Titulo: "Ordem e Progresso": engineering education for the making of a world power

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Resumen: This is a history of Brasilian engineering education from the Brasilian Empire to the present. Along the way, I use debates over engineering education (identity moments) to enter into different historical periods and begin distilling emerging and existing images of progress. Then I show how these images challenge governments and engineers to create or transform educational institutions (identity sites) to produce engineers and knowledge that will address specific challenges. Beginning with Brasil's Second Empire and the creation of the Escola de Minas de Ouro Preto and the Escola Politecnica de Rio, I analyze the scaling up of images of progress and the creation or transformation of engineering education during the Republic, the Vargas regime, the military regime, and the present. Current challenges to Brasilian engineering education can only be understood in terms of its history, the particular development of each of its institutions, and the still dominant image of Brasilian "ordem e progresso" defined in terms of reaffirming Brasil as a world power.

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Introduction

During a recent interview, EW, an engineering professor at the UFRJ, expressed his frustration with the lack of entrepreneurship among his graduate engineering students. He says: "We need to prepare them to become future entrepreneurs. Here we teach them only the technical side. This is OK for an area where there is industry but here [RJ] there is no industry…We have Petrobras and other state companies in electrical generation and that is it. We have no industry producing machines, engines, and basic products…Something is wrong with the industrial policy in this area." Inspired by the entrepreneurship of his father, a Japanese immigrant who made a good living cross-breading agricultural seeds, EW encourages his graduate students to create their own enterprises through an Incubator Center at the Instituto Luiz Coimbra de Pos-Graduacao e Pesquisa de Engenharia (COPPE). How can we begin to understand the lack of industry in the area and whether the circumstances behind this lack of industry and the development of engineering education at UFRJ are related? If there is no large industry other than Petrobras, where have engineers been working since the beginning of engineering education in the Rio area in 1810? And how can begin to understand the lack of entrepreneurship among his students who come from a social environment (RJ Metropolitan area) where entrepreneurship is not an option but a way of staying alive? RJ is an area of high underemployment where people, from childhood to adulthood, learn to make ends meet. From trash collectors to UFRJ non-engineering graduates, there are plenty of highly visible examples of entrepreneurs among RJ youngsters. So why is EW worried? Is there an explanation for this lack of entrepreneurship in the historical trajectory of engineering at UFRJ? Could it be that the engineering school, its curriculum, and even its research activities, developed not in relationship to private industry but in relationship to the State?

Two weeks earlier during my research visit to the Universidad de Sao Paulo (USP), PM, an engineering professor at USP's Escola Politecnica (EPSP), explained to me how he is trying to build a special institutional arrangement to connect his students with industry. After enjoying great deal of mobility between his technical high school, his practicum at Projelectrica (a company created by the military to electrify sugar mills for high volume production of alcohol for cars), and his engineering program, PM worries now that his students do not find those pathways from engineering to industry, as he did three decades ago. How did those pathways from school to industry open for PM? How did they close for his students? Along with all the engineering professors that I interviewed in SP, PM worries that nowadays engineering students seem to be more interested in banking and finance than in industry. How did the expectation that 'EPSP engineers go to industry' emerge? Why is that expectation changing for the newer generations of engineers? Is there the same expectation for all engineers in Brasil? If not, how can we understand regional differences among engineering schools in Brasil?

AF, a senior engineering professor who is also Director of Mechanical Engineering at the Instituto de Pesquisas Tecnologicas (IPT) de Brasil, showed me with great deal of pride the laboratories where Brasilian companies have tested technological developments since 1894. Adjacent to USP but separated by a fence and a guarded gate (an indication of IPT's close relationship to but separate administration and organization from USP), IPT now contains a hull-design testing tank occupied with Petrobras latest model ships, dynamometers where Brasilian and multinational companies test their latest alcohol engines, and distillery columns for testing thermal efficiency of furnaces. After spending

the entire day together and feeling more confident with me, AF finally expressed deep concern about the new directions of IPT. Reluctantly, he showed me marketing brochures for IPT's latest initiative: continuing education short courses in technology management for business executives. Then he confessed that he is thinking about resigning.

How can we begin to understand these anxieties? Are these just plain reactions from an "old guard" to new challenges brought by privatization of the Brasilian economy and shifts in the labor market of engineers? Or are these anxieties indicative of how different notions of Brasilian progress have contributed to the creation and development of different engineering institutions, and different notions of 'what engineering is for' in different places and times? Are these fears indicative of how engineering professors at different institutional locations have come to understand that 'what engineering is for' means something entirely different than what new generations of engineering graduates want to do? If so, where do their notions of 'what engineering is for' come from? Is it different across engineering schools? Is it different in Brasil than in other countries?

Engineers and progress

A point of departure for an analysis that can help us answering these questions is the nation: the "we" that emerges as a "imagined community" (Anderson 1991) or a "collectivity" (Giddens 1985) that can relate to a common reality within a territory, a country. Quickly after the "we" emerges, the challenge of how to advance the "we" also emerges. According to most theories of nation, political and economic elites have been instrumental in defining the "we," mainly through the promotion of nationalism, and in advancing the "we," primarily through state institutions (Smith 1998). Some of these theorists argue that the legitimacy and authority of the State actually comes from its role in advancing the "we" (Breuilly 1993 [1982]). Missing from these accounts of nation, however, is the role that engineers play in advancing the "we." Our project *Engineers and the Metrics of Progress* attempts to fill this void by analyzing how engineers in different countries have emerged to address the challenges of advancing the "we."

Through the history of a country, images of progress, defined as proposals on how to advance the "we," emerge at different times often competing with each other. For a variety of reasons (e.g., internal political revolution, war, economic crisis, external threats to the country), one of these images scales up, spreads, and becomes accepted throughout a territory. Its dissemination takes place through a number of vehicles (social institutions, media, etc.) and endorsed or resisted by a number of actors (policy makers, educators, economic elites, engineers, etc.).[1] Engineers are challenged by these images of national progress but not all respond to these challenges in the same way. For example, engineering educators react to the challenges of progress in many ways, creating institutions, developing or transforming curricula, resisting to these challenges, or displaying great deal of ambivalence. In short, 'what engineering is for' is about chasing progress, facing these challenges and making them real.

1 In my book *Defending the Nation*, for example, I followed images of nation under thereat from popular and science media back and forth into congressional hearings and reports. Then I analyzed the role of key actors such as the National Science Board or the Business-Higher Education Forum in appropriating those images to justify the creation of s/e education programs at NSF.

Both conceptually and methodologically, it makes sense to look for evidence of these images (challenges) and reactions around debates in engineering education. These debates are sites of struggle for the creation of knowledge and specialized people that will advance the "we." In this sense, these debates become 'identity moments' as they reveal how engineering educators or government officials react to images of progress and propose new kinds of engineers, knowledges, and practices to address those challenges. When engineering schools are proposed as institutions that would produce the new kind of engineers, the schools become 'identity sites.'

Recently, an American image of progress, defined as the ability to compete in the market place through low cost mass production (Downey 2006), is spreading around the world and challenging engineering education in many places. Brasil is no exception. So it is possible for engineers in a particular country to be challenged by two, or more, images of progress: the one that scaled up in their own country and a new one that might be spreading around the world.

This paper is a history of Brasilian engineering education from Empire to the present. Along the way, I choose debates over engineering education (identity moments) to enter into different historical periods and begin distilling emerging and existing images of progress. Then I show how these images challenge governments and engineers to create or transform educational institutions (identity sites) to produce engineers and knowledge that will address specific challenges.

Engineering education for the Brasilian Empire

In 1871 Pedro II, Emperor of Brasil, traveled to Paris to convince Auguste Daubree, his colleague in the Paris Academy of Sciences and director of the Ecole de Mines-Paris, to move to Brasil and create a mining engineering school. Unable to leave his post, Daubree recommends Professor Claude Henri Gorceix, a student of Pasteur at the Escola Normale Superior de Paris, as director. In 1876, Gorceix opened the *Escola de Minas de Ouro Preto* (EMOP) in Minas Gerais with the goal of creating engineers who could study the Brasilian soil and geological wealth. Shortly thereafter, in response to the possible threat of EMOP engineers flooding a small labor market and, more importantly, challenging the dominance of engineering graduates from the existing Escola Politecnica (EP) in the imperial bureaucracy, Visconde Rio Branco, EP director and one of the most powerful ministers of the second Empire, opposed to the title of "engineers" that EMOP graduates were receiving. Rio Branco wanted graduates from the EMOP to be called "homens puramente practicos", not engineers (da SilvaTelles 1984), p. 520), (de Carvalho 2002), p. 53-55). As a scientist-mathematician turned politician, Rio Branco thought that the Empire needed engineers with theory-based knowledge who could build and maintain its civil infrastructure.

According to Jose Murilo de Carvalho, historian author of the most recent and comprehensive history of EMOP, there was no demand for mining or geological engineers in Brasil at that time. All the engineers that Brasil needed were being educated at the Escola Central in RJ or learning the trades in multiple construction and mining projects, usually operated by British or German companies. So what led Pedro II to create this school at a time when the Brasilian economy did not need more engineers? Why did Rio Branco, certainly one of the most powerful men of the Empire, react so strongly

against the EMOP? Could it be that Gorceix and Rio Branco, both working for the Emperor, were being challenged by the same image of progress yet reacting in different ways? Or were they challenged by different images?

Background

After the abdication of Pedro I, Brasil's first emperor, a regency government controlled by regional elites ruled Brasil from 1831 to 1840, experimented with federalism (i.e., giving more political autonomy to regions by allowing them to appoint local assemblies and control local taxation)and reduced centralized political authority (e.g., abolishing Emperor's Council of State). After a 10-year experiment with 'imperial federalism' and under pressure by increasing regional revolts, the regency government brought Pedro II, a 14-year old Brasilian-born prince, to power as a symbol of integration. Political elites had seen that disintegration was possible as it happened with the Gran Colombia in 1830. Brasil's Second Empire was born out of a delicate political and economic tension between federalism and centralism. Pedro II's Empire continued to face this tension until its end in 1889. Regional elites, particularly the coffee elites, continued to enjoy great deal of political and economic power. After all, coffee made 3/5 of all Brasilian exports in the 1870s. The Treasury relied on revenue from imports paid mainly with agricultural exports. Dissenting liberalism in key regions such as Sao Paulo and Minas Gerais continued to grow, especially after the abolition of slave importation (1850) and the law of the free womb (1871). It was becoming increasingly difficult for the Emperor and the landed oligarchy to sustain a slave-dependent economy. Internal tensions were clear.

At the same time, the imperial ambitions of European powers in Latin America were still evident as shown by the short lived Maximilian Empire in Mexico (1864-67), and the continuous influence of the British Empire in Brasil's economy in spite of the expiration of the Anglo-Brasilian treaty in 1844.[2] Furthermore, the difficult victory of Brasil in the War with Paraguay (1864-1870) showed Brasil's weaknesses as a military power. In 1876, Don Pedro visited the Philadelphia Exhibition and was impressed by the developments of other world powers. Clearly, Pedro II was worried about the political and economic transformations, within and without Brasil, and their consequences for his Empire.

Since late 18th century, European powers had been strengthening their States by the measuring, exploiting, processing, and graphically displaying their natural wealth, particularly metals (Nikolow 2001). According to Donata Brianta, historian of mining at the Universidad de Pavia, "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). European states, some potential military threats to Brasil, had rationalized mining through institutions for the application of knowledge to exploit and process minerals and metals. Mining schools in Freiberg (1765), Schemnitz, Hungary (1770), Berlin (1770), St Petersburg (1773), Almaden, Spain (1777), France (1783), and Mexico (1792) were helping their kingdoms and empires show their strength and fund their wars (Brianta 2000).

[2] For almost half a century, Britain had enjoyed preferential treatment in commerce for its role in helping the Portuguese Empire move to Brasil during Napoleon's invasion and then for recognizing and funding in many ways an independent Brasilian Empire after 1822.

Clearly, Pedro needed to strengthen his State to deal with both internal and external threats. With the help of his friend Daubree, Pedro understood that Brasil needed an Escola de Minas to educate engineers capable of mapping and extracting his empire's wealth. One of Daubree 's first recommendations for the new school was the creation of a Carta Geologica do Pais, a visual representation of Brasil's natural wealth, similar to those already in existence in Mexico and many other states in Europe. In addition, Pedro needed to find an alternative to coffee and cotton, mostly in the hands of the regional elites and still heavily dependent on slave labor (de Carvalho 2002).

Whether there was a Brasilian nation, a "we", by 1876 is a matter of historical controversy. The 'parentela,' those social relations between patrons, his extended family, and slaves at agricultural plantations, dominated people's sense of identity, of who they were in the world (Lewin 1987). It is hard to imagine the existence of a shared national community in a country as vast and regionally fragmented as Brasil. What is clear at this point is Pedro II's growing desire to reaffirm Brasil as an economic power in the world. This image of progress challenged him and his administration.

A competing image of regional economic development, and the integration of that development, challenged others to connect agricultural production sites to ports for exports. During the Second Empire neither image became dominant, maybe due to the absence of a coherent "we." However, each image challenged different social groups in the Empire and ended up materialized in different schools of engineering.

Escola de Minas de Ouro Preto (1876)

Responding to the challenge of reaffirming Brasil as an economic power coming directly from the Emperor, Gorceix established three specific goals for EMOP in this particular order: first, to form geologists and mineralogists capable of studying the Brasilian soil and creating a geological chart of the country; second, to form directors of mining and metallurgical explorations; and, third, to form engineers capable of regulating mining operations (de Carvalho 2002), p. 50). This order is significant because it reveals, first, an anxiety over the need to map and define a territory and its wealth. Military engineers had been mapping the borders of the Empire since 1843[3] and foreign commissions have been surveying its geological wealth since 1821.[4] Yet there was no control over the creation

[3] Just two years into his reign in 1843, Don Pedro ordered the demarcation of border with Guiana Inglesa by the Teniente Colonel Eng. Frederico Carneiro de Campos. From 1853 to 1862, the border with Uruguay was drawn by Eng. Francisoc Jose de Souza Soares d'Andrea (futuro Baron de Cacapava) and then by Pedro de Alacantara Bellegarde. From 1851 to 1854 the San Francisco River, "the river of national unity," was studied by a German engineer Henrique Guilherme Fernando Halfeld. Later the Amazon river was studied by eng. Joao Martins da Silva from 1851 to 1866. In 1864, the border with Peru was drawn by a commission led by Eng. Joao Martins de Silva. In 1871, a commission drew the frontier with Bolivia, and then after the peace treaty with Paraguay, a commission drew the border with Paraguay. In 1879, a commission drew the border with Venezuela and right after another drew border with Argentina (da SilvaTelles 1984), p. 542).

[4] In the first empire, Barao de Eschewege becomes the first to do comprehensive geological survey, published in Europe in 1821. He was commissioned to make the first collection of minerals, Colecao Werner (da SilvaTelles 1984), p. 551). From 1840 to 1850, French geologist Parigot and German Karl Rath discovered coal reserves. This knowledge was being disseminated in Europe and made available to companies with commercial interests in Brasil. It was Pedro II the first one to authorize in 1857 the Comissao Cientifica de Exploracao to study the least know regions of Brasil (da SilvaTelles 1984), p. 553). In 1865, a US expedition, the Expedicao Thayer funded by philanthropist Thayer and led by Louis Agassiz and Charles Hartt, becomes the first non-European expedition to visit Brasil (da SilvaTelles 1984), p. 554). In 1870 Hartt publishes the *Geology and Physical Geography of Brasil*. In 1874, the imperial government put him in charge of the Comissao Geologica do Imperio but after significant discoveries did not let the commission to

and dissemination of this knowledge. Second, this order shows a need to develop and control (note call for *directors*) mining and metallurgical industries, until now in the hands of the landed oligarchy or British and German companies (Birchal 1999). Third, it reaffirms a need for State regulation (fiscalization) of mining activities. Since early 19th century, foreign engineers had dominated the exploitation and processing of minerals and metals.[5] Since there was no organized mean by the Imperial State to regulate mining and metal exploitation and processing, EMOP was meant to fill this void.

Gorceix considered two curricular models: Ecole de Mines de Paris (theoretical and long) and Saint Etienne (practical and short). He chose the later model to meet the pressing challenges of the country, at least according to the Emperor, and minimize conflicts with the Escola Politecnica (EP). A two-year curriculum was implemented with math, geometry, physics, chemistry, surveying, and many practical dimensions of mining during the first year, and geology, metallurgy, mechanics of machines, and many practical dimensions of metal processing in the second year (da SilvaTelles 1984), p. 519-20)

Escola Politecnica de Rio de Janeiro (EPRJ, 1874)

The EP emerged from splits brought by tensions between the military and the infrastructure/administrative needs of the Empire. A first split took place in 1858 when the *Academia Real Militar*, created in 1810, began to move away from military applications towards a theoretical approach to engineering. In 1810, Joao VI, the Portuguese Emperor who moved to Brasil in 1807 after Napoleon's invasion of Portugal, needed artillery, geographic, and topographic engineers to build and administer mines, roads, ports, canals, bridges, fountains for his new home Empire that lacked infrastructure (da SilvaTelles 1984), p. 89).

After Brasilian independence in 1822, a bloodless and uneventful declaration by Joao's son Pedro I, the Academy became *Academia Imperial Militar* and the site of all military, naval, and coast guard engineering. Many of its key faculty and administrators were scientists, such as Jose Bonifacio de Andrada da Silva (1763-1838) and Manuel Ferreira da Camara Bitencourt who, after receiving a secular/encyclopedic education at Universidad de Coimbra (Portugal), went back to Brasil to occupy key posts in the Imperial administration. Some of these 'enlightened' Brasilians, and teachers at the Academia, wanted to develop a 'Brasilian' industry and created the *Sociedad Auxiliadora de Industria Nacional* (1827) "to increase the capital and wealth of the nacion." (da SilvaTelles 1984), p. 165). However, at that time, these calls for national industry went against British commercial interests which enjoyed preferential commercial treatment (de Carvalho 2002), p. 35). In the first quarter of the 19th century, industry was minimal and in the hands of German and British investors and mechanics (da SilvaTelles 1984), p. 99).

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study and classify more than 500k samples. The Emperor dismantled the commission and secured samples in the National Museum (da SilvaTelles 1984), p.555).

[5] Burgeois immigrants into Minas Gerais such as the Baron Eschwege, a german engineer who set up the Patriotica foundry (1811), (da SilvaTelles 1984), p. 165) and Monlevade, a French engineer who set up the San Miguel de Piracicaba foundry (1812) (Birchal 1999), p. 24) dominated metal processing. St John del Rey Mining Co, a British company in Minas Gerais, dominated mining operations (Birchal 1999), p. 15).

This early desire for 'national' industrial development lived under the shadow of applied military applications at the Academia Imperial for the entirety of Pedro's I Empire.

After the abdication of Pedro I in 1831 due to mounting internal pressures, the ten-year Regency government represented for the first time significant political power of Brasil's regions in the administration of the country. Then Pedro II had to manage the fragile tension between centralism (Emperor and his Council of State) and Federalism (Chamber of Deputies with two chambers). This tension, which dominated Brasil's political and economic life for the second half of the 19th century, eventually came to split the Academia Imperial. Now with significant presence in the government of the Second Empire, the landed oligarchy depended on getting their agricultural exports out of the country. Concerned with the growing emphasis on the needs of agriculture at the expense of military applications, military officers obtained imperial approval for the creation of *Escola de Aplicacao do Exercito* in 1855. Concerned with connecting their agricultural economies to the political capital and to the world, regional elites got permission for the *Escola Central* in 1858 and established for the first time in Brasil, a course in 'civil engineering' to educate engineers to build the infrastructure, mainly railroads, to bring agricultural output to the world (da SilvaTelles 1984), p. 106). The civil engineering curriculum clearly reveals the new orientation of the Escola Central. After a preparatory course in general studies, the first year emphasized applied mechanics, civil architecture, strength of materials, surveying, tracing, construction, and maintenance of roads and railroads, drying of swamps, and metallurgy. The second year focused on canal construction, ports, dikes, and shore reconstruction (da SilvaTelles 1984), p. 108. The curriculum became so important for regional elites that it was often debated it in the Chamber of Deputies.

The War with Paraguay (1864-1870) clearly revealed the need for further development and rationalization of military applications. Military engineers from both Escolas had a significant participation in this war that Brasil won after many casualties (da SilvaTelles 1984), p. 111). These engineers, who witnessed significant deficiencies in both military organization and civil infrastructure, pressured the government for further organization and specialization of engineering knowledge. After the war in 1874, the *Escola Militar e de Aplicao do Exercito* received all military application activities, a Military Academy remains in place strictly for military training, and the *Escola Central* becomes *Escola Politecnica do Rio de Janeiro (EPRJ)*.

EPRJ's first director was the Visconde do Rio Branco (1819-1880), a very influential statesman who played key role in the treaty that ended the war with Paraguay and passing legislation of Free Womb in 1871 (da SilvaTelles 1984), p. 505). A natural of Salvador, a graduate of the Escola Central, and a powerful minister, Rio Branco directed the EPRJ in the direction of centralized state administration. To him, the development of the Empire would be through a rational State not through developing the interests of the landed oligarchy. He put in place a French-based encyclopedic education based on two years of General Studies, followed by one year of engineering sciences, and two more years of engineering applications. He required all EP students to take his course in Political Economy, Administrative Law, and Statistics (da SilvaTelles 1984), p. 474-5). This emphasis on civil service, construction, and administration is reflected in the distribution of EP graduates during its first 50 years: 1500 from civil engineering; 1300 from geographic engineering; 41 from industrial engineering; 21 from mechanical-

electrical engineering; 8 from mining engineering; and 3 from agricultural engineering (da SilvaTelles 1984), p. 472).

By the end of the second empire, two competing images of progress had challenged political elites to create different engineering schools. One image for the reaffirmation of Brasil as a world power challenged Pedro II to create the *Escola de Minas de Ouro Preto* and military engineers to organize military engineering knowledge in the *Escola Militar de Aplicacao*. A second image that called for the development of regional agricultural economies challenged bureaucrats and regional politicians to create the *Escola Central*. Rio Branco resisted EC's orientation towards agricultural needs and instituted a curriculum oriented towards civil service at the *Escola Politecnica*.

The abolition of slavery and Brasil's increasing reliance on labor-intensive coffee agriculture scaled up the image of regional development, contributing significantly to bringing the Empire to an end. An alliance between the landed oligarchy and positivist military officers, many of them teachers at both schools of engineering, forced the Emperor to abdicate. The Republic of the United States of Brasil was proclaimed in 1889.

Café con Leite: Engineering education for regional development

On September 28, 1922, Euzebio de Andrade, a senator representing the state of SP in Brasil's federal senate, defended the legality of Mackenzie Engineering College, Brasil first private engineering school, against the attacks from the Escola Politecnica de Sao Paulo. Highlighting the appropriateness of Mackenzie's curriculum for Brasil's changing conditions, de Andrade said:

> Programs at MC, which follow those in North America, become more adaptable to the local conditions at the same time that they allow for the immediate introduction of the latest advances in engineering…This freedom in teaching is inseparable from progress. It is unlikely that engineering schools throughout the country will face the same challenges and needs. A professional [engineer] in the Amazon will be strikingly different from one in Sao Paulo (quoted in (Mendes 2000), p. 55).

How can we explain that after the proclamation of the Republic, State and Federal legislatures with significant legislative work in front of them spent valuable time and scarce resources discussing and building engineering schools and laboratories? How can we begin to understand this concern over adaptability of engineering to local conditions? Could it be that the image of progress as state economic development had scaled up to the point that it challenged State deputies and engineers to build engineering schools to develop their economies? Could it be that some of these state schools felt threatened by the incursion of a private American school with connections to a nascent industry? How do we explain that with the birth of the Republic, a national school of engineering was not created as it happened in Mexico, for example, right after its independence in 1822 (with the Colegio Nacional de Mineria) or after the Maximilian Empire (with the Escuela Nacional de Ingenieria)?

Background

The Republic of the United States of Brasil was not a manifestation of a coherent "we." Far from it. The political stability of the new country depended on a political negotiation among regional interests. The politics of governors (coronelismo) allowed state governors and the landed oligarchies to control regional and national elections. Their delegations ensured that a weak federal government ultimately benefited their region. The most significant of these political agreements was that between SP and Minas Gerais (the politics of café com leite) where Brasil's two most important regions agreed to share power for their own benefit.

Early in the Republic, state legislatures began the process of creating state institutions to develop their economies. In spite of a number of ups and downs in international prices, coffee and rubber still made 80% of all Brasilian exports up to WWI. States began attracting capital and industrial investment from other parts of the world.[6]

In spite of the early presence of foreign investment, the development of domestic industry was thwarted by the subservience of nascent industrial groups to powerful agricultural elites. The federal government tried to promote industry through protective duties but the regional agricultural elites opposed them because they hurt export agricultural economy. Funded by agricultural capital, nascent industrialists had to rely on imported foreign machinery to construct Brasil's factories. Foreign companies benefited from the lack of competition from domestic manufacturing and the demand for electricity required by a growing urban population and machinery necessary for agriculture. According to Steven Topik, a historian of the political economy of Brasil, "the middle class, far from actively championing a modern industrial nation, was the most vocal critic of protective duties" (Topik 1987), p. 158).

The demand for engineers grew due to the increase in the number of public functionaries, both at the state and federal levels, the boom in railroad construction,[7] particularly in Sao Paulo and Minas Gerais, the mechanization of labor and rationalization of coffee production, and the growth in civil infrastructure necessary to support foreign and domestic immigrants into the cities.[8] Different regions had different engineering needs. Sao Paulo's dependency on coffee and civil construction for the coffee elite translated into demand for railroads and urban civil construction of new political, economic, and public service institutions in the city of Sao Paulo. New foreign companies located in Sao Paulo also required engineers. Rio de Janeiro, the political capital of the new Republic, was transformed from 1903 to 1906 into the "Paris of Latin America." Engineer Francisco Pereira Passos who in 1871 visited England, developed passion for railroads and laissez-faire, became prefect of Rio and transformed the city (McDowall 1988), p. 25), building neoclassic buildings, new avenues, squares, theatres and tunnels (da Silva Telles 1993), chap 2). Building on its German-born tradition for

[6] For example, the government of SP lured the Ford Motor Co to increase its production from 2000 autos in 1919 to 45K in 1925. The SP Tramway, Light, and Power Co. (1899-1908), a Canadian company, first extended its operations into Rio with the RJ Light Co. (1903-1908) and then consolidated to become the Brasilian Traction, Light and Power Co. in 1908, the biggest privately owned company in Brasil for a long time.

[7] Railroads increased from 9,355 kms in 1900 to 26,642 in 1915, with SP and MG having half of these.

[8] To deal with the challenge of replacing slave labor, state and federal government recruiting immigrants from Europe and Asia. 3 million immigrants arrived between 1889 and 1930, mostly to SP, from Italy, Germany, Portugal, and Japan.

iron works, Minas Gerais built bigger iron smelting plants, mostly with pools of capital coming for few families (Eakin 2002). The ports of Belem, Salvador, Porto Alegre, Recife and Rio Grande were built and opened between 1909 and 1918. (da Silva Telles 1993), chap 5)

In education, as in many other policy areas, the states were given plenty of autonomy from federal control. The Constitution of 1891 did not define a federal educational policy. Benjamin Constant, positivist leader and minister of education, tried to implement a meritocratic system of access to higher education that was rejected by state elites who wanted aristocratic access to education. Having lost their nobility titles with the fall of the Empire, elites were anxious to enhance their status through educational titles (Hack 2002), p. 108-9). This autonomy allowed state legislatures to create professional schools. Between 1891 and 1910, state legislatures created 27 higher education schools: 9 in medicine, obstetrics, and dentistry; 8 in law; 4 in engineering; 3 in economics; 3 in agriculture (Hack 2002), p. 110). Within ten years of the birth of the Republic, four engineering schools were created by state legislatures: EPSP (1894), the Escola de Engenharia de Pernambuco (1895), Escola de Engenharia de Porto Alegre (1896), and Escola Politecnica de Bahia (1897). SP State legislature reluctantly approved the creation of Escola de Engenharia Mackenzie (1896), Brasil's first private engineering school (da Silva Telles 1993), chap 1).

During the first two decades of the 20th c, educational policy continued to emphasize state development. The educational reform of 1911(Law of Rivadavia Correa) further guaranteed programmatic and administrative autonomy to institutions of higher education. In response, other states created engineering schools as follows: Escola Livre de Engenharia de Minas Gerais (1911), Facultad de Engenharia do Parana (Curitiba) (1913), Escola Politecnica do Recifice (1913), Instituto Electrotecnico de Itajuba (1914), Escola de Engenharia de Juiz de Fora (1914) (da Silva Telles 1993), p. 1]. A number of federal educational reforms between 1911 and 1930 which attempted to regulate and organize higher education at the federal level were mostly ineffective.

How did the scaling up of the image of progress challenged state elites to create elite schools? How was this challenge interpreted and materialized at different locations and in different curricula?

Escola Politecnica de Sao Paulo (EPSP, 1893)

The coffee elite consolidated its political project through the creation and organization of a State in SP, including organization of municipalities and justice system, electoral and public order systems, and education. According to historian of education Elza Nadai, Sao Paulo's coffee elite in their Project of Higher Education clearly indicated that "higher education schools (Escolas) should be institutions at the service of progress and modernization…this objective meant the modernization of agro-industry." (Nadai 1983), p. 7). The State Assembly first envisioned an agricultural school. According to state deputy Paulo Egidio, "Brasil is a country essentially agricultural and the prosperity of the State is only possible through the development of coffee…[Hence] an agricultural school would serve the creation of specialized labor for the development of intensive agriculture of interest not only to the big capitalist but also to the small capitalist, not only to the son of the rich man but also to the son of those who will give themselves to labor" (quoted in

(Nadai 1983) p. 7). However, Sao Paulo political elite understood that, in order to advance, the state of Sao Paulo needed more than farmers and professional lawyers, graduating from the Faculty of Law in existence since 1827. According to Nadai, "the rhetoric of modernization coming from the lawyers was not enough; progress needed to be achieved through technology" (Nadai 1983), p. 8).

Only four years after the proclamation of the Republic, Prof. Antonio Francisco de Paula Souza, a deputy to Sao Paulo state assembly, drafted legislation to create the Escola Politecnica de Sao Paulo (EPSP). The next year he became the school's first director. EPSP would be Brasil's first institution of higher education under the control of a state government (da Silva Telles 1993), p. 28). A former Minister of Foreign Relations, Agriculture, and Roads early in the Republic, with deep personal connections into SP coffee elite, de Paula Souza enjoyed great deal of trust from SP political elite. This trust allowed him to direct the new Escola towards the model of the Zurich Polytechnic and the Technical University of Karlshue where he had studied. At an exorbitant cost to the treasury of SP, de Paula Souza bought laboratory equipment in Europe in order to make EPSP the experimental site for material testing of the railroad and civil construction companies and government commissions in charge of developing SP infrastructure (Nadai 1983), p. 7). In 1934 this laboratory would eventually become the Instituto Tecnologico de Pesquisas (IPT) dedicated to technological R&D at the state and national levels. But an image of national progress had not scaled up.

Reflecting the needs of SP urban and agricultural development, EPSP offered the following engineering programs: civil (5yrs), industrial (5yrs), agricultural (3yrs), mechanical arts (3yrs), and surveying (2yrs). Architectural and geographic engineering were added in 1895 and chemical engineering in 1918 (da Silva Telles 1993), p. 4-5). EPSP first graduating classes went mainly into agriculture, railroad construction, and public works. It is only after 1910 that graduates begin to enter state industries in significant numbers (da Silva Telles 1993), p. 9).

Mackenzie College (1896)

In 1870, a Presbyterian College opened in Brasil to offer educational opportunities to Presbyterians who were encouraged by Pedro II to migrate to Brasil and develop empty lands. In 1895 John Mackenzie, a NY lawyer, made a significant contribution to establish an engineering school in SP under the auspices of the Presbyterians. The Presbyterian College changed its name to Mackenzie College and opened Brasil's first private engineering school in SP. Ruled by the Board of Regents of SUNY and modeled after Union College (1795), Mackenzie offered comprehensive education from elementary to college built on a philosophy of integration between theory and practice. School President, Horace Lane justified the school in terms that resonated with the proclamation of Republic:

> from old Europe we should not expect much, their educational models are set and invariable…North America is different. The fast progress and rapid changes in the landscape require constant changes in education. Their schools make a great effort to educate men and women that know how to appreciate the freedoms of a free country while religiously respecting the law…We will continue to follow the American methods, not copying them blindly but adapting and perfecting them

and avoiding commercialism and 'book erudition' at the same time (quoted in (Mendes 2000) p. 27).

This rhetoric was not yet threatening in SP. For more than five decades, relations with Britain had become difficult after the British blockade of slave ships. After US Civil War US emerged as a model nation for Brasil. The Constitution of 1891 was greatly influenced by the US Constitution. The political and cultural influence of Britain diminished while the American influence increased with the proclamation of the Republic. Segments of the SP coffee elite open to liberal economic ideas from the US and to Protestantism as an alternative to the conservative Catholicism that had supported the Emperor (Hack 2002), p. 45).

As a comprehensive college, by 1905 Mackenzie offered degrees in Humanities, Sciences, and Engineering. Those who finished engineering received a B.E. diploma in civil engineering granted by SUNY Regents and valid both in the Brasil and the US. Later, the College offered electrical engineering (1915), electro-mechanical engineering (1918), industrial chemistry (1915) which later becomes chemical engineering (1922) (Hack 2002), p. 165). From its inception, the engineering curriculum was guided by Dewey's educational principle of "learning by doing." Co-operative education and practicum were key parts of the curriculum (Mendes 2000), p. 32).

As regulation of higher education by federal government began to increase just prior to 1930, a sign that the image of progress as national development was scaling up, Mackenzie found it more difficult to justify its existence in Brasil. Until 1930, the school was able to secure the political support of SP politicians whose sons studied engineering at MC and who had interests in SP urban development, heavily reliant on engineers from both EP and MC. As long as the dominant image of progress called for regional development, and Mackenzie could make contributions to this development, the College would be allowed to operate.

Escola de Minas de Ouro Preto (EMOP)

EMOP's educators and administrators are also challenged by the scaling up of the image of progress as state development. First, in 1891, Benjamin Constant, Minister of Education, tried to reform the school according to his positivist ideas. Director Gorceix, a devoted catholic, successfully opposed the influence of positivism in the school but at a price (de Carvalho 2002), p. 96). He had to side with state elites who now viewed the school as provider of civil engineers for the infrastructural and industrial needs of Minas Gerais. Originally created to reaffirm the power of the Brasilian Empire, the school now graduated mining and civil engineers to serve in the federal government (e.g., Servicio Geologico E Minereologico do Brasil created in 1907) and in the MG's new mineral and metallurgical companies (de Carvalho 2002), p. 104-105).

An image of national progress was beginning to scale up during WWI when, for example, the federal government realized that Brasil had to supplement its iron imports and decided to build iron smelters and plants. EMOP engineers played a key role in the creation of these iron industries[9] and in key sectors of the federal government

[9] Especially after 1917 with the creation of the Companhia Siderurgica Mineira (CSM), the largest smelter in LA, by EMOP alumni. In 1921, the CSM merged with a Belgium company to create Cia Siderurgica Belgo-Mineira, the largest smelter in the world to run on vegetable coal. Later EMOP engineers played a

bureaucracy.[10] When the image of national progress began to scale up as result of The ambivalent position of EMOP between the federal and state governments led state elites to create the *Escola de Engenharia de Belo Horizonte* in 1911. From 1916 to 1940, the school was directed by Arthur da Costa Guimares from the powerful Guaimares family and graduate of EMOP. The school was created by the state legislature to address the growth of Belo Horizonte as the new capital of Minas Gerais and an emerging industrial city in Brasil (Eakin 2002).

Escola Politecnica de Rio de Janeiro (EPRJ)

On the eve of the Republic, EPRJ faculty is split between republicanos, mainly positivists, and monarquistas, especially Andre Reboucas, first black engineer and supporter of the Emperor. With the proclamation of the Republic, EPRJ became the seat of positivism where nationalist military engineers disseminated positivist ideology. As first minister of education of the new Republic, Benjamin Constant Botelho, one of the Republic's most influential positivists, lengthened and organized engineering degrees and eliminated scientific and math degrees. The new engineering program consisted of a 4-year basic engineering course followed by a 4-year course in either civil or industrial engineering. In spite of the weak educational reforms of 1900-1920, EPRJ continued its emphasis on state planning/administration started by Rio Branco during the Empire and continued by the positivists during the Republic (da Silva Telles 1993), p. 479 and p. 524). EPRJ graduates held a monopoly on two key federal ministries: Ministry of Agriculture[11] and the Ministry of Roads and Public Works.[12] During the presidency of Epitacio Pessoa

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dominant role in all smelters, except in Volta Redonda who became the domain of military engineers from RJ and german engineers working for Mannesmann (de Carvalho 2002), p. 119-21). EM graduates were mainly responsible for the increase Brasil's iron output from 2KT/yr in 1900 to 185KT/yr by 1940. (da Silva Telles 1993), p. 481). The demand for EMOP engineers also grew due to new constitutional rights of property owners over the mining rights in their properties garnted by the Constitution of 1891.

[10] 75% of EMOP graduates went into public sector. First, they played key roles in the Geological and Mineralogical Survey of Brasil (later became the Departamento Nacional de Producao Mineral of the Ministry of Agriculture), and then in the Secretaria de Agricultura, Industria, Comercio e Trabalho in 1930s (Eakin 2002), p. 80)

[11] Engineers worked in Servicio de Estadistica, Servicio de Pavimento, Servicio de Propaganda and Economic Expansion of Brasil (ended in 1910), in the Fabrica de Ferro de Sao Joao de Ypanema (which moved to Ministry of War in 1910), in Servicio Geologico e Mineralogico de Brasil. Between 1909 and 1930, 19 new divisions were created, including Instituto de Quimica, Estacao Central de Quimica Agricola, Directoria de Metereologia, Observatorio Nacional, Directoria General de Propiedade Industrial, Estacao de Biologia Marihna (1915), Superintendencia de Abastecimiento (1920), de Servico de Algodao, de Beneficiamento de Cereais (1920), Estacao Experimental de Combustiveis e Mineirios (1921), Servicio Florestal Brasileiro. Between 1910-30, there were 4 engineers out of 10 directors that held the position for 10 out of 20 years, reflecting a strong connection between the technical and executive body of the Ministry of Agriculture and graduates of EPRJ and EMOP (Dias 1994), p. 21)

[12] Engineers were also in control of Inspetoria de Aguas e Esgotos, Estrada de Ferro Central do Brasil, and Inspetoria de Portos, Rios e Canais. "From the point of view of engineers, a career in the Ministry of Roads constituted an end in itself." (Dias 1994), p. 32) The actual construction of public works was left mainly to foreign companies who employed foreign engineers in the top positions. EMOP and EPRJ engineers did the planning, budgeting, and funding of public works. With regulation of profession and the monopoly over two Ministries, engineers paved the way for the construction of a state machinery. (Dias 1994), p. 39)

(1919-1922), known for its heavy fiscal investment in infrastructure, engineers occupied the top posts in Agriculture, War, and the prefecture of Distrito Federal (Dias 1994), p31).

"Ordem e Progresso": Engineering education for the Brasilian nation

> "The Interim President of the Republic of the United States of Brasil, using the powers given to him by Article 1 of Executive Order No 19.398 of November 11 of 1930, decrees that the diplomas issued by the Engineering School of Mackenzie College of Sao Paulo will not be recognized as valid…" (Signed Francisco de Campos, Minister of Education, and Getulio Vargas, Interim President of the Republic) (quoted in **(Hack 2002)**, p. 185)

What could possibly lead a new interim president of a country in political turmoil to spend time and attention issuing a decree to invalidate engineering diplomas from a private school? A plausible explanation, proposed by Hack, is that a Presbyterian school had no place in Brasil under a new regime supported in large part by conservative Catholics (Hack 2002). Then why didn't the government close the entire College, or at least the Humanities program probably with more explicit religious content, instead of invalidating engineering diplomas? Is this action a reflection of a scaling up of an image of national progress that now challenges the interim president to go after foreign engineers and engineering knowledge? If so, did the Vargas government create a concept of or plan for national engineering education?

I argue here that the military coup of 1930 that placed Getulio Vargas in power was indeed a political manifestation of the scaling up of an image of national progress defined as "ordem e progresso." This image was first proposed by positivist engineers and stamped in Brasilian flag in 1889 by engineer Texeira Mendes but never fully scaled up during the Republic According to the positivists, this image called for 'order' by integrating individuals into humanity via a patria (fatherland) (Diacon 2004), pp. 81-4). A fatherland (patria) requires a State, that organizes social, political, and economic life within the territory (country), and a Nation or community that is emotionally tied to the fatherland and has come to accept the legitimacy of the State (Hooson 1994; Kristof 1994). Reacting against the political and economic chaos created by the interests of state elites and the international economic crisis of 1929, the Vargas transitional government (1930-34) set out to build a strong State to organize Brasilian social, political, and economic life. As Jerry Davila, professor of history of Brasilian education and scholar of Brasilian nationalism, argues

> the Revolution of 1930 ushered in a new political era for Brasil by bringing together Getulio Vargas and his alliance of regional political bosses, nationalist intellectuals, and the emerging industrial, professional, and managerial middle classes. This new political coalition replaced forty-year old decentralized political system that concentrated political power in the hands of the regional oligarchies, most notably the powerful coffee barons of Sao Paulo…the Revolution of 1930 ignited expectations that a new regime would narrow the social gap and pave the road to a modern industrial and urban nation. The new regime also engaged in extensive institution building and adopted the new nationalism as its official ideology (Davila 2003), p. 56).

The most visible political manifestation of this 'order' would come later as the authoritarian *Estado Nuovo* put in place by Vargas in 1937.

For the positivists, the nation was a means to a higher end: humanity. For Vargas, however, the nation was an end in itself. Hence the Vargas regime set out to construct a nation that would recognize the legitimacy of the State through a very strong emotional connection to the fatherland. This was not easy in a country marked by deep racial and regional differences, now enhanced by ethnic ones brought by massive migration from Europe and Asia. Daryle Williams, a cultural historian who specializes in this period of Brasilian history, argues that "the contentious politicking over the administration, content, and meaning of a national culture specifically marked as *Brasilian* was endemic to the authoritarian-nationalistic policies associated with the populist dictator Getulio Vargas (1883-1954). In these culture wars, bureaucrats, artists, intellectual, critics, and everyday citizens competed against one another and the state for control of *brasilidade,* an intangible but highly coveted sense of Brasilianess" (Williams 2001), p. xvii). In spite of the "contentious politicking", the Vargas regime created and controlled state mechanisms for the creation and diffusion of what it meant to be Brasilian.[13]

The image also called for 'progress' which the Vargas regime defined primarily in terms of building a strong national industry based on the pillars of steel and energy and inspired by a nationalist policy of import substitution and the methods of Taylorism and Fordism, all endorsed by engineers and Vargas's close advisors Roberto Simonsen and Julio Caetano Horta Barbosa (Weinstein 1996). By the end of the Estado Nouvo (1946), Brasil's industrial development had gone from a disorganized collection of small industries dispersed around the states and some notable sites of foreign investment to a centrally orchestrated collection of large national industries organized around federal institutions such as the Conselho Nacional de Petroleos (CNP), Companhia Siderurgica Nacional (CSN), Usina de Volta Redonda, and Conselho de Aguas e Energia Electrica (Wirth 1970; Dias 1994). In short, the image of "ordem e progresso," different from what its Republican positivist authors had in mind, scaled up during the Vargas regime (1930-1946) defined in terms of nationalism and industrial development. This image came to challenge engineering education and practice and elicited a number of reactions from engineers.

Education

A key mechanism for the expansion of nationalism and the creation of a nation was the Ministry of Education and Public Health (MES) created by Vargas in 1930. MES was to become the main instrument for the "moral and physical saneamento [cleansing]" of the people, as Vargas proclaimed during his first address as provisional president in 1930. During his first period, 40,000 primary schools were established with State orchestrated curriculum and activities designed to create a meaning of Brasilianidade, immigrant colony schools were closed, and the Pedro II high school was made into an exemplar of

[13] This included the construction of federal institutions of cultural management such as the Conselho Nacional de Cultura, Servicio de Patrimonio Historico e Artistico Nacional, the Departamento Nacional de Propaganda, etc. (for a complete analysis of cultural management and the construction of Brasilianidade, see (Williams 2001)

nationalist secondary education (Davila 2003). Brasilianization of cultural life became one of the main goals of the State during the Vargas regime. According to Daryle Williams,

> As the Estado Nuovo matured, federal cultural management became the wedge issue that Campos [Minister of Education] envisioned for educational and health reforms in 1930. An editorial published in July 1938 issue of the *Revista do Servicio Publico* summed up the historical, functional, and ideological place of federal cultural management under the *Estado Nuovo*: "The era has ended in which state intervention into the nation's culture was believed to amount to nothing. A false and empty liberalism once denounced any State initiative as an invasion into the territory which should be exclusively reserved for free intellectual initiative…Only an imbecile would now be capable of defending this position, which is unsustainable in today's world. Those nations that do not demonstrate active consciousness of their unique characteristics will find it difficult to survive this tempestuous era in which we live. No aspect of national life can be left at the margins of state actions, as the State is the sole entity capable of imprinting upon each citizen a truly nationalistic mark" (Williams 2001), p. 69)

A key institution of cultural management is the university. But Vargas encountered a higher education landscape where professional schools controlled by the states had enjoyed great deal of autonomy for three decades and were not organized under a federal system. Although in 1920 President Epitacion Pessoa (1919-1922) created the *University of Rio de Janeiro* as an aggregate of three professional training schools (law, medicine, and engineering), this organization did not create any significant structural, functional, or pedagogical changes to existing faculties (Haar 1977), p. 54). It was Francisco Campos, Vargas's most influential ideologue as architect of the *Estado Nuovo* and MES first minister from 1931-32, who significantly reformed Brasilian higher education, until now in the hands of the States, through his 'Statute of Brasilian Universities.' This decree set forth the concept of a university system in Brasil and became Vargas's instrument to control higher education, including all existing schools of engineering. According to this decree, a university could be only be organized with three faculties: law, medicine, and engineering, or the substitution of any of these three for a faculty of education, science, and letters" (Haar 1977), p. 55). Subsequently, the constitution of 1934 gave the Federal government the power to develop a National Plan of Education as the means to coordinate and oversee its execution around the entire country, and to determine which institutions of secondary and higher education would be recognized to grant diplomas. For the Vargas regime, "the university would develop a backward country, add dynamism to Brasilian society, help Brasil integrate into an international arena, and create a space for those interests that been repressed from higher education due to hegemony of the coffee elite." (Nadai 1983), p. 13)

The concept of 'university' also allowed more control over engineering schools. As Lili Kawamura, professor of sociology of Brasilian education at USP,

> the measures introduced in the schools of engineering --at the levels of organization, administration, curriculum and laboratory instruction-- showed a tendency in engineering education towards patronage, in addition to an increasing control from the [federal] State. On one hand the state schools were going through

> changes promoted by educational reforms set by the federal government under the units denominated 'universities.' These reforms allowed a larger control of higher education by the [federal] State. On the other hand, private engineering education –which before the Vargas period was not under the purview of legislation— undergoes significant modifications once it is included in the new educational legislation. The most significant examples of these reforms in schools of engineering are the Escola Politecnica and Escola Mackenzie in Sao Paolo (Kawamura 1981), p 74).

This control had the goal of directing engineering schools towards industrial development and production. According to Lili Kawamura,

> The disarticulation of the domination of the agricultural bourgeoisie, the economic international crisis of 1929, and the domestic political contradictions experienced in Brasil at the end of the 1920s gave a new configuration to engineering education. As the segment of the political society interested in expanding the internal market [those supporting Vargas] extended its actions through various levels of social reality, significant changes would take place at engineering schools during the period of 1930-1945. The authoritarian and interventionist character of the [Vargas] government , especially after 1937, led to normative actions over the entire school system, trying to direct it towards the economic objectives that favored urban-industrial expansion…Hence the [federal] State established educational reforms at all levels which had particular impact on engineering education. During this period there would be no new engineering schools but the existing ones would undergo significant transformations towards a pragmatic professional formation with specializations directed to industrial production (Kawamura 1981), p. 72-73).

What specific challenges did the image of "ordem e progresso" create for the different engineering schools? What were the reactions to those challenges?

Escola Politecnica de Sao Paulo (EPSP)

The most significant challenge for the EPSP was its incorporation into a university. However, the political compromise between the Vargas government and the State of Sao Paulo after the Revolution of 1932, when paulistas fiercely fought and lost to the Vargas regime, was to allow the university to remain an institution of the state of Sao Paulo and have more than 3 faculties. According to historian of higher education, Elza Nadai,

> the first true Brasilian university under the Campos reform is the University of Sao Paulo created in 1934. Unlike other universities in Brasil, USP had professional schools in Engineering, Agriculture, Pharmacy and Dentistry, Law, Medicine, and also a Faculty of Philosophy, Science and Humanities. The Vargas government and the SP political elite reached a compromise to create a university with all professional schools and the faculty of philosophy, sciences, and humanities so the latter could "fulfill its sacred mission of educating an elite capable of creating a political regeneration of the nation and proposing a political project to be assimilated by the middle class (Nadai 1983), p. 14).

The image of "ordem e progresso" also brought changes to previous curricula. According to Lili Kawamura, "curricular reforms under the Vargas regime, which

affected all disciplines, courses and length of study, took engineering education in the direction of industrial production. The Escola Politecnica whose emphasis was predominantly theoretical in previous period saw its curriculum reformulated towards industrial production" (Kawamura 1981), p. 75). For example, before the Vargas reforms, chemical engineering at EP was conceived as a program in chemistry with some added courses in engineering. After the reforms of 1939, intended to develop more specific curricula for industrial production, chemical engineering changed to include unit operations, processes, and installations in chemical industry (Kawamura 1981), p. 75). During the same time, new disciplines were included such as technical organic chemistry, electrical machines, transmission distribution and utilization of electrical energy, layout of electric lighting, electric telecommunications (Ibid.). The existing laboratory of strengths of materials, originally conceived to educate EP students on industrial applications for local industry, was transformed into the Institute for Technological Research (Instituto de Pesquisas Tecnologicas, IPT) in 1934. In addition to its pedagogical activities and service to local industries, IPT had now a national mission to develop and repair machinery for national industry and the military (Kawamura 1981), p. 76). IPT's role as one of the nation's leading technological R&D labs continued to grow until the present.

Some engineering educators at EPSP resisted the narrow orientation brought by the Vargas regime arguing that engineers had a larger role in public service and industrial administration, not just in production. For example Mario Lopez Leao, a prominent engineer at the time who like others used the *Revista de Engenharia* as an outlet to express their frustrations with educational reforms, argued that "engineering education plays a fundamental role in the formation of professionals necessary for our country, not only in technical functions of execution but also in the organization and direction of large projects. Engineering education should enable students with the knowledge and methods to stimulate and develop their capacity to understand the essential problems and orient them to provide the most convenient solutions for our community" (quoted in (Kawamura 1981), p. 79).

Mackenzie College (MC)

Ironically, MC's engineering programs were probably more appropriate than any other to address the challenges of industrial production because of their emphasis on integrating theory and application and their US-inspired co-operative education. However, as the image of "ordem e progresso" scaled up, it became more difficult for MC to justify its existence in Brasil. After all, it was an institution governed by the Board of Regents of SUNY, based on a US educational model, and granting diplomas recognized in the US. The new image challenged engineering education to be national. At the same time, the Vargas regime wanted control over all higher education institutions. This led Vargas to question and eventually invalidate MC's engineering programs. The "Mackenzie Case", as the controversy over the validity of MC engineering diplomas became known in the press, reached national attention. After a number of heated exchanges in the *O Estado de S. Paulo*, SP main conservative newspaper, the editor finally weighed in and declared that:

> the information that we have of that school [MC], which has been in operation for more than 20 years, has always been positive. Its courses are accredited as serious

> and useful. This is why it has more and more students every year. But is that enough? Maybe not. Also *our* Escolas Politecnicas (do Rio e Sao Paulo) are very good. In addition they have the advantage of being *national* while Mackenzie is foreign. Engineering is not yet so specialized that it can afford to be detached from *national* needs…The education [at MC] could be beneficial for its students but detrimental for the citizens that consider it coming from a culture foreign to *our* way of being. The number of those *denationalized* engineers [from MC] will grow year after year and will push aside those from *our* escolas, created as instruments of organization of *national* culture… An immense country, scarcely populated and cultivated but full of possibilities, Brasil has become for some time now a field of foreign missions of all faiths fed by a spirit of spiritual penetration and pacific conquest (quoted in (Mendes 2000), p. 59) (italics mine).

Here the editor describes MC engineering as foreign and religious and contrasted it to Politecnic engineering which is national and secular. Struggling to get its legal status back and prove its usefulness to Brasilian nation, MC engineering included a course on military applications administered by the military. But as we have seen, MC lost its ability to grant engineering diplomas recognized in Brasil, continuing operations and granting of diplomas recognized only in the US (Hack 2002). In 1938, MC had to break all ties with the Board of Trustees of New York and to create a governance mechanism in Brasil in order to obtain legal recognition of its engineering degrees inside Brasil. As a result of this "nacionalizacao" (Hack 2002), MC changed its legal status by becoming a civil society ruled by Brasilian law under a new name: *Instituto Mackenzie* (Hack 2002), pp. 194-5).

Other engineering schools were also incorporated into universities. In 1931, *Escola de Minas de Ouro Preto* (EMOP) was incorporated to *Universidad de Rio de Janeiro*, only to be quickly separated and incorporated to the *Universidad de Ouro Preto*. During the Vargas regime, the degrees of surveyor and geographer engineer were abolished and the two remaining programs in mining and civil were restructured with emphasis on mechanical engineering, specifically on design and maintenance of machines for industrialized agriculture and iron works (da Silva Telles 1993), p. 525). Eventually, EMOP became part of the *Universidad Federal de Ouro Preto* as a compromise not to move school from Ouro Preto to Belo Horizonte.

In 1937 the EPRJ became the *Escola National de Engenharia* (ENE) of the *Universidad de Brasil*, a national university created under the Estado Nuovo. This was the first time that Brasil had a *national* engineering school. However, according to historian of Brasilian engineering Pedro da Silva Telles, this change of name created a great deal of anxiety among alumni whose identities were linked to the Escola Politecnica de Rio. Eventually, the name would change back to Escola Politecnica (da Silva Telles 1993), p. 470). In 1933, Vargas created the Instituto Nacional de Tecnologia (INT) to conduct research specific to areas of interest to the development of national industry.[14] In the decree to create INT, Vargas described it as "similar to the research institutions in the US and with the same ends, and guiding our National Industry [sic], facilitating its

[14] For example, in response to increasing oil prices and the significant energy needs of his industrialization programs, Vargas decreed a mandatory addition of 5% alcohol to imported gasoline, creating a national need for research and development of alcohol-ready automobile engines and large-scale alcohol production (Magalhaes and Schwartzman 1981).

necessary expansion in order to realize the greatness of our fatherland" (quoted in (Magalhaes and Schwartzman 1981).

In spite of their incorporation to universities, which facilitated federal control, engineering programs were seriously criticized by engineer and industrialist Roberto Simonsen, Vargas's closest advisor on industrial matters, for their lack of connection and relevance to industry. As a result, Gustavo Capanema, Vargas minister of education from 1934-45, created the National Service for Industrial Training (SENAI) in 1942 to provide industrial training in large scale. Meant as a vocational training mechanism, SENAI also became a pathway for engineers to gain industrial training (Weinstein 1996), p. 135).

Engineering profession

Brasilian engineers sided with the Vargas government to keep the engineering profession free from the incursion of foreign engineers. Key engineering groups, including the Club de Engenharia, the Sindicato Central dos Engenheiros, Instituto de Engenharia, among other, convinced Vargas to issue Decree 23,569 of 1933, the first federal law regulating the practice of engineering in Brasil. This decree required that 1) all persons practicing engineering, architecture, or surveying –especially in public service at all levels-- hold a diploma from recognized national schools, or from foreign schools as long as the diploma is validated by the Brasilian government; 2) plans and projects be developed and executed by recognized professionals in order to have any legal value; 3) all companies, societies or firms executing any kind of work in engineering have recognized professionals in charge of those works. The Decree also created the Federal Council of Engineering and Architecture (CONFEA) and the Regional Councils of Engineering and Architecture (CREA) as regulatory mechanisms of the professional practice of engineering. Council members would be chosen by the government, engineering schools, and professional societies. The Decree also created a professional registry at the Ministry of Education which issued a required document for the practice of the profession. This document substituted the diploma for all practical effects (da Silva Telles 1993), p. 700). These regulatory mechanisms are still working today.

"Brasil Potencia:" engineering education and research for a rising world power

In 1975, military president Ernesto Geisel launched the Plan Nacional de Pos-Graduacao (PNPG) with funding of 1.2 billion dollars to triple the 3500 MS and 500 PhDs already exiting in Brasil.[15] During his government, funding for science and technology increased twentieth fold from the previous government (Motoyama 2004), p. 323-36). According to historian of Brasilian science Shozo Motoyama, "Geisel invested in scientific and technological development like no other president in Brasil…This support in the creation of human resources in science and technology is still felt today [2005] through a large group of tens of thousands of researchers who started their careers at that time of significant expansion for science and technology" (Motoyama 2004), p. 337-9).

How can we begin to understand this level of support, especially at a time when Brasil had already accumulated significant foreign debt and began to experience high

[15] For comparison, the total NSF budget for 1975 was $766 million of which only $73 million went to s/e education.

levels of inflation? Why did the government change emphasis from undergraduate education for industry to graduate-level education and research? How did the institutions and mechanisms that created the existing 4000 scientists and engineers with graduate degrees develop?

I argue that after the Vargas era the image of "ordem e progresso" was redefined in terms of reaffirming Brasil as a world power. The process of scaling up began with the Estado Nouvo, particularly with Brasil's participation in WWII[16], continued through a 10-year period of democratic governments, and reached its peak in the military regimes of the 1960s and 1970s. In the mid 1970s Carlos de Meira Mattos, deputy chief of staff during the first military presidency (1964-67) and one of the most influential thinkers of the entire military period, was already declaring that "we possess all the conditions that enable us to aspire to a place among the world's great powers" (de Meira Mattos 1975). This image challenged government officials to develop, implement, and fund, at unprecedented levels, graduate education and research in science and engineering.

Background

The end of the Vargas' authoritarian Estado Nuovo in 1946 brought a significant degree of liberalization to higher education, allowing, for example, the creation of new universities and important institutions for the support of science and technology (s/t). Influenced by Vannevar Bush's *Science The Endless Frontier* (1945), the Brasilian constitution of 1946 called for the creation of an organization to support scientific research. The Conselho Nacional de Pesquisas (CNPq) was created during the Dutra government (1946-1951). In this environment of relative political and academic freedom a number of important scientific institutions were created: the Sociedad Brasileira para o Progresso da Ciencia (SBPC, 1948), Centro Brasileiro de Pesquisas Fisicas in RJ (1949) (Motoyama 2004), p. 283). According to Shozo Motoyama, a historian of Brasilian science and technology at the USP, "the 5 or 6 years between the end of the Estado Nuovo and the beginning of the second Vargas regime were of great importance for science and technology. The creation of a diverse number of institutions such as the CNPq, CTA, and SBPC, among others, show great dynamism in science and technology policy, at a time when economic policy was completely stagnated…This is in great part due to a transition from a centralizing government to one more sensitive to democratic participation (Motoyama 2004), p. 295).

One of the key engineering education institutions created during this period of relative political freedom was the *Instituto Tecnologico de Aeronautica (ITA, 1947)*. Prior to its creation, key civil and military engineers visited the US to study aeronautical engineering at MIT and Stanford and observe research facilities such as those at USAF Wright Field Research Center.[17] The fall of Vargas nationalist regime in 1946 allowed these military officers to consider MIT as a model for the first Brasilian engineering

[16] After Brasil entered WWII and fought with the Allies, it became Latin America's most powerful military power.

[17] Capitan Benjamin Manoel Amarante and Air Force Colonel Casimiro Montenegro were sent to MIT to study aeronautical engineering. Army Second-Liutenant Aldo Weber Viera de Rosa and Navy capitan Helio Costa studied at Stanford. Eventually Montenegro would lead the effort to create ITA and CTA. Viera de Rosa would become president of CNPq in 1956 (Junqueira 1999)

school to be under the direct jurisdiction of the federal government and aimed at making Brasil an air power after WWII. These high-ranked Brasilian military engineers convinced Prof. Richard H. Smith from MIT to draft a plan for a new aeronautical engineering school. The "Plano Smith" proposed the creation of ITA with a) three degree programs with fully equipped labs in aeronautical engineering, meteorology, air commerce, and aircraft production to be added later; b) Centro Tecnologico de Aeronautica (CTA), a research lab supervised by ITA faculty to provide technical support to the newly created Ministry of Aeronautics; c) direction by a civilian, assisted by an autonomous group of faculty[18]; and d) complete academic freedom (Junqueira 1999). According to Simon Schwartzman, one of Brasil's leading social scientists of science, technology, and education, "in the 1950s the institute became known as Brasil's best engineering school; it drew students from all over the country through very competitive entrance examinations…The institute was not organized as a military establishment and was open to civilians. Its location under the Ministry of Aeronautics freed it from the bureaucratic regulations of the Ministry of Education and provided it with many more resources than any other teaching institution in the country. The close cooperation with MIT assured a constant flow of personnel between the institute and several American institutions and made it easy for its best students to continue their courses in the US" (quoted in (Junqueira 1999), p. 206).

The scaling up of "ordem e progresso" as "Brasil Potencia"

The image of "ordem e progresso" began to be redefined in terms of reaffirming Brasil as a world power during the Estado Nuovo. Vargas's development of national industry, achieved through import substitution, modernization, and a corporate state, showed that it was possible for an agricultural country to be transformed in Latin America's industrial powerhouse (Schneider 1996). Brasil's participation in WWII reaffirmed its position in the world as it became Latin America's most powerful military power, even surpassing Argentina. Vargas's tragic suicide in 1954 and the economic crises brought by coffee and cotton overproduction in 1952 and 1954 forced Vargas's successors to move away from 'economic nationalism' but not from a path of rapid development. When Juscelino Kubitshek took power in 1956, he reaffirmed his commitment to the image of "ordem e progresso" with the slogan "fifty years of progress in five years of government." With foreign capital, Kubitshek planned and built industrial poles to attract foreign auto makers in an unprecedented scale (Eakin 2002), Brasil's new capital, and large-scale transportation, energy, manufacturing industries(Alexander 1991). In short, the image of "ordem e progresso" did not die with Vargas. It was redefined according to the economic and geopolitical circumstances of the time and challenged the government of Juscelino Kubitshek (1955- 1960) who continued with rapid industrialization and development through foreign capital and intervention. During Kubitshek government, industrial production grew 80% with higher percentages in steel industry (100%), mechanical industry (125%), electricity and communications (380%) and transportation (600%). For the decade of 1950s Brasil per capita growth was approx 3 times the rest of Latin America (Eakin 2002), p. 91).

[18] Smith became ITA's first director. Saul Steinberg, former dean of engineering at Univ of Maryland, would be ITA's second director

This industrial growth was mainly sponsored by foreign capital with increasing presence of foreign companies which conducted all their R&D in their home countries, not in Brasil. With the exception of single laboratories like IPT, INT, and CTA, there was not an integrated system for technological R&D. In addition, the lack of nuclear technology transfer from the US, at least until the Atoms for Peace program, and the realization of a need for the development of space technology, motivated in great part by Sputnik, led the Quadros government and some state governments to create a number of bureaucratic mechanisms to deal with the lack of research capacity. These included the Universidad de Brasilia (1961), Fundacao de Amaparo a Pesquisa do Estado de Sao Paulo (Fapesp, 1962), Coordenacao de Programas de Pos-Graduacao em Engenharia at the Universidad Federal do Rio de Janeiro (Coppe, 1963), the Fundo de Desenvolvimiento Tecnico e Cientifico (Funtec, 1964), and the Fundacao de Amaparo a Pesquisa do Estado do Rio Grande so Sul (Fapersgs, 1964). The democratic political environment was conducive to the creation of mechanisms to support science and engineering but the funding was very limited (Motoyama 2004), p. 312-3).

On March 31, 1964, a military took power arguing the existence of a communist threat after Goulart, Quadros's vice-president who took power after Quadros resignation, tried to expropriate land and renewed relations with the USSR. Although there were differences among the first four military presidents in their economic policies and funding levels for science and technology (s/t), they were all challenged by the image of "ordem e progresso" now more clearly defined in terms of reaffirming Brasil as a world power. Each military government responded in different ways. The governments of Costa e Silva (1967-69) and Ernesto Geisel (1974-1979) stand out for the unprecedented levels of technology-driven desenvolvimiento to make Brasil a world power. Their views came from the "Programa Brasil Potencia" ("Program Brasil a Power") developed at the Escola Superior de Guerra (ESG). Inspired by doctrines of national security and 'geopolitical destiny' (de Meira Mattos 1975), this program called for education and technical research as essential elements in establishing Brasil's power in an international arena. At the beginning of Costa e Silva's government (1967), the situation for science and technology improved radically from the previous government. In his Plano Trienal (1968-1970), Costa e Silva made s/t research and education strategic areas for the acceleration of desenvolvimiento (Motoyama 2004), pp. 323-36). Existing science-oriented government mechanisms and small research infrastructure in places like CTA, ITN, and IPT facilitated small-scale research. But the levels of R&D scale and sophistication required for "Brasil Potencia" key areas necessitated large levels of infrastructure and human resource development.[19] Accordingly, the quantity and qualities of human resources in s/e envisioned for large-scale desenvolvimiento required a major reform in the existing university and research system, including the development of graduate engineering education and research, until now almost non-existent in Brasil.

Graduate engineering education and research for "Brasil Potencia"

[19] Key areas of the Programa Brasil Potencia include hydroelectric and petroleum-based energy, improvement of highway and air transportation, telecommunications, iron production, production of radioactive materials, and exportation of minerals.

First created in 1951 and then subordinated directly to the President in 1961, the Coordenacao de Aperfeicoamento de Pessoal de Nivel Superior (CAPES) was transformed in 1981 into the federal entity responsible for the elaboration and execution of the Plan Nacional de Pos-Graduacao (PNPG) [National Plan for Post-Graduation]. This plan included developing, evaluating, and coordinating all activities related to graduate education, including engineering. Ernesto Geisel (military regime third president from 1974-79) put in place a second plan for development (II PND) which emphasized the creation of "competitive technical knowledge" to address the national problems in technological development, including a heavy dependency on foreign technology and expertise. After establishing import substitution policies for high-capital technologies, Geisel significantly increased graduate programs in engineering. Challenged by a scaled up image of progress of Brasil as world power, Geisel decided to triple the number of s/e with graduate degrees and increased support for s/t twenty-fold. What were the institutional models available to ramp up graduate engineering and research? What were the new institutions? What kind of specific projects came to dominate the employment of new engineering researchers and developers?

In many aspects, ITA was a pioneer of the university reforms of late 1960s of 1970s. It served as a model for the organization of disciplines along a departmental structure, competency requirements for faculty including professional experience and a record of accomplishments, and the close linkage between education and research. Eventually, ITA's model influenced the organization of engineering education and research at other institutions and the transformation of the Escola Tecnica do Exercito into the existing Instituto Militar de Engenharia (IME, 1959), and the creation of Unicamp (1965) (Junqueira 1999), p. 149-50). In the 1960s and 70s new universities in Bahia, Pernambuco, Rio Grande do Sul were also created (Motoyama 2004), p. 349).

But the new challenge required more than universities. "Brasil Potencia" called for technological development in air and road transportation, nuclear and alternative energy (particularly to make Brasil independent of foreign oil), telecommunications, computer technologies, steel production, and military technology (Motoyama 2004), p. 323).

For air transportation and military power, the creation of Embraer in 1969 had a significant role in engineering employment and research, particularly due to its close affiliation with ITA. By 1990, ITA graduates represented 40% of its 1,200 engineers, more than half of its fifty managers, and five of its six directors (Conca 1997), p. 41). Even before its privatization in 1994, Embraer came to symbolize Brasil's capacity to develop and export high tech commercial and military aircraft (Silva 2004).

In energy, research focused on nuclear energy and alternative to fossil fuels. Initially established by presidential decree in 1975 to protect the sugar sector from collapsing, the Proalcohol program sought to stabilize sugar prices by transforming excess sugar into anhydrous ethanol to be blended with gasoline to create gasohol for use in automobile engines. After the oil crises of the 1970s, air force engineers developed an alcohol-burning engine for the government's alternative fuels program for automobiles (Conca 1997). By 1985 with 85-90% of all new cars being alcohol powered (Demetrius 1990). The Itaipu hydroelectric project was also a great source of engineering research and employment. For the development of nuclear technologies, each branch of armed

forces developed their own nuclear program, utilizing engineers from different schools (Adler 1987; Conca 1997), p. 55).

In telecommunications, engineering R&D focused on the massive expansion of telephone, radio, and television communications under Telebras and Embratel, state companies created during the military regime (Vargas 1995), part III).

In computer technologies, engineering R&D focused on the development of a Brasilian computer which resulted in two computers –Cisne Branco and Patinho Feio— developed for the Navy by engineers at the Laboratorios de Sistemas Digitais de EPSP(Langer 1989).

In military technologies, engineering R&D focused on ship and submarine building (Conca 1997), p. 52), armed vehicles, short-range rockets, explosives, missiles, and helicopters (Vargas 1995), part III)

Engineering education for "Ordem e Progresso" or "Market Competitiveness"?

During a recent interview, Marcelo, a Brasilian engineering professor who benefited from the technological expansion of the 1970s and is now teaching in the US, declared

> when I went back to Brasil in 1995 after my PhD in the US I worked very hard as professor teaching, writing proposals, developing grad programs, building the mechatronics program at USP, organized two conferences…I was really involved in my career…my plan was to stay in Brasil…but during the 1990s with the privatization of state companies, and in spite of the stabilization of the economy, it became very difficult to develop technology in Brasil…[eventually] I asked myself 'what am I doing here? To teach engineering kids to work in banks? They are not working on technology; they are working as businessmen…what I am doing here? to develop technologies that have no meaning for Brasilian industries?'...at the same time I was writing papers to be published in the US and realizing how much support there is for technology in the US…I came to the realization that I was having no impact on the big picture of developing Brasilian society…engineering designs became paper exercises…private companies were now bringing technology from outside into Brasil…during my engineering student years [in the early 1980s] I had that connection with Brasilian technology but then it lost all meaning." Marcelo would eventually leave his very prestigious position as Profesor de Livre Doscencia at EPUSP to take a tenure-track faculty position in the US.

How can we begin to understand the changes that Marcelo experienced in engineering education and research from his college years in the early 1980s to his teaching years in the late 1990s? How can we understand his reaction to engineering graduates taking jobs in banking and finance and his realization that he was having no impact on the development of Brasilian society?

Background

After the end of the military regime in 1979, subsequent governments engaged in policies of privatization of state companies and economic liberalization. The policies of high-tech large-scale development could no longer be sustained during periods of hyper-inflation

and massive foreign debt. In the early 1990s, the levels of funding for s/t were only one third of those reached in the late 1970s. In spite of the creation of the Ministry of Science and Technology (MCT) and planned spending of 2% of the GDP in s/t during Jose Sarnay's government (1985-1990), engineering research and development decreased significantly. However, the role that engineers played in technological development and in high-level government positions[20] to help Brasil become a world power during the military regime was still very attractive to potential engineering students in the 1980s, including Marcelo. Students still enrolled in engineering programs in high numbers creating a high supply of engineering graduates in spite of the low demand in the job market brought by the economic crises of the late 1980s and early 1990s.[21] High demand for engineering education led to the creation of private engineering schools. Enrollments grew from 93K in 1960 to 1.345 million in 1980 (Conca 1997).

To address the challenges of higher demand for engineering degrees and privatization of engineering education, the government, probably with support of engineering educators from established public universities, began accreditation of undergraduate engineering programs in 1996 through the Instituto Nacional de Estudos e Pesquisas Educacionais Anisio Teixeira (INEP).

With the State divesting and privatizing its large technological projects and companies, engineering graduates in late 1990s sought employment in private banking and financing sectors. Still challenged by the image of "ordem e progresso" as reaffirming Brasil's place in the world through technological development, professors from Marcelo's generation complained about students' new career paths. Marcelo, like PM in the Introduction, worries about the future of Brasil's technological development and question the career path of today's engineering students. But they, like their students, are also being challenged by an American image of competitiveness defined as the ability to compete in the market through low cost mass production. No wonder that AF worries about IPT's new commercial endeavors and is considering leaving his job.

The challenge from this image of competitiveness is also visible in the themes from the last 5 years of engineering education conferences of the Brasilian Society for Engineering Education (ABENGE). These themes include accreditation, mobility, and entrepreneurship, among others. No wonder that EW in the Introduction was worried about the lack of entrepreneurship among his students. This year ABENGE will host the Global Colloquium for Engineering Education, a new event created by ASEE to enhance visibility and dissemination of engineering education reforms for competitiveness. Under the names "Engineering for the Americas" and "Curriculum Development for the Global Engineer," two of the Colloquium tracks will be devoted entirely to mobility of engineers. Likely, entrepreneurship of engineering students, new career paths, and competitiveness of engineering education and research institutions will be among the conference themes. However, the challenge that these themes presents to Brasilian engineering education can only be understood in terms of its history, the particular development of each of its

[20] Whereas from 1946 to 1964 60% of federal cabinet ministers had had legislative experience and only 26% technical experience, between 1964 and 1974 only 29% had served in the legislature but 52% had had technical experience…" (Hagopian 1996), p. 109-10)

[21] At the beginning of the military rule (1964), there were 2,289 engineering graduates per year (compared to 4,170 lawyers and 2,049 economists). By 1970, there were 7,552 engineering graduates per year (compared to 6,587 lawyers and 5272 economists) (Conca 1997).

institutions, and the still dominant image of Brasilian "ordem e progresso" defined in terms of reaffirming Brasil as a world power.

Hence EW's worries about lack of entrepreneurship of his students have to be understood in terms of the long history of the EPRJ and its focus on imperial and federal State administration and planning, not on private industrial development. If 'what is engineering for' at EPRJ came to signify working for the State through civil construction, planning, administration, and (later) research for national problems, then one might expect EPRJ curricula and practices to lack the entrepreneurship required for competitiveness.

Similarly, PM's and Marcelo's worries about the new career paths of their students have to be understood in terms of the long history of EPSP and its focus on the development of the State of Sao Paulo through urban and industrial technologies. If 'what is engineering for' at EPSP came to signify working for SP's industries, including foreign subsidiaries, then one might expect PM and Marcelo to question the new career path of their students.

Likewise, AF's anxieties about the new commercial directions of IPT have to be understood in terms of IPT's long history as a research lab serving SP and Brasil's companies. If 'what is engineering for at IPT' came to signify technological R&D for state and national industries, then one might expect AF to question IPT's new commercial endeavors.

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