

Engineers in Mexico: Crear y Servir la Patria (Part I)

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Introduction

During a recent engineering accreditation visit in Mexico, one evaluator read through the engineering curriculum submitted by the institution under evaluation and exclaimed: “These courses are not engineering sciences! These are applied engineering courses! Only if it has mathematics, a course can be counted as engineering science.” While reading the section related to faculty experience, she said: “Can you believe this? They are trying to equate 20 years of industrial experience with a graduate degree in engineering...” Later that week, I interviewed the director of an engineering alumni association of engineers. In his mid 20s and looking very managerial (reading his email on a Dell laptop, two cell phones on his desk, electronic agenda...) he confessed that he almost broke family tradition by attending Monterrey Tech instead of studying engineering at UNAM. Most of his upper-class high school friends were going to pursue well-paid careers in the private sector after attending Tech. He was seduced by this career path and enrolled at Monterrey Tech in spite of a long family tradition of civil engineers that worked building public infrastructure projects in Mexico. Succumbing to the powerful image of the engineer as a builder of Mexico, represented in his father, our young engineer transferred to UNAM after only one year at Tech. “Engineering at UNAM has more math, physics, chemistry,” he said. “At UNAM you have labs...you get a larger picture of your country...you can work better for your country...At Tech you just go to industry.”

What is going on here? Could it be that the institution requesting the accreditation mislabeled their engineering courses and hoped that evaluators would not notice the difference between 20 years of industrial experience and a graduate degree in faculty credentials? Could it be that our young engineer flunked out of Monterrey Tech and had no other place to go but UNAM? Or could it be that throughout the history of Mexico as a nation-state different meanings

of what an engineer is and what constitutes engineering knowledge have emerged, hence creating the tensions described above?

This paper traces the development of engineering education and practice throughout the history of Mexico as a nation-state, from Independence to post WWII, to show the emergence of three sharply different engineering education institutions, curricula, and expectations of how graduates should serve their country. These are not the only institutions in Mexico that educate engineers but have been, and continue to be, the most influential in the development of Mexico's private and public sectors.

Building state-strength for Spain: Engineers at the Real Seminario de Minas

In late 18th century, the strength of the state was greatly measured by the measurement, exploitation, processing, and graphic display of its natural wealth, particularly metals. (Nikolow, 2001) "The mining of gold and silver, besides copper, lead, zinc, nickel, and bismuth, supplied ores for the mint of war, on which the national states founded their power and wealth." **(Brianta, 2000)** To rationally organize the exploitation and treatment of minerals and metals in Nueva Espana, Carlos III, King of Spain, created an administrative framework -- Real Tribunal de Minería – in 1783. This tribunal collected taxes from noble Spaniards who received mining concessions from the Crown, channeled the mining wealth to the Spanish Crown, resolved disputes in mining operations, and supported a school of mines. Other European states, some of them military enemies of Spain, had rationalized mining, particularly through institutions for the creation, dissemination, and application of knowledge to the exploitation and processing of metals. Among these institutions were the mining schools at Freiberg (1765), Schemnitz, Hungary (1770), Berlin (1770), St Petersburg (1773), Almaden, Spain (1777) and France (1783). **(Brianta, 2000)** For Spain, the need for silver to sustain the administration of its State, monarchy, and continental wars was paramount. Wars with England (1779-83, 1796-1802, 1805-08) and

with France (1793-95) increased Spain's need for productive and efficient silver mining in Nueva Espana.

On July 2, 1788, Fausto de Elhuyar sailed from Spain to Mexico to become director of the Real Seminario de Minas. Carlos III gave Eluyar this mission after realizing that the potential for mining exploitation resided in Nueva Espana, not in Spain. Elhuyar took with him Prussian, Austrian, and Spanish professors trained in mining techniques in Germany. (Ponds, p. 24)

Opening its doors in 1792, the school had a secular administration and teaching. In the interest of the State, religious orders were kept out of the school's organization and teaching so ideas and books could circulate freely to facilitate knowledge discovery, dissemination, and expediency that the needs of Spain demanded. (p. 27)(Diaz y De Ovando, 1998) ¹

The curriculum included a first year of mathematics (arithmetic, algebra, geometry, trigonometry, and conic sections), a second year of applied geometry (subterranean geometry, dynamics, and hydrodynamics), a third year of mineral chemistry, mineralogy, and metallurgy (including labs), and a fourth year of physics, subterranean chemistry, and mining techniques, from surveying to extraction techniques. Drafting and French were spread throughout (Pons p. 18) Students and faculty studied from books by French mathematicians, scientists, and military engineers, e.g., Lavoisier's Chemistry, and Belidor's Science for Engineers, and by German chemists and metallurgists (Ponds 26, 27). Theory from France and mining techniques from Germany were at the heart of the curriculum.

Social origins of the students

The Seminario depended entirely for its funding on the money that the Real Tribunal de Minería collected from mining concessions. Proximity to the main source of wealth for the Spanish

¹ However, radical views on the origin of the earth, which often came accompanied by enlightened views on human rights and liberty and questionings of church and royal authority, were kept in check by the Holy Inquisition. (p. 143)(Diaz y De Ovando, 1998)

Crown brought the school close to top-levels of state bureaucracy and viceroyalty. Its facilities were used by visible public events. Award ceremonies and public examinations were often attended by bureaucrats and noblemen. High-level nobility and 'criollo' aristocracy often requested to Elhuyar that their children be admitted and given scholarships (Diaz y De Ovando, 1998) (p. 71) Belonging to the 'Colegio Metalico', as was known by the press of the time, was a big deal. Around 25 students gained admission every year and were paid by the Spanish Crown to become *ingenieros de minas* and research and manage the mines. Initially, admission was limited to Spaniards and white criollos (sons of Spaniards born in Mexico).²

Before Independence, the social hierarchy of mining engineering was well established: noble Spaniards in control of institutions; criollos blancos as students; few criollos mestizos serving as instructors in the classroom and, when needed, as foremen in the mines; indians worked the mines. Graduates of the school became directors of operations in the main mining areas in Mexico, such as Zacatecas, Guanajuato, San Luis Potosi, and other Spanish colonies such as Peru, Buenos Aires, Guatemala, Quito, and Chile. As enrollment grew and European professors retired, top graduates became instructors at the Seminario.

In 1803, Alexander Von Humboldt --graduate of the Freiberg Academy of Mines, mining inspector of Franconia (Prussia), and later in his life science advisor to Frederic William III, King of Prussia -- visited Mexico and taught in the Real Seminario. In his *Political Essay on the Kingdom of Nueva Espana*, Humboldt exalted the quality of scientific teaching and research in Mexico, particularly at the school, stating that the "Real Seminario has nothing to envy of the best schools in Europe." (quoted in (Diaz y De Ovando, 1998) p. 115)

² Admission requirements included a certificate of birth to show legitimacy of parents, signed by the priest and authenticated by a notary; a certificate of baptism as proof of faith (only Catholics were granted admission); official letters from other recognized members of society describing the candidate's decent life style and his familiar relationship to the owner of a mine concession in good standing with the Real Tribunal; and certificate of 'limpieza de sangre' as proof of purity of blood. Mestizos were excluded from admission. (Diaz y De Ovando, 1998) (p. 76, 82) Once Eluyar requested two mestizo instructors from the Academia de San Carlos in drafting and architecture. The Viceroy approved two mestizos and denied one, upsetting the Criollo mestizos.

Building La Patria: Mexican engineers from Independence to the Maximilian Empire

Different from but related to ‘nation’ – a concept related to a common history that unifies inhabitants of a geopolitical unit— ‘patria’ is a concept related to place and includes knowledge of natural resources that serves as pride and inspiration. From 1810 to 1867, Mexican engineers participated directly in the making of La Patria Mexicana by creating, disseminating, and popularizing knowledge of Mexico’s natural resources.

The Real Seminario became the center of creation and repository of the knowledge used to construct a scientific image of Nueva Espana, as separate from, and in many cases superior than, Spain. (Diaz y De Ovando, 1998)(p. 187) In 1807, el *Diario de Mexico* published Humboldt’s geographic and political charts of the Kingdom of Nueva Espana, showing for the first time in a comprehensive manner to the literate public the natural wealth of Nueva Espana. Depicting Mexico as “five times larger than the Iberian Peninsula”, the charts included information on surface area, demographics, agriculture, industry, commerce, mining, and military forces. (Diaz y De Ovando, 1998) (p. 154) In 1808, news from Spain arrived on the abdication of the throne by Carlos IV and Fernando VII to Napoleon. In the same year, *El Diario de Mexico* published an essay written by Andres del Rio, a notable Spaniard scientist and teacher at the Seminario, on the wealth of ferrous metals in Mexico. Del Rio compared the amazing wealth of Nueva Espana with the instability of metal supply in Spain under French rule. Literate criollos and mestizos viewed their territory now in a different light. The king lived in Spain but Spain’s strength lived in Nueva Espana.

The shaping of engineering knowledge in the battle for Independence

After September 16, 1810, news of El Grito de Dolores and the conspiracies of Guanajuato, Queretaro, and Mexico City reached the Real Seminario. By this time many engineering graduates were directing mining operations in places where insurgency was growing. In spite of their noble and ‘clean’ origins, these engineers sided with the independence movement after

experiencing the social conditions of the mines. As Hidalgo marched with his insurgent troops to Guanajuato, he met three engineers who were working in the mines: Casimiro Chovell, Rafael Davalos, and Jose Mariano Jimenez. Hidalgo commissioned these engineers to use their engineering knowledge for 'la causa independentista.' Using his knowledge of and skills in metallurgy, Chovell established the first coinage operation for the Independence cause while Davalos produced cannons for the troops out of chapel bells from Spaniards haciendas. (Pons, p 48). Soon Mexican mineral wealth was named after these engineering national heroes. So "Chovelia" --aluminum silicate—was named after Casimiro Chovell, director of the mine in Valencia, who was hanged from treason to the King. "Valencita" –silver iodide—was named after Isidro Vicente Valencia who, as engineer of the Zacatecas mines, joined Hidalgo in the fighting but later executed by Spanish troops. (Diaz y De Ovando, 1998)(p. 191)

At the Seminario, the struggle for Independence had different effects. The Real Tribunal reacted to the French invasion and threats of independence by canceling Latin and French courses at the Seminario. The viceroy wanted to prevent further diffusion of enlightened ideas, available mostly through French books, and insult the French by prohibiting the teaching of French language in his most prestigious academic institution. Director Eluyar, a staunch loyalist to the Spanish Crown, could not agree with this decision for he understood the value of French in the study of math and science for his engineering students. For Eluyar, to be an engineer meant to understand science and math from French authors, even at the risk of acquiring ideas that threatened the Crown's authority. He argued that the hatred for the French should not be extended to the language that his students needed to become engineers. (Diaz y De Ovando, 1998) (p. 180-83) In 1811, el Real Tribunal, with approval from the Viceroy, ordered engineering students from the Seminario to organize and fight in an royalist army company. (p. 194) To guarantee Elhuyar's unconditional help to organize the students, the Viceroy reinstated French language at the Seminario. (Diaz y De Ovando, 1998)(p. 197)

During the struggle for Independence, political uncertainty and military conflict created an economic crisis for the mines. Apoderados of the mines who contributed financially to the Real Tribunal for the support of the School asked the Viceroy to close the Tribunal and the Seminario due to economic crisis created by the wars of insurrection. The enrollment at the school dropped to an all-time low - 3 to 5 incoming students per year between 1815-1818—and the school had a number of temporary closings. With mining operations diminished during this period, 'Mineros apoderados' questioned the usefulness of the Seminario and the theoretical knowledge and laboratory experiments that graduates learned before reaching the mines. Mineros argued in favor of hiring local apprentices and against expensive graduates of the Seminario. During an audience at the Real Tribunal to discuss the value of the Seminario, Fermin Reygadas, author of important mining works and apoderado of one of Mexico's largest mines, argued that "practical men with simple principles could do more than graduates from the Seminario... A miner with simple instruments and principles has enough science to operate a mine. This principles are not taught in el Seminario but obtained during practice. On the other hand, those protected by the Tribunal [graduates of the Seminario] have unrelated ideas, exotic jargon, and too much pride which makes them detestable to the miners and workers who abandon them." (quoted in (Diaz y De Ovando, 1998) p. 530) Instead of theoretical engineers, regional mineros called for the establishment of regional mining schools with short and practical curricula (Diaz y De Ovando, 1998)(p. 516-17)³

Engineers to serve the interests of their new nation

³ (see quote by Reygadas on p. 528).

On 27 of September, 1821, 11 years after the Grito de Dolores, independence troops entered Mexico City, concluding the Independence struggle with Spain. Elhuyar resigned immediately and went back to Spain while faculty and students took an oath to the Independence movement. In 1822, the Real Seminario changed its name to *Colegio Nacional de Minería*. Its faculty participated in the Congress that wrote the first political constitution of Mexico. Students took an oath to obey new Congress. On 1824, the Act constituting the United States of Mexico and its new Federal Constitution was signed. The Tribunal de Minería was dismantled and the Colegio reported now directly to the President of Mexico who could make decisions on admissions, curricula, faculty and students life. The new constitution also changed the admission requirements for the Colegio, removing nobility and legitimacy of parents as requirement. The new title given to its graduates was "Perito facultativo de Minas."⁴

The new needs of the nation brought changes to programs and curricula, extending them to 5 years in order to include one more year of math (calculus), experimental physics, and the study of English (in addition to French). Interestingly, instead of making the curriculum more practical, the needs of the new nation made it more theoretical, with the exception of the inclusion of English to understand the technological developments of Great Britain. (Diaz y De Ovando, 1998) (p. 618)

From the onset after Independence, engineers acquired a sense of national service. Faculty and students viewed themselves as patriot soldiers at the service of their new nation. At the dismay of students who wanted a military uniform, the President revoked the use of uniform to prevent attacks from army and military engineers from the Colegio Militar who wanted the exclusive privilege to serve Mexico as its soldiers. (Diaz y De Ovando, 1998)(p. 642). During a cholera outbreak in 1833, faculty of the Colegio was commissioned to study possible solutions

⁴ In spite of the difficult fiscal situation of a nascent nation, funds were made available to bring 30 students, 1/3 with full scholarship, 1/3 with half scholarship, 1/3 with one fourth scholarship.

to the cholera epidemic, even though there was a Colegio de Medicina. Engineers were now called to help solve public policy matters.

In 1822, Congress approved the creation of El Colegio Militar to train military engineers. Engineers from this school justified their existence by serving not as ordinary soldiers but as builders of the defense and civil infrastructure of a nascent nation. (p. 122)(Galvez, 1996) This school shared resources and faculty with the Colegio de Minería. In 1847, engineering students became “los niños héroes” after defending the Castle of Chapultepec⁵ from the US invaders. After the Treaty of Guadalupe-Hidalgo, where Mexico signed the loss of more than half of its territory to the US, military engineers went to establish the new political frontier and to conduct a new geographical inventory of the newly shaped nation. (Galvez, 1996)

Between 1821 and 1867, there were more than 40 changes in executive power. Liberals (federalistas) and conservatives (centralistas) struggled to define and interpret the new political constitution. On educational matters, liberals advocated progressive ideas, anti-clericalism, education for the masses, and centralization of the educational bureaucracy. Conservatives advocated moralism, religious involvement, and decentralization of educational control. Power changes between these two sides reflected immediately at the Colegio due to its proximity and importance to political power. For example, in 1833 liberals took power, closed the Universidad Pontificia for its aristocratic and religious roots, changed the foreign language at the Colegio from English to German, and authorized the construction of a new building where the Colegio operated until 1952. Later when Santa Anna, a conservative military dictator, came to power, he reinstated the uniform and the teaching of English as the language of industrialization, and established a vice-director in charge of morality and religious education.(Díaz y De Ovando, 1998)

⁵ Closely related to the political destiny of the new Mexican emperor Agustín I Iturbide, el Colegio Militar had to move to from downtown Mexico City to El Castillo de Chapultepec to avoid internal confrontations with Corps de Etat after the downfall of Iturbide in 1824.

In spite of the deep ideological differences between liberals and conservatives stalling the development of the Mexican state until 1867, there was a deep patriotic feeling among the Colegio's faculty and students that Mexico belonged with the European industrial nations. The Colegio's students, faculty, and alumni provided the rhetoric, supported by scientific evidence collected at the school, to compare Mexico to commercial powers of the time. A speech by Eligio Romero, alumni of Colegio de Minas, during Independence celebrations at the school (September 15, 1837), called for students to develop Mexican own resources in order to compete with the great nations of the time: "Mexico, I repeat with pleasure, Mexico does not need anything from outside our territory, while all civilized nations need Mexico. Our silver changed Europe: from conqueror and backward to merchant and civilized. If we were to take it away, Europe would succumb in chaos. We should not give away this advantage... We have to develop our own elements without needing those from outside, to foment our industry with our own arms, to circulate among ourselves our gold and silver. Why does our commerce have to be passive? Why do we have to be passively colonized? Why should our trade balance tip in their favor? (quoted in (Diaz y De Ovando, 1998) p. 684)

The Colegio, its faculty and graduates, also served as instrument of Mexican diplomacy and foreign affairs. During the first war with France (1838) over unpaid debt, the Mexican government expelled French citizens, except faculty of the Colegio. Faculty and staff offered their service in the war against France. As a symbolic attack to the French and to lure British foreign investment and support, in 1840 the Colegio opened its doors to the biggest British celebration in Mexico: the wedding of Queen Victoria with Prince Albert. The richest and most influential people in Mexico attended the party that the Mexican government used to show its intimacy with the British and distance from the French. (Diaz y De Ovando, 1998) (p. 694-5)

The Colegio also served a political purpose by magnifying Mexican glory during foreign and domestic conflict. When visiting European insulted Mexico by inaccurately reporting the poverty of the Mexican soil, faculty from the Colegio responded to set the record straight. Sixty

years after the first hot-air balloon flight in France, in 1843 Benito Acosta, an engineering graduate of the Colegio, became Mexico's first aeronaut with a flight in an aerostatic balloon and a national hero. A widely circulated newspaper reported the day after the flight: "Long live Acosta! Long live Mexican honor! Long live the national enlightenment! Long live our compatriot! Long live Mexico!...This day will be remembered in the history of Mexico; a brilliant chapter in our scientific progress, and a monument to the illustrious institution that educated him: El Colegio de Minería." (Diaz y De Ovando, 1998)(p. 729) With Humboldt's praise of the school now 40 years old, the Colegio continued to be recognized as one of the most prestigious in the world. **(Diaz y De Ovando, 1998)**(p. 985)

The US invasion of 1847 put into question Mexico's sovereignty as a nation. With the Treaty of Guadalupe-Hidalgo in 1848, Mexico lost more than half of its territory to the US. Media exchanges between newspapers reveal a deep polarization of opinions about the past and future of Mexico. Pro-monarchy conservatives argued that Mexico would have been better served by remaining (or becoming again) a colony of Spain or another European empire to have prevented the embarrassment of the US invasion and the loss of territory. Conservatives also argued that the so-called heroes of independence did not serve Mexico at all. With such a close involvement in the battles of Independence and in the making of Mexico into a sovereign nation, the Colegio, even his conservative director Tornel, took these criticisms to heart. Caught in the dispute over the future of Mexico, Tornel made an unequivocal patriotic call to his students during 1849 graduation in case of another invasion: "Students of Colegio de Minas whose foreheads just received olive crowns [during the ceremony], raise your eyes and read the glorious names of the heroes who, like you, cultivated the sciences and the virtues, and who died for our independence like Chovell. Their example opened a path for you to walk. If our patria were to encounter new risks, we know that you are its best hope; you will lead this generation that grows among conflict and threats to victory." (Document 68 quoted in (Diaz y De

Ovando, 1998)p. 1157)⁶ In spite of the political confrontations of mid 19th c, engineers continued to serve the State and construct a scientific image of la Patria .

The shaping of curricula in mid 19th century

Ideological and political divisions of mid 19th century were also played out through the curriculum as liberals and conservatives debated on the kind of knowledge that engineers needed to know la Patria. In 1843, President Santa-Anna dismissed Jose Francisco Robles, a liberal, as director of the Colegio, and appointed Jose Maria Tornel, a conservative. The same year the Ministry of Public Instruction issued the general plan of studies for the Republic. Conservative ideas shaped the new curriculum by advocating the inclusion of “solid religious principles”, basic and applied sciences, and the humanities. In addition to calling for the inclusion of applied mechanics, descriptive geometry, metallurgy and chemistry, conservatives strongly advocated geology as the science that engineers needed to know to differentiate themselves from the “practicos” and become better than the English and German engineers who controlled most foreign mining operations in Mexico. Geology, “the summary of all other sciences which should occupy in this nation the first level of importance,” would give engineers knowledge of “nuestros valles, nuestras Colinas, nuestros cerros y nuestras mas elevadas montanas; nuestros rios, nuestras lagunas, lagos, y mares, y desde las humeantes cenizas del Jorullo hasta las frias y endurecidas lavas del Popocatepetl...” (see complete document 2 for powerful rhetoric in (Diaz y De Ovando, 1998) p. 1277). Geology would give them an intimacy with the Mexican territory that foreign engineers did not have. According to this view, engineers needed to know Mexico if they were going to build and exploit Mexico in order to make it a great nation. Conservatives also believed that geology had a significant pragmatic dimension,

⁶ Poems and essays, first read to the students during school public functions and soon published in the newspapers, called for the students to follow the path of the highest sciences, to emulate scientists like Biot, Gay-Lussac, Newton, Franklin, and to construct la patria which will bring them immortal glory. (For other great examples of poetry that reaffirms the identity of engineers as patriotas see (Diaz y De Ovando, 1998)p. 1175.)

allowing engineers to save companies from investing in worthless lands and projects: “it is not a simple curiosity; it forms one of the most essential knowledges of the mining engineer without which he would walk blind into enterprises and bring ruin to families and mining districts.”

(quoted (Diaz y De Ovando, 1998)(p. 1020) Geography was also portrayed as a necessity for engineers to know the world outside of Mexico: “Geography, speaking scientifically, enriches human knowledge, giving useful knowledge, indispensable for those in the study of sciences and arts. Those who acquire geographic knowledge without leaving their ‘patria’ get to know all the countries of the world...their governments, religions, industries...” (document 24 in (Diaz y De Ovando, 1998) p. 1381)

The humanistic learning advocated by the conservatives did not include Revolutionary thinking from French philosophers like Rosseau and Voltaire. Religion was first to any kind of social and scientific thought. According to Tornel, the Colegio’s conservative director appointed by Santa Anna: “Without religion, society is impossible; without morality; government is impossible; without science, regeneration of the nations is impossible.” (Tornel quoted in (Diaz y De Ovando, 1998) p. 1052-55) Specifically at the Colegio, Tornel included religious and moral education in the form of mass, rosary, communion, prayer, spiritual exercises, thanksgivings, religious lectures, and holy history. According to the Colegio’s leading historian, during this conservative period “[students] looked more like seminarians than students of exact sciences.” (Diaz y De Ovando, 1998)p. 1033)

Liberals called for a precise and empirical curriculum, void of humanities and the study of morality. Andres Del Rio, the most prominent liberal scientific scholar of the time and professor at the Colegio, criticized the inclusion of logic and rhetoric in the curriculum. According to him, empiricism was enough for students to know reality. Logic and rhetoric would turn them into arguers: “the spirit of observation leads necessarily to discoveries; the spirit of debate is their[engineers] biggest enemy; the observer and the debater are true opposites.” (quoted in (Diaz y De Ovando, 1998) p. 1009) Del Rio later continued: “Our logic is geometry whose

concepts are certain and indisputable; our metaphysics is chemistry which tells us the composition of the bodies around us.” Furthermore he criticized applying mechanics to mining and chemical analysis for it subordinated metallurgy and chemistry to an applied science. According to Del Rio, chemistry and metallurgy were the foundational sciences; applied mechanics was for “arts and crafts in general.” (document 23 quoted in (Diaz y De Ovando, 1998) p. 1010) Tornel defended logic and rhetoric from Del Rio’s attacks: “A nation of geniuses [geometers] could become barbarian; a nation of literary men would never be.” (Diaz y De Ovando, 1998)p. 1017)

Science vs. practice

In the midst of these ideological debates over the constitution of engineering knowledge, the curriculum was also criticized for lacking training and practice in mining techniques. Scientific knowledge, required to know and construct la patria, stood in tension with practical techniques required by the mining industry. Mexican engineering students were criticized for not being ready to work in the mines and not understanding foreign equipment and machines. Foreign engineers were portrayed as being more practical, knowing equipment and machines better, hence occupying better positions (Diaz y De Ovando, 1998)p. 1035) During a heated debate in the Mexico’s newspapers in 1843, an influential alumni who had become the advocate for practical knowledge wrote: “We see the hopes of our ‘patria’ destroyed in this positivist world when at the time to apply knowledge, we find in our students an encyclopedic man, incapable of executing the simplest of practical works. We want our students to acquire less illustrated education and more solid and firm in applications and experiences than in theory” (quoted in (Diaz y De Ovando, 1998) p. 1037)

Calls for practical training had to wait 10 years until the return of Santa Anna to power in 1853 when he created the Escuela Practica de Minas y Metalurgia en Fresnillo under the administrative control of El Colegio. At that time, a hierarchy between theory and practice was

established with the organization and location of the two schools. On top, theory was located at the Colegio, close to political power. Next, practice was located at La Escuela, near important mining centers, first in Fresnillo and later in Pachuca. In early 1850s, the addition of practice to the curriculum resulted in an 8-year plan of studies with the first two years dedicated to math, geometry, drafting, and languages, the third year focused on rational and industrial mechanics and English; the fourth year mainly devoted to physics and English; the 5th year to chemistry and German; the 6th year to mineralogy and German; and the last two years to practical education at La Escuela in Fresnillo. (ref??)

With the liberal triumph in shaping the Constitution of 1857, the new carta magna expropriated the property of the Church and increased the State responsibility over civil society with the secularization to civil life. Hence the new constitution created a further need for surveying new available land and building public infrastructure. The subsequent law of education (Ley Organica de Educacion de 1861) emphasized math and theory in the curriculum at the expense of practice, by adding an additional year of math and reducing practice to one year, and created a the new civil engineer by establishing separate curricula for mining and civil engineers. Other career offerings at that time were mining engineer, metal tester, topographic engineer, geographic engineer. (Diaz y De Ovando, 1998)(p. 2010). Liberals had realized that Mexico needed more that mining engineers.

Technical education for the masses

The Constitution of 1857 also made education free of cost and religious influence and the government responsible for establishing requirements for the professions. Under this new legislative framework, the government created the Escuela de Artes y Oficios (EAO) to provide Mexico's semi-literate populace with the opportunity to train in industrial techniques now required by the beginnings of industrialization.

This experiment in technical education was interrupted by the French invasion and the Maximilian Empire from 1864-67. The EAO closed its door until the Porfiriato.

(Almost) Building state strength for France: Engineers during the Maximilian Empire

In 1861, Spain, Britain, and France agreed in the London Convention to block Mexican trade in order to recover unpaid debt but without occupying Mexican territory. Napoleon III did not honor this agreement. Wanting to free Latin America from English domination, he decided to invade Mexico with the support of Mexican conservatives and the clergy who wanted to defeat the liberal constitutional reform.

Deeply divided over the separation of Church and State in the new constitution of 1857, liberals (led by constitutionalist Benito Juarez) and conservatives (led by pro-monarchy and pro-cleric Miguel Miramon) engaged in civil war. The conservatives, including Joaquin Velasquez de Leon, the Colegio director, supported French imperial ambitions, rejected the new Constitution, and endorsed an European emperor on Mexican soil (Diaz y De Ovando, 1998)(p. 2036).

After President Juarez left Mexico City, Bruno Aguilar, a graduate of the Colegio, took over as interim president, followed by a Junta de Gobierno that remained in charge until the arrival of Maximiliano in 1864. The new emperor changed the school's name to *Escuela Imperial de Minas*.

By now the Colegio (or Escuela) and its engineers enjoyed great prestige and visibility in European scientific and technological circles, particularly after representing Mexico in the 1855 Paris World Exhibition: "The Mexican exhibit, after the US, is the one that offers the most abundance and better products of the American continent." (Diaz y De Ovando, 1998)p. 1986) Understanding the importance of la Escuela for the French empire, Emperor Maximilian created a Franco-Mexican Commission of science, literature, and art—L' Commission Scientifique du Mexique. With significant participation from the Escuela, the new commission served as an instrument to bring knowledge of Mexican natural wealth to the French state with the goal of

increasing French investment in Mexico. At the same time, Maximilian tried to shape la Escuela along the lines of the French Ecole Polytechnique in order to provide knowledge for the administration of the State. (Diaz y De Ovando, 1998)(p. 2313) Scientific experiments, such as meteorological observations, were supported by Maximilian but with specific uses for the State, such as agriculture, public health, etc. (Diaz y De Ovando, 1998) (p. 2363) On his side, Napoleon III created a counterpart Commission in France with similar purposes. According to Diaz y De Ovando, the school's leading historian "the French viewed Mexico like a Latin American Algiers that Napoleon III envisioned for the benefit of France."(Diaz y De Ovando, 1998) (p. 2292-97)

During the Empire, conservative Jose Salazar Illarregui became president of the Commission Scientifique and director of the Escuela, and brought back religion and morality to the core of the Escuela's curriculum and student life. Illarregui proposed that the study of morality should supersede and lead to the study of science, which in turn will bring material well-being. Calming any possible nationalistic feelings among his students, Illarregui reminded students to stay focused in their studies and to dismiss any intention of fighting against the Imperial government. Social order would be ensured by a strong emperor who would obey the law and not become a tyrant. (Diaz y De Ovando, 1998)(p. 2323) To help promote Austrian industrial interests in Mexico, the Emperor endorsed the organization of an Austrian industrial expo at the Escuela. (Diaz y De Ovando, 1998)(p. 2339) This event was resisted and ridiculed by faculty and students alike who were ready to serve the French empire with theory but not the interests of industry.

In 1867, US government did not recognize the legitimacy of the Empire any longer. It wanted the French out of their backyard. At the same time, the Vatican did not want relations with a nation that separated church and state in its Constitution. Napoleon III was forced to withdraw his troops from Mexican soil. Without foreign support, Maximilian left Mexico City, to be later captured and executed on June 19, 1867.

