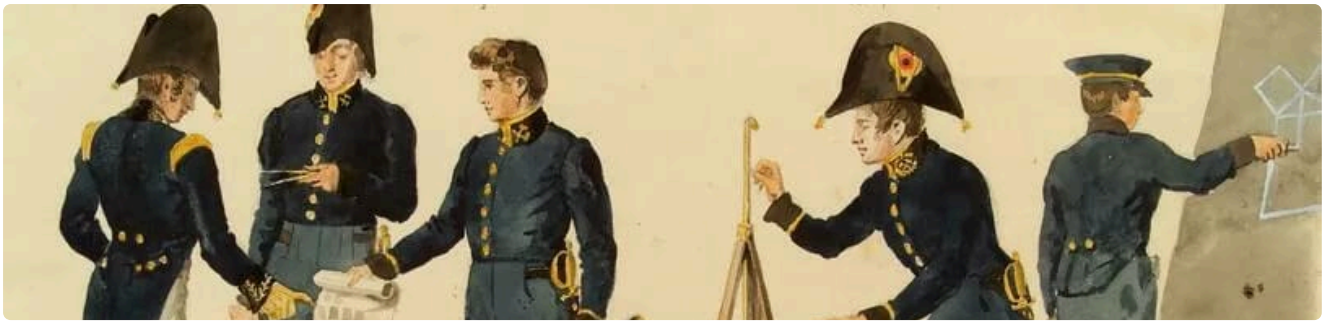
trans atlantic cultures
Cultural Histories of the Atlantic World 18th–21st Centuries

ISSN 2739-6614
transatlantic-cultures.org



The Training of Colombian Engineers in the Nineteenth Century

Bertrand Eychenne

Various transatlantic circulations accompanied the training of Colombian engineers after the country became independent. This article describes the development of these transfers during the nineteenth century, underscores the diversity of the approaches and stakeholders involved, and highlights the emergence of a national self-confidence.

PUBLISHED	May 14, 2023
ORIGINAL LANGUAGE	French
AVAILABLE IN	English, French
TOPICS	Education
SPACES AND PLACES	South America · Europe
PERIODS	Atlantic Revolutions and Colonialism · The Steam Atlantic
KEYWORDS	latin-america, learned-culture, education, sciences-and-techniques
PERMANENT LINK	https://transatlantic-cultures.org/en/records/la-formation-des-ingenieurs-colombiens-au-xixe-siecle/

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Colombia faced several major challenges after it became independent in 1819. The new republic's first governments had to bolster the country's political and economic self-sufficiency, safeguard its cohesiveness and ensure its material development. Building means of communication and exploiting natural resources became critical issues. In 1823, Secretary of the Interior José Manuel Restrepo bemoaned the poor conditions of the country's roads and bitterly noted that its national budget would be too small to build roads and bridges, "at least for several years". [1] At the same time, the congress approved a foreign scientific mission and recognized that Colombia's natural riches "are vital to the progress of its agriculture, arts and commerce, the wellsprings of the people's" happiness. [2] The speech's utilitarianist accents underscore the links that the government established between material development and national construction. But as it was unable to afford the cost of building infrastructure, it turned to private investors and focused on education and the dissemination of "useful sciences". However, several obstacles hindered the training of engineers, technicians and scientists, namely, the lack of teachers, books and equipment; political unrest; a weak education system and economy; and above all, meager public finances.

It took nearly three decades for the government of Colombia (known as New Grenada between 1830 and 1858) to set up a stable system for training civil and army engineers. It did so by founding the Colegio Militar (Military College) in 1848. This article will highlight the connections that appeared between the training and professionalization of Colombian engineers in the nineteenth century and transatlantic circulations. Colombia's postcolonial and South American context allows us to approach the question of the circulation of scientific and technical knowledge with a decentered perspective that invites us to depart from the classic schemes of historiography.

First, we will discuss how the plan to exploit natural resources and train mining engineers was based on European models. Then, we will see how the Colegio Militar and its evolution set into motion the circulation of men and complex, varied forms of knowledge. Lastly, we will analyze how the formation of a Colombian engineers' professional association led to a questioning of foreign models and the emergence of a national science and civil engineering program.

The *Museo* and the Bogota Mining School (1823-1835)

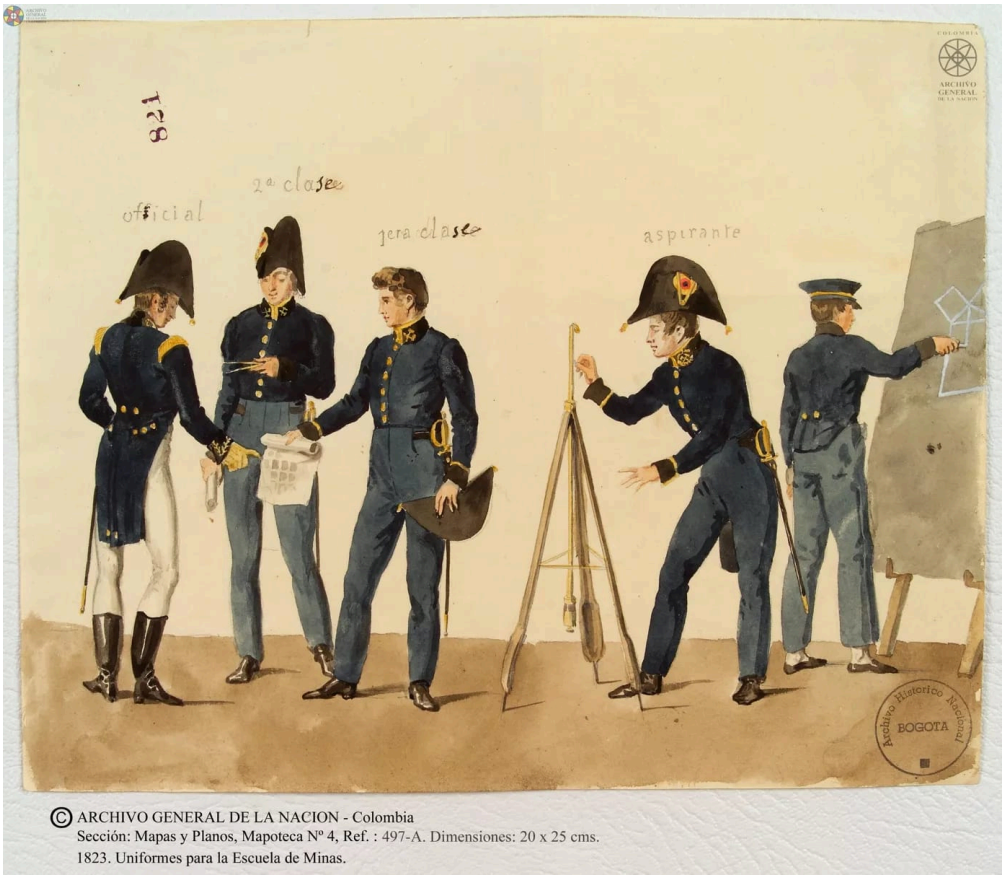
In 1819, President Simon Bolivar gave Francisco Antonio Zea (1766-1822) full powers to contract a national loan in Europe. The main purpose was to pay back the debts incurred during the war of independence, but Bolivar added that Colombia also had to "revive agriculture and the mining industry and unlock once and for all the endless sources of public wealth in a country so extraordinarily gifted by nature." [3] The goal was to lay the groundwork of a government plan that would replenish public coffers and boost the economy by reviving the exploitation of natural resources. Zea's mission included recruiting scientists in Europe to participate in a scientific expedition in Colombia. The project had three aims: mapping the republic, setting up a mining school and building a natural history museum in Bogota.

A botanist, Zea was a former member of the New Grenada expedition and director of the Madrid Botanical Garden who leveraged his connections, especially in Paris, to recruit scientists. In May 1822, the emissary wrote to the Muséum d'histoire naturelle and Georges Cuvier (1769-1832), then president of the Académie des Sciences, about his plan "to send from France to Colombia men capable of founding institutions in our country dedicated to the study of natural history; men who, after putting my compatriots on the road to useful knowledge and returning to Europe, can boast of having left long memories of esteem and gratitude for the French Nation in the New World." [4] However, his first two recruits were fellow Americans. José Maria Lanz y Zaldívar (1764-1839) was an engineer and mathematician from New Spain, the future

Mexico, who had graduated from the Cadiz Naval Guards School in Spain. Zea asked him to draw a map of Colombia. A Peruvian, Mariano Eduardo Rivero y Ustariz (1798-1857), who had studied at the École des mines and the Muséum d'histoire naturelle in Paris, was tasked with founding and heading a mining school in Bogota. Zea cajoled the French scientists with the prospect of advantages if they heeded his call. Relying on connections in private as well as institutional circles, he recruited Jean-Baptiste Boussingault (1801-1887), a recent graduate of the École des mines in Saint-Étienne, physicist Jacques Bourdon (1791-c. 1859), physiologist François-Désiré Roulin (1796-1874) and naturalist Justin Marie Goudot (?-c. 1849) to teach at the mining school and museum in Bogota.

The scientists were expected to found institutions based on the École des Mines and the Muséum d'histoire naturelle in Paris. Zea was especially interested in adopting various features that he had studied during his 1802 stay in the French capital. For example, like its Paris counterpart, the Colombian mining school (*Escuela de minas*), established in 1823, offered a two-year program focusing on the same subjects (mineralogy, geology, docimasy, mining and mineralurgy), to which mathematics were added. As in France, the students received three ranks depending on the year of study, starting with first class before moving up to second class and aspirant, and the rank of mining officer upon graduation. Roulin's watercolor of their uniforms shows that they were based on those of the École des mines as well. The *Museo* not only had to house collections but also provide public education in various fields of science. Its program and aims were similar to those of the Muséum d'histoire naturelle in Paris, where several members of the Zea expedition had studied (namely, Rivero, Goudot, and Bourdon).

However, not only were all these measures difficult to implement, but they also failed to achieve the expected results. The *Escuela de minas* opened as scheduled on January 2, 1824 but stopped functioning after two years. The *Museo* did not fare much better. Its courses were interrupted several times and limited to just a few subjects. Nevertheless, teaching continued until the 1830s. While the results missed the mark, it is worth taking into consideration that the *Museo* included several entities: a natural history museum, a chemistry laboratory, an astronomy observatory and a botanical garden. This concentration of institutions was a milestone that encouraged political elites to go even further.



Uniforms of the Escuela de minas, attributed to François-Désiré Roulin, 1823

Source: AGN, SMP.4, Ref.497A

The creation of the Museo and the Escuela de minas by a foreign scientific mission highlights the circulation of science and technology between Europe and Latin America. Various players were involved, including French, Mexican and Peruvian scientists, go-betweens like botanist-diplomat Zea, and famous scholars such as Cuvier and Alexander von Humboldt (1769-1859), who gave the travelers instructions on the observations to be made, the measurements to be taken and the objects to be collected. For example, Cuvier expected to receive specimens for the Muséum d'histoire naturelle and Humboldt asked for some measurements he needed to publish his *Voyage aux régions équinoxiales du nouveau Continent*. The Prussian explorer, geographer and naturalist even tried to influence the scientific mission by sending Bolivar a letter in which he offered to hire Boussingault to write a geological description of the country, measure the barometric leveling of the Isthmus of Panama and rectify maps that he himself had helped to draw. These experts, while remaining in Paris, sought to leverage their role as go-betweens to carry out personal scientific research or enhance their institutional standing.

Another type of exchange involved in Zea's mission was the importation to Colombia of scientific materials that were still scarce in the country in the early nineteenth century: scientific, surveying and taxidermy instruments, a chemistry laboratory and mineral collections. It cost between 25 and 30,000 pounds sterling to equip the mission.

Lastly, in addition to fulfilling their commitments to the Colombian government, the expedition's members undertook various personal scientific research projects that led to correspondence with European experts, followed up by the sending of samples and, sometimes, submissions of papers to institutions such as the Académie des sciences in Paris or to specialized journals. For example, when Rivero and Boussingault found a meteorite at Santa Rosa in 1823, they immediately sent a sample to

Humboldt through a Colombian trader. The discovery was announced at the Académie des sciences in Paris on October 20 and a paper was published in Bogota at almost the same time: *Memoria sobre diferentes masas de hierro encontradas en la cordillera oriental de los Andes*. The article was translated into French and published in 1824 in the *Annales des mines* and *Annales de chimie et de physique*. [5] A summary appeared in English in *The Quarterly Journal of Science* [6] and in German in the *Annalen der Physik de Leipzig*. [7] In 1849, the paper appeared in Spanish in a book published in Paris by Colombian Joaquín Acosta (1800-1852), who had studied science in France. Acosta wanted the text to return to New Grenada, to publicize Boussingault and Roulin's discoveries in country where they had been made. In the introduction, he wrote, "Few Grenadians, Venezuelans and Ecuadorians have had the opportunity to read about them even though they are of the utmost interest for the development of our common homeland's resources and the dissemination of science". [8] Acosta made his own contribution by introducing basic concepts about geology for the understanding of the scientific text and adding specifics and corrections in many footnotes.

Zea's scientific mission demonstrates that knowledge moved in different directions. The Colombian government took inspiration from European models and called for foreign experts to disseminate scientific knowledge and develop the exploitation of natural resources. In return, the South American country offered European institutions and scientists a field of observation, collection, and experimentation that nurtured their research.

The training of engineers at the Colegio Militar in Bogota (1848-1884)

In 1848, the government of New Grenada created the Colegio Militar, an institution that played a key part in training Colombian engineers in the nineteenth century. The school was originally designed as a military academy to train officers in the different arms, meeting a longstanding request from secretaries of war who since 1833 had been pleading for the state to become involved in military instruction. The training of civil engineers was added to the objectives of the Colegio Militar only after the bill had been debated and passed. This process shows that the project was adapted to different expectations: the need to train military and civilian engineers, but also to concentrate resources as an economic measure.

Although historians may have occasionally mentioned that the school was based on a similar model to the École polytechnique in Paris or West Point, this was not the case. Shortly after independence, Colombian leaders learned about various kinds of foreign educational institutions. They visited European and North American schools when they had the chance, as did Santander around 1830. In addition, they asked their diplomats for the purchase of teaching materials, the recruitment of foreign teachers, and reports on educational institutions. But the quest for information was not limited to countries located far away from the major centers of scientific learning. European and North American officials did the same thing. The multiplication of sources of information about education meant that they did not necessarily seek to import a particular model but rather, as Victor Cousin wrote, "to borrow what is good everywhere and improve it by appropriating it". [9]

Research on the creation of the Colegio Militar shows that the approach was different from the one chosen for the Escuela de Minas and did not aim to replicate the structure or curriculum of an already existing institution in Bogota. While Colombian elites sometimes drew similarities between the Colegio Militar and

prestigious institutions, as Secretary of War Tomas Herrera did in 1851 in relation to West Point, this was a rhetorical argument used to enhance the government-supported school's legitimacy rather than to single out a model.

In fact, the Colegio Militar was different from other institutions of the same kind, such as the École Polytechnique, to which it could have been compared. First, it offered both military and civilian training and echoed the utilitarianism of English philosopher Jeremy Bentham (1748-1832), which prescribed that an action is right if it promotes happiness, and that the greatest happiness of the greatest number of people should be the guiding principle of conduct. Moreover, and unlike the prestigious French school, the institution's curriculum included preparatory, general, and applied courses. In addition, applicants did not have to take an entrance examination, which limited the selection process, so that as many students as possible could complete the program.

While the Colegio Militar was not based on any particular model, knowledge circulated and received multiple and heterogeneous influences, mostly from the teachers: Except for military law, all the courses were taught by foreign professors or Colombians trained abroad.

Teachers were recruited in various ways. Some were directly hired in Bogota in circles close to the government, including politician Lino de Pombo (1797-1862), a Spanish-trained former army engineer who co-founded the Colegio Militar as a senator before teaching mathematics there, and Scottish-born officer Santiago Fraser (1800-1878), who had fought in the war of independence and was in charge of military instruction. Two were recruited outside Colombia but from South American countries: Italian-born military geographer Augustino Codazzi (1793-1859), who taught practical geometry and was the inspector in charge of discipline at the Colegio Militar, and a young Venezuelan officer trained at the Academia de matemáticas in Caracas, Miguel Bracho, who taught drawing and the preparatory class. Both were personally recruited in Caracas by the President of New Grenada, Tomas Cipriano de Mosquera (1798-1878). Lastly, the government had mathematics professor Aimé Bergeron (1816- ?) brought over from France to complement scientific instruction.

Bergeron's story sheds light on the process of recruiting teachers in Europe and the personal motives that may have led some of them to sail for the New World. For Bergeron, who held a doctorate in science from the Université de Montpellier, a stalled career seems to have been a decisive factor. He tried for several years to take the teaching exam in order to obtain a position in the South of France but administrative roadblocks and constant changes to official texts thwarted his plans. Bergeron turned to his member of parliament, Léonce Guilhaud de Lavergne (1809-1880), for help. Lavergne, a senior civil servant at the Ministry for American and West Indian Affairs, seems to have put him in contact with New Granada's government. The French consul in New Grenada, trader Édouard Gardère, met Bergeron and, after they agreed on conditions, he notified New Grenadian government representative Manuel María de Mosquera (President Mosquera's brother), who eventually signed the hiring contract with the teacher and organized his departure. Thus, it turns out that various go-betweens were involved in the process of recruiting foreign teachers. While not scientists themselves, they also contributed to the circulation of knowledge.

During the creation of the Colegio Militar, teachers trained abroad strongly influenced the curriculum. The institutional framework and control by the executive branch gave them some leeway to spell out the details of the subjects in the program of studies, and the courses they set up later served as a springboard for subsequent reforms.

Analyzing the professors' lectures can therefore shed some light on how the circulation of knowledge influenced the training provided by the Colegio Militar. Different approaches can be distinguished. Some teachers drew inspiration from their own training, such as Lino de Pombo at the Spanish academy, but they could also use course notes or lithographed versions, such as those of Charles Sturm's differential calculus course at the École Polytechnique, which Bergeron repeated word for word. Others used published treatises. French texts dominated the field for two reasons: first, the renown of certain authors—Pombo spoke of "the French school, which has produced great masters in the sciences" [10] — and second, the high number of treatises and textbooks published in France. However, there were also Spanish texts (Zorraquín, Vallejo) and, later, North American ones (Davies, Smith). Here again, sources were used in different ways. Some teachers went by the books, as Bergeron did for differential calculus, or adapted them by selecting passages (Bergeron took certain chapters from Arthur Morin's treatise for the mechanics course). Others, like Pombo in his analytical geometry course, preferred using different sources and designing their own lessons. Lastly, to make up for the lack of scientific texts in New Grenada, teachers at the Colegio Militar published their own courses, contributing to the local supply and dissemination of scientific knowledge.

In 1854, a coup shut down the Colegio Militar, which remained closed until 1866 but could resume its curriculum only when it became part of the Universidad Nacional in 1868. The radical government established this large university as part of its policy to centralize higher education, with the aim of promoting the country's development and strengthening its national cohesiveness, which had been weakened by federalism and regional tensions. In the same spirit as the Museo in Bogota, the new institution concentrated various resources: six schools (literature, philosophy, law, medicine, the natural sciences and engineering), a museum, an astronomy observatory, a botanical garden, a chemistry laboratory and two hospitals. At first, the Colegio Militar, which became the Escuela de Ingenieria (engineering school), consolidated its curriculum. The teachers, most of them alumni, taught the same courses they had taken in the 1850s. But some gradually tried to introduce the experience they had acquired as practicing civil engineers, most of them through contact with their foreign counterparts. In the early 1870s, the Colombian government drew up a development plan while recognizing its inability to undertake major infrastructure projects. It consequently turned to foreign investors such as the London-based Public Works Construction Company Limited, which won a contract to build a railway line between Bogota and Magdalena. The agreement signed with the government required the British company to hire young Colombians trained at the Colegio Militar as assistants of the English engineers on the ground. Among them was Manuel H. Peña (1836-1900), who reinvested his experience in the practical geometry courses he gave at the engineering school. Peña took inspiration from Pombo's lessons and European treatises; but he believed that the latter were not suited to surveying in Colombia. Drawing on his personal experience, he introduced error estimation procedures that he believed better fit the local geographic and cultural context.

After the 1876 civil war, the engineering school was separated from the university. Driven by Rafael Nuñez's (1825-1894) ideology of "regeneración", the government advocated a return to a strong executive branch and a stronger national defense. The Colegio Militar became independent from the university again and, under the guidance of two West Point instructors, Thomas Brainard Nichols (1848-1902) and Henry Rowan Lemly (1851-1925), it resumed a key role in the training of officers. The cadets practiced daily military drills based on the North American model and participated in parades and public celebrations. But foreign officers also influenced the transmission of values and behavior. In 1881, the school adopted house rules based on those of West Point as well as that institution's grey uniform. The United States

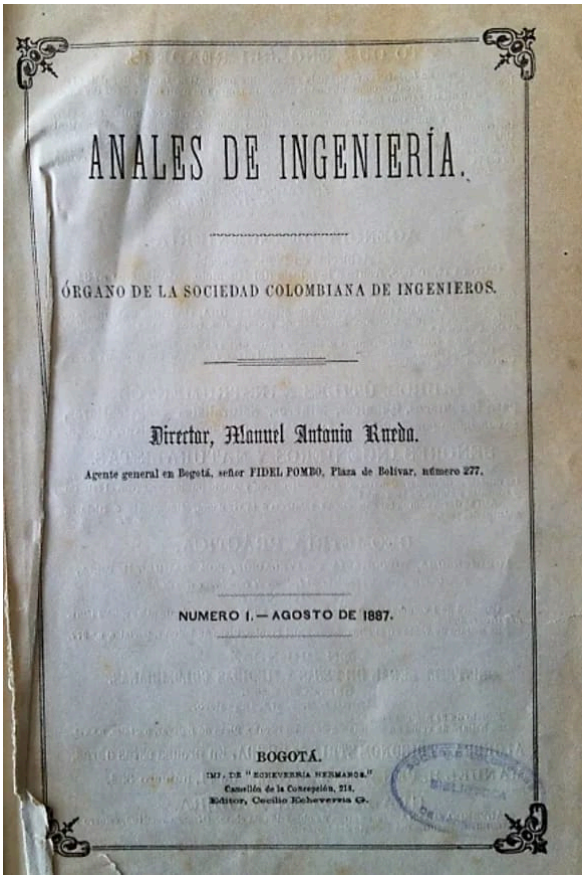
military academy's influence spread beyond the Colegio Militar: In 1882, Lemly's translation of Emory Upton's (1839-1881) book on infantry tactics and demonstrations by the school's cadets led to the adoption of West Point's military code by the entire Colombian army. Lemly, who served as director of the Colegio Militar twice, also acted as an intermediary between the secretary of war and a North American company for the procurement of weapons in the United States.

The professional recognition of Colombian civil engineers

In the 1880s, Colombian engineers felt the need to join forces to increase their professional prospects and obtain recognition from the government and society as a whole. The executive branch, instead of keeping its promise, made in 1847 when the Colegio Militar was founded, systematically preferred to employ foreign engineers rather than the school's graduates. In 1887, engineer Abelardo Ramos (1852-1906) wrote that "the railroads built with the Republic's money have been the exclusive domain of foreign citizens". [11] Ramos explained the lack of confidence in the skills of Colombian engineers by "the spirit of routine and sectarianism" that, according to him, dominated the country along with the belief that "everything that is industrial and scientific must come from abroad, like matches and scented soap." [12]

On May 29, 1887, Ramos and a handful of colleagues, most of them from the Colegio Militar, founded the Sociedad Colombiana de Ingenieros. To broaden the circle of its membership, they stated three goals: to defend the interests of Colombian engineers, promote pure and applied mathematics, and study material improvements. Part guild and part learned society, the organization had two main purposes: to play an institutional role as a "consultative tribunal" of engineering works and to circulate scientific knowledge.

To strengthen its action, the society published the *Anales de Ingeniería*, whose goal was to promote professional recognition, spread scientific knowledge and civil engineering practices, and attract foreign investment to Colombia. The journal's 500 copies were distributed in the country to the society's hundred or so members and a few individual subscribers, but above all it crossed borders thanks to a system of exchanges (*canjes*) with other publications. By 1895, relations had been established with 50 Colombian newspapers and over 80 foreign publications in Spain, France, the United States and thirteen Latin American countries (69% of the copies sent abroad). Their number draws attention to the continent-wide exchanges that have sometimes been underestimated.



The first issue of *Anales de Ingeniería*, August de 1887

Source: Órgano de Comunicación de la Sociedad Colombina de Ingenieros, Bogotá

The *Anales de Ingeniería* was a place where Colombian engineers could share their experiences and exchange information. The challenges they reported were numerous. First, the lack of appeal of scientific studies made engineering less visible in the eyes of society. Second, there was not enough funding to procure the necessary equipment and undertake projects. Third, Colombian engineers had to cope with arduous geographic conditions (rugged terrain, the tropical climate, diseases) and manage relationships with both clients and contractors. But the main hurdle was competition from foreign counterparts.

This issue gradually led the society's members to distrust foreign influences and view them with a more critical eye. Ramos, the head of the society, insisted that Colombian engineers had to develop their own ways of working, as these would be better suited to the national context. His message appealed to his colleagues' patriotism and played on their frustration with foreign competition to get them to change their ways:

> *"Colombian engineers! We must dedicate ourselves to applying and [...] adapting engineering to our country's own needs by ensuring that each particular case is studied and solved in the country itself without resorting, on every occasion, to foreign resources, inventions or systems. Otherwise, we will never move forward in our worthy profession."* [16]

Ramos called on his colleagues not only to organize a form of resistance to outside influences, but also to go beyond occasional adaptations and empirical innovations to lay the groundwork for a reasoned practice of civil engineering in accordance with the country's needs and natural resources. He discussed the need to establish a national scientific program as being part of the natural evolution of states. "The first task of any country setting out on the path to intellectual independence," he wrote," is to train its own school, to apply the general science to which all nations contribute to the study of regional phenomena and knowledge of the country's own characteristic conditions; in other words, to construct a national science." [13] For Ramos, Colombians had to change their very idea of science: "Today our science is made up of copies or compilations. We learn and repeat what others have thought or done instead of finding our own solutions. This lack of originality in our aspirations and methods is undoubtedly responsible for the malaise afflicting us." [14] That malaise was attributable not only to the lack of recognition from the state and society, but also to how the profession was practiced and to an attitude towards outside influence. The engineering society's leaders hoped that an awareness of the latter would bring about a change in mindsets and in the practice of science and technology.

This change did not mean rejecting outside influences altogether, but changing the attitude of Colombian engineers towards them. It was hard to develop hands-on training in Colombia, therefore many of them studied abroad to gain experience. Some, such as Peña and González Vásquez (1839-1910), chose to study in Europe while others, like Ramos, went to the United States, which in their eyes better embodied the practical ideal. In his 1885 report on the Santander railway, Ramos wrote:

> *"The Universidad Nacional and the Colegio Militar have granted engineering degrees to many bright, active and patriotic young people who possess all the skills they need to exercise their profession. Theoretical studies, which in these institutions are taught with French, German and North American textbooks, prepare students for the profession rather well, especially if they are followed by a tour of the United States, a country that has built and owns half of the world's railways, and which is essentially practical."* [17]

In 1887, the issue of practical training triggered a debate echoed by the *Anales de Ingeniería*. In 1884, the Colegio Militar was divided into two schools, one military, the other dedicated to science and civil engineering, which was reintegrated into the Universidad Nacional as the Facultad de Ciencias matemáticas. Two Colegio Militar graduates, Miguel Triana (1859-1931) and Manuel Antonio Rueda (1858-1907), disagreed on the curriculum. Triana wanted to strengthen practical training and limit theoretical studies. Rueda argued that mathematics, which he taught at the university, should take precedence over engineering. "Science commands and art obeys," he said. [15] In 1888, the government sided with Rueda by adopting a curriculum where practical training was spread out over three years like a supplement after two initial years of mathematics. This program was an improvement on Triana's position by limiting the mathematics program and strengthening applied training.

Conclusion

The challenges of training Colombian engineers after the country became independent led successive governments to take different approaches that addressed transatlantic circulations in their complexity. The players they involved were on three different continents (South America, Europe, North America) and had various motivations and profiles, as scientists, teachers, diplomats, traders, engineers. The sources,

the content of the exchanges in which they participated and their adaptations on both sides of the Atlantic were just as diverse, ranging from scientific and technical knowledge to field practices, instruments, books, scholarly journals, natural resources, and financial investments.

Studying these circulations in connection with the training and professional recognition of Colombian engineers highlights a shared historicity. Attempts to import foreign models quickly gave way to the adaptation of various sources to political, economic and social contexts. Then, the implementation of a national engineering training program and the emergence of a professional organization led to the dissemination of original scientific and technical knowledge based on a local practice of engineering. Critiques of outside influences led to an emphasis on local specificities and the search for a national scientific program that guided exchanges towards developing practice.

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