Engineering Education in France

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Abstract— The aim of this paper is to present the main characteristics of Engineering Education in France. For historical reasons, the French system is not easy to analyze succinctly and the authors have had to resort to some oversimplifications. Aspects such as the mutual recognition of degrees and professional qualifications have not been examined in this paper.

I. INTRODUCTION TO THE FRENCH ENGINEERING EDUCATION SYSTEM

Compared to the relative simplicity of the Anglo-Saxon model in engineering education (B.S./3-4 years, M.S./1-2 years, Ph.D./3-4 years), the French system may be characterized by the extreme diversity of its components, namely:

* The varying size of its institutions
* The eclectic nature of the organizations which run and fund the institutions
* The organization of the academic curricula and the subjects taught.

Another important difference between the Anglo-Saxon and French models concerns the social status of engineers. In France, engineers tend to occupy the upper echelons of management posts, competing with other specialists (such as economists and business school graduates) for the highest positions in government and industry. Prestige and salary put the French engineer near the top of the social ladder. In France, almost all high government officials in engineering are graduates of the prestigious *Grandes Ecoles Scientifiques.*

It should also be noted that one major Management School, the *Ecole Nationale d'Administration* (ENA) has produced many high-level decision-makers over the past four decades. Formed on 9th October 1945 by General de Gaulle, with Michel Debré as its first Director, it recruits at the strikingly young age of 31. (At post-graduate level!) Its initial aim was to train high-flyers for the French Administration in a spirit which owed much to the French Resistance Movement of World War II. Its graduates have occupied many positions of high power in recent French governments but are now considered, by the French public in general, to incarnate the philosophy of the "heartless, inhuman bureaucrat," aloof from everyday problems which they solve at the stroke of a ruthlessly-effective pen. The ENA is directly attached to the French Prime Minister's Office. It is now based in Strasbourg but also has strong roots in Paris.

In training engineers, two institutions have evolved over the past 200 years :

- The *Grandes Ecoles*
- The *Universités*

Figure 1 provides a contrast of engineering education in France and in the USA.

	QUALIFICATIONS AWARDED		
YEARS	FRANCE		UNITED STATES
9	Doctorat		Ph.D.
8			
7			
6			MS
5	Diplôme d'ingénieur	Diplôme d'Etudes approfondies (DEA)	(MS)
4		MAITRISE	BS
3		LICENCE	
2	Competitive Entrance Exams to *Grandes Ecoles*	Diplôme d'Etudes Universitaires Générales (DEUG) DUT/BTS	
1			
YEARS	Grandes Ecoles	Université	University
	Baccalauréat		High School

Figure 1. Engineering Education in France and the USA

In order to compare how the two systems operate, consider three hypothetical students :

i) John Smith. Upon passing his High-School leaving exam he goes to an American university to study for a B.S. in Electrical Engineering and then goes on to earn an M.S. and Ph.D. (Total = 9 years.). As a result, his job prospects include an (Assistant Professor) academic post (Salary ≈ $47,000)[1] or an engineering position in industry (Salary ≈ $ 64,000)[2].

ii) Elisabeth Dupont. She passes *Baccalauréat* well with a *Distinction in Sciences* and goes to a *Lycée Préparatoire* to prepare entrance exams to a "*Grande Ecole* finishing 749th out of the 10,000 students who took the national competitive exam, which enables her to enter a Telecoms *Grande Ecole*. (Note: She knows nothing about telecoms and, initially, is not particularly motivated by the subject.) She then spends three years at the *Grande Ecole*, one-third of which is on an exchange program at University College-London, where she obtains an M.Sc. in Microwaves and Optoelectronics and, at the same time, her *Diplôme d'Ingénieur*. (For a total of 5 years of study.) Her job prospects include possible engineering positions at, for example, NORTEL in London. (Salary = £17K) or Alcatel in France. (Salary = 210KF.)

iii) Claude Martin. He passes *Baccalauréat* but not very well (11 out of 20 in Sciences) and then goes to Brittany University to study Computer Science for 3 years (*Licence*) and then stays on for a one-year *Maîtrise*, for a total of 4 years of study. His job prospects include, for example, a position as a Technician with Thomson (Salary = 130KF). He decides to

try for a *Diplôme d'Ingénieur* and so applies to Telecom *Grande Ecole* as a direct entrant on its 2nd year (Year 4 in Figure 1). He is accepted, thanks to his *Distinctions* in his CS degrees. He spends 2 years at *Grande Ecole*, the second of which is on an M.Sc. course at Sussex University-England in "Knowledge Based Systems." He obtains his M.Sc. + *Diplôme d'Ingénieur* (6 years total.). He is then hired by an small to medium-sized enterprise (SME) in France at a salary of 220KF.

So, in a French context, what are the differences between the *Grandes Ecoles* and the U*niversités*?

GRANDES ECOLES : These are high-prestige institutions having good links with industry (by way of mandatory internships in industry) having highly selective admissions and flexibility of curriculum (including participation in international and/or dual-degree programs). The qualification awarded is equivalent to the British M.Sc + French *Diplôme d'Ingénieur*. Class sizes are small, tuition is more individualized and foreign languages and economics are also part of the syllabus.

UNIVERSITES : These institutions provide less individualized tuition, fewer resources and fewer links with industry and little international exposure. In addition, admissions are not selective and there are no humanities in the syllabus.

Although this picture is something of a caricature, it does contain an element of truth. Perhaps the most striking feature of the *Grandes Ecoles* is their admissions process, which effectively "creams off" the top 1% of all students. The results of the 1997 National Competitive Exam to a group of applicants to 9 of the most prestigious *Grandes Ecoles*, are shown in Figure 2. The foreign-domestic breakdown for these 9 *Grandes Ecoles* is shown in Figure 3.

NATIONALITY	CANDIDATES	PASSED	ADMITTED
French	9494	2539	785
Non-French	469	113	35
TOTAL	9963	2652	820

Figure 2. 1997 National Competitive Exam Results for the 9 most prestigious *Grandes Ecoles*

GRANDE ECOLE	FRENCH STUDENTS	NON-FRENCH
Ecole des Mines-Paris	85	4
Ecole des Mines-St Etienne	107	3
Ecole des Mines-Nancy	106	1
Ecole des Ponts et Chaussées	79	6
Ecole des Telecoms-Paris	119	6
Ecole des Telecoms-Brittany	104	8
Sup-Aéro/Toulouse	101	4
Techniques Avancées-Paris	83	3
Ecole Polytechnique	1	0

TOTAL	785	35

Figure 3. 1997 National Competitive Exam Results: Foreign-Domestic Breakdown

Figures 1 and 2 indicate that one candidate out of 12 (8.5%) is successful and that the non-French population (in 1st year) is very low (4.2%).

It is important to mention note that, overall, most *Grandes Ecoles* have a non-French population of around 15%. The difference is due to a higher percentage of non-French students in 2nd and 3rd years + Ph.D students (Figure 3 reports exam results, not student population). This figure is rising thanks to exchange programs within the 15 nations of the European Union.

II. THE DEVELOPMENT OF ENGINEERING EDUCATION IN FRANCE

The first *Grande Ecole* was established in 1747 under the title of *Ecole des Ponts et Chaussées* and this college claims to be the oldest engineering college in the world. It can still be found in the Latin Quarter in Paris. The second *Grande Ecole*, the *Ecole des Mines de Paris***,** followed in 1783 and still occupies a superb site at the top of the Boulevard St. Michel near the Luxembourg Gardens in Paris. Today, it also houses the Governing Body for all the *Grandes Ecoles* in France, called the *Conférence des Grandes Ecoles*. Initially, these old colleges were created to reinforce the central power of the monarchy and provide military might. They have retained their names and prestige and have adapted well to social change. During the French Revolution, with the rise to power of scientists who saw science as the primary instrument of social progress, a “Second Wave" of scientifically-oriented schools was established. The *Conservatoire National des Arts et Métiers* (CNAM) as well as the most prestigious of all French *Grandes Ecoles*, the *Ecole Polytechnique*, were founded in this spirit. A "Third Wave" of schools was founded at the end of the 19th century in response to industry's demands for well-educated, technical professionals. The *Ecole Nationale d'Electricité* (Sup-Elec) was created in 1894 by the *Société des Electriciens* and is still affiliated to the founding society even though it is now government-subsidized. Sup-Elec now has three sites, one near Paris, one in the north-east town of Metz (which runs a joint M.S. program with the Georgia Institute of Technology in the USA) and the third center is in the Breton town of Rennes. The "Fourth Wave" of schools came about in the 1950's when a number of university departments were converted into Schools of Engineering to form the *Ecoles Nationales Supérieures d'Ingénieurs* (ENSI) recruiting directly after the *baccalauréat* on a 5-year program**.** At the same time, the *Instituts Nationaux des Sciences Appliquées* (INSA), based on the model of the German applied-science *Fachhochschulen*, were established in Lyon, Rennes and Toulouse, with the Lyon site being the largest (4,000 students). In 1972, the *Université de Technologie de Compiègne* (UTC) was founded near Paris. It was based on the model of the American technological institutes, such as MIT.

As the need for engineers became even greater during the 1970's and 1980's, many *Universités* were given the right to award the *Diplöme d'Ingénieur* by adding a fifth year of specialized studies after the *Maïtrise* (M.S./ 4 years). As from 1983, university science students having reached the level of *Baccalauréat* + 2 years of Higher Education (with a DEUG, DUT or BTS at Higher Technician level) have been able to integrate the *Grandes Ecoles* and obtain a *Diplôme d'Ingénieur* after having gone through a rigorous selection process.

The process which began with the creation of the *Ecole des Ponts et Chaussées* in 1747 has now developed over the centuries to encompass 238 institutions which can award the *Diplôme d'Ingénieur*.

As can be seen in Figure 4, the old, parallel systems of *Grandes Ecoles* and *Universités* have become more flexible with a considerable degree of cross-fertilization. Research, initially conducted exclusively in the *Universités* has become an important activity in the *Grandes Ecoles*, many of which can now award their own *Doctorats* (Ph.D's). The present French government has expressed its desire to see more integration between the *Universités* and the *Grandes Ecoles*.

Type of college	No. of Colleges	No. of Students	No. of Females	% Females	No. of Fresh-men	*Diplomes* Awarded
All Public Colleges and Universities from Ministry of Education	124	44,646	9,874	22.3	16,182	12,722
Public Colleges attached to other Ministries. (Aerospace, Telecoms, Environment…)	46	13,202	3,547	26.9	4,646	4,312
Private Colleges	68	18,993	3,811	20.1	6,846	5,856
TOTAL	238	76,841	17,332	22.6	26,638	22,689

Figure 4. Engineering Colleges in France in 1996-1997

II. ACCREDITATION, INTERNATIONAL PROGRAMS, RELATIONS WITH INDUSTRY

Each institution awarding a *Diplôme d'Ingénieur* does so under its own auspices. However, quality control of curricula is assured by an organization called *La Commission des Titres d'Ingénieurs*. Since 5th July 1985, this Commission has been made up of 32 members who are nominated for a 4-year period by the Ministry of Education. The 32 members include faculty from colleges attached to the Ministry of Education, faculty from other colleges which are not attached to this Ministry, representatives from industry and from professional engineering associations, including the Trade Unions. Half of its members (16 our of 32) come from professional engineering associations and industry, a fact which ensures that the subjects taught are in tune with the needs of industry. Its statutes state that the Commission must meet at least five times per year. In practice, it convenes every month and its brief is as follows :

- To study any question relative to engineering training, in whatever field.
- To examine requests for accreditation in engineering education emanating from the colleges and to follow closely the development of curricula.
- If necessary, to act in order to maintain the quality of the *Diplôme d'Ingénieur* by assessing the curricula and determining whether the needs of industry are being met.

The Commission oversees all aspects concerning the award of the *Diplôme d'Ingénieur* and can withdraw a college's previously-held accreditation if it deems that standards are not being respected. Mr. Bernard Decomps, who has been active in creating new programs enabling technicians to attain the level of engineer, recently gave the following definition of what constitutes the modern "engineer":

"An engineer must be capable of designing, developing, manufacturing, selling and maintaining "objects" and services of quality, which must please the public."

In other words, engineers produce high-quality goods and services for a market which exists or which can be created. This idea is also at the forefront of the work of the *Commission des Titres*.

In a European context, a whole host of international exchange and research programs have taken off over the past 10 years, mainly due to the fact that the 15 Member States of the European Union (EU) are trying to converge towards Economic and Monetary Union (EMU) and, in the longer term, to some form of political union. Whether this will ever reach the stage of a "United States of Europe" (USE) is the subject of passionate, often acrimonious debate.

Engineering institutions have been very active in developing international activities, as befits a profession which is truly "global." Some of the main features of these international activities are:

- Teaching *mandatory* foreign languages in engineering courses. In France's Telecom *Grandes Ecoles*, a variety of languages are on offer and every student must reach a high level in two of them in order to satisfy degree requirements for the *Diplôme d'Ingénieur*. This has meant considerable investment in facilities, time and money.
- Introducing *mandatory* internships abroad for *all* students. The Telecom *Grandes Ecoles* in France require every student to spend a minimum of 2 months working abroad at some period of their academic careers. This can de achieved in one of four ways:
  - + A summer industrial placement. (Duration: 2 months)
  - + A final-year internship. (Duration: 4-6 months)
  - + A complete academic year abroad. (Duration: 9-18 months)
  - + A "Young Engineer Abroad" program taking place in industry, typically between the second and third year. (Duration: 12 months)

Such programs have necessitated taking the following measures:

- Creating an "International Service" within each college in order to initiate, develop and coordinate all aspects of such programs, both inside and outside the college.
- Developing links with foreign universities. In the case of the Telecom colleges in France, this has already led to "Dual Degree Programs." (French *Diplôme d'Ingénieur* + Spanish Engineering Diploma/British/Swedish/Finnish M.Sc., for example. Throughout the 15 Member

States of the EU, a program called ECTS (European Credit Transfer System) is being launched enabling a student from one Member State to validate in his/her home university, credits obtained at a university in another Member State.

- Developing links with foreign industry, a vital aspect in engineering education at the global level.

It is noteworthy that sponsorship has been made available for many of these activities by the European Union, while companies have become interested in recruiting highly competent young engineers from another Member State, who speak a couple of foreign languages fluently and who, in some cases, have registered for new electives in "Business Engineering" during their curriculum.

As described earlier, industry plays an important role in the accreditation process in France. It has also been incorporated into college life in the following ways:

- **Teaching :** Many of the final-year specialties in French engineering colleges include lectures given by industrialists. In certain cases, more than 50% of the whole course is taught in this way. This is not without problems for permanent faculty who have to find the competent lecturers in industry and achieve a balance in the objectives to be met in the different courses. Lecturers from industry are at the leading-edge of technology and can also appreciate the problems of bringing a new product to the market-place. At the end of the final-year course, a two-day seminar is held with all the industrial lecturers present. The seminar is led by a permanent member of faculty and has the following aims:

  + To see if pedagogical objectives have been met.
  + To analyze the questionnaires completed by the students on courses given by industrialists.
  + To modify objectives for the following year, if necessary.

  Courses given by industrialists are also corrected and graded by the same industrialists in collaboration with full-time faculty.

- **Internships :** The vast majority of final-year projects in French engineering colleges are performed in industry, either in France or abroad. The fact that so many industrialists actually participate in course-design and in teaching activities, means that they (and the students) are well-prepared to undertake internships in a serious manner.

- **Research :** Because teaching activities are closely associated with industry, both professors and industrialists have become more aware of their partners' preoccupations. More and more research is being undertaken in the laboratories of French colleges using equipment and funding from industry. This is a relatively recent phenomenon in the *Grandes Ecoles* but is proving to be a fertile breeding-ground for all those involved (industrialists, faculty, Ph.D. students and final-year students).

III. FUTURE TRENDS

The French *Grandes Ecoles* in engineering evolved slowly during the first 150 years of their existence. The past few decades have seen a rapid change in their relations with industry and with the *Universités*. The fact that they are so selective means that their life-blood is made up of the brightest of the nation's young people. The first author of this paper works in the field of telecommunications. The Information Technology industry is particularly vibrant and dynamic and hardly an hour goes by without our becoming aware of its presence and economic importance. Mergers, alliances, the Internet, Netscape, Microsoft, the (US) Justice Department, teleconferencing, telecommuting, cable TV/Satellite TV, etc. are all terms very familiar to any regular reader of a national or even local newspaper. One needn't be an IT-specialist to recognize how so many aspects of our lives are being affected profoundly and quickly by information technology.

Students should be given a global vision of what is occurring in such rapidly-evolving technological fields—both in the technology itself as well as in its social and economic impact. To achieve this, the main actors should be brought together, including our students who will be the leaders of the future. Attractive, stimulating courses should be designed with feedback from all of the participants, students, faculty and industrialists. These courses should include an international dimension by, inter alia, teaching foreign languages and introducing elements of economics.

IV. REFERENCES

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VIII. BIOGRAPHICAL INFORMATION

IAN SIMPSON (Ian.Simpson@enst-bretagne.fr) was educated at University College-Durham, UK and at the Sorbonne, France. He worked as an English-language lecturer at the Sorbonne from 1971 to 1976. From 1976 to 1978, he was a lecturer in the English Department at ENST-Paris. Since 1978, he has been both Head of the Language Department and Head of International Relations at ENST-Bretagne (htpp://www.enst-bretagne.fr). His main publications are: "English for the Telecommunications Industry" (Oxford University Press, ISBN 0 19 437843 5 / 1985) and "English for Telecoms" (York Associates, ISBN 0 948333 54 5 / 1995).

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