

Complementary formations of Doctorate in Electrical and Information Engineering: Internal Credits or ECTS

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Introduction

Following the set-in of the doctoral studies in the frame of Bologna process (B, M, D) [1], the functioning of the associated structures, called doctoral schools or post-graduate study departments in function of the countries, have now more than four years of functioning for most of them. It is clear that the complete harmonization is not yet reached in Europe 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 THEIRERE and SURVEYOR[2]. Even if it remains some difference in the functioning and on the policy of the European academic institutions (European High Education institutions), similar activities are now well established and performed. On the base of the first approach that was made in the frame of the final report of Surveyor programme [2], and following a review on the doctoral studies in electrical and information engineering for the Bologna handbook [3], this paper wants to highlight the point of the complementary formations during the preparation of the thesis, that are more and more required, more especially by the socio-economical word. These formations are organized by the doctoral schools (or the graduate schools) [3] and are presently conditioning the attribution of the diploma to the doctors in the most part of the institutions accredited to deliver the doctorate diploma. On the basis of a personal experience of the author as director of a French doctoral school in the field of EIE and on the fruitful discussions and exchanges with colleagues in the frame of EAEEIE association, this paper thus arises several questions about these complementary formations and more especially:

- The definition of the number of lectures,
- The equivalence in hours, and the equivalence in credits,
- Their distribution in time,
- How to get the credits? Is it useful to organize an examination to get a credit?

- Are these credits available for another institution?
- Are these credits validated when a student move in the Europe Union?
- Are these credits available for life-long learning or continuing educations?
- What the EIE community should do to reach a better harmonization in Europe?

After a presentation of the context and after description of the types of formations, the aim of this paper is to try to answer to these points and to give some suggestions towards a European Union harmonization of the High Education.

Mandatory conditions to prepare a PhD and context

To prepare a doctorate the student must reach a specific environment that allows developing new researches. This environment is summarized in figure 1 that shows the main points that must be fulfilled to prepare a doctorate in suitable conditions. It is well accepted since a very long time that to prepare a doctorate (or PhD) a student must produce a scientific work that is mainly performed, at least in the field of electrical and information engineering (EIE), in a research laboratory or research unit. In this ambience, the student may manage some technical experiences, create new tools or instruments, analyze the existing results in the international environment, propose modelling etc.

However, this approach reduces the education of the doctorate to a scientific work while several aspects are presently mandatory to well perform doctorate. In previous papers [3, 4], these aspects were analyzed in detail giving the conditions to fulfil in order to prepare a doctorate that are, to summarize, high scientific quality that means high technical skills and competencies (if possible "excellence"!), very good knowledge of the economical and industrial environment, high intrinsic knowledge including languages and communication. Although the students are severely selected at the entrance of doctorate studies by the doctoral schools and the associated research units, due to the permanent and very strong increasing of

the general scientific level, additional or complementary knowledge and skills must be acquired during these studies; thus, one of the main roles of the doctoral school is to organize such additional formations, to insure the quality of the additional knowledge, or in other words the improvement of the global capabilities of the doctors. The doctoral school has to warranty their skills and competences with a large spectrum in order to cover all the facets of their future job.

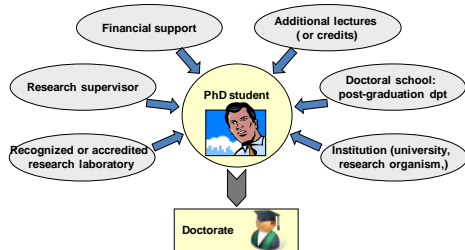


Fig. 1. Main general conditions for preparing a doctorate. Not only the research environment is required. Credits or additional formations must be performed

It is clear that the doctoral school has to financially contribute to the organization of these lectures. In order to minimize the cost, a mutualisation is frequently organized. This mutualisation passes through the gathering of the doctoral schools and called college of doctoral schools. The college is thus a superstructure gathering the doctoral schools of a site or at the level of a land or of a Region. All the formations that can be common to several fields are then managed at this level.

Nature of the complementary formations

As above mentioned, the complementary formations can be sorted in three categories that are summarized in the Fig. 2. The three main categories are:

- Scientific oriented lectures and seminars;
- Professional oriented courses;
- General skills.

These three kinds of complementary courses are supposed covering the wide spectrum that is expected. They are detailed in the following. Let us note before that the academic position objective remains in many minds of the doctoral students. It is treated apart of the professional oriented course due to the particular interest.

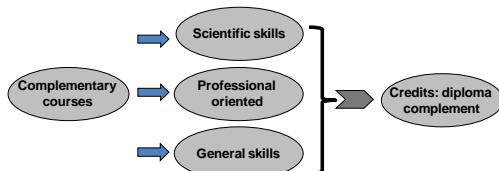


Fig. 2. Categories of formations required during the preparation of a doctorate: scientific deepening, general knowledge and professional approach of the economic world

Scientific complementary courses. 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 the research works are multidisciplinary, that means a strong need for the PhD

student to increase his (her) knowledge in another field of his (her) initial background and to be a specialist in a transverse research.

For the scientific purpose, the formations can be shared in several aspects. keynotes, summer or winter schools, national, regional or local seminars and workshops of the PhD students. We give in the following some typical examples of high level lectures in the fields of electrical and information engineering and selected on the websites of several doctoral schools:

- new approach of the reliability in micro and nanoelectronics,
- reliability and industrial maintenance
- the new reconfigurable antennas,
- actives devices involved in the high power electronics,
- adaptive command and regulation,
- visual perception,
- electromagnetic compatibility,
- Beyond Moore's law in microelectronics,
- new device concepts,
- innovating devices for ultimate integration on silicon.

In addition of this courses organized in the frame of the doctoral schools or in the frame of colleges of doctoral schools, some students are encouraged to attend to elective courses spent at the level of the master degree or in the curriculum of some Engineer schools. In this case, the course is integrated in a classical scheme of a master degree with the possibility to get ECTS (European Credits System) for Transfer System).

Professionally oriented courses. The second category of formation is devoted to increasing the knowledge on the companies and on the associated work life. Indeed, if during the beginning of the 20th century almost all the doctors were initially devoted to academic positions, this behaviour turned out in the second half mainly for answering to the increasing need of innovation. In practice, more and more doctors were attracted by research and development services of international companies or start-up. Thus some additional knowledge became more and more required. After a survey made in France on the jobs evolution in the companies involved in microelectronics, we deduce that all the human resource services demand some competencies in soft sciences from human psychology, project managing to finance. Depending of the origin of the students, these competencies can be obtained in the frame of the master or of the Engineer diploma. However, many students have not this experience, unfortunately. Because it is not specific to a field but available for all the doctors, the courses can be organized by mutualised structures. The following list gives some examples of lectures professionally oriented:

- company creation,
- fund market and financing of enterprises,
- company strategy
- innovation, creation, discovery,
- enterprise and environment,
- industrial property
- economical intelligence,
- analyse of the value,
- project management,

- oral communication,
- management of human resources.

General skill complementary courses. The first goal in this case is the widening of the knowledge spectrum. Knowing that in EIE about fifty per cent of the PhD students are recruited from abroad, a major part of them want to improve their practice of the French language. For this purpose, the doctoral schools must manage with their attachment institution this international policy.

In other big need in the EIE for not English mother tongue students, is an improvement of the scientific English language practice as well for the international conferences as for publications in international journals. Dedicated courses are thus organized and in average, more than the half of the PhD students attends to these formations.

Other more soft sciences, such as psychology, Health and Safety are also frequently proposed.

Academic position oriented complementary courses. Even though the percentage of doctors reaching an academic position after obtaining the doctorate diploma is low, a large part of the student has this aim at least in the mind. Specific pedagogical formations are then organized including the teaching techniques, oral expression, communications, and animations. This type of formation can be inserted in the professional oriented category.

Validation of the complementary courses. All these formations are usually validated by the doctoral school or the graduate department of the university. Depending of the institution and depending of the general field (human sciences, engineering sciences), hours or credits are attributed within the frame of these formations. The student will obtain the defence authorization by the director of doctoral school if the number of credits, clearly defined in categories at the beginning of the doctorate is reached.

Diploma additive. When the PhD student fulfils the formation requirements, a document is produced and signed by the director of the doctoral school that attests of the work of the student; it gives the green light for the defence and is finally added to the diploma document.

Management of the complementary formations: analysis and discussion

If in the frame of Bologna process, the doctoral studies are now including the complementary formations in the preparation of the doctorate, the diversity of exigencies depends of the countries and of the institutions. Several points are thus treated below.

The approach can be a global equivalence of number of hours spent by the students, or, similarly to master credits, a global number of credits. In this case, when the student has spent for example five hours, one credit is delivered. It is current to deliver 30 credits. This choice corresponds in fact to a semester at the bachelor or master level. However, the amount of worked hours is not really equivalent. If this number is increased, there will be a consequence on the research work that must remains intense and of a high quality; in other words, a good compromise must be found.

The second point is the repartition of the courses in categories. A classical approach consists to share the

credits between the three categories, for instance, a third each. Another way consists to define a minimum of credits (or hours) in each category, for example a quarter. This approach appears well adapted to students that have already built a carrier plan and that are able to manage their professional life.

The third point concerns the distribution in time. Many doctoral schools in the world prefer to start by these formations and deliver at the end of the first semester or year the authorization to pursue the thesis by research activities in laboratories. If the approach warranties the success of the student on this mandatory part, it is not the best way to adapt the research and scientific approach in function of the research progress. In addition, the need of general skills appears clearly after several months or even years of experiences. That is the reason of the new trend to propose a repartition among the two first years of the doctorate. Of course, this approach has consequences on the control of the student by the doctoral school secretary. That is also the reason that many doctoral schools are presently validating summer and winter schools, or tutorials organized in the frame of international conferences and workshops. They are usually well adapted to the research plan.

The fourth point deals with the attribution of credits. If the credits correspond to a work, is it mandatory to have a qualitative evaluation of the work in terms of examinations? This point generates frequent discussions and controversy feeling. The students are usually considered in their first professional experience during the preparation of the doctorate; they have usually a salary or an equivalent grant. They are frequently employee of a company in the frame of a joint programme. Thus they are supposed to be adult enough to learn themselves and to conduct their professional life. However, what is the value of a course without examination? If a traditional exam seems not to be the best approach, maybe a short report or a short discussion with the professor could be a good answer. The best example is the tutorial or keynote in an international event. The credit could be delivered by the supervisor on the base of a short report on the content of the attended lectures or seminars.

The next point concerns the validation of the credits in Europe. Thanks to the internationalisation of the research, and also thanks to many research European programmes, many PhD students are preparing a doctorate in the frame of joint international supervising agreement between two institutions of two countries. If the agreement frequently includes the validation of the credits, it is not presently a common rule. A European harmonization in this way could be interesting and time saving for establishing the content of the agreement document.

A last but certainly not the least point is the connexion with life-long learning. It is clear that this aspect is more and more taken into account in the European High Education policy. It is also a subject of the ELLEIEC network. A good approach should be to validate these credits for an engineer working in a research and development service of a company in order to accumulate them. This means a specific organization of the graduate department that could deliver an attestation validating the

credits that could be used for doctorate obtained in the frame of life-long learning validation.

Conclusion and extension of the approach to ELLEIEC network activities

This mentioned reflexion is a starting point for European harmonization of doctorate studies more especially in electrical and information engineering. Of course, the first objective is to warranty the quality of the doctoral studies in such a field, that means a high level of competencies in the dedicated domain. The doctoral studies and the institution delivering the doctorate are now evaluated. In France the new Evaluation Agency is expected to evaluate the doctoral schools and the research units each four years. The criteria of the evaluation include the quality, the organisation of the validation of these complementary courses.

The final goal could be that the EAEEIE association and the members of the ELLEIEC network may suggest to the European commission some recommendations' that could be applied.

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In the frame of the new mission of the doctoral schools in the scheme of the Bologna process, the PhD students must now attend to lectures and complementary formations to be better prepared to the economical world. These formations are taken into account in the diploma under several forms, depending of the country or of the institutions. The resulting questions are the following: the definition of the number of lectures, the equivalence in hours, and the equivalence in credits. How to get the credits? Are these credits validated when a student move in the EU or for life-long learning? Is it mandatory to organize an examination to get a credit? The present paper tries to explain the origin of these different questions and to carry out some answers based on a long experience of functioning.. Ill. 2, bibl. 4 (in English; abstracts in English, Russian and Lithuanian).

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Анализируются принципы изучения мировой экономики с учетом количества кредитов в студиях докторантуры. Дана методика анализа числа кредитов лекций и других способов обучения докторантов. Ил. 2, библи. 4 (на английском языке; рефераты на английском, русском и литовском яз.).

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