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ENLIGHTENMENT AND ITS REFLECTION IN MATHEMATICS IN LATIN AMERICA, PARTICULARLY IN BRAZIL, IN THE 19TH CENTURY *

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Abstract

I present a few remarks on the period known as Enlightenment. These remarks are based on a concept of knowledge which contemplates its generation, organization and diffusion by a cultural group (family, community, society). This concept is the basis for my interpretation of Enlightenment. Then I proceed to a brief presentation of Mathematics in Latin America in the 18th and early 19th centuries.

Keywords: Enlightenment, Mathematics in Colonial Latin América., Mathematics in the 19th century, Mathematics in Brazil.

Resumo

Apresento algumas observações sobre o período conhecido como Iluminismo. Essas observações são baseadas em um conceito de conhecimento que contempla sua geração, organização e difusão por um grupo cultural (família, comunidade, sociedade). Esse conceito é a base para minha interpretação de Iluminismo. Então procedo a uma breve apresentação da Matemática na América Latina no século XVIII e início do século XIX.

Palavras-chave: Iluminismo, Matemática Colonial na América Latina, Matemática no século XIX, Mahematics in Brazil.

Introduction.

The discussions about Enlightenment generally focus the *Encyclopédie* and philosophical ideas and defend the unity of knowledge, without care about special disciplines. They refer

* Based on the talk prepared for presentation in the Session on History: Ibero-American mathematics in the 19th and in the 20th centuries, in the International Congress of Mathematicians 22-30 August 2006, Madrid, Spain.

to well defined goals and to political and religious freedom. When we reflect about the interactions of sciences, techniques and culture in the 18th century, we recognize that all the domains of knowledge and behavior are integrated. Philosophy and science, politics and economics, literature and the arts, are all integrated in the movement called Enlightenment. A special role on this is played by education, but also by the scientific expeditions, the emergence of academies, associations and journals for the learned, and public exhibitions and museums. Naturally, the mutual influences of philosophy, stressing the discussions between empiricism, experimentation, rationalism, materialism, utilitarianism must be taken into account.

For this I need a reflection of the nature of man. I will examine the emergence of life, the uniqueness of the human species among other animal species. It is important to understand how *ad hoc* knowledge, generated to cope with reality, to face new situations and solving problems, and to explain facts and phenomena, is organized into methods, which are socialized and organized as theories, allowing for invention and creation of the new. We have also to understand how knowledge, thus generated and organized, is expropriated by the power structure and transmitted and diffused according to its interest.

I propose a research program on the History of Mathematics in the so-called Era of the Enlightenment. It is important to examine, compromising with the current classification of subjects in the mathematics, the influence of the State in transmitting and diffusing mathematical knowledge, ideas and practices. In this short communication, I give a brief relation of names and facts which have to analyze with a detailed research methodology in order to recognize these influences. This will be done elsewhere, under the theoretical support of a research program which I call, for reasons explained elsewhere, the Program Ethnomathematics.[1] This research program can be very briefly synthesized in three basic questions: i) how do *ad hoc* practices, generated to deal and cope with situations, questions and explanations, give rise to methods; ii) how are methods organized into theories; iii) how do theories result on invention and creativeness.

After a brief explanation of the theoretical background for this research program, we will examine the mathematical scenario of 18th century and early 19th century in Latin America.

Generation, organization and diffusion of knowledge.

We want to discuss knowledge systems, in particular Mathematical knowledge. Knowledge is associated to a cultural group (family, community, society), is dynamical and its evolution contemplates the generation, intellectual and social organization and diffusion, in a cumulative process. It goes back to the early stages of the group.

It is generally accepted that the emergence of life on Earth occurred 3-4 billion years ago. I would characterize life in one single word: continuity. Life has no meaning without continuity of the individual and of the species, which depend on survival. Survival of the individual and of the species is the imprint of life.

[1] Ubiratan D'Ambrosio: Ethnomathematics: A Research Program on the History and Pedagogy of Mathematics with Pedagogical Implcations, *Notices of the American Mathematical Society*, December 1992, vol. 39, n°10, pp.1183-1185.

The survival of the individual is resolved by drawing from nature the support of life. Breathing, feeding are essential factors of life. With the emergence of complex forms of life, breeding became essential for the continuity of the species. In complex animals, continuity depends on mating, and the survival of the species is resolved by meeting the other, the different, female and male. Besides the struggle for survival, common to every animal species, the human species searches for understanding and explaining the phenomenon of life and other natural phenomena, thus transcending mere survival. Mathematical ideas can be traced back to these early stages of the evolution of the species. Humans soon recognized that nature and mating are the support for the autonomy of life and for the continuity of the species. Survival and transcendence became the complementary pulsions which characterize the human species. Although the human species share the pulsion of survival with all living species, the pulsion of transcendence is unique to the human species. Obviously, the satisfaction of the pulsions of survival and transcendence generate knowledge and behavior, which are responses to natural and social environment. Sharing knowledge and behavior, hence language, myths and values, characterizes the culture of a group.

In all myths of creation, it is recognized that nature provides basic elements, nourishment, for individual survival of the living. Individual nourishment depends on other species, and procreation depends on another, of the same species, but different, female and male. This is clear in the dominant Biblical and Greek traditions. In this recognition, the human species understood the essentiality of other living species for survival and of the different of the same species for procreation. For varied reasons, some individuals prevail upon others. From this remark, Darwin's theory follows. This leads to a hierarchical social organization, and to power structure. Power structure is driven to maintain itself.

In all animal species, the response to the pulsion of survival is instinctive behavior, which is an action in the instant and which draws on previous experiences [knowledge]. This instinctive response does not contemplate time as such. Instinct has only the dimension of the instant, it do not allow for past and future and do not distinguish where. The instinct of survival is resolved, in all animal species, here and now. Although time is incorporated in the individual biological functions of every living species and in the ecological laws of nature, it is not recognized by species other than humans. Time and space, which are recognized by the human species, are the most basic mathematical ideas.

Humans have the same responses to survival as every living species, they subordinate instinctive and instantaneous responses to will. Differently than every other species, humans recognize time beyond the instant. Before and after, action and consequence, cause and effect, beginning and end, all are associated with, and in fact subordinate to, the pulsion of survival. Humans transcend the instant, and besides the pulsion of survival, human behavior reveals, also, the pulsion of transcendence.

Enlightenment as a strategy of expropriation/exclusion of knowledge.

Knowledge thus *ad hoc* generated by the individual, is intellectually organized and, through a very sophisticated mean of communication, is shared and socially organized. This knowledge becomes, as method, inherent to a group, and go through the search of explanations, thus giving rise to theories. Theories allow for critical analyzes of the

methods, giving rise to new methods. This is the process of invention, revealing the creativity of individuals and groups.

Power structures are driven into maintaining themselves. When power structure recognize that knowledge systems generated and organized by groups, can be useful for maintaining the structure in power, they expropriate this knowledge. Equally, power structure exclude knowledge, generated by the groups, when recognize this knowledge as a threat. There are different levels of exclusion, from a controlled tolerance through a total elimination. Political, religious and academics struggles are well explained by the dynamics of expropriation/exclusion. It is possible to explain, in this theoretical framework, Enlightenment and its influence in philosophy, religion and science, in politics and economics, in literature and the arts, as well as in all quotidian activities such as theatre and music, urbanism and architecture, public welfare, museums and exhibits. In particular, the study the three major revolutions of the 18th century, namely the Industrial Revolution, the American Revolution and the French Revolution, as well as the Republican movements for Independence in the Iberian colonies. The European scenario of the evolution of mathematics in the 18th and 19th centuries, or Enlightenment, which is responsible for the emergence of mathematical rigor as a step towards formalism, can be explained in this theoretical framework. It is of basic importance to examine the influence of Enlightenment in the life the American colonies.

Mathematics in Latin America in the 18th century.

In late colonial times, since the middle of the 18th century, a good number of expatriates and *criollos* played an important role in creating a scientific atmosphere in the colonies. This happened under the influence of the *Ilustración* [Enlightement], the important intellectual revival that began in Spain, under Carlos III (1716-1788), and in Portugal, under José I and his strong minister, Sebastião José de Carvalho e Melo (1699-1782), the Marquis of Pombal, his strong minister from 1750 to 1777.[2]

The most important developments of mathematics in Latin America in these days took place in Mexico. In the first half of the 18th century, there were a number of textbooks on Geometry, Arithmetics and Astronomy used in Mexico. These were not important, in the sense that they were mostly minor expository works. But in the second part of the century we recognize some important contributions. Particularly noticeable are the *Lecciones matemáticas*, of José Ignacio Bartolache, published in 1769. In 1772, an anonimous built a "calculating wheel", capable of performing the four basic operations for numbers up to 10^8 digits. Benito Bails publishes, also in 1772, the *Elementos de matemáticas*, which treated infinitesimal calculus and analytic geometry. It is remarkable the development of a special kind of applied mathematics, stimulated by the complexity of problems related to water and to mining. These two constitute the most important problems in the technological development of the country. A "subterraneous geometry" became a major theme in Mexican Science. Particularly important was the efforts for urbanization which took place

[2] Kenneth Maxwell: *Pombal. Paradox of the Enlightment*, Cambridge U. Press, 1995.

in all the colonies.[3] The book *Comentarios a las Ordenanzas de Minas*, by Francisco Javier Gamboa, published in 1761, is most representative of these developments.

Moving towards the South, in Central America, important developments took place in Guatemala, which included what is now Costa Rica. In Guatemala, the most renowned scholar is José Antonio Liendo y Goicoechea (1735-1814). He taught at the Universidad de San Carlos de Guatemala, which had already become a very important academic center after a plan of studies, which was essentially a medieval proposition, published in 1785. This plan was written in Latin in the form of 25 theses, under the title *Temas de Filosofia Racional y de Filosofia Mecánica de los sentidos, de acuerdo con los usos de la Física; y de otros tópicos físico-teológicos según el pensamiento de los modernos para ser defendidos en esta Real y Pontificia Academia Guatemalteca de San Carlos ...".* Goicoechea was responsible for modernizing this plan of studies, incorporating experimental physics to the project, and introduced modern mathematics based on the texts of Christian Wolff.

In this period, a number of intellectuals, well versed in a variety of areas of knowledge, were responsible for introducing, the then Modern, Mathematics into the colonies. Among these eminent philosophers, the most distinguished is José Celestino Mutis (1732-1808), of Colombia. He was not only is responsible for an unpublished translation of Newton, but was also responsible for introducing modern mathematics in Colombia, mainly relying on the books by Christian Wolff. He was the founder of the Observatorio de Bogotá, in 1803. His most distinguished disciple, Francisco José Caldas (1771-1816), became the director of the Observatory. Caldas was deeply involved in the Independence War and was shot by the Spaniards.

In the Vice Royalty of La Plata, Juan Alsina and Pedro Cerviño lectured, in Buenos Aires, on Infinitesimal Calculus, Mechanics and Trigonometry. In Peru, Cosme Bueno (1711-1798), Gabriel Moreno (1735-1809) and Joaquín Gregorio Paredes (1778-1839) are best known.

In Chile, the Universidad Real de San Felipe, which was inaugurated in 1747 in Santiago, was provided with a "catedra" of Mathematics. Fray Ignacio León de Garavito, a self-instructed *criollo* mathematician, was responsible for this chair.

In Brazil, José Fernandes Pinto Alpoim (1695-1765) wrote two books, *Exame de Artilheiros* (1744) and *Exame de Bombeiros* (1748). They are elementary and representative of the efforts to prepare military cadres in the colony. Both books focused what we might call Military Mathematics, and both were written in a very didactical, catechetic style of questions and answers.

In late 18th Century, the influence of the Marquis of Pombal in Brazil was of major importance. Pombal was responsible for expelling, from Portugal, the powerful *Companhia de Jesus*. The Jesuits were in entire control of education and scientific research in Portugal, dominating the important University of Coimbra. The role of the Jesuits in Science and Education is controversial.[4] Pombal has been criticized by the fact that the consequences of

[3] See José Sala Catalá: *Ciencia y Técnica en la Metropolización de América,* Theatrum Machinae, Madrid, 1994.
[4] See the book by Luis Miguel Carolino and Carlos Ziller Camenietzki (cords.): *Jesuítas. Ensino e Ciência. Séc XVI-XVIII*, Caleidoscópio, Casal de Cambra (Portugal), 2005.

removing Jesuits from education, the existing infrastructure of Education was dismantled, particularly in Brazil. On the other hand, his action was praised by some historians, for opening the doors for the renewal of Portuguese Science.[5] In Brazil, for it favored the emergence of new mental attitudes.[6]

His actions affected particularly Mathematics. He was responsible for creating the *Aula do Commercio*, probably the earliest attempt to establish a School of Economics in Europa. It was contemplated such an *Aula do Commercio* in Pará, Brazil. The Statutes of this school contemplated a good curriculum in Mathematics.[7] Another important figure the Enlightenment is Luis Antonio Verney (1713-1792). Although born in Portugal, Verney went to Rome in 1736 and remained there for his entire life, having received religious order. While in Rome, he followed the emerging ideas of the Enlightenment and was influenced by Isaac Newton, John Locke and Christian Wolff. He wrote a treatise, in four volumes, *De Re Physica*. Volume 1 is devoted to an integrated History of Mathematics and Physics.[8] Verney wrote also a pedagogical treatise, in five volumes, *Verdadeiro Método de Estudar*, which contemplates a curriculum in which mathematics does not have autonomy as a discipline, although it recognizes the focal importance of Mathematics in society and in all the disciplines of the curriculum.[9]

Another action of Pombal, particularly important for Mathematics, is the renovation of the Universidade de Coimbra and the fortuitous appointment of José Anástacio da Cunha (1744-1787) for a chair in the remodeled section of Mathematics. Anastácio da Cunha was a brilliant young artillery officer, but with no academic background. He is, probably, the most eminent Portuguese scientist of the Enlightenment.[10]

The Movements of Independence and Early 19th Century.

The tides of Independence were greatly influenced by the Enlightenment and, mainly, by Republican ideals. This is particularly noticed in the independence of the United States of America and its influence in the French Revolution. This Republican ideal prevailed in the movements in the Spanish and Portuguese colonies. The Spanish colonies obtained their independence in the early 19th century, although Spain succeeded in retaining sovereignty in Puerto Rico and Cuba, until the Spanish-American War of 1898. Brazil obtained the independence from Portugal in 1822, but remained a Monarchy until 1889, when the Republic was proclaimed.

It was soon recognized in the newly independent countries that [Western] Science and Mathematics are essential in the modern world. Public opinion is ready to support

[5] See Kenneth Maxwell, *op.cit.*

[6] Antonio Candido: *Formação da Literatura Brasileira*, 2 vols, Livraria Martins Editora, São Paulo, 1959.

[7] *Estatutos da Aula do Commércio*, Lisboa, 1759.

[8] A commented translation of volume 1 is the doctoral dissertation of Frederico José Andries Lopes: *Verney e o De Re Physica*, Doctoral Thesis, UNESP, Rio Claro, 2002.

[9] Ubiratan D'Ambrosio: O Iluminismo e seus Reflexos na Matemática Luso-Brasileira, *ANAIS-ACTAS do Encontro Luso-Brasileiro de História da Matemática e Seminário Nacional de História da Matemática*, ed. Sergio Nobre, Águas de São Pedro, SP, 1997; pp.53-66.

[10] See the recent collection of papers organized by Maria Elfrida Ralha, Maria Fernanda Estrada, Masria do Céu Silva e Abel Rodrigues: *José Anastácio da Cunha. O Tempo, as Idéias, a Obra ... e Os Inéditos*, Arquivo Distrital de Braga/Universidade do Minho, Braga, 2006.

investment in scientific and mathematical research in spite of being absolutely unable to guess what kind of research is being supported.

A different History of Mathematics in Latin America begins. The influence in the colonies was, essentially from Portugal and Spain. After independence, France became very influential, and French textbooks were amply translated. The newly independent countries attracted immigrants from other European countries. New waves of immigrants arrived, mainly from Italy and Germany. This changed considerably the academic atmosphere and, of course, the presence of mathematics in it was intensified.

The independence of the Viceroyalties of New Spain (Nueva España), New Granada (Nueva Granada), Peru, La Plata and Brazil was achieved in the first quarter of the 19th century. The political division in countries, following the independence, is practically the same as today. The pattern of cultural dynamics since colonial times did not change much, except for the fact that Spain and Portugal were replaced by other empires as Central Nations.

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The influence of Mexico, as a new independent country, was very important as a reflection of the importance of New Spain in the colonial times. But the independence of Guatemala, in 1821, lessened the influence of Mexico in Central and South America. The establishment of new universities and the renewal of the old ones, immediately preceding and after the independence, generated open attitudes with respect to sources of knowledge on which to build up the newly established countries of Latin America. Formerly restricted to an almost exclusivity of influences coming from Spain and Portugal, the new countries attracted considerable attention from the rest of Europe, and a new wage of scientific expeditions came to South America. They had a great influence in creating new intellectual climates throughout the region. This new source of intellectual interest is seen very strongly in the building up of large and diversified libraries, both public and private, and the acquisition of modern literature.

In Costa Rica the colonial authorities established the *Casa de Enseñanza de Santo Tomas* in 1814, in which the most influential teacher was Rafael Francisco Osejo, born in 1780. He wrote in 1830 *Lecciones de aritmética*, written in the form of questions and answers, a common feature in that period. In 1843 the *Casa de Enseñanza* [House of Teaching] was transformed in the *Universidad de Santo Tomas*, where careers in Engineering were established, but no career in Pure Sciences and Mathematics.

Colombia soon attracted foreign mathematicians. The Frenchman Bergeron introduced Descriptive Geometry in the country, and the Italian Agustín Codazzi (1793-1859) was influential in creating the *Colegio Militar*. Lino Pombo (1797-1862), who was particularly influential in founding the *Academia de Matematicas de Venezuela*, wrote a complete course of Mathematics.

In Brazil, the decision of the royal family of Portugal to transfer the capital of the Kingdom of Portugal from Lisbon to Rio de Janeiro, in 1808, to escape Napoleon invasion, was decisive in changing cultural life in the colony. The Portuguese court settled in Rio de

Janeiro, where it was necessary to create an infrastructure to run, from a colonial town, the vast Kingdom of Portugal. They founded a major Library (*Biblioteca Nacional*), and a Military School (*Escola Militar*). Both were influential in the development of Mathematics in Brazil. In the Military School, a doctorate in Mathematics was established and a number of theses were submitted and defended. A brief analyzes of all the theses is presented by Clóvis Pereira da Silva in his important book (2003). Translation of the textbooks of Lacroix, of Legendre and others, were quite important in generating what we might call a mathematical style in Brazil.

Particularly interesting is the case of Joaquim Gomes de Souza (1829-1863), known as "Souzinha", the first Brazilian mathematician with an European visibility. He presented his results in the *Académie des Sciences de Paris* and in the *Royal Society*. They appeared in the *Comptes-Rendus de l'Académie des Sciences de Paris*, tomes XL, p. 1310, and XLI, p. 100 and in the *Proceedings of the Royal Society*, 1856, pp.146-149. It is quite interesting to read the referee's reports and the reaction of Gomes de Souza to the fact that Liouville did not give an appraisal of the paper, according to Gomes de Souza, because of "la petite jalousie". Only short notice of the papers was given, and they were posthumously published as *Mélanges du Calcul Intégral*, as an independent printing by Brockhaus, of Leipzig, in 1889. This work, dealing mainly with partial differential equations, is permeated by very interesting historical and philosophical remarks, revealing access to the most important literature then available. This was possible probably due to the existence of important private collections in Maranhão, his home state in the Northeast. "Souzinha" became a member of the Imperial Parliament and his first intervention reveals how important the thinking of Charles de Montesquieu in his political ideas was. A thorough study of the scientific works of J. Gomes de Souza, as well as of his political and philosophical ideas, is still due.[11]

Argentina, independent since 1816, experienced a remarkable intellectual development. In 1822, the ephemeral *Sociedad de Ciencias Físicas y Matemáticas* was founded in Buenos Aires.[12] There was an emergence of private libraries in Buenos Aires. Much later developments include the important private library of Bernardino Speluzzi (1835-1898), which listed the main works of Newton, D'Alembert, Euler, Laplace, Carnot and several other modern classics. Another intellectual, Valentin Balbin (1851-1901), while Rector of the National College of Buenos Aires proposed a new study plan, in 1896, which included history of mathematics as a distinct discipline. This is probably the first formal interest in the History of Mathematics in South America, which eventually led to an important school of History of Science in Argentina.

[11] Ubiratan D'Ambrosio: Joaquim Gomes de Souza, o "Sousinha" (1829-1864), *Anais do 3° Encontro de Filosofia e História da Ciência do Cone Sul*, (Águas de Lindóia, SP, 25-27/maio/2002), promovido pela AFHIC/Associação de Filosofia e História da Ciência do Cone Sul, eds: Roberto de Andrade Martins, Lílian A-C.P. Martins, Cibelle C. Silva, Juliana M.H. Ferreira, Campinas: AFHIC, 2004; pp.453-460 (ISBN 85-904198-1-9) (edição eletrônica, CD).

[12] J. C. Nicolau: La Sociedad de Ciencias Fisicas y Matematicas de Buenos Aires (1822-1824), *Saber y Tiempo*, 2(1996), vol. 2, pp.149-160.

In Peru, it is to be mentioned an interest in Statistics, beginning with the book *Ensayo de estadística completa de los ramos económico-políticos de la provincia de Azángaro...* by José Domingos Choquechuanca (1789-1858), published in 1833.

In Chile, the Universidad de Chile was created in 1842, with a Faculty of Physical and Mathematical Sciences. A most distinguished member of the Faculty was Ramón Picarte, a lawyer, who had his paper *La división reducida a una adición*, accepted and published by the Academy of Sciences of Paris in 1859. I did not have personal access to these papers and to the records of Picarte's presence in Paris. Much emphasis is given, in Cile, to teacher training.

Conclusion.

The History of Mathematics in colonial times in the Americas reflects, more than the developments of Mathematics in Europe, the political atmosphere in the colonies and in the newly independent republics. The influence of the Enlightenment is felt more in the development of political ideas which led to the declarations of independence and the constitutions of the new countries. The republican ideal was present and the consolidation of the newly independent countries depended of the emergence of intellectual elite capable of absorbing the advances of Science and the Technology of the 19th century. The emergence of mathematics schools in the Americas was the response to the need of an infrastructure supporting the new advances in Science and Technology.

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