

Moving the Universities to the «Third Mission» in Europe, New Impulses and Challenges in Doctoral Education

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Abstract: In a society in which knowledge plays an increasing role, European universities have become essential actors. This has been reflected in demands to redefine their traditional missions and open the door to a «third mission». Links with external partners become a central part of its mission and priority of science policy and higher education. This set of trends is presented in this paper based on the analysis of one of the contemporary university components: the doctoral education. We have been seeing a renewed debate about the doctoral education that trigger changes in terms of their characteristics, functions and values. To this end, we developed a review of the scientific literature produced on the subject and the use of secondary sources regarding the development of scientific and educational systems in Europe. We also use the Portuguese case as an illustrative example of the analysis. We consider the agents operating in higher education within its borders and outside the sector, at global and national levels. What we see analyzing the doctoral education in Europe is the creation of new institutions, openness to more student groups, other teaching methods and more collaboration with industry. The development of doctoral programs is seen today to prepare researchers for careers in academia, but also for other sectors. Changes in the nature of research and knowledge produced by doctoral students, as in their own training paths, are important aspects.

Keywords: doctorate education; knowledge society; education-industry relations; training-employment relations.

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1. An object of analysis, a European problem

Literature and politics describing the relationship between higher education and the outside world conjures up an image that universities were «ivory towers», far from the problems of the societies that created and financed them (Shapin, 2012). However, a number of changes in society have influenced the higher education institutions, reducing their «indifference» and leading to a progression of the complexity of their mission.

The «knowledge age» focuses the universities and the impact that they has on the economy and society has never been considered so prominently on the global agenda.

Scott (1995) believes that higher education institutions are no longer just institutions of knowledge, but are essential tools in the society. Policy makers aim to create the conditions to affirm Europe as a knowledge and innovation economy, justifying its policies with what Neave & van Vught (1991) call the «gods» of technological development, international competition, market forces and of the knowledge society. In the European context, universities are increasingly seen as having a key role in strengthening economic competitiveness, particularly in relation to the United States. At the same time, paradoxically, financial constraints increase uncertainty in universities and emphasize the need for a social and economic impact.

These requirements have resulted in a rethinking of universities in Europe. The Newmanian paradigm of the nineteenth century, and universities designed by von Humboldt, responded to the missions of their days linked to teaching and research, respectively. Now the universities are in a period when they have to listen to and work more closely with external partners in every aspect of their mission. The extent of the relationship with the outside world becomes part of the «third mission» and, in large measure, influences education and research missions. The traditional dedication to education and research extended to direct engagement with industry and other institutions in society. This connection is related to the promotion of closer links between the three sides of the «knowledge triangle» defined by Borrell-Damian (2009): education, research and innovation. In this way, universities are now recognized as producers of «mode 2» of knowledge (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994) and develop dissemination strategies of the knowledge produced.

All this creates a new context for the doctoral education. It recognizes the importance of research and innovation in a competitive and globalized economy, implying the availability of a highly qualified workforce (Auriol, 2007, 2010). It also recognizes the contribution that PhDs can provide for the development of a European Area Research and Higher Education Area. The doctoral training becomes one of the answers to the challenges associated with the three missions, giving Europe an effort to expand (successfully) this level of education.

With its passage from the «periphery» to the «center», the doctoral education began to receive more attention in Europe; and questions relating to purpose, structure and quality became the subject of international debate. New models of programs in Europe – such as professional programs and programs in collaboration with companies – have been subject of reports, from supranational organizations. European University Association (EUA) have played a prominent role in this context.

This paper will attempt to «unwrap» the current context of the university, specifically the doctoral education. We intend to show how changes in the

structure of the university system condition and shape the nature and structure of doctoral programs; simultaneously, the challenges associated with this level of training serve as a lens to understand changes in the functions of universities. So, we decided to look for agendas and agents that set the trends and challenges in doctoral education, exploring both the concepts and particular issues at this level, as a contribution to the broader debate on the role of the university.

We begin by discussing the issue through the characterization and trends in doctoral education in relation to the changes in higher education systems. Although there is not much work relative to doctoral education and its challenges, there is relevant scientific literature to develop an analysis of common trends in the European Union. It is intended to answer questions such as: what are the main lines of European and national policies affecting this level of education? How has the doctoral education changed in Europe? What new forms of doctoral education have emerged and with which functions? When relevant, we explore and illustrate the trends and challenges from the Portuguese case, in order to confront the European convergence with the meaning acquired in a national context.

In the second part of this article, we trace three of the challenges that may arise from the trends presented. 1) What impact have these trends had in terms of recommended knowledge and skills? 2) How far is it possible to combine academic and business values and meanings in socialization and training of researchers? 3) How this context affects the training course for doctoral students?¹ Finally, we present some reflections and other questionings, emphasizing the complexity of factors underlying the doctoral education and deeper questions about its nature.

2. Doctoral education in the political agenda: between higher education policy and science policy, European agendas and national agendas

Higher education is one of the aspects most affected by global trends and pressures (Altbach, 2007). Regarding this, international organizations (as OECD) have important roles, bringing together a range of knowledge and visions for European higher education – and for doctoral education – and outline ways that affect the formulation of policies and processes at the national level. However, if

¹ We disregard challenges that are important to this debate, but whose scope and complexity obscure the clarity we seek for this analysis. For example, those related to the development of joint doctoral degrees. How joint degrees can operate with the contextual and educational differences? What are the experiences of professors and doctoral students in education process that pierces different academic traditions? There is evidence on the differences in terms of skills and competencies acquired by students involved in joint degrees?

these trends are a key variable, they are not the only one. Academic institutions are embedded in national systems and their role should not be ignored. Teichler (2002) warn about the no homogenizing character of the Europeanization processes: common traits are identifiable, but promoted guidelines and models are adapted to national contexts. Policies and national policy instruments also play a key role in carrying out missions aimed at university and its priorities. In other words, the complex interaction between national circumstances, on the one hand, and the broader international trend is central to the contemporary analysis of university and therefore the trends in the doctoral education in Europe. The discussion below focuses on these two levels. Also in the fact that this level of education is in the intersection between higher education policies and science policies.

Higher education systems were forced to adapt to the current context and explore new models². Looking at the programs and objectives of both European and national higher education policy we can identify the emergence of a new paradigm in doctoral education. Initially left out the Bologna Process, the creation of the European Higher Education Area and European Research Area brought the doctoral education to the agenda. In addition, Europe has set ambitious goals and tried to establish itself as a knowledge economy through the training of highly qualified human capital. In this sense, also the widely spoken Europe 2020 Strategy defined the role of innovation as a priority for smart growth through the involvement of skilled work force, with qualifications at the doctorate level (European Commission, 2010).

The EUA has been a partner in this process. An important aspect of its activity is collecting empirical evidence about doctoral education. In 2005, this organization published a first report entitled «European Doctoral Programmes for the Knowledge Society», which carried out an overview of doctoral programs in Europe. The main message is that doctoral education is the bridge linking the European Higher Education Area and European Research Area. That document has led to focusing on thematic discussions as interdisciplinarity, collaboration with industry and other relevant sectors, promotion of internationalization and training in soft skills. In 2010, the commitment was reinforced through the definition of «Principles for Innovation in Doctoral Training».

At the national level doctoral education was also affected by policies aimed at the modernization of the graduate school. In Portugal, in the space of a decade, the strategic priority given to qualification and the investments made have increased the number of graduates in scientific and technological fields. The

² The US higher education system often serves as a model in this adaptation. For an enlarged view of this aspect see e.g., Altach (2007).

«Operational Programme for Human Capital» of the Portuguese Government regarding the Europe 2020 Strategy is a example by enhancing training models that combine science and entrepreneurship in order to create diversified job opportunities for doctorates in fields aligned with national priorities research and innovation.

On the other hand, since the 1980s, a new formulation of knowledge, with the emphasis on «mode 2» of research (Gibbons *et al.*, 1994), and the innovation paradigm had influence on scientific policy. The open innovation idea became important as a circulation network of knowledge and technology, based on the belief that economic growth was increasingly dependent on the ability of companies, universities and government cooperating to develop new products, processes and services. A theoretical contribution to this analysis is Etzkowitz (2008), which highlights the strengths of relationship between the three institutional spheres based on the model «triple helix».

The academia-industry relationships have become a penetrating characteristic both with regard to higher education policies as the science policies, and the bet in these relationships and their growth results, largely, with the encouragement of governments. Assuming that there is a cultural gap between universities and businesses, governments focus on frameworks and financing instruments that facilitate the transfer of knowledge and innovation, emphasizing the role played by doctoral students in that process (Butcher & Jeffrey, 2007). On the other hand, the ambition of building a European area of knowledge, innovation and competitiveness, such as the increasing the number of doctorates in OECD countries, imposed an agenda that stopped ignoring the employability of doctorates in the business sector. The integration of PhDs in companies has been an aim for European policy, and simultaneously for national policy, in order to maximize the development of new products and services that make the productive sector more competitive.

The «fears» of employability of doctorates were formulated in diagnoses of international organizations such as the OECD. For exemple, OECD, in partnership with UNESCO and Eurostat, has set out recommendations regarding to promote and track the employability of doctorates outside the university (see Auriol *et al.*, 2010). Their statements establish criteria for doctoral programs regarding economic and employment reality of the European Union. Also Marie Curie Actions, which include the allocation of research grants in the industry, are important sources of funding to establish cooperation with industry in doctoral education. At the Portuguese level, governments have sought to accelerate institutional responses and, between 2010 and 2013, 133 doctoral grants in companies were funded (FCT, 2013).

3. Changes in supply and demand of doctoral education: institutions, programs, PhD students and doctorates

Several important changes in the higher education sector may be identified during the past few years, but one of the most important features is «massification» (Scott, 1995). In recent decades, higher education mass has become generalized in European countries, and most countries have academic systems with substantial resources and are preparing a growing number of students.

Despite it not being possible (or desirable) to mention the massification of the doctoral education, national and European guidelines and public investments in recent years have also increased the number of doctorates in most European countries; and it is estimated there will be 4800964 doctorates in the EU27 (Pordata, 2016). In Portugal this growth was particularly high since 1998. Between 1998 and 2006, annual growth of doctorates was over 20%, and in 2012 there were 24,992 doctorates (DGEEC, 2012). Even so doctoral students still represent a smaller proportion of the population, compared with the average of European countries (see Figure 1).

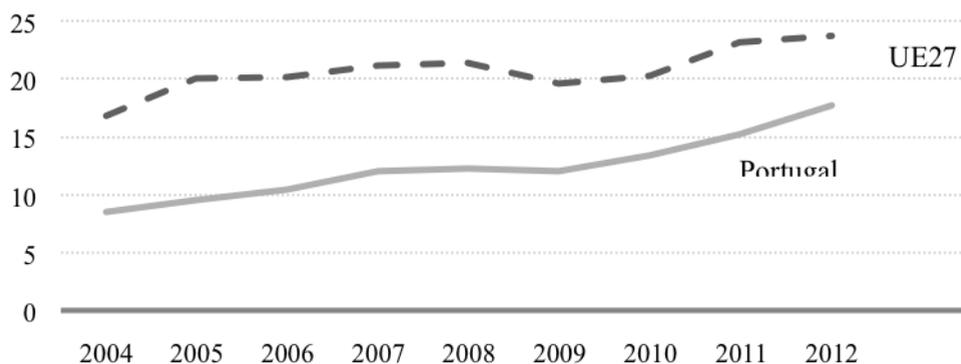


Figure 1. Number of doctorates per 100,000 inhabitants in UE27 and Portugal, between 2004-2012. Data Source: Eurostat | OCDE. Source: Pordata, 2016.

The increase in enrollment in doctoral programs may also be related to the deterioration of professional prospects for graduates. The classic study of Barbagli (1982) about the relationship between school education and employment showed that also university education have been expanded when employment opportunities are smaller, with a pattern that has been labeled «university car park». Thus, it would not be surprising that a similar pattern emerge in doctoral education in a time of economic crisis.

Also as a result of increasing the number of doctoral students, doctoral education expanded and new types of institutions were created to provide a more

diverse education and training for a more varied clientele. In this regard, a report done in 2007 by the EUA, which brought together more than 400 academics from Europe, found that an important trend is the creation of doctoral schools or graduate schools. The same report says that 30% of European higher education institutions have established some type of school of this nature. In the Portuguese case an illustrative example is the Madeira Interactive Technologies Institute (M-ITI) created at the end of 2009 by the University of Madeira and Carnegie Mellon University³. This institute was designed as a framework for research and postgraduate teaching skills. The idea was to enhance the capabilities of knowledge production and innovation of the University, increasing internationalization and interdisciplinarity, and providing a better link with the business community and the regional and local arena. These types of schools seem to try to elude the traditional boundaries between types of research (basic, applied, developmental), sectors (industry, government, university) and disciplines.

The evolution of the characteristics of doctoral students it also can be observed. A pressure to expand enrollment and provide access to broader segments of the population in doctoral education can be observed. First, the growing number of women who obtain doctoral degree in all European countries should be noted. The proportion of women among new doctorates, in 2012, was 47.2% in the EU27 (Pordata, 2016). Although there has been some equity gains, particularly in relation to women's access to students, as other underrepresented groups, there has been little emphasis on the qualitative aspects (Morley, 2007). For example, we know that men and women are positioned unequally while students in different academic areas – some disciplines where women are proliferating are losing *status* (Morley, 2005; Ropers-Huilman & Winters, 2011), with effect on their employability. Also, women are concentrated in areas and institutions with the lowest levels of research funding (Lafferty & Fleming, 2000).

Another aspect to consider in the opening of doctoral education to marginalized public is companies recruiting practices. In the study by Morley & Aynsley (2007) employers in the private sector give priority to students in elite universities, where the students from more privileged classes are, as a way to save time and money and reduce risks. In such way, the socioeconomic privilege can be transferred to the production of qualifications and skills and the social and cultural capital can be converted into economic capital.

Second, the evolution of the age structure of doctorates has been towards diversification. This arises from the high influx of increasingly younger doctorates

³ This partnership was part of a government program with several initiatives between Portuguese universities and US universities. For details about the benefits and challenges in this case see Santos (in press).

(Auriol, 2010). On the other hand, currently the doctoral route can also be started in the later stages of professional development. Third, it is important to say that social sciences increased over the decade 2003-2012. A greater representation of Social Science and Medical and Health Sciences in the new PhD programs is another important aspect (Auriol, 2010). Beside that, doctoral programs in collaboration with companies are specially programs in Engineering, Technology, Nanotechnology, Medical and Life Sciences (Borrell-Damian, 2009).

Another aspect to consider is internationalization. At the institutional level, attracting the best doctoral students, encouraging mobility within the doctoral programs and supporting international programs are key aspects. As a result, doctoral students are more internationalized than students at other levels (Auriol, 2010). This mobility can be, for some institutions and countries, a way of training young researchers in disciplines and research areas where «critical mass», capabilities or infrastructure not exist or are unavailable.

There is no doubt that as we move towards the knowledge society the demand for human resources with doctoral level qualifications will continue, and the expansion of higher education systems in entire world will continue to supply the labour market with doctorates. But in the light of previous characterization, the prospects for training and preparing the doctoral students changes. The growth and diversification of students and institutions adds new functions and responsibilities to doctoral education, as we will see below.

4. Extension of the doctoral education functions: from the requirements of the knowledge economy to the demands of the labour market

Although the university systems, policies and historical traditions are different between European countries, the role of doctoral training has targeted training researchers and advancing the state of art in a particular scientific field (Gomes, 2010). In simple terms, it has become an entry requirement for academic positions (Fulton & Holland, 2001) and, in practice, the only gateway for junior academic. But, if historically graduates became members of «full right» of a subject after receiving the doctoral degree, today's it is not so linear. The terms of an academic career that offered status, adequate income and a substantial degree of security have changed⁴.

At the same time, the current understanding of the mission of the university is going in the sense that the system must be designed not only to promote teaching and research but also a «third mission». The goal is to strengthen its

⁴ Altbach (2007) stresses that these changes in the nature of the academic work force can have significant implications with regard to the attraction of qualified human resources for universities.

role as an institution capable of creating knowledge and, ultimately, to position itself as a prominent institution that knowledge-based societies and economies are demanding. Different missions generate new university concepts such as the «entrepreneurial university», a term used by Burton Clark (1998), which refers to changes in the organization and operation of the university to respond actively and intentionally to societal changes.

Between these two contexts, the doctoral education has diverse – and sometimes contradictory – functions resulting in a fundamental change of its role in the university and the changing role of the university in society. The doctoral education has been redefined to form not only a community of scholars, but also human resources in a globalized economy (Nerad & Heggelund, 2008). PhDs continue to play a key role in the investigation and are the most qualified human resources for the creation, implementation and dissemination of knowledge (Auriol, 2007). But universities have been doing an effort to get better links and employment opportunities for their doctorates, taking into account that vacancies in academia haven't grown in proportion to the number of doctorates (De Grande *et al.*, 2014). As we saw earlier, the underlying idea is that intersectoral mobility and the placement of doctoral students in industrial laboratories strengthen the industry-university cooperation, creating employment opportunities for students (and also increasing the prestige of departments) as Blumenthal, Causino, Campbell & Louis (1996) describes. The currently approach in Europe is that the employment can be defined in terms of characteristics of the PhD. There has been a change in training doctorates aimed precisely at the capacity to apply a diverse set of knowledge and skills transferable to different contexts (De Grande *et al.*, 2014). The goal is to improve the range of skills that doctoral students develop and acquire as a way to also improve their employment prospects both in academia and in the broader labour market (EUA, 2007).

But if the training of doctoral students to a wider labor market and employability in sectors beyond the public sphere have been considered crucial for policy makers and universities, when we analyze the employment of doctorates we see that is focused on higher education, and there are few doctorates carrying on their main activity in enterprises (Eurostat, 2013). Portugal stands out as one of the countries with the highest concentration of doctorates in the higher education sector (83.2%) and a lower prevalence of doctorates in companies. In 2012 there was a slight decrease in employment in the higher education sector, but only 4.2% of doctorates exercising their activity in companies (DGEEC, 2012).

In the case of Portugal, the economic structure consists mainly of small and medium companies, and the importance attached to human capital and innovation in these companies is still tenuous, as the demand for highly qualified resources

is scarce (Gomes, 2010). In general, we know that the ability of a company to absorb scientific knowledge depends on several factors such as the company's knowledge level, its size, activity sector and ability for research and development (Lança, 2007; Fontana, Geuna & Matt, 2006). The study by Wallgren and Dahlgren (2005), based on qualitative data on Swedish PhD students, indicates that the intensity of R&D company involved in collaborations has an impact on how companies are as research environments for doctoral students.

A number of barriers to link doctorates are documented in literature and studies on this aspect often keep the focus on the perspectives of employers of companies. Among the main factors, the private sector employers point out a distance between academia and industry and the existence of a gap between the profiles of doctorates and the skills sought by companies. This is expressed in the studies of MacDonald and Barker (2000), Jackson (2007), Borrell-Damian *et al.* (2010). In the study of Sugars & Pearce (2010), the expectations of industry employers were not confined to technical and scientific skills acquired during the university education, they expected the doctorates to understand and integrate the values and culture of the company and to be able to seek the commercial value of their research. De Grande, De Boyser, Vandeveldel & Van Rossem (2014) employers in Europe do not contest doctorate techniques and expertise, but report gaps in non-academic skills. This view was also expressed in the Portugal context in the study of Baroque *et al.* (2015). Some of the heads of companies surveyed said that universities are formatted to respond to basic research and the work is intended to increase the number of articles without having in mind the development of a product.

In the past, in general, companies have had few opportunities to intervene in the curriculum. Today, companies can become important actors in doctoral programs. Professional programs are examples of that. These programs have been a significant growth over the last 20 years, particularly in Australia and the United Kingdom. They were developed by universities in the face of the growing criticism about the relevance of research to practice, context and content of knowledge in the new economy (Banerjee & Morley, 2013). Professional doctoral supporters claim that training is more attuned to the real needs because it focuses on the practice of the workplace and is flexible enough to respond to the needs of the knowledge economy (Usher, 2002).

Also doctoral programs in collaboration with companies that emerge throughout Europe begin to be seen as an important channel to support innovation in companies and the recruitment of doctorates. In a Borrell-Damian (2009) study, developed from a comparative analysis of doctoral programs with companies in European countries, this is a type of partnership that is particularly valued by intensive R&D companies because it gives them access to highly skilled

labor and advanced research that it is in their long-term strategies. The close contact between the candidate and the company during the doctoral process also appears to improve the chances of employability of the doctoral student; of the 31 companies interviewed, 19 offered employment opportunities after the candidate received the degree. In Portugal Doctoral Programmes in Business Environment were advocated by the government in 2012. These 25% are financed by companies at least and include scholarships for students with a maximum duration of four years. Multidisciplinarity and the mobility of doctoral students are characteristic of the curricular structure of these programs that, in theory, allow doctoral students to get a broad view of the scientific area and how to transfer their scientific talents to the industry.

Ironically, while the innovation agenda could announce a bonanza time for doctoral degrees, there is a strain on the purpose of this level of education. So, considering the utility point of view, the purpose of doctoral education is to train PhDs demanded by society, as expressed by the requirements and needs of the labor market and the knowledge economy. Under pressure to be relevant, programs adapt the curricula and offer new programs to provide the required professionals. Considered from a symbolic point of view, this feature is designed for the creation of knowledge networks and open innovation, combining skills. The doctoral education seems to try to respond to different and sometimes conflicting demands of stakeholders. Also, this portrait adds fuel to an already warm debate about the number of doctorates produced and the skills acquired. All this has consequences in terms of the adjustment and development of new doctoral programs, with possible effects on the trajectories of doctoral students.

5. Enunciating three challenges in doctoral education today

Important expectations fall upon doctoral programs, doctoral students and doctorates. The growing demands for highly qualified personnel in knowledge-based economies create a continuous increase in the number of PhD students and a greater supply of graduates in Europe. The diversity of students in doctoral programs reflects this opening. The absorption capacity of the labour markets seems to be in the match, especially in the business sector. The employability of doctoral students has acted as a catalyst for reformulations in existing programs and for developing new ones. Increased industrial collaboration often originates doctoral professional programs. The listed transformations influence and challenge the doctoral education, and a number of challenges are open for discussion. We emphasize three of these challenges, inextricably intertwined, regarding which it is not our intention to give answers, but ask questions and articulate reflection tracks.

5.1. *Challenge 1. What kind of knowledge and skills that doctoral education promote?*

Over the past decade, the number of doctorates has grown with governments pushing such developments; hopefuling that would result in increasing productivity and innovation. In this way, universities have come to «roll up their sleeves» to be closer to external actors with regard to doctoral programs. But non-academic employers have not «bought» this message, particularly industry. There is a demand for greater integration between training for academic activities and training for skills perceived as necessary in the economy and required by the labour market.

In this sense, it is important to analyze the type of knowledge that is now prioritized and produced as part of doctoral programs which would change the conception of role of knowledge in doctoral programs: from producing disciplinary knowledge to producing relevant knowledge for application contexts and soft skills? If so, what are the consequences of these changes for scientific knowledge in general? What are the consequences for how the doctoral degrees are organized and developed?

For this discussion, primarily, it may be relevant to reflect upon the learning process at this level of education in terms of an orientation towards outputs and outcomes, or more holistic and analytical with an orientation to knowledge and learning processes. As has happened in the curricular reform at other levels of higher education, the concept of «knowledge» in doctoral education seems to be replaced or focused on concepts like «competencies» and «results». Becher, Henkel & Kogan (1994) about UK policies for the post-graduate education, said that the discussion paid less attention to students' needs to expand the disciplinary and scientific knowledge, than the economic relevance of their training. Maybe this is why professional programs often are considered more relevant than the «traditional programs», in the sense they present a training model that «serves» the economy, linked to the knowledge produced at an appropriate context for the application (Lyon 1995).

In this regard, an increasing importance of applied research in doctoral school is highlighted (see Barnacle, 2005). For exemple, it is considered that the professional doctorates are better opportunities to develop the «mode 2» of knowledge. However, Banerjee & Morley (2013) argue that the binary opposition between «mode 1» and «mode 2» can not be clearly defined in practice. They showed that the claim about traditional programs producing original research that contribute to academic knowledge, while professional programs make an original contribution to professional practice, is not clear and when it comes to assessing the research examiners tend to use traditional

criteria (theoretical strength and methodological rigor). In this context, it is worth considering Huff (2000) proposal of «mode 1.5» of knowledge. In this approach the research questions arise from the practice, which are framed using theoretical insights of «mode 1», allowing researchers to clarify structures and relationships in a broader context. Such approach could allow a process of knowledge construction based on theory and practice and create knowledge that goes beyond finding a balance between rigor and relevance, but maximizing both (Schultz & Hatch, 2005).

Discussing the competencies aspect, we can highlight the importance of transferable skills for doctorates career, both inside and outside academia. But Marton, Hounsell & Entwistle (1997) call attention to the fact that learning occurs in a context of particular influences, which takes place within a tradition of knowledge derived from the scientific area. So the different scientific areas develop knowledge and define the specific skills to be developed by doctoral students. Also, Holmes (2013) considers that there is no universally accepted classification of relevant skills and competencies and there are problems with regard to the methodology used to define these lists. In most cases, these lists are based on questionnaires to students, teachers and particularly employers already presenting a list and asking an indication of their relative importance. For this author, such studies can not legitimately identify the skills or attributes required by employers.

Another aspect to consider is that soft skills are learned, especially through experience. Knowledge, as we know, is cumulative and develops from dynamic processes that include both codified knowledge and experience (Lança, 2007). In fact, tacit knowledge plays an important role (Nelson & Nelson, 2002). Some universities and programs have promoted, therefore, experiential learning opportunities with possible consequences in terms of developing scientific and technical capital of students. Doctoral students working in a research laboratory or group can develop and improve skills such as teamwork, negotiation, and conflict management. PhDs who have teaching or guiding functions also developed a series of soft skills. Intersectoral mobility of students, for example through internships in the business environment, facilitate access to knowledge either of encoded character, or tacit nature. Of course we can question whether it will not be an overload of this level of education. But in all cases, as sociologists have shown, doctoral students can form links and an informal network – the «invisible colleges» (Crane, 1972) – important for the acquisition and transmission of scientific knowledge. Also in this regard, Bozeman & Corley (2004) consider, in general, that scientific collaboration often plays a critical role for the junior researcher by enhancing their knowledge, skills and know-how.

Regarding the collaboration with industry in doctoral programs, a series of studies show great differences in the degree of engagement between the industrial scientific areas. There are lower rates of industrial interaction between the areas traditionally associated with basic research, and relationships with industry which are closer to fields oriented toward applied science, as evidenced by the study of Meyer-Krahmer & Schmoch (1998). Here there could reside a critical issue: the «marginalization» of some scientific areas. In terms of doctoral education, doctoral students and those already having PhD in social sciences have limited opportunities to participate in doctoral programs in collaboration with industry (Borrell-Damian, 2009) – despite being an area where the flow of doctoral students have increased, as stressed earlier. In general, humanities and social sciences are relatively less committed to a user type – companies – but interact with a diverse range of groups, including government agencies, non-profit organizations, and the public (Olmos-Penuela *et al.*, 2013). According to Hall & Tandon (2014), these broader partnerships are not only supporting educational and research purposes, but are increasingly relevant when the production of knowledge becomes multidisciplinary, collaborative and oriented to the problem.

On the other hand, a simplistic view may consider that the skills acquired during the training in collaboration with companies would be related only to short-term solutions for immediate business benefits. But empirical studies show that short-term commercial returns are not the only or predominant reason for industry collaboration with academia. In the study by Blumenthal *et al.* (1996), although research relationships with academic institutions can produce specific products or services with immediate commercial value, the industrial partners perceive themselves as dependent on the academic sector more regarding access to ideas and knowledge. Theoretical investigation can thus play a critical role in feeding applied advances (Rosenberg, 1992).

The caveat that seems more pertinent is that the experiences during the doctoral project must be relevant and appropriate to the development of the research project. Thune's (2010) study provides empirical illustrations on this aspect from an exploratory method with 25 PhD students involved in research projects in collaboration with industry. At least for graduates in scientific disciplines where university-industry collaboration is common, extensive experience in collaborative research with supervisor allows to negotiate the development between academic requirements and industrial requirements, making the design suitable for the thesis but also to the needs of industry.

5.2. Challenge 2. How far is it possible to combine academic and industrial values and significance in socialization and training of researchers?

It is important to remember that doctoral education is a place of formation of new scientists. Therefore, it is reasonable to assume that researchers acquire their normative guidelines for academic work, in part, in this level of education. Anderson, Louis & Earle (1994) showed that this period of study involves close contact with the faculty and other researchers and professional standards are socialized in formal and informal contacts. They also found that most guidance variables are positively and significantly related to scientific standards, suggesting that the supervisor has an important role in strengthening the value orientation of the student – but not always in the direction proposed by Mertonian frame.

The development of the doctoral education system around the university-industry relations makes companies actors in educational programs and «natural» locale for research carried out by students. This leads to complaints about the academic values being threatened, and when companies become part of the socialization process, the «substance» of the profession transmitted can go through reformulations. The idea is that scientists work according to a set of norms – described as CUDOS (communalism, universalism, disinterest, originality and scepticism) – and industry presents another set of rules. Thus it is important to understand how the involvement with companies can compromise the doctoral programs with a «new type» of research culture. If the active involvement of the industry changes the education programs by incorporating new values. In other words, will the economic rationale of the industrial sector be compatible with the «ethos of science» (Merton, 1973) in socialization and training of researchers? Doctoral education is becoming too oriented to the values of the business sector?

There has been an extensive public discussion on the issue of relations between the university and industry in general that can be transferred to this problematic. In general, the risks of academia-industry collaboration treated either in theoretical and empirical literature are related with distortions in the selection of research agendas, or with restrictions on reporting results.

The State acted as a «shield» against external interests, and sometimes conflicting interests, in the implementation of the modern university (Amaral & Magalhães, 2003). Efforts were concentrated on protecting the academic freedom to allow an appropriate environment for the production of knowledge. Since then, university research is often identified as basic research related to the generation of new knowledge and forms of open dissemination of this knowledge (Caraça *et al.*, 2000). In turn, the timing and the demands of the market orient companies, since the ultimate goal is economic. Bleiklie (1998, p. 307) argues

that in the corporate sector, the most important «is efficiency linked to the speed and cost at which it produces useful services».

This more instrumental view of research may not be aligned with academic values or lead to changes in the agenda and direction of scientific work: from the most fundamental type to the most applied type. A relevant study to discuss this issue is Gulbrandsen & Smeby (2005). These authors analyzed data for 1,697 university professors (in all fields), and the results show that teachers with industry funding were more likely to describe their research as applied. In the opposite, some studies suggest that students' research activities are little influenced by industrial requirements. Thune (2010) found that interaction with industry does not affect the research of doctoral students. This is, according to the author, also because the companies involved rarely have big bets in collaborative research, especially research involving PhD students. Thus, a challenge for universities and companies willing to start or expand relations is to find research projects carried out by doctoral students that meet the needs and standards of the two sectors (which might be easier to find in basic research).

Another central aspect of tension between values and norms of academia and industry is, in the classic formulation of Merton, «communism» – an element that integrates the scientific *ethos*, characterizing the findings of science as a common heritage. Regardless of industry influence, as Birnholtz (2007) points out, researchers may be inclined to data retention because of increasing competition in science and the desire to be the first to present and publish the results of a study. But the secrecy seems to be the norm for industrial collaboration, and industry funding often comes with restrictions that limit the ways in which academic scientists can communicate their results (Campbell, Louis & Blumenthal, 1998).

According to some authors, students can be particularly affected by industrial policies in this field by the refusal of the possibility of publication of the results of their studies in an adequate timing. Gluck, Blumenthal & Stoto (1987) surveyed more than 700 doctoral students in life science departments of US universities and found that if the doctoral student or his supervisors were involved in collaborations with industry, their behaviour toward publication and dissemination changed. Also Powles (1994) found that a significant number of students agreed that the industry confidentiality requirements were in conflict with the desire to communicate the results of their studies, assuming (more than their supervisors) the restrictions that made the recognition of their work difficult. In the case of collaborative doctoral programs with industry, Borrell-Damian, Brown, Dearing, Font, Hagen, Metcalfe & Smith (2010) found that there can be a tension between the doctoral student's needs to publish and the company protecting the exploitation of its results: leading to delays of up to

2-3 years. Again, in the collaborative doctoral education some universities and companies tend to work on fundamental research areas to mitigate this type of conflict.

There is no unambiguous collaboration with the scientific industry. This naturally requires an understanding of how collaborations between science and industry are developed, and why and how the actors – who have different rules – collaborate in doctoral education. And if it is a «symbiotic logic» (as formulated by Joly & Mangematin, 1996) it is possible to have benefits for science developed in both sectors and also for researcher training. (And, as we saw, it seems that this logic is more easily provide in basic research.) From the strategic network approach (Hagedoorn, Link & Vonortas, 2000), we can consider that the importance of networks resides precisely in the different contributions to the learning processes. The interaction with other actors enhances new perspectives and new knowledge when the parties involved in collaboration exploit their strengths and develop their areas of expertise, but also new avenues of research (eg Lee, 2000).

5.3. *Challenge 3. Where the doctoral student is in this picture?*

The collaborative research, by its nature, is a «high risk mode» and «potential high reward» for all parties: society, science, academics and external stakeholders (Butcher & Jeffrey, 2007). For doctoral students to be at the center of a collaboration between university and industry – as producers and transfer knowledge motors (Dasgupta & David, 1994) – can be challenging.

We already know from previous studies that the supervisors and students need to be cooperative (Becher, 1987), but also that there is a power dynamic between doctoral students and supervisors. Armitage (2007) concludes that the supervisors would rather work in a way that suits their comfort zone in their own paradigms, methodologies and disciplinary specializations. Opening the doctoral programs to the demands of the knowledge society adds external actors to this complex process. In the case of industrial partners, it is a dynamic in which each partner has its own values, culture and interests which can lead to potential conflict situations. The doctoral student may have to integrate different objectives and pressures of academic and non-academic worlds. All this raises questions about how the doctoral student is located in this scenario. Also, we can ask if different foci, expectations and needs by academic and non-academic supervisors may disrupt the educational process.

A key variable here is the ability to choose the research purposes. Doctoral students are faced with what Ziman (1987) calls the «problem of problem choice». In order to determine their research agendas, they are dependent on choices

of material incentives, and estimated social or intellectual satisfaction. Since any collaborative research requires the definition of a common theme, research collaborations between industry and academia can involve significant costs for doctoral students. Doctoral students may postpone the demand for their own purposes. Borrell-Damian (2009) found that in programs in collaboration with companies, in about 60% of cases the theme was selected by negotiation between the university and companies; only 5% of cases were the doctoral candidates bringing and developing their ideas.

On the other hand, there is often an unequal distribution of the capacity to impose their own views, according to the trumps that different actors have (Bozeman & Corley, 2004). If the students are invited to find answers to questions previously set by other actors, some authors also question the autonomy and the students' control over their training paths. Hodge (1995) stresses the pressures for changes in the methodology of the research carried out. Slaughter, Campbell, Holleman & Morgan (2002) found that teachers and companies might be in a position to decide how the findings are treated; if disseminated to the academic community or «delivered» to companies. In addition to this we have to stress the question of relations and institutionalized gender inequalities and difficulties that women face as scientists. Elg and Jonnergård (2003), studying a Swedish university department, found that the organizational characteristics negatively influence women's strategies to get a PhD and subsequent careers, especially in areas dominated by men.

Doctoral students, concerned about the protection or advancement of their career, can also act strategically in response to incentives to improve their positioning (Belkhdja & Landry, 2007) and, as Bourdieu (1976, reproduced by Ortiz 1983, pp. 126-127) say, «maximizing scientific profit». As such, they can be more focused on the types of results that are recognized and rewarded by the system and less free to set their course of investigation and to learn in an independent and academic way. In one extreme, they can keep the level of production of results in accordance with the academic reward system, which tends to enhance scientific contributions, especially through articles and conferences where researchers share knowledge. On the other one, they meet the career demands outside the academy and focus on developing solutions and products. Of course, these are extreme types of a spectrum whose mid-ranges must be distinguished, but it seems that the issue of academic freedom of doctoral students is fundamental in this analysis.

The contrasting images developed by John Krige (1993) can be useful for this discussion: the scientists as an artisan and the scientists as a factory worker. The scientist as an independent artisan controls his work and schedule to create

new knowledge, free to share the acquired knowledge. The scientist as a factory worker is in an environment where the hierarchical relationships replace the «free exchange among equals» (1993, p. 234). Control does not allow freethinking and decision-making about the research agenda, and this could decrease creativity and innovation of these new scientists. Therefore, in a route where the collaborative project merges with the doctoral degree students' creativity can be limited by pre-set limits. And they lose «distinctive value of their products and originality» (Bourdieu 1976, reproduced by Ortiz, 198, p. 131), which is an important symbolic capital acquired in the training path.

However, collaboration with partners cannot be considered only as a cost. Doctoral students can explore synergies with respect to their schedules and cross-fertilization. In the case of students involved in research projects in partnership with companies as part of their formation process, Thune (2010) found that in areas where there are a variety of career opportunities, doctoral students have more positive experiences than in research fields with fewer opportunities. Students of chemical engineering and ICT interact with the industry during the doctoral program which gives them skills, access to vital data and research material for future research careers within and outside the university.

5.4. *What is the future of doctoral education? Final remarks*

Doctoral programs are substantively related to the trajectories of society and the knowledge economy, the political and institutional trajectories of universities, the learning of doctoral students and their possibility of career.

The state contributes decisively to the construction, demand and supply of this level of education. The changes do not depend only on national policies, but European policies also play an important role. The doctoral education affects the activities of the European Higher Education Area and European Research Area, and these Areas affect national policies. Both levels have been contributing to the establishment of a favourable framework for the formation of PhDs, but also to encourage their hiring by companies.

The average number of doctorates has increased exponentially, and this growth pattern has brought changes. It has allowed the program to expand, to meet the needs of society and the knowledge economy. Institutions multiply organizational strategies (such as creating doctoral programs), technical strategies (such as the diversification of educational models, for example the importance of internships) or symbolic strategies (as the use of a rhetoric about the enlargement of the traditional labour market). These steps are meritorious but, at the same time, have created uncertainty concerning the doctoral education functions.

The doctoral education has become an investment in the future of society – not only for the doctorate. Now it has value beyond academic knowledge production and the formation of new academic staff. A larger attention has been dedicated to producing innovation and technology transfer to strengthen the applicability of scientific research produced in the context of doctoral programs. European universities are increasingly embracing an open innovation model whose ambition is to make a more productive use of knowledge, technology and resources, increasingly involving the industry in doctoral education. If this involvement generally is accepted as positive, it also has complex implications for the structure and organization of this formative level in their forms of financing, what is taught and learned, and again, in the understanding of the functions of doctoral educational. The question about whether this can be done while preserving the core values of science and not limiting the scientific and technical capital of the new doctorate are relevant.

Concluding, the «bricks» and «mortar» of the doctoral school are moving slowly. Some of these changes have been gradual, other transformative. Most of the challenges are «old» in the university, but in a new «apparel». Anyway, it is important to develop empirical studies on these trends and answer a series of questions that are still in the air. How are higher education institutions or doctoral schools «airing» the socialization of new researchers and what to learn? How are training and socialization tasks of this level being overshadowed by the idea of formation of technical professionals? Can focus on fundamental research in doctoral education allow the strengthening of partnerships with external actors and promote innovation in companies? What are the dangers of doctoral programs being evaluated based on employability of doctoral students? How can the areas that have grown in terms of number of doctorates drive the social and economic development? What are the real conflicts and contradictions experienced by students in this picture, and how they can be managed?

6. References

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