

Training engineers to face global challenges: the role of accreditation agencies

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Abstract: Accreditation agencies must fulfill their missions in awareness of societal and professional challenges and in permanent exchange with the different stakeholders. By establishing appropriate standards and guidelines, they can act as a catalyst for the implementation by higher education institutions of suitable strategies for addressing these challenges.

Since its creation in 1934, CTI has been in permanent contact with the needs of industry and society. In this paper, we present some main initiatives conducted by CTI in this direction over the last years. Specifically, the results of a very broad study (50000 responses) conducted jointly by the CNISF (Conseil National des Ingénieurs et Scientifiques de France) and CTI in 2008 among French engineers in activity will allow us to show some interesting insights on the importance of societal and environmental problems for French engineering professionals and the implication of French engineering schools.

Keywords: Engineering education, accreditation, CTI, sustainable development, EUR-ACE.

1. Introduction

CTI (*Commission des Titres d'Ingénieur*) is a non profit organisation officially recognised as the independent body in charge of performing establishments' accreditation to grant engineering degrees in France. Like other similar bodies in other countries, such as ABET in USA, CTI establishes the standards for the higher education institutions (HEIs) which wish to deliver engineering diplomas and defines the general competence profile of engineering degrees. [1]

In France, In order to fulfil its mission, CTI performs a periodic evaluation and accreditation of all French engineering programmes (generally, every 6 years). Upon the result of CTI's programme accreditation, the Engineering Schools are accredited ("habilitated") to deliver the Engineering degree ("Diplôme d'ingénieur") by the concerned Minister(s).

CTI also performs accreditation of engineering programmes outside of France. Moreover, CTI is part of the European Network for Accreditation of Engineering Education (ENAE) and one of the 7 organizations that can deliver the EUR-ACE label, a European quality label for engineering degree programmes at Bachelor and Master level. [2]

CTI's decisionary organ is composed of 32 members, appointed upon legislative order, 16 coming from academia and 16 coming from industry. This equitable composition, which is a unique feature in the landscape of evaluation of higher education in Europe, makes CTI especially well placed to be aware of the needs of industry and society.

Since its creation in 1934, CTI has emphasized the role of human, social and management sciences in engineering education; the new challenges, such as the world energy challenge and the global sustainable development challenge, have indeed strong human and societal impacts and cannot be addressed only from the scientific and technical points of

view. The objective of this paper is to present some main initiatives in this direction conducted by CTI, as well as their possible impact over French engineering graduates and French engineering schools.

2. Structure

In the first place, the results of a very broad study conducted jointly by the CNISF (*Conseil National des Ingénieurs et Scientifiques de France*) and CTI in 2008 addressed to French engineers in activity are presented in section 3 [3]. This survey, which obtained around 50000 answers, provides some interesting insights on the importance of societal and environmental problems for French engineering professionals and the implication of French engineering schools.

Secondly, CTI's standards for the accreditation of engineering programmes [1] are analyzed in section 4, in order to highlight CTI's purpose of developing societal and sustainable development awareness among French engineering schools and graduates.

Finally, some main conclusions are drawn in section 5 concerning the role of accreditation agencies and CTI in the development of environmental awareness in engineering education.

3. Study on the competences of French engineering graduates

3.1. Description of the study

CTI standards shape a generalist engineering professional with a strong and broad basis in fundamental sciences, but also with a vast business culture and economic, social, human, environmental and ethics awareness. Thereby, CTI considers that all French higher education institutions offering engineering programmes must comply with the following essential components of engineering education [1]:

- Knowledge and understanding of a broad range of basic sciences and the related capacity to summarise and perform analysis,
- Aptitude to use the scientific and technical resources related to a specialty,
- Understanding of engineering methods and tools: identification and resolution of problems, even those that are not familiar and not fully defined, possibly using experimentation, innovation and research, the collection and interpretation of data, the use of computing tools, the analysis and design of systems,
- Capacity to join an organisation, to lead it and drive it forward: self-awareness, team spirit, commitment and leadership, project management, project coordination, communication with specialists and non-specialists alike,
- Aptitude to take on board professional issues: corporate spirit, competitiveness and productivity, innovation, intellectual and industrial property, respect for quality procedures, security, health and safety in the workplace,
- Aptitude to work in an international context: command of one or more foreign languages, cultural open-mindedness, international experience, business intelligence,
- Aptitude to put sustainable development principles into practice (environment, economy, labour and corporate governance), as well as to consider and foster other societal values (endorsing social values, responsibility, ethics, health and safety).
- Aptitude to conduct investigations.
- Capacity to follow through on their professional choices and fit into a professional context.

In 2008, CTI conducted, together with the CNISF, a survey addressed to all French engineering graduates [3]. The main objective of this survey, which obtained 50000 answers, was to determine the importance for these professionals of the professional components listed above, as well as the ability of French engineering schools to prepare engineering students regarding these aspects.

Two questions were asked to the survey participants:

1. "How would you assess the importance these different components for your professional activity? ("neutral", "important" and "unimportant").

2. How well do you think your engineering school has prepared you regarding these items? (“neutral” “well” and “bad”)

3.2. Analysis of the importance of the different competences

Table 1 shows the results obtained concerning the assessment of the importance of the different items. As we can see, the most valued professional competences are those concerning scientific and technical knowledge, methods and tools as well as basic professional aptitudes and capacities, such as the capacity to join an organisation, to lead it and drive it forward or the capacity to follow through and fit into a professional context. The capacity to conduct investigations and the aptitude to work in an international context received a considerably lower evaluation, even if they are still considered as “important” by more than 50% of engineering graduates.

Significantly, a much more limited value (just a 36% of graduates consider this item as “important”) is assigned to societal competences, including the capacity to put sustainable development principles into practice.

Knowledge, abilities and professional capacities	Important	Neutral	Unimportant
Knowledge and understanding of a broad range of basic sciences	64%	19 %	16 %
Aptitude to use the scientific and technical resources related to a specialty	69%	18%	13%
Understanding of engineering methods and tools	73%	16%	11%
Capacity to join an organisation, to lead it and drive it forward	80%	13%	7%
Aptitude to take on board professional issues	64%	22%	14%
Aptitude to work in an international context	60%	23%	17%
Aptitude to put sustainable development principles into practice as well as to foster other societal values	36%	35%	29%
Aptitude to conduct investigations	54%	28%	18%
Capacity to follow through on their professional choices and fit into a professional context.	65%	23%	12%

Table 1. Importance of the different competences for the professional activity of French engineering graduates

3.3. Assessment of the contribution of engineering schools

Table 2 shows the percentage of engineering graduates belonging to different groups of age who considered that their engineering HEI had adequately prepared them with regards to the different professional competences considered.

Higher Education Institutions are highly valued by all groups of age regarding their capacity to foster the following competences:

- Knowledge and understanding of a broad range of basic sciences
- Aptitude to use the scientific and technical resources related to a specialty
- Understanding of engineering methods and tools

Knowledge, abilities and professional capacities	HEI has well prepared me (less than 30 years)	HEI has well prepared me (between 30 and 44 years)	HEI has well prepared me (between 45 and 64 years)	HEI has well prepared me (all)
Knowledge and understanding of a broad range of basic sciences	76%	77%	75%	76%
Aptitude to use the scientific and technical resources related to a specialty	73%	74%	73%	73%
Understanding of engineering methods and tools	66%	65%	65%	65%
Capacity to join an organisation, to lead it and drive it forward	48%	35%	25%	35%
Aptitude to take on board professional issues	30%	23%	18%	23%
Aptitude to work in an international context	40%	27%	9%	25%
Aptitude to put sustainable development principles into practice as well as to foster other societal values	24%	13%	10%	15%
Aptitude to conduct investigations	47%	48%	48%	48%
Capacity to follow through on their professional choices and fit into a professional context.	33%	27%	24%	28%

Table 2. Percentage of engineering graduates who consider being well prepared

The contribution of the HEIs regarding the rest of aspects receives a considerably lower evaluation (less than 50% of engineers across all groups of age consider having received a good preparation). The percentage of favorable answers concerning the aptitude to put sustainable development principles into practice as well as to foster other societal values is the lowest of all (15%). However, we can appreciate an increase in satisfaction as graduates get younger, which indicates that some progress has been done by the HEIs in the fulfillment of these issues.

The progression in the preparation received in order to develop an aptitude to work in an international context is especially significant. Only 9% of engineering graduates between 45 and 65 years consider to have been well prepared regarding this issue, whereas the percentage increases up to 40% in the case of graduates below 30 years.

This important progression with regards to the international component is a consequence of the efforts made by French engineering higher education institutions over the last 15 years. These efforts have been actively promoted by CTI, who has included specific criteria such as the establishment of a compulsory minimum English level for all engineering graduates (currently, the B2 level of the Common European Framework of Reference for Languages-CEFR- is requested to all engineering students in order to be graduated). CTI has also encouraged the introduction of professional internships and academic stays abroad, as well as the establishment of double and joint degrees.

3.4. Comparison between the importance of the different competences and the contribution of the engineering HEI in young graduates

The comparison between the importance given by young graduates to the different professional competences and the assessment of the preparation provided by the HEI is shown in Table 3.

According to these results, engineering graduates consider to be well prepared regarding the following issues:

- Knowledge and understanding of a broad range of basic sciences
- Aptitude to use the scientific and technical resources related to a specialty

Knowledge, abilities and professional capacities	The element is considered as important	The preparation received is considered as “good”
Knowledge and understanding of a broad range of basic sciences	65%	76%
Aptitude to use the scientific and technical resources related to a specialty	71%	73%
Understanding of engineering methods and tools	74%	66%
Capacity to join an organisation, to lead it and drive it forward	81%	48%
Aptitude to take on board professional issues	65%	30%
Aptitude to work in an international context	61%	40%
Aptitude to put sustainable development principles into practice as well as to foster other societal values	40%	24%
Aptitude to conduct investigations	55%	47%
Capacity to follow through on their professional choices and fit into a professional context.	68%	33%

Table 3. Importance vs preparation received regarding the different competences

According to these results, engineering graduates consider to be well prepared regarding the following issues:

- Knowledge and understanding of a broad range of basic sciences
- Aptitude to use the scientific and technical resources related to a specialty

However, they consider that there is a significant lack of preparation (a difference of more than 30 percentage points between the importance and the preparation received from the HEI) with regards to:

- Capacity to join an organization, to lead it and drive it forward
- Aptitude to take on board professional issues
- Capacity to follow through on their professional choices and fit into a professional context

Finally, the preparation obtained with regards to the aptitude to work in an international context, the aptitude to put sustainable development principles into practice as well as to foster other societal values and the aptitude to conduct investigations is slightly less valued than the importance attributed to these competences.

The universe of engineering higher education institutions in France is particularly rich and complex, and includes institutions with different status (public, private, consular), different organizational natures and orientations (research oriented vs. training oriented) and under the supervision of different ministries. The data shown in tables 2 and 3 are average values grouping all kinds of engineering higher education institutions. Apart from the results exposed throughout section 3 of this paper, additional analyses have been conducted by CTI over the 50000 responses of this study, which have permitted to observe important differences in the results according to the type of institution. Even if these analyses provide valuable lessons to CTI, these results have not been included in this paper, as they have been judged to be specific to the French environment.

4. CTI's standards regarding sustainable development in engineering education

The 2008 CNISF-CTI study shows that, even if the new generations of French engineers seem to be better aware and prepared to face societal problems, still much progress is needed to develop engineers' awareness and preparation regarding these issues.

CTI's standards are permanently under revision by various permanent thematic monthly working groups. At the moment, three working groups are in operation:

- The engineering education group, which is consecrated to engineering education curriculum and structure,
- The international group, in charge of international issues affecting engineering education,
- The downstream group, which is in charge to develop relationships with industry and the engineering profession.

These groups are composed of various CTI members and counts on the participation of the different stakeholders, mainly, engineering HEIs and representatives of the engineering profession.

Under the light of the results of the 2008 CTI-CNISF study, the engineering education group decided to include specific guidelines regarding sustainable development in CTI's 2009 version of its accreditation criteria and guidelines [4].

CTI's guidelines have been developed within the framework of the 2009 French *Grenelle* Act. According to article 55 of this law, all French HEIs must develop a "Green" strategic planning which integrates not only the environmental aspects, but also the social and economic components [5]. CTI controls the existence and characteristics of this strategic planning in the context of the periodic accreditation campaigns.

According to the new 2009 CTI's criteria, the "Green" strategy developed by French engineering schools must comply with the following minimum requirements [4]:

- Concerning engineering education:

In order to adequately perform his/her tasks and responsibilities, an engineering graduate must be aware of the different challenges posed by the sustainable development paradigm. Moreover, any qualified engineer should be trained in the principles and tools of sustainable development.

This applies to a great number of scientific and social disciplines, tools and techniques, which could be taught in the core training. Additionally, all necessary specialized, cross-disciplinary and integrative modules (eco design, analysis of the life cycle of a product ...) should be placed during the final semesters of the engineering curriculum.

The behavioural aspect (ethics, co-construction solutions, compromise) should be also emphasized in this final module.

Finally, institutions are encouraged to develop specific sustainable development continuing education courses.

- Concerning engineering research:

It is desirable that research in engineering schools integrates sustainable development objectives, such as adaptation to climate change (improvement of energy efficiency, reducing greenhouse gas emissions Greenhouse ...). These research actions must be developed in closed link with the engineering curriculum.

- Concerning the higher education institution:

Consideration of sustainable development in training engineering students and in research activities must be complemented by a global commitment of the engineering institution, which implies:

- defining a strategy for sustainable development and publishing regular reports of activities referring to the monitoring of indicators,
- adopting a policy of recruiting for diversity in respect of the Equal Opportunities principle,
- prevention of hazards and addictions of the students and the staff ,

- ecological management of campus: energy, water and waste consumption control, reduction of greenhouse gas emissions, transportation policy ...

Since the instauration of the Grenelle Act, French engineering schools have put in place different initiatives to respond to these standards, which range from the creation of specific teaching modules, specialties or even a whole cursus to the establishment of integrated “green” management systems which impregnate the whole institutional culture [6].

The French Conference of University Presidents (Conférence des Présidents d’Universités- CPU) and the Higher Education Schools Conference (Conférence des Grandes Écoles- CGE) are currently collaborating in different initiatives, such as the development of a management standard for the implementation of sustainable development principles in French higher education institutions or the creation of a sustainable development label [7].

In the same line, the European Foundation for Sustainable Territories-EFST- together with the CPU, have jointly developed the website www.campus-durables.org with the objective of assisting HEIs in the implementation of the Grenelle Law and creating a community of environmentally aware institutions.

5. Conclusions

Accreditation agencies must fulfill their missions in awareness of societal and professional challenges and in a constant exchange with the different stakeholders. By establishing appropriate standards and guidelines, they can act as a catalyst for the implementation by higher education institutions of suitable strategies for addressing these challenges.

Since its creation in 1934, CTI has been in permanent contact with the needs of industry and society, by means such as:

- Its academic-professional equitable composition.
- Three monthly working groups which count on the participation of the different stakeholders.
- A permanent monitoring of the evolution of French engineering graduates and their professional competences, in cooperation with other French organisms related to engineering higher education and profession (CNISF and CEFI- Comité d’Études pour le Formation d’Ingénieurs)

The results of the 2008 CTI-CNISF study presented in this paper show that the introduction over the last years of specific accreditation criteria in order to encourage internationalization of French higher education institutions has provided fruitful results.

This same study has detected important lacks related to sustainable development and other societal issues. Thus, the results of the study clearly show that even if the new generations of French engineers seem to be better aware and consider being better prepared to face societal problems, still much progress is needed to develop French engineers’ awareness and preparation regarding these issues.

Under the light of these results and within the framework of the 2009 Grenelle law, CTI has introduced new specific accreditation criteria on sustainable development addressed to engineering higher education institutions. CTI is considering introducing specific criteria regarding other societal aspects, such as diversity and equal opportunities practices.

Future studies on the competences of engineering graduates should continue to orientate CTI’s global strategy, as well as serve to verify progression in the involvement of French engineering students and professionals in environmental and societal aspects.

Abbreviations

ABET Accreditation Board for Engineering and Technology

CEFI Comité d’Etudes pour le Formation d’Ingénieur

CEFRL Common European Framework of Reference for Languages

CNISF Commission Nationale des Ingénieurs et Scientifiques de France

CPU- Conférence des Présidents d’Universités

CTI Commission des Titres d’Ingénieurs

EFST European Foundation for Sustainable Territories

ENAAE Engineering Network for Accreditation of Engineering Education
EUR-ACE European Accreditation of Engineering Programmes
HEI Higher Education Institutions
RNCP Répertoire National de Certifications Professionnelles

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