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## **Using industry internships to improve the quality of engineering higher education in Europe. The experience of French graduate engineering schools**

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### **Abstract**

*Internships are a widely established practice in French engineering schools, encouraged but also supervised by CTI. In this article, the experience of French graduated engineering schools after more than three decades of industry internships is explained. The perspective of the Commission des Titres d'Ingénieur, as well as other different national approaches in Europe and the United States are addressed. Finally, some conclusions are drawn regarding the main challenges affecting industry internships and the impact of this practice into engineering education quality.*

**Key words:** engineering programs accreditation, engineering education in France, Internships, relationships between university and industry.

### **1 Introduction**

There is an overall consensus, among engineering accreditation bodies in Europe, that research and educational partnerships between universities and industry improve the quality of Engineering Education and strengthen the competitiveness of industry. In order to be an effective entry route to the engineering profession, engineering curricula should include an early exposure of the students to practice [1, 2, 3].

In France, especially during the last three decades, many relationships have been developed between graduate engineering schools and companies, aiming at adapting the programs to the needs of the job market. In traditional in-school engineering programs, these partnerships may result in different extra and intra curricular activities, such as sponsoring of student activities, forums and seminars, lending equipment, teaching by company representatives and, particularly, internships in companies scheduled within the school curriculum.

The French engineering accreditation body (CTI -Commission des Titres d'Ingénieur-) establishes, for all French five-year engineering master programs, a minimum internship period of 28 weeks (14 of them must be compulsory done in industry, whereas the rest could be done in a research laboratory). This requirement, quite specific to the French engineering education system, is recognized to have a number of positive effects, such as increasing the short-term employability and the international mobility of engineering graduates [4]. Nevertheless, different challenges and questions marks arise such as what should be the

extension for the internship period, the best way of measuring the learning outcomes or debriefing the experience [5, 6].

In this article, the experience of French graduated engineering schools after more than three decades of industry internships is explained. The perspective of the Commission des Titres d'Ingénieur, as well as other different national approaches in Europe and the United States are addressed. Finally, some conclusions are drawn regarding the main challenges affecting industry internships and the impact of this practice into engineering education quality.

## 2 Internships in industry in French Engineering Schools

### 2.1 A brief historic account

Among French Engineering Schools, the existence of internship periods in industry as well as testimonies of the importance of an early exposure of the student to the engineering practice can be traced back to the XVIIIth century. As an example, students at a well established French engineering school such as the *École des Ponts et Chaussées* used to organize summer industry placements in different regions of France or even abroad. Related to this, it is interesting to read a fragment of an article of Konstantinos Chatzis [7] which describes the organization of the cursus at the *École des Ponts et Chaussées* not long after its creation (1747):

*Sur cet enseignement théorique vient se greffer une formation pratique poussée que les élèves reçoivent, au cours de la belle saison et auprès des ingénieurs du Corps, sur les chantiers les plus intéressants, formation accompagnée par ailleurs de gratifications. Des élèves expérimentés, tout au plus au nombre de dix, appelés "appointés", se voient parfois détachés, pour un ou deux ans, auprès des ingénieurs de province à la demande de ceux-ci.*

*Quelques heureux élus peuvent compléter leur formation à l'étranger: une mission de huit mois en Italie, terre d'architecture, puis en Hollande mais aussi en Angleterre, pays plus technicien, est offerte chaque année à un élève, celui-ci devant réaliser "des dessins cotés des principaux ponts, des écluses, des machines et autres choses les plus pittoresques qu'il aura rencontrées dans son voyage, et ces dessins ou une copie, ainsi que les mémoires relatifs, seront déposés à l'École pour servir à l'instruction des autres élèves".*

Similarly, the organization of on-the-field placements was a classic practice in certain engineering disciplines, such as agronomy [8].

Nevertheless, the systematic organization of industry internships within the engineering cursus in France started in the 60's. According to certain authors, the upcoming of integrated industry internships in France is directly linked to the systematic introduction of non-technical subjects within the engineering cursus and the development of a particular engineer conception: the engineer as a generalist professional who is able to operate in a variety of complex environments [8].

Not surprisingly, as we will see later, one of the main positive effects that's usually attributed to industry internships is that they provide opportunities for the student to apply a combination of knowledge, capacities and attitudes acquired along the engineering cursus to a real professional situation [9].

CTI has played an important role in the consolidation of this practice with the introduction in the 90's in its accreditation standard of a compulsory internship period of 28 weeks for all engineering programs in France. Currently, the average length of the internship period in French engineering schools is 32 weeks.

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## 2.2 Characteristics and objectives

Typically, French engineering cursus include several integrated internships periods which are progressively introduced from the beginning of the third year; these internships can be of different kinds and lengths and serve to different purposes.

Regardless of the kind of internship, we can find some main common characteristics:

- The experience is controlled and mentored by both the engineering school and the hosting institution (company, research laboratory, NGO, etc.).
- There is always a previous planning phase in which the objectives, the assessment methods, and the intended learning outcomes are clarified.
- After the internship experience, there is always some sort of return of the experience. Typically, a report has to be handed in by the student. Very frequently, debriefing sessions are organized in order to extract the main lessons of the experience.
- In France, all internships of an extension longer than 2 months have to be remunerated [10].

As to the purpose of internship experiences, we can identify some major objectives [8, 9]:

- To assure a certain awareness and openness of the students to the professional world, particularly to the societal, ethical and human aspects.
- To become acquainted with organizations and organizational structures. To be able to acquire some basic professional reflexes and relational skills and understand their future role within the organization.
- To apply a combination of knowledge, capacities and attitudes learnt along the engineering curriculum to a real professional situation.
- To provide a first contact with the professional sector, which is meant to improve the short term employability of the student. Notably, more than 35% of French engineering graduates find their first job at the same company in which they made their internship.

## 2.3 Typology of internships at French engineering schools

A possible typology of internships organized at French engineering schools is proposed below:

- **Operative Internship** (*Stage ouvrier*)

This kind of internships is usually placed at the beginning of the engineering cursus (after the two first years of preparatory courses) and they are of a short duration (less than one month). In these operative internships, the students need to perform a low-level (usually manual) operative work (such as the work done by a building worker, a cashier, a farmer or a bricklayer). The aim is to make the student better understand the nature and difficulties of the work done by people at the base of the companies; people to whom he/she will probably have to directly or indirectly coordinate during his or her career.

The return of the experience in this kind of internships is not articulated around the specific content of the job but rather around such as the fostering of basic professional attitudes and routines (professional ethics or providing feedback to the immediate hierarchical superior, for example), or even the analysis of the analysis of societal or human aspects, such as health and security [11, 12].

- **Company internship** (*Stage entreprise*)

In this case, the student is placed in a real working situation; ideally, he or she will be in charge of a real working assignment. Despite of different authors maintaining the importance of the authenticity of the experience [13], the degree of real integration of the student on the organization varies according to the particular situation and the profile and characteristics of the student.

These internships are organized along several months (the length varies depending on the specific programme).

CTI's standards establish a minimum length of 14 weeks for internships in companies.

- **Research internship** (*Stage recherche*)

French engineering programmes correspond to a master level (level 6 of the European Qualification Framework), and hence enable direct access to doctoral studies. Consequently, it is important for engineering programmes to include a research dimension. A number of CTI's standards are linked to research practices in the institutions and their impact in the engineering cursus [14].

Moreover, research internships are intended to develop innovation skills [15], which is an important component of the French engineering competences profile defined by CTI [14].

Many engineering institutions in France include internships which are performed in research laboratories (within or outside the institution).

- **Final engineering project** (*Stage fin d'études*)

At the end of their studies, engineering students need to face a real (hence complex) engineering problem; It is a final capstone experience that will force them to employ the competences acquired along the program.

This final project is frequently performed in a company or in a research laboratory and constitutes an additional internship period.

- **International internship** (*Stage international*)

The main objective of CTI's international policy is facilitating the mobility of French engineering graduates and professionals [16]. As a consequence, CTI promotes the international development of the French engineering higher education institutions. According to the last survey made by CNISF (*Conseil National des Ingénieurs et Scientifiques de France*), 70% of French engineering students make an educational period abroad (well ahead of the 20% goal, fixed in 2009, at the ministerial conference in Louvain).

Internationalization of French engineering schools has been actively promoted and supported by CTI through diverse initiatives. Notably, CTI is a member of the *European Consortium for Accreditation* and has established mutual recognition agreements with other European Accreditation bodies, such as NVAO (*Netherlands Vlaamse Accreditatieorganisatie*) and OAQ (*Organe d'accréditation et d'assurance*

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*qualité des hautes écoles suisses*). CTI also supports and controls the quality of the different international cooperation initiatives of engineering schools (joint degrees, offshore sites of French HEIS, etc.).

At the professional level, CTI has signed different agreements for the mutual recognition of engineering professionals between France and Canada [17].

One of the consequences of this focus in internationalization is that, increasingly at least one part of the company internship or of the research internship is made in another country.

International internships pursue a number of objectives that should be added to the standard goals of a national internship experience, such as the development of communication skills and international openness and awareness [18]

- **International Development Internship** (*Stage cooperation au développement*)

Without altering the essence and main purpose of the internship, engineering schools usually provide opportunities for the student to develop his internship experience in a variety of environments. Increasingly, some students might be interested in developing their internship period in a *Non Governmental Organization* in the field of cooperation for development, which, in addition, enables also an international experience [19].

- **Gap year** (*Stage long/année de césure/année sabbatique*)

In this case, the students interrupt their studies for a whole year in order to work full time in a company (in France or abroad). Depending of the institution, between 5% and 80% of the students in a cohort turn to this option.

Advocates of this practice maintain that this gap year provides the students with an opportunity to configure or refine their professional project, which will help them make better academic and professional decisions during the final year of studies [12]. On the other hand, a number of difficulties associated to the gap year are frequently pointed out, such as the ambiguous academic and professional status of the student during this period or the extension of the studies [20, 21, 22].

### **3 Internships in other countries**

Internships as compulsory and integrated components of the engineering curricula seem to be more developed in France than anywhere else [23]. According to Maury, we can elaborate the following international comparison taking in account the actual importance of internships within the engineering cursus [8]:

- Regular presence of internships:
  - Germany: *Fachhochschulen* students (2/3 of engineering students) must make a one-semester internship, other engineering students at least 2 months, final degree projects are often done at companies. However, German engineering higher education is mainly focused on fostering technical competences rather than in providing an early professional experience.
  - United-Kingdom: even though internships are rarely part of the curricula, in practice, few students join a Master program right after the Bachelor. Additionally, students frequently go on a gap year before finishing their studies and in some institutions they are encouraged to do summer internships [24]. According to Onof, the differences between UK and France regarding the the

relevance of internships in the engineering cursus are due to two main reasons. Firstly, engineering education in UK is more applied and specialized than in France. In UK, the student's constant exposure during the regular cursus to application makes internships less of an urgent matter. Secondly, the broad range of internship experience which is offered in the French system seems well adapted to the profile of the French *ingénieur* (a generalist professional who will probably work in a variety of societal and economic contexts). In contrast, the UK engineer is historically viewed much more as a high-level technical expert.

- Occasional presence of internships:
  - North America: leaving aside some exceptions such as the one of Sherbrooke University [5], integrated internships are not frequent in the engineering curriculum; however, many students acquire a professional experience (not necessarily related to their studies) through summer jobs [17].
  - Spain: up to year 2007, the contents of the Spanish engineering curriculum were fixed by law. Integrated internships didn't have a place in this system, even though they were frequently offered as an optional subject. After a regulatory change in 2007, higher education institutions can now define program content in an autonomous way. As a result of this, in many engineering schools internships are currently being integrated in the curriculum [25, 26].
  - Italy: very few students will make internships as part of their engineering curriculum. This practice seems to be increasing in some Italian institutions, but in any case as a compulsory subject [23, 27].
  - Switzerland: internships are not usually present into the engineering curriculum. L'École Polytechnique Fédérale de Laussane constitutes an interesting exception; after an international CTI accreditation in 2003, EPFL decided to include a period of compulsory internships within its curriculum, which has proved to have very positive pedagogical effects.

The reason for those important differences in the use of internships is more than a question of pedagogical practices. It is the whole model of relation between academic training and professional practice which sets the main keys; this model includes two dimensions:

- The relations between the industry and academic institutions, and in particular the fact that teachers have a professional experience or intense relations with industry or not;
- The conception of engineering careers as an essentially two-phase line where some years of sound scientific education prepare for several decades of professional practice and specialization (this is the case, for example in UK or Canada), or either, as an spiral of life-long training where several academic and professional experiences are enchainned and interact with each other (which is mainly the case in France).

As a consequence, those countries with fewer relations between industry and academy, or further away from the life-long training paradigm, will coherently rely less on the importance of internships. At the end of this article, after analyzing the advantages and problems of the internships, we conclude with an overall positive outcome, but it is important to be aware that their use is related to more general education and professional policies.



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## **5 Some main problems and challenges**

In June 2010, L'École des Ponts et l'Université Paris Est Creteil organized two conferences [28, 29] in order to discuss the main issues related to the integration of internships in French engineering schools and abroad [30]. Without questioning the important role of internships in the French engineering education model, participants in these conferences pointed out a number of challenges and problems connected to this practice. Moreover, an expert network on internships has been created as a result to these two meetings, aiming at continuing with the debate and develop some general guidelines (Research Network on Internships and their Governance [29]), which show that the improvement and the effective integration of internships in the curriculum are sources of concern for French engineering schools. In the following paragraphs, a brief summary of the main challenges and problems discussed during these initiatives will be done.

A first source of concern about internships in France is related to their own success. As they get more present in curricula, and not only in engineering studies, company will face an increasing demand which enhances the risk that some less interesting internships are offered to the students.

Still from the perspective of the companies, it is clear that an internship must offer them a return and not just be done for the benefit of the student. Moreover, high-value internships for the company would likely represent a real professional experience useful for the student. Additionally, the company might be able to promote itself among students, get a better knowledge of the profile of young professional that will soon come to the job market and, in particular cases, appreciate the quality of an intern and offer him a job when he ends his studies. The risk is that this last component (internships as a recruitment source) is quite often the most important one for companies, which somehow neglect other important pedagogical objectives.

From the point of view of academic institutions, the main risk is that internships become a comfortable (and even inexpensive) choice where students are not in the campus and someone else is responsible for their education. Internships should never be just an accumulation of periods working in companies; they need to be intimately integrated with the academic components of curricula, considering the following aspects:

- Internships terms, conditions and objectives must be linked to the skills already developed by the students, and accordingly, subsequent academic periods must take into account the internship outcomes;
- As a consequence, internships can be either searched by the university or by the student (as it is also something to be learnt) but, in the second case, the university must also verify their content and interest, and discuss about them with the company and the student;
- The student must have an academic tutor who must be regularly informed about the internship progression so that he can help him to get more profit of the experience, and correct the eventual problems that may arise; additionally, this represents an excellent opportunity in order to develop industry-academy relations. Some questions arise as to the profile and competence portfolio that this academic tutor should have. The European project PROCERTU [31], has proposed a competence referential and a certification procedure for academic tutors. This referential is structured around the ISO/CEI 17023:2003 norm.

- The internship, as a hybrid of professional and academic activity, must conciliate two components: the engagement of the student with the company objectives and the fulfillment of professional tasks; and the essential pedagogical element which is the “right to fail and to be mistaken”. In other words, students have to consider the internship as a real-life job experience while they are doing it, but then the pedagogical and training component should never be forgotten. With the help of the higher education institution, students should be critical and reflective about the professional practices they have witnessed (both technical and deontological) and about their own career perspectives (an internship which makes a student change its professional orientation is sometimes more useful than one which confirms him in his original choice).
- All engineering schools have developed some kind of formalized procedure in order to plan and assess internships and organize the students’ return of the experience. However, there is some debate as to what the most effective methods would be. To this respect, the great quantity and variety of internships poses additional pedagogical challenges to higher education institutions.
- Finally, there is also a concern, not only about quality of internships but also about quantity. At the current moment, internships account for an important part of the French engineering cursus. In order to allocate such a great number of internships, program content has been substantially lightened over the last decades. Some critical voices coming from companies point out a lack of technical background of current engineering graduates.

## **6 Conclusions**

Integrated internships within the French engineering curriculum have a long history and currently constitute an important component of the French engineering curriculum.

CTI has played an important role in the development and consolidation of this practice among French engineering schools. At the current moment, CTI establishes, for all French five-year engineering master programs, a minimum internship period of 28 weeks (14 of them must be compulsory done in industry, whereas the rest could be done in a research laboratory); moreover, different international accreditation experiences show that the French internship model could be successfully, if not exported, at least adapted to institutions in other countries.

Comparisons with other countries seem to indicate that the presence of internships in engineering education is more than a pedagogical matter; internships are closely linked to the particular profile and role of engineering graduates within the different countries and also to the relations between the industry and academic institutions.

Without denying the benefits and the important role played by internships in France, a number of challenges and difficulties have been pointed out by French engineering schools and have been discussed along this text. The academic and professional community together with CTI are currently working together through different initiatives in order to find the best answer to these problems.

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