

Needs And Management of the Complementary Courses for PhD Candidates in the Field of Electrical And Information Engineering: an Answer to Economical and Industrial World

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Abstract—Since the Bologna process requires harmonization of degrees in the European Higher Education Area, doctoral programs have become subject to intensive analysis. This applies particularly to two components: the first one is directly linked to research activities performed in a research environment. The second one corresponds to complementary means devoted to preparing the future doctor to the professional life in research institutions, academic environment but also in companies. Today, in average two third of the doctors in the developed countries must find a professional position in commerce and industry. Academic institutions have adapted their doctoral programs to the changed situation. This paper highlights this development by giving some examples in the field of electrical and information engineering

Keywords—Bologna process, Doctoral studies, Electrical and Information Engineering, Doctorate diploma supplement

I. INTRODUCTION

Initiated by the Bologna declaration and the communiqué of the Bologna-follow-up-conference 2007 in London [1-2], and as a consequence of a Decree of 07th August 2006 by the French Ministry of Education related to the doctoral studies in France [3], and similar to situations in other developed countries as for instance the US, the UK or far-east countries), doctoral programs have been analyzed in order to find out requirements concerning skills and competences of future doctors of engineering. Two particularly important components have been identified concerning the professional development of candidates: the first one concerns the candidates' ability to successfully work in a research-oriented environment, as for instance an academic laboratory, or research & development service of a company, or other research institutions. The second one concerns the development of other skills and competences to prepare future doctors for executive and managerial functions not only in an academic environment, but also in commerce and industry. Meanwhile, about two third of the doctors in developed countries must find their professional position in companies and administrations, while fifty years ago, the great majority of doctors of engineering found positions in universities or other academic institutions (e.g.:

Academy of sciences, Observatories, Research Institutes). As a consequence, academic institutions have adapted their doctoral programs to better prepare their doctors to the industrial and economical world. These changes will be described in this paper.

First, it is dealt with the requirements for competences and skills of doctors in general, which will be exemplified in the field of electrical and information engineering. A detailed list of these competencies is then explained and justified, a large part of them concerning the "soft skills and competences" as for instance mastery of other languages, or social and individual competences. Finally, it is suggested how to improve harmonization of doctoral programs in Europe particularly in the frame of the Tuning Approach and in the framework of European Thematic Networks such as EIE-Surveyor or ELLEIEC.

II. SKILLS AND COMPETENCIES

Figure 1 gives an overview of the skills and competencies that are required for a doctor on the base of a survey performed with managers of human resources in companies and in research laboratories. In addition to professional expertise, many other individual and social skills and competences are considered that are expected from every doctor; for example team management, communications for knowledge transfer, human resources management in a research group, aspects of intellectual and industrial property (patents, transfer and application of licenses), project management and methodology, and financing.

Combining exact and empirical sciences with the objective to create applications for the benefit of people, doctors of electrical and information engineering should acquire [4]:

- the proven ability to use profound knowledge at the most advanced frontier of a highly specialized field,
- the most advanced personal skills, and methodological abilities required to solve critical problems of this field, and substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of

work or study contexts including research ([5] Hoffmann 2007). In other words, this must be the result of serious and in-depth activities in the field, mainly acquired under the supervision of a professor at an academic research laboratory. This academic laboratory is “the unique environment in which young researchers are trained by and through research” (AERES 2008 [6]);

- the proven ability to establish an up-to-date bibliography on a chosen item, to analyze the main results and to extract the main ideas related to innovation in terms of experiments, approach, methodology, etc.;
- the proven autonomy in disclosing new sources of knowledge;
- the proven ability to develop further this knowledge by applying scientific methods;
- the proven ability to manage an own research or development project;
- the proven ability to analyze obtained results critically and to evaluate them in a scientific, creative, and innovative way;

- the ability to work in a team, and in the environment of large facilities, e.g. using large instruments or common experimental platforms;
- the social competence to guide and instruct less qualified members of their team, including definition of work packages, and planning of tasks for those who technically or administratively support the research activities;
- the ability to circulate knowledge in a suitable form to others, mainly by means of the thesis, or by presentations at national and international conferences, and by peer-reviewed publications, thereby enhancing the body of knowledge in their fields of expertise;

These competences are summarized in figure 1 and also developed in [7].

These soft competencies must then be acquired during the studies and for the most cases during the preparation for the doctorate. Programs of doctoral schools are one possibility to impart missing knowledge, skills, and competences. This is analyzed in the next sections.

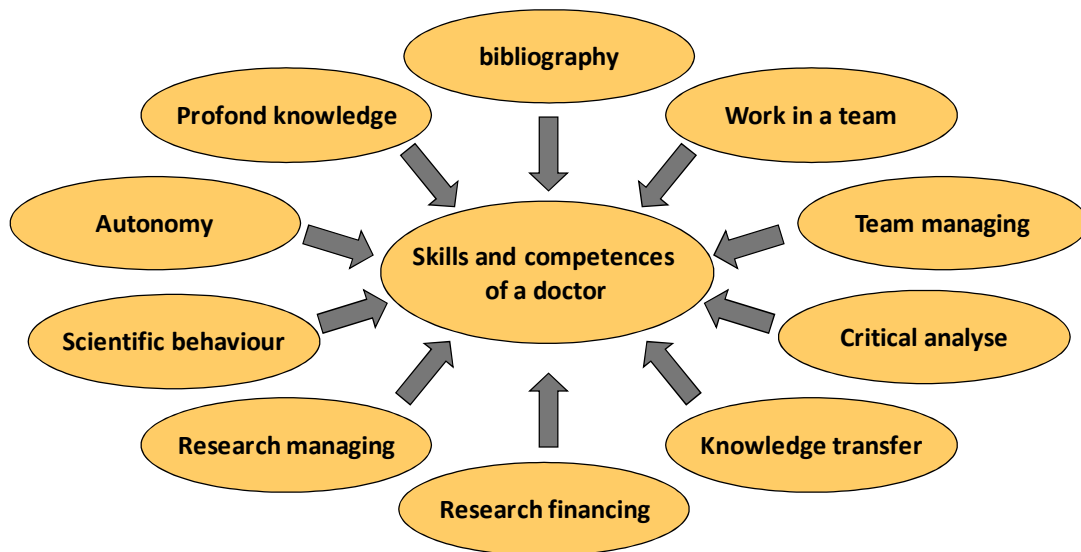


Figure 1. Skills and competencies required at the end of a doctorate or PhD. They combine professional expertise in the abroad subject with individual and social skills and competence)

III. COMPLEMENTARY FORMATIONS

Having in mind the required skills and competences of a doctor of engineering, the courses at doctoral schools are classified into three main categories, i) scientific, ii) general iii) professional, as shown figure 2. The categories are presented and justified in their own contexts. The scientific courses are selected with the goal to improve the scientific background of the doctors, mainly with a multidisciplinary objective. It is a way to enlarge scientific knowledge, skills and competences of the doctors. These courses include summer and winter schools, tutorials organized in the frame of international conferences and workshops, high level international courses, and specialized master lectures, mainly. The general courses correspond mainly to improvement of language practice in the scientific fields, preparation to the writing of international

papers in a scientific journal, English communications, but also additional practice in other foreign languages. The third categories is much more devoted to the preparation of the economic and industrial world that include the intellectual properties, patents, project management, legal structures of companies, human resources management.

For some years, these courses are offered in many doctoral schools or graduate schools, but also as stand-alone modules. These complementary formations and associated specific lectures aim at preparing the future doctor to the industrial environment.

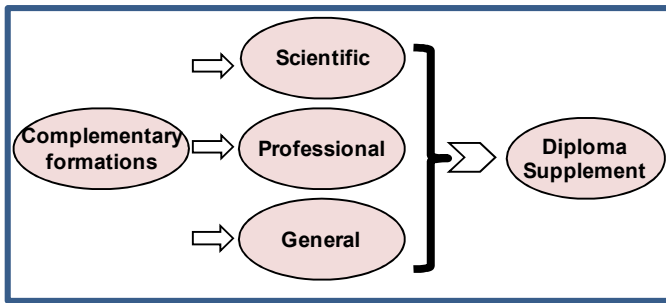


Figure 2. The complementary formations are splitted in three categories: scientific, professionnall and general. They constitute the matter to the diploma sumpplement

The Bologna-process has led to an outcome-oriented description of degrees. If there is an agreement on knowledge, skills, and competences of a doctor of engineering, then it does not matter how these are achieved by a candidate. Therefore, harmonization of the doctorate will probably not be achieved in a sense of harmonization of methods, but there will be a hope for harmonization in terms of outcomes.

The engineering doctorate as it is organized at German universities, or Doctoral schools like in France might serve as examples for best practice, but with different methods for the achievement of the required skills and competences. The following sections concentrate on the formation as given by doctoral schools.

IV. : 4. SETUP OF FORMATIONS

A. Kinds of formations

During the preparation for the doctorate, candidates must attend several special courses shared in three main categories:

- scientific courses corresponding to master modules, high level international seminars, summer or winter schools, tutorials, national or regional events for and by doctoral students,
- modules that support the development of social and individual skills and competences,
- modules that prepare for work in commerce and industry, and in administration, like languages, business administration, etc. .

Modules of these three categories require approximately the same workload of candidates.

As a particularity, French doctoral schools have created a reference in terms of workload: depending on the school, they require a workload that corresponds to thirty, fifty or sixty ECTS credits. Note, however, that there are normally neither exams nor marks in relation to the modules. Anyway, in the case of joint international doctoral programs, credits might be validated by both international partners.

In order to encourage doctoral candidates to develop organizational skills, they are encouraged to take over organizational activities, which are rewarded by allowance of a certain amount of workload on top of the actual workload..

B. Qualification

When the doctoral candidate fulfils the formation requirements, a document is produced and signed by the director of the doctoral school. It gives the go-ahead for the defense of the thesis and is finally part of the official qualification of a doctor of engineering. This document is not only due to the requirements of the French Ministry of Education, but it has also a similar functionality as the diploma supplement for the bachelor or the master qualification. It is a proof for knowledge, skills, and competences that have been acquired by the doctor, and that is very appreciated for the recruitment)

V. DETAILS ON COMPLEMENTARY FORMATIONS

We analyze in this section the three categories of formation that are usually proposed.

A. Formations linked to professional expertise

This first category is mainly devoted to the improvement of the scientific level, the most adapted to the field of the thesis. Let us note that in more and more cases, the subjects of research work are multidisciplinary, that means a strong need for the doctoral candidate to increase his (her) knowledge in broader field of expertise.

For this purpose, several approaches could be thought of as for example keynotes, summer or winter schools, national, regional or local seminars and workshops of doctoral candidates, or specialized lectures.

These lectures are devoted to new domains and – in contrast to master modules – at the real forefront of research, generally. They are opened to a wide audience and have another spectrum than the classical research seminars, internal to the laboratories. For some doctoral candidates, modules dedicated to master students can also be opened to complete some fundamental background such as in mathematics, computer science, or other lectures in a multidisciplinary approach.

B. Courses for the professional development

These formations are devoted to improve skills and competences that are necessary to work in a professional all-days situation. The more frequently offered courses are listed below:

- Organizational structure of a company,
- Company creation,
- Fund market and financing of enterprises,
- Company strategy,
- International competitiveness,
- Innovation, creation, discovery,
- Enterprise and environment.

This non-exhaustive list, gives an overview on the different types of lectures that are offered. Due to their generality, these modules are frequently offered jointly by several doctoral schools. Commerce and industry appreciate good education in this sector.

C. Individual and social skills and competences

Working in a team, or human resources management, or courses on self-organization are examples for subjects that are

addressed in modules for the development of individual and social skills.

It might be debated, on whether language skills belong the category of individual and social skills or on professional skills. Anyway, in a world that is growing together, mastery of at least two languages is a must. In French doctoral schools, for instance, doctoral candidates are expected to master at least French and English in an adequate way

VI. CONCLUSION

Organizational means to support doctoral candidates in achieving necessary skills and competences appear to be more and more useful. The main reason for it is the increasing number of doctors that join companies either directly after the doctorate or after a post-doc position. This applies to seventy percent of the French doctors, in the average, while twenty five years ago, seventy percent of doctors had the opportunity to choose an academic career. Of course, doctors of engineering must always have in-depth scientific knowledge, skills, and competences [8] but they also need to acquire other skills and competences in a much wider spectrum. The most difficult point today is to avoid a too long duration of the doctorate and to define a compromise that is compatible to the necessary excellence in a research specialty. This corresponds to one of the tasks that are treated in the frame of SURVEYOR [8] and ELLEIEC [9] networks in the frame of EAEEIE association [10] and in the Tuning project (that corresponds to a harmonization of several European Thematic Networks).

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