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# On the way of harmonization of PhD in Europe in Electrical and Information Engineering: status and recommendations

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**Abstract**— In the frame of the thematic networks devoted to the development of LifeLong Learning (LLL) in Europe, the ELLEIEC project, more especially focused on Electrical and Information Engineering, the situation of PhD students in Europe was analyzed. Thanks to a questionnaire submitted to all the members of this network, an overview on 23 European countries was obtained. This paper tries to highlight the several aspects of the status and proposes recommendations in order to make easier the mobility and exchange in Europe at PhD level. The final part of this work is devoted to recommendations to the European partners in order to improve the present situation and to create a real European space for doctoral studies.

**Keywords**-component; doctoral studies, mobility of PhD student in Europe, harmonization in the frame of Bologna process.

## I. INTRODUCTION

Following the set-in of the doctoral studies in the frame of the Bologna process (B, M, D) [1], the associated structures, called doctoral schools or post-graduate study departments depending on the countries, have now almost ten years of functioning for most of them. It is clear that the complete harmonization is not reached in Europe yet but in the field of Electrical and Information Engineering their missions and their evaluation criteria are now well established and discussed; these activities constituted a part of the work of previous networks, more especially THEIERE [2] and EIE-Surveyor [3-4]. Even if some differences remain in the functioning and in the policy of the European academic institutions (European Higher Education institutions); similar activities are now well established and performed. In parallel, a Communiqué of the European Commission [5] established between the Ministries of Higher Education aims to encourage and develop the lifelong learning and the validation of professional experience through the European space.

On the basis of the first approach made in the frame of the final report of the EIE-Surveyor program [6-7], and following a review on the doctoral studies in electrical and information engineering for the Bologna handbook [8], this paper wants to

highlight several weaknesses in the global harmonization at the doctoral level, following a survey based on a dedicated questionnaire analyzed in the frame of ELLEIEC network [9]. Several aspects will be approached:

- organization of doctoral studies,
- missions of doctoral schools,
- administrative approach for the diploma delivery,
- conditions of defense and diploma delivery
- recognition in the European space
- need of additional lectures; European credits,
- validation and acceptance of the diploma by the socio-economical world,
- European extension of this approach in the frame of the ELLEIEC [9] project and LLL (LifeLong Learning).

After a presentation of the context and after the development of the mentioned points, the aim of this paper is to give some suggestions towards a European Union harmonization of the Higher Education in order to foster the European mobility of doctors and researchers, with a real equivalence of PhD diploma through Europe, even if parts of these recommendations are already made by the European Commission.

## II. COMMON APPROACH FOR DOCTORAL STUDIES

Whatever the differences that can remain within European Space, common approaches already exist for the doctoral studies. To prepare a doctorate, the student must reach a specific environment that allows developing new researches that include original approach, innovating applications, international recognition of the main results. After the doctorate diploma, the doctor must manage research activities that include several aspects as shown Fig. 1. The doctor may manage some technical experiences, create new tools, design and set-up new instruments, analyze the existing results in the international environment by a way of a deep bibliography, propose modeling and simulation involving recent tools, suggest innovating ideas, etc.

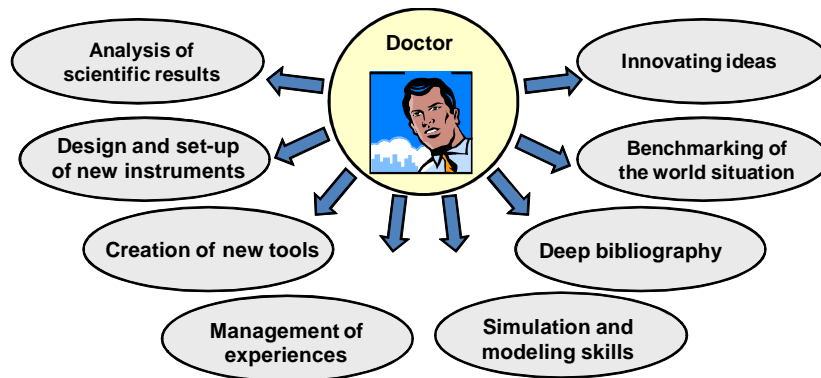


Figure 1. Main activities of a doctor. The doctor is able to manage research activities whatever the professional environment. The main skills and competences are displayed in this figure.

However, this approach reduces the education of the doctorate to a scientific work, while several aspects are presently mandatory to well perform doctorate and to prepare the future doctor to his (her) future professional position.

In addition of this scientific environment and scientific work, the doctors must have gained and also proved several skills and competences, which would provide their future job in an academic institution or in a research organism, as well as in a department of Research and Development (R & D) of an industrial company. These skills and competences are summarized in Fig. 2. Discussions and comments were given in previous published studies [7, 8, 10-12]. However, it is important to notice that the main aim corresponds to the capability of the doctor to manage researches, not only thanks to scientific knowledge and knowhow, if possible close to excellence, but also to prove a very good knowledge of the

economical and industrial environment, and a high intrinsic knowledge including languages and communication.

Although the students are severely selected at the entrance of doctorate studies by the doctoral schools (or post-graduate schools) and the associated research units, due to the permanent and very strong increasing of the general scientific level, some complementary knowledge and skills must be acquired during their studies [11]. Thus, one of the main roles of the doctoral school is to organize such additional education or training, to ensure the quality of the additional knowledge, or in other words the improvement of the global capabilities of the doctors [13]. Fig. 2 summarizes the main skills and competences learnt and acquired by a doctor during the PhD preparation. The doctoral school [see for example 14] and the institution where the student is enrolled must ensure their skills and competences, with a large spectrum in order to cover all the aspects of their future job.

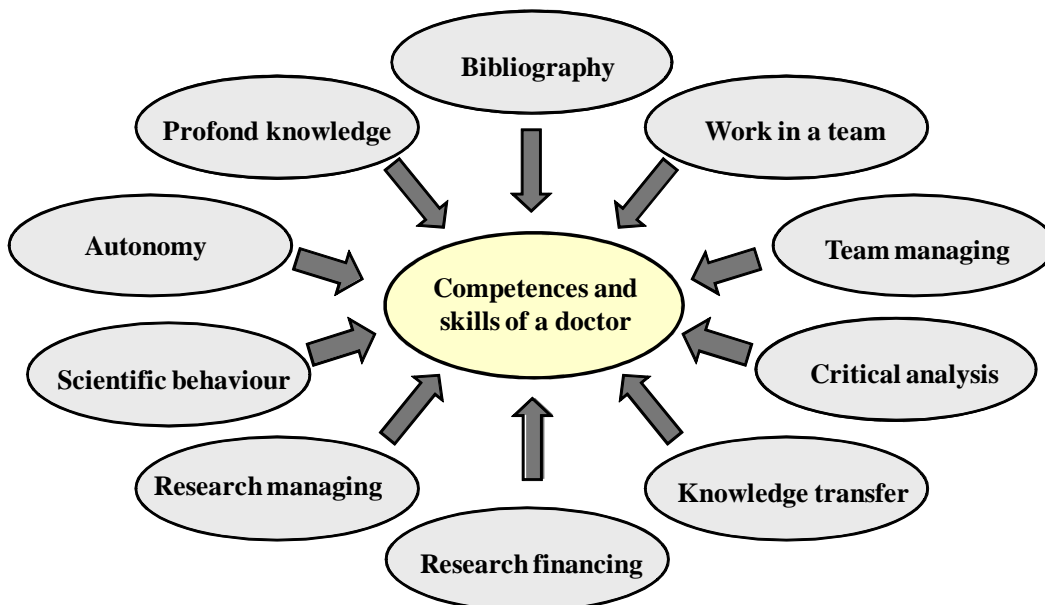


Figure 2. Required skills and competences at the Doctoral level [10]. Whatever the way to obtain the doctorate these skills and competences should be reached by the doctor.

The main question arisen at this stage is what is the situation in Europe? Is there some difference on recruitment of PhD students, on duration of the studies even though European

recommendations already exist, on the condition of defenses, and on the application of LifeLong Learning European rules [15-16]? To try to answer to these questions, the task 4

working group of the ELLEIEC network [9] set-up a survey and analyzed the results. The next section deals with this point.

### III. RESULTS OF A SURVEY

In the frame of the ELLEIEC network, a survey dedicated to doctoral studies was set-up in order to evaluate the approaches developed in Europe for this purpose. Initially devoted to analyze the organization of LLL at this high level [15-16], the results given by the specific questionnaire was also able to highlight the following points:

- information about the target population,
- admission process of doctoral students,
- administrative situation of students in doctoral position,
- organization of complementary lecture leading to credits,
- requirement for defense of the PhD,
- organization of defense.

27 partners of the network answered, representing 19 different European countries. This means that the results may be considered as significant.

Let us note that during the preparation of the questionnaire and brainstorming between the European partners of this network, the first major information that arose is the different interpretations of LLL at the doctoral level [12-16]. For many institutions in Europe in the field of Electrical and Information Engineering, the doctorate position corresponds to a first professional experience or job and thus the diploma is considered as delivered in a LifeLong Learning frame. In several countries, the major part of the PhD students is considered in this situation because a significant part of the research work is performed in a company or in the frame of a joint program with industry.

Even though the definition of LLL can be a little bit different, including or not the APEL (accreditation of prior experiential learning) [12], the final goal is the same for all the countries and institutions: the scientific quality of the results and thus the recognition of the PhD everywhere in Europe whatever the approach.

Fig.3 shows an example of the answers. In this case, the question was the requirement of the master diploma to get a PhD position in the institutions of your countries.

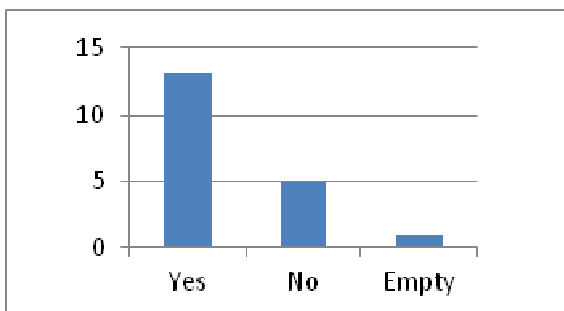


Figure 3. Example of results extracted for the questionnaire. The presented answers concern the requirement of the master diploma to access to PhD position. In this example, Germany and Malta institutions do not require the master diploma.

Depending of the countries, the recruitment can be made with or without the master diploma, the selection being processed by the advisers, the laboratories and the doctoral schools. One fourth countries enroll students without the master diploma, but in continuation of the master studies. Whatever the local rules, the first objective is to recruit good applicants. We can notice that more and more of the candidates in the field of Electrical and Information Engineering are coming from outside Europe. This is a consequence of the observed decreasing since more than ten years of the attractiveness of scientific studies (physics, chemistry, electronics, electrical engineering, etc.) in more and more European countries. We have detected that some doctoral schools (or postgraduate study departments) could have now more than fifty per cent of PhD students coming from outside Europe [15].

In addition we may notice that to recruit PhD students, previous research experience is not mandatory if the master is mandatory. The experience becomes mandatory in the contrary. Because the majority of masters include research activities in Europe, usually in the frame of an internship either in a research laboratory or in R &D department of a company, this means a mandatory research experience before in all cases.

A major part of the students receive a grant, a scholarship or a financial support based on contracts with industry or with the academic institution. Some of them have a temporary position in the university as assistant professor. In some institutions, the PhD students are enrolled only after they have found by themselves a financial support for the duration of the thesis. More than ten percent have a scholarship supported by their origin country (outside of Europe, such as Brazil, China, Vietnam, Middle East countries). As a conclusion, almost all the PhD students have some financial resources to ensure the minimum daily expenses of life. Let us notice that it is not the same situation for the PhD students in Human Sciences; in average, fifty per cent have no financial support during their thesis.

The duration of the thesis is at least three years, following by this way the European recommendations (see Communiqués [5]). However, the average duration of the thesis is in practice, close to four years. One of the reasons is the parallel activities of the PhD students: some of them are teaching; others are producing some professional activities linked to the industry. The additional lectures useful for professional purpose lead also to an increase of the duration. The last major reason is due to the long process for publication by the international journals; indeed, the reviewing procedure can take several months and for some prestigious journals more than one year. Some institutions impose the effective acceptance for publication that frequently postpones the date of the defense.

We have detected no significant difference on the requirements for the defense, and attribution of the diploma. In each case, recognition by the international scientific community via the publication in journals or in major prestigious conferences is needed even if the number of items can vary from one institution to another; the average is two major items in the analyzed data.

The composition of the jury varies from one country to the other. Fig. 4 shows the variation of the composition of the final jury. Reports, before and/or after defense, are requested in the wide majority of cases. A strong majority requires two or more reviewers for the final evaluation of the work.

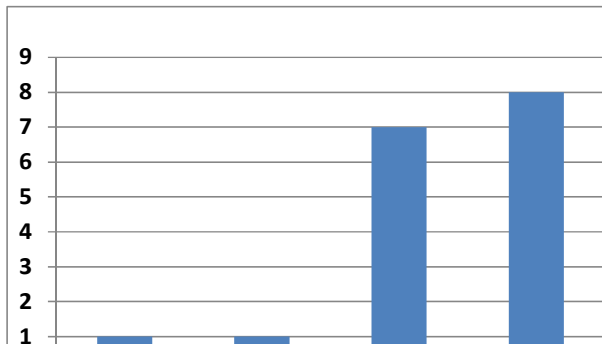


Figure 4. Number of reviewers in the final jury for the defense of PhD. A strong majority requires two or more reviewers for the final evaluation of the work.

In almost all cases, the complementary credits are needed. For some countries, credits are delivered similarly to ECTS at bachelor and master levels. In other countries, a supplement to diploma is produced; this document details the lectures attended by the doctor during the preparation of the thesis.

To summarize, some minor differences between European countries remain but the main goal to ensure a high quality of the research activities is globally respected everywhere. In order to decrease the remaining differences, the team group of the network has emitted some suggestions and recommendations.

#### IV. RECOMMENDATIONS

All the partners agree with the need to take care of the scientific quality of the research whatever the path. This good behaviour must be followed in all the new procedures.

The organization of the defense with some specific local requirements is built to get the same diploma that can be recognized everywhere in Europe and elsewhere. At the end, there should be no difference, the diploma is unique. However, the choice of two reviewers for each defense should be a good way to have comparable evaluations.

Even if the institutions in Europe are more and more free about their own organization and on the delivery of their diplomas, the Bologna process and the related recommendations via several Communiqués [5] must be considered. The attributed freedom must also ensure a high quality of the diploma.

During the preparation of Doctorate, almost all the institutions propose to organize some additional courses that are mainly oriented to an improvement of the scientific skills and competences of the future doctors. These courses include summer schools, winter schools, and high level seminars, in very specialized fields. These courses may lead to the delivery of credits that can be available for all the European Institutions. There are not really ECTS because in many countries there are not credits required to deliver the diploma but they can appear

in the diploma supplement, a paper that is validated by the graduate school or doctoral school and the scholarship office of the institution where the student is enrolled. Maybe a European harmonization could consist to create a credit reference for all the PhD.

The European institutions if possible with the support of the European Commission should continue to organize at least annually, some seminars of reflection on the policy about doctoral preparation in order to adapt the procedure with the very fast evolution of the environment. ELLEIEC network has enough experience to confirm this general interest. EAEEIE European association [17] can play the role of European reference in this domain. A European financial support to the EAEEIE association allowing a continuation of ELLEIEC network should be a good way to perpetuate the efforts.

#### V. CONCLUSION

This mentioned thinking is a starting point for European harmonization of doctorate studies in the frame of Electrical and Information Engineering. Of course, the first objective is to ensure quality of the doctoral studies in such a field. This means a high level of competencies in a dedicated domain. The doctoral studies as well as the institution that delivers the doctorate are now evaluated. In France the new Evaluation Agency [18] is expected to evaluate the doctoral schools and the research units, each five years. The criteria of the evaluation include the quality, the organization of the validation of complementary courses and probably in a short future the capability to develop a procedure of lifelong learning at this higher education level.

We have made some suggestions in order to minimize the difference, mainly on the possible appreciation of international evaluation. Of course, if some differences will remain, the most important point will be to ensure a quality of the diploma with an international recognition, everywhere in the world.

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