Evaluation and Accreditation practices in France.

A powerful tool for improving quality in engineering education

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Our topic is the evaluation and accreditation of engineering curricula, specifically arising from the years of experience of the French commission for habilitation/accreditation in engineering ***(Commission des Titres d'Ingénieur* - CTI*)*** in France. This body exerts its activity from outside the institution (Grandes écoles, university engineering schools) and it has defined a set of references and orientations, relevant evaluation criteria and evaluation techniques necessary for the accreditation process.

The objectives are to :

1. Modernize and internationalize of engineering training
2. Close the gap between 'products' and 'needs' by a strong involvement of industry
3. Develop a constantly reviewed accreditation system
4. Search for excellence to attract the elite.

The need to modernize engineering training needs no further comment. Key words are : broader skills, new industrial requirements, new learning technologies, capacity for lifelong learning, creativity, innovation, adaptation.

Quality management can be a means to improve

- The quality of teaching and learning, including recruitment, introduction to industrial activities, international training, internal actions taken by the management of the institute
- The evaluation process by external body with a view to accreditation

Here we describe and comment on the orientations and references defined and practiced by the ***Commission des Titres d'Ingénieur*** – CTI.

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The ***Commission des Titres d'Ingénieur*** was appointed by an Act of 1934. Its aim is to accreditate (habilitate) the ***Ecoles d'Ingénieurs*** and to award the title of '*Ingénieur diplômé*' . Total education and training duration is five years and equivalency is given as Master degree. The Ministries of Education, Industry, Defence or Agriculture subsequently take up its recommendations for their public institutions and attribute the budget and personnel. Private institutes make their own decisions.

Kommentti:

Subsequantly, the absence of accreditation leads to the end the institution to deliver the title of "ingénieur diplômé".

The CTI has 32 members. Half of these hold positions of responsibility in higher education or are members selected for their scientific or technical experience. The other half represents the various aspects of the profession. This twin composition is particularly interesting as it brings together engineering trainers with experts, representatives of the professions and of industry as well as representatives of the main trade union organizations and engineering associations. Members are appointed for 4 years renewable once, i.e. for 8 years in general. The workload is quite heavy around (40 days/year). Members are assisted by experts (32), including visits and seminars. There is a high rate of attendance (90%). The CTI meets 11 times a year in plenary sessions.

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Any public or private institution that has developed a higher level course of training in science or technology for specific vocational purposes can apply for this course to be recognized as awarding the title of "ingénieur diplômé".

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The Commission then appoints reporters from amongst its members and possibly also experts. A mission is organized in situ to study the teaching program, meet the management and teaching teams, the students, employers, and former students and to inspect the teaching facilities and laboratories. The

report is presented to the CTI who pronounces their opinion or their decision (private institutions).

Following an experimental phase in 1990-1995 general recognition for a fixed term of maximum 6 years was established in 1997. The CTI is empowered to intervene at its own initiative. The courses in the 250 institutes, which together grant 30 000 degrees per year, are periodically evaluated.

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Other activities

The Commission organizes meetings and surveys and participates in formal or informal consultations on developments in technological training. Examples of such surveys are:

- Training for industrial engineering
- Training through apprenticeships
- Grouping certain engineering courses to reinforce the synergies between the various teaching establishments
- International comparative surveys

The engineer: job, experience and training

1. What does an engineer do?

   Essentially the job of an engineer is to identify and find solutions to problems of a concrete and often complex technological nature related to the design, realization and use of products, systems or services. This aptitude arises from an ensemble of technical knowledge on the one hand and economic, social and human experience on the other hand, with a basis in sound scientific training.

   The main areas of activity for engineers are in industry, construction, agriculture and the service industries. This activity mobilizes human, technical and financial resources, usually in an international context. It receives economic and social sanctions and is concerned with protecting man, life, the environment and collective well being.

   A “ingénieur diplômé” has built up a range of knowledge and know how during the course of a long cycle of higher education organized in an institution approved by the CTI, and including multidisciplinary academic teaching as well as periods of work experience.

2. What training does an engineer receive?

Objectives and developments:

- the purpose of training : Transversality and concreteness
- the place of information technology and modeling

Training does not just involve mastery of a tool or a computerized approach to problems. The notion of technological purpose has been changed by the increasing importance of computerized simulation, which in turn leads to the need for a high level of skill in modelling and optimization techniques.

3. Programs

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Course content

We see from these aspects that an engineer requires multidisciplinary training, proof of his/her ability to handle the various missions with which he/she will be entrusted during the course of his/her career. The training course should include:

- Detailed teaching of basic science that may well include a first research experience
- Full training in general engineering techniques, including mastery of complex systems.
- A sufficiently long course in the main aspects of the desired training
- General education: foreign languages ; economic, social and human sciences, a concrete approach to problems, communication, ethical issues, social relationships in all contexts
- Training for the industrial environment and the constraints involved, in particular with regard to the environment, safety, health, quality, globalization, and industrial property.

Duration

The CTI recommends hours of formal teaching which allow sufficient time for private study of the course content. It encourages the use of information and communication technologies). The schedules shown below have been agreed:

- An initial training of three years (plus 2 years' external or integrated experience and higher education, the Classes préparatoires aux grandes écoles - CPGE) of 2 200 to 2 700 supervised hours – taught classes – directed study – practical tasks and projects.

- By initial apprenticeship: 1 800 hours plus 6 months per year in a company – 3 years (plus 2 years external or integrated experience and scientific higher education).
- By in-house training: 2000 hours formal teaching; professional experience is taken into account.

4. In-company placements (internships) as part of the training of engineers.

   The CTI regards giving student engineers an awareness of industry as an essential part of this type of training. The institutes have integrated this element into their curriculum in the form of various types of training course. It is important that a training course should have a well-balanced content: advancement in knowledge and relevance to the structure of the industry and the job in question.

   Long internships can be evaluated in 3 ways: by the tutor, by a professor or by a jury. An intra-muros internship is not considered valid from the point of view of learning about the industry or as vocational training.

   The accumulated length is between 20 and 36 weeks.

Missions and structures of an institute offering the title of qualified engineer

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1. With regard to the engineering profession, the CTI notes the fundamental role of the company, which is required to take account of international awareness and the need for permanent innovation. The CTI defines an engineering institute on the basis of an entrepreneurial model:
   - Its prime vocation is to train engineers and also to develop research directed towards the needs of the industry.
   - An engineering institute should behave "like a company": demands on autonomy, development, competitiveness, and cooperation.
2. Affirmation of four organizational principles
   - An engineering institute is an establishment that has both a legal and a physical identity. Its principal activity is to train engineers, taking advantage of research methods that have a technological component.
   - Whatever its legal status, the institute should have real autonomy with regard to its organization, pedagogy and the use of material and human resources.
   - Apart from representatives of the teaching staff, the students and its own personnel the governing body should include a high proportion of

external members, mainly appointed by the public or private organizations concerned within the world of economics.

- The institute should come under a strong management. There should be a head of institute with clear and wide-ranging powers, answerable to the governing body.

2. The CTI recommends those structures provided for under the law that best corresponds to these criteria.

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International awareness

Multicultural awareness is a basic requirement for the practice of engineering skills. This means that the curriculum should include, alongside the practice of foreign languages, the development of institutional exchanges between France and other countries.

The CTI also encourages growth in the number of foreign students accepted onto engineering courses leading to a Master's Degree.

1. The use of foreign languages, preferably two, is recommended by the CTI both in initial and in-house training.
2. Acceptance of foreign students and granting the title of qualified engineer. The CTI encourages the various institutes to design a curriculum with the needs of the foreign student in mind: integration can take place in the 2nd year following selection amongst the Bachelors. The degree is obtained in 2 years, consisting of one semester adaptation, two academic semesters and one semester in a company or laboratory doing industrial training or research.
3. Organization of student exchanges between French and foreign institutes. The CTI recommends that the exchanges include exchanges of teachers, teaching techniques, research partners, R & D in industry, etc.
4. Recognition that includes foreign institutes: a double degree: two complementary programs in 2 establishments and the award of 2 degrees.
5. Accreditation of foreign institutes, e.g. in Lausanne, Zürich, Karlsruhe, Luxembourg to deliver the Title of " Ingénieur diplômé".
6. International recognition, e.g. Canada, BCAPI

Kommentti: .

Agreement for mutual recognition of an engineering degree between the CTI and the CCI dated 21/10/99

CTI : ***Commission des titres d'ingénieur*** – Commission for Awards in Engineering

CCI : ***Conseil canadien des ingénieurs*** – Canadian Engineering Council

Motivation for the agreement

- Recognition /accreditation of training programs in engineering is a key element fundamental to the practice of the engineering profession in any country
- Representatives of the CTI and CCI met several times in 1998 and 1999 and took part in accreditation / recognition missions in France and Canada.
- Following these visits it was agreed that the methods are equivalent.
- It was agreed that it is possible and desirable to allow engineers who graduate from institutes recognized by the CTI or who complete training programs accredited by the BCAPI to exercise their profession.
- Both parties recognize the standard of engineers who train under programs approved by the CTI and accredited by the BCAPI of the CCI.
- Mobility of qualified engineers / professionals between the 2 countries mutually beneficial.

The agreement allows:

1 –An engineer who has qualified in a teaching establishment recognized by the CTI to exercise his/her profession in Canada.

> gives any engineer qualified in an institute approved by the CTI access to the orders and associations in Canada without having to sit for further technical examinations.

2 – Exercise of the engineering profession in France for professional engineers with an academic qualification from a program accredited by the BCAPI

> At the request of the Canadian government and in line with the French law of 1934, relative to the conditions for granting and using the title of qualified engineer, the Minister issued an order that the French state should recognize the qualifications awarded by Canadian engineering teaching programs that are accredited by the BCAPI.
>
> Holders of the qualifications from these programs who in Canada have obtained the right to call themselves professional engineers are authorized to bear the title of qualified engineer.

3 – Means of implementing and following up the agreement

In Canada the right of an engineer to practice his profession is both a regional and a national issue. The agreement is therefore subject to ratification and the CCI undertakes to seek this.

There are to be periodic meetings to follow up implementation of the agreement combined with meetings between the CTI and CCI to advance the modalities of putting accreditation into practice.

The agreement is concluded for an initial period of 6 years with tacit renewal.

Means of application

- Field of application of the agreement

  All Canadian professional engineers holding a degree obtained at the end of a study program in engineering accredited by the BCAPI and all French engineers qualifying from an establishment approved by the CTI.

  In Quebec: professional engineers whose title ends ing. or eng. (English speaking) and in the other territories Professional Engineer (P. Eng.)

  The Canadian engineers who are registered in the associations of the CCI have met the following requirements:

  - Academic qualification (degree from a training course approved by the BCAPI)
  - Linguistic competence
  - Initial experience of engineering
  - Examination in professional practice

  Length of experience in engineering

  The length is 2 years or 4 years in Canada. The Canadian associations take into account the length of practical training courses, the industrial final year projects and the length of 5 years for engineering studies in France.

Bologna agreement and students mobility

Figure 13

European Ministers of Education have signed the Bologna Agreement. This agreement stipulates three levels for the delivery of higher education degrees : one three years after the secondary school, one five years after and one eight after at the doctorate level. However this agreement does not stipulate anything

about the content of the degrees and has no specific indication about engineering studies.

Usually, European institutions plan to deliver after 3 years a degree similar in level and specifications to the bachelor's degree of the American engineering schools and after 5 years a degree at the level of the master's degree in Sciences or in engineering sciences. In France this can be done easily within institutions or Universities which keep their students during five years.

But many engineering studies in France are organized using a 2 – 5 years system. After the secondary school, students who have obtained good marks in mathematics and physics may enter "Classes préparatoires" for a two years cycle where they receive a strong general education in mathematics, physics, chemistry and, eventually, life sciences : roughly 1800 hours of education in basic sciences useful for engineering studies. The program of these "classes préparatoires" is the same over the whole France. At the end of these two years, students fill applications for the engineering schools of their choice and have examinations on a national level, allowing them to enter the chosen school, depending on their marks at the examination and on the number of places available in the school.

The regular duration of studies in such engineering schools is then of three more years, including roughly 2000 hours of courses in specialized sciences, technology, engineering projects, management and social sciences, foreign languages (in English a level equivalent to TOEFL 550 is mandatory), and at least 4 months of engineering practical stay in industry.

From the CTI point of view, it is mandatory for a student to stay at least three semesters in the same school in France for being awarded of his degree, but the last semesters may be spent elsewhere, in an equivalent institution, under mutual agreement of the two institutions.

Every institution has to adopt ans has adopted the ECTS system. It facilitates entry 2, 4 or even 6 semesters after secundary school and from foreign institutions and universities.

The Diploma Supplement is under development.

Gateway to working in industry

In their teaching program the institutes should give priority to four methods of reinforcing the student’s capacity for innovation, initiative, entrepreneurial skills and rapid insertion:

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1. Alternation

A student's study time is divided between training in an institute and in-company training. In the company training is based on a more inductive method, allowing the young trainee to acquire practical know how that will facilitate his/her integration into the company culture (clients, safety, environment). For the company the advantage lies in having quicker access to an operational member of staff and in creating a reserve of possible employees. Alternation can take a number of very different forms and applies both to engineering training courses and to apprenticeships (salaryman contract).

2. Project-based learning

Engineers are encouraged to work alternatively in 'hierarchical' mode and in 'project' mode or both at the same time. Group work around a project is very close to the professional situation. It shows the typical development of a project, how it is evaluated and the typologies: initiation, case study, response to specifications, transversality, bibliography, etc. This is why project work is the ideal means of implementing particular aspects of the training program. In particular it develops the skills of relation, organization and innovation.

3. Use of new technologies

Another teaching method needs further reinforcement: the use of TICE (*Technique d'Information et de Communication* or techniques for information and communication in teaching) on engineering training courses, whereby:

- The new information and communication technologies are used to broadcast know how and skills and to practically delocalize knowledge by putting it onto a network. Linking institutes up in a network could be an effective way of teaching the common core program of industrial chemistry that has been proposed in the context of this collaboration.
- Enable engineers and managers to use information technology in a working situation: training in the effective use of computers and communication services (cooperation at a distance, ability to dialogue with the experts in these domains).

4. Professionals in the institute

The decision whether or not to appoint professionals as teachers is made by the center for recruitment of specific permanent posts and the solutions are worked out individually in each case. This makes it possible to transmit professional competence. Whether or not these moves are successful depends on the creation of a real spirit of awareness of the needs of the industry.

Students benefit from the technological research and in-house training that goes on in the companies.

CTI criteria

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Presenting a summary of CTI criteria is not very easy, as the standard of training has to be measured against the aims and objectives that each training institute has set itself. The points in common in all the training courses are:

1. General presentation of the establishment
2. Curriculum
3. Human resources and scientific environment
4. Finance, equipment, etc.

Various assessment tools are used. For example it is possible to give a more in-depth assessment of an establishment and its training programs by applying more detailed criteria graded from mediocre to very good (1 to 5).

Status and organization	- geographic unit
	- autonomy
	- part of a network
Management	- communication
	- strong government
	- strategic position
	- quality proposals
Ties to industry	- participate in proceedings
	- permanent staff from industry
	- part-time staff from industry
	- practical training and industrial projects
	- in-house training in the companies
	- technology transfer
Means allocated to the training scheme	- financial means
	- Materials
	- Student life

Training ideology / a balanced program

- concrete purpose
- basic sciences
- engineering sciences
- existence of specific dominant topics
- English
- personal development
- training in economic and business aspects
- entrepreneurial spirit
- how to control knowledge
- teacher evaluation
- management of student failures

Organization of alternation

- quality of the organization
- quality of the follow-up
- new teaching input
- evaluation of the skills acquired in industry

Recruitment

- level of selection
- national characteristics
- diversity of recruiting agencies

Part played by research in the training program

- student engineers in the laboratories
- researchers at the black boards

International awareness

- training courses abroad
- degree courses abroad
- reception of foreign students
- foreign members of teaching staff

Follow-up of job insertion and suitability to the employment market

- Efficacy of the means of observation
- Quality of insertion
- Suitability training / employment

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Comparison EFQM (European Foundation for Quality Management) versus ISO 9001 version 2000 quality assurance standard and CTI practices

Although the CTI did not officially choose a model for quality management in its references and orientations its practice is close to that of EFQM (TQM) and ISO.

- The EFQM model is based on the choice of a strategy of excellence. It defines the relevant criteria for the key areas of a company (institution)'s activity and describes the tools and indicators that can be used to evaluate the extent to which these objectives have been realized. 'Reaching excellence requires total management involvement and acceptance of the concepts.'
- The ISO describes a system for quality management, which is designed to enable a company(institution) to constantly adapt its objectives in line with changes in its environment. It describes the means and operational tools that this type of system uses. 'One of the management disciplines of the organization.'
- The EFQM necessitates global long-term involvement whereas ISO 9004, ISO 9001 - 2000 version , with its periodic readjustment under management review, provides a framework for defining successive objectives and referring back to results that have already been obtained: graded character of the ISO.
- This difference of approach conditions the choice between the 2 systems of reference. The choice depends not only on the level of development and on the state of maturity that quality has attained but also on the strategic need of management to modify behavioral patterns and especially its own capacity for involvement in this change.

Figure 11

Common points

- Client sensitivity
- Leadership
- Implication of personnel
- Process approach
- Continuous improvement
- Practical approach to decision taking
- Mutually beneficial relations with suppliers

Differences

- Orientation towards the results, the prime EFQM principle, is not mentioned by the ISO
- The ISO does not list responsibility towards the community as a management principle
- The EFQM includes the principles of flexibility, apprenticeship and innovation with the principle of improvement

The CTI reference system is closer to EFQM than to ISO, both in its own operational mode and in the practice it recommends to the training institutes.

Halfway through this evaluation, the CTI notes that even though about 80% of the training schemes examined meet their expectations quite fully and in a variety of ways, 20% are markedly at variance. The CTI is confident of the goodwill of institution managers to rapidly put into practice consistent across-the-board improvements in the training process: this would give future young graduates the best chance of adapting to new demands in the engineering profession and of rapidly developing their skills in a professional environment.

Figure 12

Inspection visits to certain establishments occasionally revealed a large disparity in the areas of:

- Descriptions of links to industry and the reality
- Low priority given to students' practical training, where follow-up by the academic tutors is practically non-existent
- Teaching hours which clearly allow students no time for self study nor for cultural activities
- Frequently, no account taken of the new communication technologies
- The study of risk management essential to the industrialist is not implemented.
- The development of in-house training, which remains on the agenda of the traditional engineering institutes. Is there really a common will amongst the training teams to look closely at individual cases and validate the skills that candidates on engineering courses have acquired outside the academic world?
- To overcome these difficulties and to make further progress towards excellence our system is regularly revised and improved on the basis of our experience.

- Our system for training engineers is innovative and related to a concept where the engineer is not just a 'super technician' trained in one discipline but also a person capable of leading project teams and with a wide perception of his/her environment. Transversality of his/her knowledge is therefore essential but this must be achieved by proper links between in-company placements and study outside France with the student's academic training: simply juxtaposing these elements would be to caricature the given objectives.

- This means that the training schemes must be on a sufficiently large scale to be able to provide the competent services to organize relations with industry and other countries and to manage the students' individualized study programs.
- The recent creation of the Master degree awarded to all engineers will make it easier on the international level to understand the French title of '*ingénieur diplômé'* (qualified engineer) and the engineering institutes should take advantage of this opportunity to propose the title to young students from other countries.
- It is important that the curricula maintain the same level of excellence reached by the majority of the engineering institutes in order to continue to attract an intellectual elite from all sources looking for a career as an engineer in industry.
- It is essential for engineering training courses to anticipate and adapt to the dynamic of change. Our national economy has a place in the world beyond its representation in terms of population, which is a good reason for developing training courses open to young students from other countries.
- It is essential that a qualified engineer be conscious of his/her responsibilities with regard to innovation, safety, reliability and management of complexity in an international economic context.

If we refer to the EFQM European model of management we see that it is possible to aim for and obtain excellence in institutes of higher education. Even if the CTI has not taken up an official position its practice approaches this model in many respects.

The factors and the results that define the EFQM model are all represented in the orientations and references of the CTI.

> The votes of the Commission have a high level of credibility. They have never been contested.
>
> Recognition is based on an institute's initiatives for quality and continuous improvement. The challenge lies in the quality of their young graduates, ready to step out into active life.

The personal involvement of the members of the CTI is measured by their very high attendance.

Conclusion

In conclusion, the practical efforts of the CTI ***Commission des titres d'ingénieur*** have produced some remarkable results.

1. Its verdicts on whether or not institutes should be accredited have been accepted and recorded by the responsible ministries without exception since its creation.
2. The CTI has defined orientations and references that are recognized and accepted by all the parties concerned.
3. The CTI has the role of advisor rather than that of censor. It is there to influence and improve the results of institutes and to encourage innovation and attract the best people.
4. The CTI encourages alignment with other national systems of recognition or accreditation to facilitate mobility for young people and help them evolve in their professional life.
5. The CTI experience may well answer to some questions raised by Viviane Reading : How to create the conditions within which universties can attain and develop excellence ? How to establish closer cooperation between universities and enterprises ?