studies were invested in so-called urgent issues in that period. Military engineering, for example, gained strength and space in the curricula of Jesuit colleges.

Although Santo Antão was a prominent center of learning and had much appreciation for astronomical development, it was not safe from problems. In the seventeenth century, a great and significant reform was carried out in the studies, so that the priests, who had more precise knowledge of mathematical knowledge, could be sent to the East, specifically to China, since the intellectual formation with which they arrived there was desired and It was not possible to advance in missionary work or studies.

The most critical of the priests is that the 'Classroom of the Sphere' was compared to scientific and mathematical classes in major university centers across Europe. Therefore, there was a very great concern with the quality of teaching and even investments in masters of international institutions. That is, the Lusitanian standard was compared to large centers of research and teaching.

For this reason, so many investigations and criticisms were made, through researchers, to the 'Classroom of the Sphere', because, besides being part of a curriculum of religious order, it comprised principles and investments of the Society of Jesus. After all, they were theories developed, consolidated and disseminated by parents.

Final considerations

With these reflections, it is evident that the missionaries had a fundamental role in the conquest of the East. It was requested that priests with knowledge of astronomy and mathematics be sent to that place. As a response to these needs and requirements, not only did the level of education at the College of St. Anthony in the Portuguese province, but also the training of mathematicians throughout central Europe intensified.

What we can say at the end of this article is that there is no way to study the history of education in

²³ Translation: "[...] conjunto de matérias, que incluem noções de trigonometria, uma introdução à geometria de Euclides, e noções sobre o computo eclesiástico. [...] A parte mais interessante, naturalmente, é a dedicada à astronomia" (Leitão, 2007, p. 53).

²⁴ In the original: Não tem qualquer fundamento supor que em Portugal não se conhecessem as excepcionais novidades cosmológicas descobertas por Galileu e os debates que elas originaram. Pelo contrário, o local por onde essas novidades entraram no país, onde foram conhecidas e discutidas, foi precisamente o Colégio dos jesuítas em Lisboa (Leitão, 2007, p. 56).

Portuguese America as well as the development of modern science in Europe if we do not speak and consider the deeds of the Ignatian people. The Jesuit presence was fundamental, especially in Portugal, in the propagation of ideas and in the development of scientific techniques.

Although it was linked to scholastic theology and philosophy, priests produced science without demeaning or prejudicing Christian precepts. The documents and the works produced and abandoned by the Ignatians are true treasures that demonstrate to us how the Company has traced so many overseas conquests and how rational were their reflections in missioning, for example, in the East. With the so-called 'Scientific Revolution', these supporters of modern science, in their discussions, seem to have had no demerits, either in relation to Descartes, to Bacon, or to Galileo himself.

The Society of Jesus had among its priests countless intellectuals who were responsible for the diffusion of science in various places. To form mathematicians, physicists, astronomers, among many other scientists, was not something simple and, over time, was completely planned and prepared in the College of Santo Antão.

The Ignatians were able to prepare not only servants of kings, in the case of the Lusitanian king, and great men of that time, but also priests for the conquests of all Portuguese patron saints, men capable of conversing with great Chinese masters and members of great navigations.

So the educational action consecrated by these priests of the *Societas Iesu*, both through the Church and society, was objectified to the intellectual and human preparation that led their students not only to technical knowledge but also to the possible dialogue between science and The faith; This already in that conjuncture in Portugal of the 'Five hundred'.

The Society of Jesus was an unmistakably modern and ambitious project that did not only influence the Portuguese society of the sixteenth century. Although with the impediments and limitations put by the Christianity, were men of its time and formed lay people beyond the necessities of that period. The Jesuit teaching methodology and its scientific advances were fundamental, not only for the conquest of the missions of the Portuguese patron, but also for that of all the territories for which those priests passed.

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