

SPANISH INITIATIVES TO BRING MATHEMATICS IN SPAIN INTO THE
INTERNATIONAL MAINSTREAM

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THE INTERNATIONAL MAINSTREAM: A PROBLEM OF DEFINITION

Historiographic terminology and concepts are not always as well defined as mathematical ones. This happens with the concept of *international mainstream*, mostly understood as opposed to *periphery*, a term that has become fashionable over the last few years, to politically correctly name any human group, which is not on the crest of the wave of a certain activity.

Thus, in national terms, the international mainstream is determined, in mathematics and in science as in economics or politics by a reduced –extremely reduced– group of leading countries, whose standards the rest of the planet tries hard to adapt to, in the hope that the effort will bring them some of the benefits that are enjoyed in such agreeable environments.

Historians of mathematics have the task of evaluating the level of modernity, that is, determining if there were, in quantitative terms, sufficient individuals, groups or schools producing and teaching mathematics to a sufficiently advanced, qualitatively speaking, level; if, in the optimum case, one can talk of a socially recognized mathematical community that shares internal characteristics (the actual mathematical activity), external characteristics (organization and communication) and teleological characteristics with its foreign contemporaries; and if, in any case, it is possible to detect a human group whose average mathematical yield in terms of these characters enables their inclusion in the band of modernity.¹

In this regard, Spain belongs to the much larger set of mathematically peripheral countries of the planet. Although much has been written about Spanish intellectual isolation since the time when Philip II forbade Spanish scholars to study abroad and decided to censor foreign books (1559), history of Spanish mathematics shows that even under the hardest political circumstances there were always individuals and even groups of scholars perfectly aware of what was going on in mathematics, at least at the level of *normal* (in the Kuhnian sense) *mathematics*.

But from the standpoint of average yields, it is necessary to identify the problem in terms of the mathematical community. In this sense the process of

¹ Mariano Hormigón, "Paradigms and Mathematics," in *Paradigms and Mathematics* (Zaragoza: Siglo XXI, 1996), 2-113.

the involvement of Spain in the international mathematical mainstream could start only when the Spanish mathematical community was large enough to ensure its institutionalization process and start professionalization. After the efforts of leaders such as Galdeano, Echegaray or Torroja by the end of the 19th century, the Spanish mathematical community was ready to start this process. Two institutions –the Spanish Mathematical Society and the Mathematical Laboratory and Seminar of the Council of Research– and one journal –*the Revista Matemática Hispano-Americana*– were key agents in this development, which was suddenly cut off by the last Spanish Civil War (1936-39).

This paper tries to show how one of the large set of mathematically peripheral countries of the planet, Spain, made its way to the international mathematics mainstream, and up to which (modest) extent it succeeded.

THE ENLIGHTENMENT

On acceding to the Spanish crown in 1700, the Bourbons found a scholastic university system with three major universities (Salamanca, Valladolid and Alcalá) and a pleiad of minor universities. The colleges existing within them governed these three major universities, as they controlled the academic posts and the chair system. Even more, they acted as invisible colleges in the whole state administration, constituting networks of influence and lobbies.

In turn each university could have a maximum of four faculties, Theology, Law, Medicine and Arts, the first two being major faculties. In this system there

was no place for science (modern or not), rather, an openly hostile attitude towards it reigned in the intellectual environment.²

The Bourbons' attempt to reform the Spanish university did not come about until the end of the reign of Charles III (1759-88), with the Royal Charter of 1786 of Minister Campomanes. The reform tried to put an end to the power of the colleges, placing the Spanish university under state control. At the same time, it attempted to rationalize the teaching structure by systematizing degrees, curricula and textbooks, and by arranging the provision of chairs. Although the reform ended the profusion of minor universities, which were left void of content on not complying with the minimum requirements to grant official professionally recognized academic titles, as a whole it failed, mainly due to the fierce corporate resistance of the major universities, but also due to the lack of allocation of financial resources, which would at least permit –if not guarantee– its launching.

More efficient were, as usually happens in non-revolutionary change processes, the efforts made in a whole series of institutions parallel to the university, where scientific renovation advanced with the century: military schools (engineers, artillerymen), navigation schools, schools for the education of the nobility (*Seminario de Nobles* and *Reales Estudios de San Isidro*). There are also noticeable progress in newly created institutions, such as the Academies

² Mariano Peset and José Luis Peset, *La Universidad española (siglos XVIII y XIX)*. Madrid: Taurus, 1974.

(Language, History, Medicine) and above all, in the so-called Economic Societies of Friends of the Country (*Sociedades Económicas de Amigos del País*), the institutional invention with which an attempt is made in Spain to carry out the enlightened ideal of transforming society through productivity. Situated in the general wave of utilitarian progress, which ran through 18th century Europe, the Economic Societies are concerned with issues related to agriculture, industry, trade and political economy and, in their attempt to instruct the artisans, they create schools where the level of development of scientific disciplines such as mathematics or chemistry is quite significant.³

One can hardly conceive the biography of a Spanish scholar at that time without at least one European tour. The transfer of this constant to the scientific field is expressed in the start-up of a scientific policy aiming at bringing Spain into line with European standards based on education abroad. The *pensiones* (grants) enabled a considerable group of young scholars to go abroad to be educated in order to establish, on their return to Spain, similar institutions to the ones where they received their education. Thus, for example, the civil engineers corps is created in 1799, a singular group in the development of mathematics in Spain since it published the Spanish translation of Monge's *Géométrie Descriptive*.⁴

³ See, for instance, Víctor Arenzana, *La Enseñanza de las Matemáticas en España en el siglo XVIII. La Escuela de Matemáticas de la Real Sociedad Económica Aragonesa de Amigos del País*. Zaragoza: Universidad de Zaragoza, 1987.

⁴ Gaspard Monge, *Geometría Descriptiva. Lecciones dadas en las Escuelas Normales en el año tercero*

This set of initiatives is reflected in the Spanish mathematical production: almost one third (71) of the 203 works of mathematics published between 1700 and 1809 appear during the reign of Charles III, almost half (100) during the successive reigns of Charles III and Charles IV. During this period of time, the full introduction of differential calculus⁵ occurs, and what is more important, the expression of the modern mathematical knowledge in Benito Bails' great work, *Elementos de Matemáticas*, published in 10 volumes which appeared between 1772 and 1783.⁶

Benito Bails (1730-97), the most influential Spanish mathematician in the late 18th and early 19th century, was the director of the Mathematics Section of the *Real Academia de Nobles Artes de San Fernando* in Madrid. He was charged by the Academy to write a complete course on mathematics, which appeared in ten volumes between 1772 and 1783.⁷ He then published a synthetic version of this work in three volumes in 1776,⁸ the first one devoted to pure mathematics

de la República, por Gaspard Monge, del Instituto Nacional. Traducidas al castellano para el uso de los estudios de la Inspección General de Caminos. Madrid: Imprenta Real, 1803. Facsimile ed. Madrid: Colegio de Ingenieros de Caminos, Canales y Puertos, 1996.

⁵ Norberto Cuesta Dutari, *La invención del cálculo infinitesimal y su introducción en España*. Salamanca, Universidad de Salamanca, 1985.

⁶ For a synthetic approach to mathematics in 18th-century Spain see Mariano Hormigón, "Las matemáticas en la Ilustración Española. Su desarrollo en el reinado de Carlos III," in *Ciencia, Técnica y Estado en la España ilustrada* (Zaragoza: MEC/SEHCYT, 1990), 265-278.

⁷ Benito Bails, *Elementos de Matemáticas*. 10 vols. Madrid: Vda. de Joaquín Ibarra, 1772-1783.

⁸ Benito Bails, *Principios de Matemáticas*. 3 vols. Madrid: Vda. de Joaquín Ibarra, 1776.

(arithmetic, geometry, and plane trigonometry), the latter two to mixed mathematics (dynamics, hydrodynamics, optics, astronomy, and calendar in the second; geography, gnomonics, architecture, perspective, and tables of logarithms in the third). A proof of the success of this work is that the second edition was already printed in 1788-90, the third in 1797-99, and the fourth in 1805-16. The third edition was substantially changed, with the two first volumes devoted to pure mathematics (arithmetic, tables of logarithms, geometry, plane trigonometry, and an appendix on probability in the first; algebra, differential and integral calculus, and spherical trigonometry in the second), the third one devoted to mixed mathematics (dynamics, hydrodynamics, optics, and Copernican astronomy). The former third volume, more specifically adapted to the practical needs of the students of the Academy, was never reprinted, which seems to show that the *Principios* were reaching a much wider audience.

All these initiatives point out to France as the main source of foreign influences, in accordance with the new ruling dynasty and the general intellectual framework of the Enlightenment. The French reference remained constant until the last quarter of the 19th century, in spite of its beginning with the war against Napoleon I (1808-1814).

THE 19TH CENTURY

Throughout the 19th century civil and military engineers, artillerymen and naval officers, together with secondary and higher education teachers gradually formed a mathematical community articulated around the corporate links inherent to the different corps of civil and military officials.⁹

Thus, during the first half of the century, together with lonely rare *avis* such as José Mariano Vallejo (1779-1846) or Jacinto Feliú (1787-1867), three essential groups are formed within the Spanish mathematical community: military men,¹⁰ secondary education teachers¹¹ and civil engineers.

Among military men, engineers, artillerymen and naval officers are especially important, since their work, with interesting results in the field of differential calculus¹² and higher geometry,¹³ represents a certain institutional involvement of their respective Academies and Observatories in the mathematical activity:

⁹ Mariano Hormigón, "The Formation of the Spanish Mathematical Community," *Istorico-Matematicheskie Issledovania* (1997): 22-55.

¹⁰ M^a Angeles Velamazán, *La enseñanza de las matemáticas en las Academias militares en España en el siglo XIX*. Zaragoza: Universidad de Zaragoza, 1994.

¹¹ Fernando Vea, *Las matemáticas en la enseñanza secundaria en España en el siglo XIX*. Zaragoza: Universidad de Zaragoza, 1995.

¹² M^a Angeles Velamazán and Elena Ausejo, "De Lagrange a Cauchy: el Cálculo Diferencial en las Academias militares en España en el siglo XIX," *LLULL, Revista de la Sociedad Española de Historia de las Ciencias y de las Técnicas* 16 (1993): 327-370.

¹³ M^a Angeles Velamazán, "Nuevos datos sobre los estudios de geometría superior en España en el siglo XIX: la aportación militar," *LLULL, Revista de la Sociedad Española de Historia de las Ciencias y de las Técnicas* 16 (1993): 587-620.

translation and preparation of text books, an incipient and timid incorporation into research, initiatives in the field of scientific periodicals.¹⁴

Spain followed, as almost the entire world, the model of Lagrange and his colleagues of the French revolutionary period, especially in mathematics and physics. The popularity of Gaspard Monge (1746-1816) in scientific circles, especially among engineers, was remarkable. In 1819, colonel Mariano Zorraquín wrote an Analytic-Descriptive Geometry to be used at the Military Engineering Academy, explicitly arranged in the manner of Monge.¹⁵ Zorraquín's most brilliant student was Fernando García San Pedro (1796-1854), who wrote a dissertation on kinetic geometry already in his school years. To his credits is also the first textbook on differential and integral calculus by a military professor in 19th-century Spain,¹⁶ which became an unavoidable reference in calculus teaching at that Academy because it tried to rigorously approach the gaps of Lagrangian analysis.¹⁷ A similar case is the artillery

¹⁴ Elena Ausejo, "Le *Periódico Mensual de Ciencias Matemáticas y Físicas* (Cádiz, 1848), premier journal scientifique espagnol: la constitution d'une communauté?" *Rivista di Storia della Scienza* 3 (1995): 55-66.

¹⁵ Mariano Zorraquín, *Geometría analítica-descriptiva* (Alcalá de Henares: Imprenta Manuel Amigo, 1819), p. XIII.

¹⁶ Fernando García San Pedro, *Teoría algebraica elemental de las cantidades que varían por incrementos positivos o negativos de sus variables componentes, o sea Cálculo diferencial e integral*. Madrid: Imprenta que fue de García, 1828.

¹⁷ Velamazán and Ausejo, pp. 328-366.

lieutenant José de Odriozola (1786-1863), who wrote a complete Course on Mathematics¹⁸, which established solid references to the Ecole Polytechnique of Paris.¹⁹

The work of secondary education professors was especially relevant in textbook translations. Secondary education was organized from 1836 onwards. The creation in the provincial capitals of secondary education high schools (*Institutos*), which offered permanent posts for civil servants whose job was science teaching represents a quantitative contribution to the formation of the scientific community, since it entailed the creation of a layer who earned their living thanks to their knowledge –not necessarily overwhelming– of a scientific discipline. These people also took on the task of preparing the textbooks, as always under the French influence. The Spanish legislation on teaching matters in the 19th century cannot be explained in a few words: there were more than twenty-five study plans in less than three quarters of a century. This variety

¹⁸ José de Odriozola, *Curso completo de Matemáticas puras*. 4 vols. Madrid: Imprenta García, 1827-1829.

Vol. I: *Aritmética y Algebra elemental*. Madrid, Imprenta García, 1827, 3 eds.

Vol. II: *Geometría elemental y Trigonometría*. Madrid, Imprenta García, 1827, 5 eds.

Vol. III: *Algebra sublime y Geometría analítica*. Madrid: Imprenta García, 1829.

Vol. IV: *Cálculo diferencial e integral*. Madrid: Imprenta García, 1829, partial reprints in 1833, 1843, 1844, 1850, 1852 and 1855.

¹⁹ Cauchy's derivative was later introduced at the Artillery Academy by Francisco Sanchiz y Castillo [Francisco Sanchiz y Castillo, *Tratado de Cálculo Diferencial*. Segovia: Imprenta Baeza, 1851].

was the consequence of the political instability, of the different liberal and conservative viewpoints –the first promoting scientific contents, the latter humanities, and of the influence of the academic lobbies. The introduction of German references into practically all the different professions was a new factor among Spanish intellectuals which came in the last quarter of the 19th century from a private initiative, the *Institución Libre de Enseñanza* (Free Teaching Institution, ILE)²⁰.

As regards civil engineers, it is worth mentioning the institutional involvement of their High Technical Schools in mathematical activity. The first and ephemeral foundation of the Civil Engineering School dates back to 1802, and was the work of one of the most interesting characters of the history of Europe in the first third of the 19th century, Agustín de Betancourt (1758-1824). The newborn school was closed because of the war against Napoleon I, and remained closed during Fernando VII's reign except for the short period of the Liberal Three-year period (1820-23). In 1834, after Fernando VII's death, the school was reorganized.²¹ The Mining Engineering School was founded in 1835, the Forestry Engineering School in 1846, the Industrial Engineering School in

²⁰ The ILE followed the German philosopher Krause. The first German references in mathematics appear in secondary teaching with the translations of *Baltzer's Elementos de Matemáticas* between 1879 and 1881, in university teaching with von Staudt's geometry (see next section).

²¹ Antonio Rumeu de Armas, *Ciencia y tecnología en la España Ilustrada. La Escuela de Caminos y Canales*. Madrid: Turner, 1980.

1851, and the Agronomist Engineering School in 1855, all of them following essentially French models. Civil engineers, as well as mining and industrial engineers, agricultural and forestry experts introduced scientific contents – especially mathematics– as a differential element between the professions inherited from the Old Régime and those corresponding to the modern liberal spirit. Engineers –especially civil engineers– wished to be distinguished by being key pieces in the moderate development of the state, trying –successfully in quite a lot of cases– to combine the economic growth and the reform of the economic and social structures with individual advantage and own fortune. In that sense, the power of the different engineering bodies in Spain was relevant and significant. Starting from this reality, it can be concluded that the stable development of Spanish scientific culture was guaranteed, even though in a rather biased way. Thanks to the gradual infiltration of the different engineering bodies into all the aspects of Spanish life the number of potentially educated people in scientific questions, who were progressively interested in their publications, increased. Moreover, the proliferation of preparatory schools for the extremely hard entrance examination to the engineering schools represented a complement, if not a *modus vivendi*, for many people whose main intellectual and professional skills were placed around science –especially mathematics. This represents an unquestionable milestone in the scientific history of Spain, because for the first time mathematics and science were placed as a theoretic key to practice a civilian profession with growing social prestige.

The Faculty of Philosophy became a High Faculty, with a section devoted to science, in 1843. The Law of Public Education of 1857 –known as Moyano Law, after the Minister of Education, Claudio Moyano (1809-1890)– founded the Faculties of Science, which conferred two different degrees, one in physics and mathematics, the other in physics and chemistry. Nevertheless, the science degree was not accompanied by suitable professional perspectives, so that the first university groups that modestly try to join the European mainstream do not appear until the last two decades of the 19th century, first in teaching, hardly in research.

During the second half of the 19th century university professors joined the Spanish mathematical community. Little by little research groups became stable in different university centers of the country (mainly Madrid, Barcelona and Zaragoza),²² the first Spanish mathematical journal (*El Progreso Matemático*, 1891) was published,²³ and Spanish mathematicians began to take part in International Mathematicians Congresses.²⁴ Even so, the problems of

²²Mariano Hormigón, "Las matemáticas en España en el primer tercio del siglo XX," in *Ciencia y sociedad en España: de la Ilustración a la Guerra Civil* (Madrid: Ediciones El Arquero/CSIC, 1988), 253-282.

²³Mariano Hormigón, "García de Galdeano and *El Progreso Matemático*," in *Messengers of Mathematics: European Mathematical Journals 1800-1946* (Zaragoza: Siglo XXI, 1993), 95-115.

²⁴Mariano Hormigón, "El *affaire Cambridge*: nuevos datos sobre las matemáticas en España en el primer tercio del siglo XX," in *Actas del V Congreso de la Sociedad Española de Historia de las Ciencias y de las Técnicas*, 3 vols. (Murcia: DM-PPU, 1991), 1: 135-171.

professionalization persisted due to the lack of occupational perspectives of science graduates, whose only labor redoubt was secondary and university education while they saw how they were denied bread and salt in a whole series of institutions (Ministry of Public Works, Observatory of Madrid, Geographic Institute...), including the High Technical Schools of Engineers, which avoided to obey the Moyano Law with respect to their inclusion in the general university system through the channel of the *preparatory courses* in the Science Faculties. Moreover, mathematicians also underwent in their teaching redoubt the professional competition of unemployed engineers, since the State stoped being guarantor of engineers employment after the liberal revolution of 1868. In this context, the interplay of tensions was not very favorable to the mathematical professionalization faced with the strong corporate weight of Spanish engineering.²⁵

The 19th century shows the establishment of a Spanish mathematical community at least at the teaching level, hardly at the research level. This community worked under the leading French influence until the last quarter of the 19th century, when the opening to other foreign sources arrived at the hands of the efforts of some relevant individual leaders.

THE ROLE OF INDIVIDUALS IN HISTORY

²⁵Elena Ausejo and M^a Angeles Velamazán, "Mathematics and Liberalism in 19th-century Spain," in *Paradigms and Mathematics* (Zaragoza: Siglo XXI, 1996), 237-264.

In 1919 Gino Loria, on reporting of mathematics in Spain,²⁶ alluded to three Spanish mathematicians –namely, Echegaray, Torroja, and Galdeano– as the *seeders* of modernization. Let us have a look at the role of these individuals in this story.

José Echegaray y Eizaguirre (1833-1916), an engineer, a politician, a writer, and a mathematician, is a very singular case among those who contributed to bring mathematics in Spain into the international mainstream. He studied mathematics in Madrid and became a civil engineer. After a short period of professional exercise, he taught mathematics at the Civil Engineering School until 1868. Two years before, in 1866, he had entered the Royal Academy of Exact, Physical and Natural Sciences of Madrid with a famous lecture on the history of pure mathematics in Spain. He had an intense political life as a staunch supporter of free-trade: he became a member of parliament with the 1868 Revolution and occupied several important posts in the monarchic administrations (1871-73) of the revolutionary six-year period (1868-74), including that of minister on several occasions –again after General Pavía's coup d'état in 1874, and again in 1904; in the meanwhile –during the First Republic (1873-74), he went into exile in Paris. In 1896 he entered the Spanish Academy and in 1904 he received the Nobel Prize for Literature. He was appointed President of the Council of Public Education in 1904, and of the

²⁶ Gino Loria, "Le matematiche in Ispagna ieri ed oggi. I matematici moderni," *Scientia* 25 (1919): 441-449.

Mathematics Section of the *Junta para Ampliación de Estudios e Investigaciones Científicas* (JAE, Board of Scientific Research) in 1907. He was also a founding member and the first President of the Spanish Mathematical Society. He wrote scientific articles for *El Imparcial*, *Revista Contemporánea*, *Ilustraciones Española y Americana*, *Diario de la Marina de la Habana*, *El Liberal* and other newspapers and magazines, as well as book and articles on mathematics and mathematical physics. In Spain, his position as a civil engineer, a successful playwright, a remarkable orator, and an influential moderate politician gave him a corporate, professional and social recognition which none else of his time had. In this sense, Echegaray was, for decades, the clearest reference of the taste for mathematics, whose knowledge he valued highly: "Time was when every cultured person knew Latin. Time will come –and it is not very far off– when every cultured person will have to know mathematics!".²⁷ His social prestige and influence meant that, in his time, nobody in the field of science –not so in the case of literature– dared to make even the slightest criticism of him, although from a more distant historic perspective it can be seen that Echegaray, despite his unquestionable merits, was not very aware of the changes which were taking place and already characterized the new mathematics. In spite of this fact, his favorable position towards extending mathematics and

²⁷ José Echegaray, "La Escuela Especial de Ingenieros de Caminos, Canales y Puertos y las Ciencias Matemáticas," *Revista de Obras Públicas* 44 (1897): 2.

"Hubo un tiempo en que toda persona culta sabía latín. ¡Tiempo llegará –y no está muy lejano– en que toda persona culta deba saber matemáticas!"

recommending its learning in order to practice technical professions represented a vitalizing injection of optimism to consolidate the mathematical community.

Another significant personality is Eduardo Torroja Caballé (1845-1918), the starter of a saga of scientists and technologists of outstanding presence and enormous relevance in the history of 20th-century Spain –mainly during Franco's period. He was a professor of Geometry at the Central University of Madrid and the introducer in Spain of the work of Staudt. He became very influential inside and outside the mathematical community as head of the Madrid clan devoted to geometry –especially projective geometry– in a rather obsolete way of development;²⁸ since 1876, when Torroja took over the second chair of geometry at the University of Madrid, the mathematics faculty evolved around him.

The third main character in the mathematical scene of the end of the 19th century and the beginning of the 20th was Zoel García de Galdeano (1846-1924). By way of mathematical didactics and criticism, García de Galdeano linked the secondary and higher education perspectives, and both these in turn with research tasks. He was the founder of the first Spanish mathematical periodical, the most internationally connected Spanish mathematician of his time –always the Spanish representative in international mathematical

²⁸ Mariano Hormigón and Ana Millán, "Projective Geometry and applications in the second half of the Nineteenth Century," *Archives Internationales d'Histoire des Sciences* 42 (1992): 269-289.

initiatives, such as international congresses– and, due to his deep comprehension of the current mathematical developments, the great importer of modern mathematics to Spain. He devoted the decade of 1880 to algebra,²⁹ the last decade of the 19th century to geometry³⁰ –apart from the journal, and the first decade of the 20th century to mathematical analysis, differential equations and a brief approximation to the theory of numbers. In all these sections the level of modernity of the science written in Spanish was more than acceptable.³¹

The contribution of these three main characters to bring mathematics in Spain into the international mainstream is different in each case. Echegaray represents the social recognition of the Spanish delay in mathematics and of the urgent need to import modern mathematics. Torroja marks the connection to German sources in mathematics –especially geometry–. Finally, Galdeano, apart from being the great importer of modern mathematics to Spain, starts the physical participation of Spanish mathematicians in the international mathematical community.

²⁹ Mariano Hormigón, "García de Galdeano's Work's on Algebra," *Historia Mathematica* 18 (1991): 1-15.

³⁰ Mariano Hormigón, "García de Galdeano y la modernización de la geometría en España," *Dynamis* 3 (1983): 199-229.

³¹ Mariano Hormigón, "Una aproximación a la biografía científica de García de Galdeano," *El Basilisco* 16 (1984): 38-47.

THE FIRST THIRD OF THE 20TH CENTURY

The 20th century begins with the creation of two scientific institutions of capital importance in the process of bringing Spain into line with European standards, the Board of Scientific Research (1907) and the Spanish Association for the Advancement of Science (AEPPC, 1908),³² which in turn gave rise to the Mathematical Laboratory and Seminar (LSM, 1915) and the Spanish Mathematical Society (SME, 1911) respectively. The SME represents, in spite of the host of problems and tensions that mark its evolution during the first third of the 20th century, the stabilization of a centralizing forum, channeling the professional relationships among Spanish mathematicians abroad, and the consolidation of a specialized periodical –the *Revista Matemática Hispano-Americana*– as the most advanced line of Spanish mathematical expression in the international context.³³ The LSM represents the institutional recognition of research as a necessary and sufficient activity for the social justification of mathematicians, and the development of a line of work parallel to research in the field of preparation of secondary education teachers represents a very

³² Elena Ausejo, *Por la Ciencia y por la Patria: la institucionalización científica en España en el primer tercio del siglo XX*. Zaragoza: Siglo XXI, 1993.

³³ Elena Ausejo and Ana Millán, "The Spanish Mathematical Society and its periodicals in the first third of the 20th century," in *Messengers of Mathematics: European Mathematical Journals 1800-1946* (Zaragoza: Siglo XXI, 1993), 159-187.

peculiar and idiosyncratic execution of the dual teaching and research imperative, which characterizes the modern mathematical profession.³⁴

Nevertheless, it is worth mentioning that although both initiatives are of fundamental importance in the institutionalization and professionalization process of the Spanish mathematical community, they also offer a true reflection of the problems associated with these processes.

The Board of Scientific Research was founded as the coordinating institution for research: consisting of laboratories for the different disciplines and practicing a generous grant policy in Spain and abroad, it attempted to bring Spanish research into line with European standards and to indirectly influence on curricula renewal.³⁵ The balance of this period of Spanish culture and science is so unanimously positive that, following imperial traditions and the scale of precious metals, it is usually referred to as the *Silver Age* in Spain.³⁶ Nevertheless, the JAE was an institution parallel to –very often divergent from– the University, which was not reformed, so that young researchers from the Board did not always have the chance to return the investment made in them

³⁴ Elena Ausejo and Ana Millán, "La organización de la investigación matemática en España en el primer tercio del siglo XX: El Laboratorio y Seminario Matemático de la Junta para Ampliación de Estudios e Investigaciones Científicas (1915-1938)," *LLULL, Revista de la Sociedad Española de Historia de las Ciencias y de las Técnicas* 12(1989): 261-308.

³⁵ 1907-1987. *La Junta para Ampliación de Estudios e Investigaciones Científicas 80 años después*. Madrid: CSIC, 1988.

³⁶ Cajal's Nobel Prize of 1908 –first for science in Spain– shows that something was improving.

above the level of secondary education. As regards specifically the LSM, the strained relationship with the university that marked its existence, is just a clear expression of the difficulties posed by the implementation of the research imperative in the long-established routine that prevailed mainly in the mathematical clan of the Central University of Madrid.

In its turn, the SME shows a hyperconcentration of the activity in Madrid as a result of a national centralist structure which, in the case that concerns us, becomes patent in the exclusive monopoly that the Central University of Madrid holds over granting the doctoral degree (until 1954!), which made the consolidation and development of research groups at provincial universities extremely difficult.

If one accepts belonging to the SME as an unmistakable sign of attachment to the Spanish mathematical community, the Society's List of Members published in the sixth number of the first volume (February 1912) of the *Revista de la Sociedad Matemática Española*³⁷ enables a quantitative approach to the real degree of professionalization of this community, as it included a reference to the professional situation of its members.

The recently created Society had at that time a total of 423 members distributed as follows: 1 protector member (the AEPPC, patron of the SME), 1 honorary member (Gomes Teixeira), 1 corresponding member (Brocard), 7 subscribing members, 54 institutional members and 359 founding members. As regards the

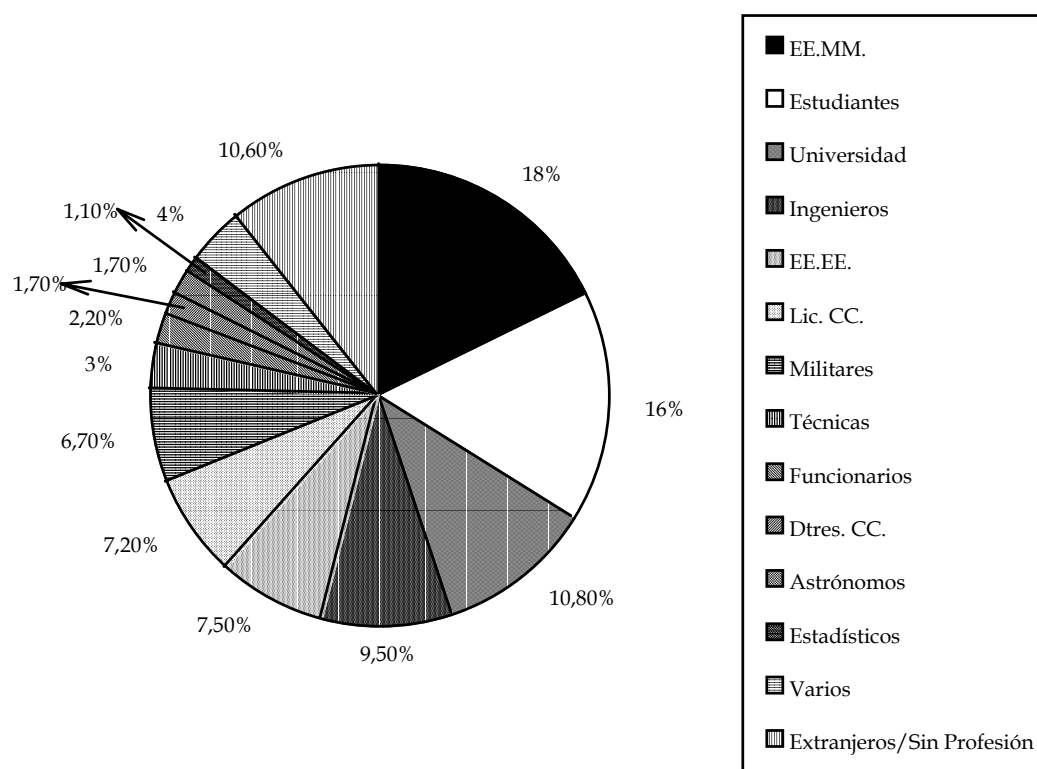
³⁷ pp. 223-233.

359 founders, deducting the 7 foreigners and the 30 whose profession is not given, we can establish the professional profile for the 89.7% of this block (Table 1 and Graph 1).

TABLE 1: SME FOUNDERS 1912

Foreigners (7) / No profession (30)	38	10.3%
Secondary Education Teachers	65	18%
Students	57	16%
University Professors	39	10.8%
Engineers	34	9.5%
High Technical School Teachers	27	7.5%
Science graduates	26	7.2%
Military men	24	6.7%
Technicians	11	3%
Officials	8	2.2%
Ph.D.	6	1.7%
Astronomers	6	1.7%
Statisticians	4	1.1%
Other	14	4%
TOTAL	359	99.7%

GRAPH 1: SME FOUNDERS 1912



This is how the main historical characters defined themselves professionally. The panorama in round numbers would be as follows (Table 2 and Graph 2): 38% teachers, 25% undecided, 18% technicians and 9% miscellaneous (together with 10% foreigners and unknown profession). This classification, debatable in detail like almost all classifications, shows that the Spanish mathematical community was only professionalized according to Prussian standards –that would end up spreading as international ones– up to 56% in the most optimistic case (combining teachers and technicians) –up to 38% in a more strict sense. The second relevant conclusion is that, together with quite a discrete percentage of *amateurs* (9% of other), a quarter of the society appears to be *awaiting a destination*. In fact, together with the students, whose 16% represents

an abnormally high percentage in a specialized scientific society, there is almost 9% of graduates and doctors in science who, it must be assumed, due to the way they define themselves and lacking more information on how professional data were effectively compiled, are unemployed or are employed in a non-scientific job but are interested in –awaiting perhaps– specifying their relationship with science and mathematics.

TABLE 2: SME FOUNDERS 1912

Foreigners / No profession	38	10%
Teachers ⁱ	136	38%
Undecided ⁱⁱ	89	25%
Technicians ⁱⁱⁱ	65	18%
Other ^{iv}	31	9%
TOTAL	359	100%

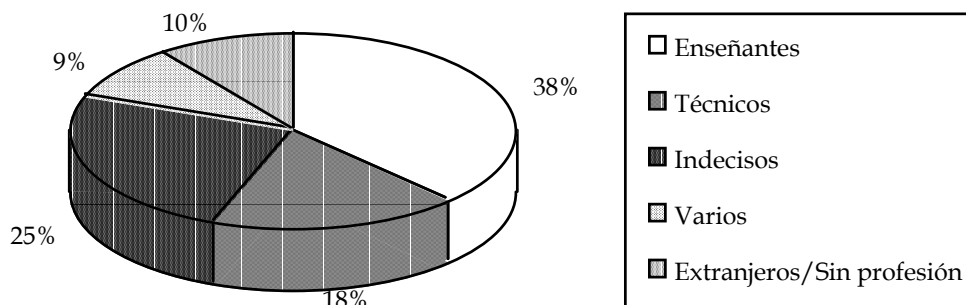
ⁱ 65 secondary education, 39 university, 27 high technical schools, 2 school teachers, 3 mercantile teachers

ⁱⁱ 57 students, 26 science graduates, 6 Ph.D.

ⁱⁱⁱ 34 engineers, 11 technicians, 8 officials, 6 astronomers, 4 statisticians, 1 seaman, 1 employee of the Bank of Spain

^{iv} 24 military men, 2 presbyters, 2 pharmacists, 1 chemist, 1 mechanic, 1 clock-maker

GRAPH 2: SME FOUNDERS 1912



Since the main source of mathematical influence in Spain throughout the 19th century was France, the evolution of the French mathematical community between 1874 and 1914 offers an appropriate term of comparison for these quantitative data. Between 1874 and 1914 the number of teachers in the French Mathematical Society (*Société Mathématique de France*, SMF) increased from 49% to 72%, while engineers decreased from 46% to 23%. More specifically, university teachers increased from 10% to 33% of the SMF (from 20% to 47% of the teachers in the Society), while other categories remained constant in percentage.³⁸ Thus, the professional profile of the Spanish Mathematical Society in 1912 hardly approached that of the French Mathematical Society in 1874.

Another young mathematical society of that period, the American Mathematical Society, offers the example of the evolution of a mathematical

³⁸ Hélène Gispert, *La France mathématique. La société mathématique de France (1870-1914)*, Cahiers d'Histoire et de Philosophie des Sciences, vol. 34 (Paris: Société Française d'Histoire des Sciences et des Techniques / Société Mathématique de France, 1991), pp. 166-167.

community placed in a context of economic power and institutional support inconceivable in Spain. The AMS focussed on research,³⁹ which in Spain was the task of the Mathematical Laboratory and Seminar⁴⁰. In the LSM Italian mathematics were established as a main point of reference for the modernization process of Spanish mathematics, which was organized by sending research students abroad and engaging guest professors from different European universities. The research lines in a first period (1915-20) are focused around projective geometry –which still constituted an international network,⁴¹ mathematical analysis –Hurwitz, Fueter and Polya in Zurich are the international references in this subject– and nomography and numerical analysis –which represents a timid introduction of Runge in Spain. In a second period (1920-30) the research wheel turns mainly around relativist mechanics and mathematical physics (with Levi-Civita and Weyl as foreign references).

In the analysis of the Mathematical Laboratory and Seminar of the JAE appear 75 individuals related in one way or another with the mathematical activity developed throughout the twenty years that go from 1915 to 1935. Of these, 36 are candidates to secondary teaching –that is, they are preparing the

³⁹ Karen Hunger Parshall and David E. Rowe, *The Emergence of the American Mathematical Research Community, 1876-1900: J. J. Sylvester, Felix Klein, and E. H. Moore*, HMATH, vol. 8 (Providence: American Mathematical Society and London: London Mathematical Society, 1994), pp. 418-419.

⁴⁰ Ausejo and Millán, 1989.

⁴¹ Hormigón and Millán, 1992.

competitive examinations to work in secondary education, 33 appear as researchers and 10 –of whom 4 come from the group of researchers– are mentioned as research directors. 35 of these 75 names appear as authors in Spanish mathematical periodicals. Therefore, it can be said that the Laboratory researchers were producing normal mathematics according to the international standards, nothing can be said against their average yield or the modernity of their mathematical production. However, 35 is such a modest number in terms of human capital –especially when compared with the number of students, graduates and doctors in science belonging to the SME in 1912– that the only possible conclusion is that mathematics was, during the first third of the 20th century, a luxury that the Spanish society could not afford. Maybe this is one big problem for the true internationalization of mathematical knowledge.

CONCLUSION

The source of foreign mathematical influences on Spain evolved from French in the 18th century, to German in the last quarter of the 19th century, and to Italian in the early 20th. Although there were always individuals and even groups of scholars perfectly aware of what was going on in mathematics, the establishment of a Spanish mathematical community –at least at the teaching level, hardly at the research level– happened throughout the 19th century. By the end of that century, the efforts of leaders such as Galdeano, Echegaray, and Torroja achieved the social recognition of the Spanish delay in mathematics and

of the urgent need to import modern mathematics, and started the participation of Spanish mathematicians in the international mathematical community. At the beginning of the 20th century the Spanish mathematical community was large enough to ensure institutionalization, start professionalization, and get involved in the international mainstream. The Spanish Mathematical Society and the Mathematical Laboratory and Seminar of the Council of Research were the two institutions involved in this development, but the low professional profile of the SME, and the low number of mathematicians full-time engaged in research show the kind of social and economic problems that peripheral countries may find on joining the mathematical mainstream.

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