The 'Industrialization' of Doctoral Training?
A Study of the Experiences of Doctoral Students and Supervisors in the French Life Sciences

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There is growing concern that academic work is becoming more and more 'industrialized' in various disciplinary and institutional settings - that the work practices, professional identities and values of academia are becoming similar to those of the private sector. While most studies discuss this topic in the context of senior scientists, this paper considers doctoral training in the life-sciences in France, and, more specifically, analyzes changes in the doctoral experiences over the last four decades. Interviews with doctoral students and supervisors allow for tracking shifts in how French life-scientists define the values of doctoral training in their daily activities. Our results challenge the idea of some univocal and radical 'industrialization' of doctoral training, instead showing a strong interplay between continuity and change. The core values of doctoral training remain, but the rationales for promoting different aspects of doctoral studies have changed, and increasingly depend on how French life-scientists position themselves in the context of contemporary imperatives of institutional relevance and scientific competition.

Keywords: doctoral studies, industrialization of academic work, generational changes

Introduction

The changing missions, professional identities and work practices of academics have been an important subject of inquiry over recent decades, and one that has been explored across all scientific fields and in various countries (Hackett, 1990; Slaughter & Leslie, 1997; Kleinman, 2001; Musselin, 2007). Some changes have been referred to as the 'industrialization' of academic work - "*the infusion of corporate, industrial, or 'for-profit' practices into the domain of knowledge* *production*" (Kleinman & Vallas, 2001: 465). Previous work has identified some possible main driving forces: university-industry relationships, the commercialization of academic knowledge and the rise of 'academic capitalism' (Slaughter & Leslie, 1997; Kleinman, 1998); the growing requirements for relevance, accountability and performance in academic scientific work (Morris, 2006; Whitley, 2007); and the changing balance of authority in the relationships between the state, scientific communities and research organizations

(Gläser, Lange et al., 2010; Whitley et al., 2010). However, knowledge about how these broad changes impact scientists' ideals, attitudes and actions is limited as yet, and we still need to investigate to what extent research becomes 'industrialized' in various national, institutional and disciplinary settings.

The aim of this paper is to deal with this question from the specific angle of the changing experiences of doctoral training among French life-scientists. More specifically, our work focuses on continuities and changes in the way doctoral students and their supervisors evaluate doctoral training in their daily activities. In doing so, it addresses several gaps in the literature. First, prior research examining issues of changing ideals and practice in academia has mostly dealt with senior researchers (Hakala, 2009b, c) and paid little attention to these matters in the lives of doctoral students. More specifically, in the life-sciences context, scholars have questioned whether biotechnologies have revolutionized senior researchers' scientific ethos and professional identity (Henkel, 2005; Kleinman, 1998; Morris, 2002; Owen-Smith & Powell, 2002), while in contrast, studies on doctoral students have so far focused on their employment difficulties (Freeman et al., 2001; Robin and Cahuzac, 2003; Stephan, 2005). As doctoral training primarily socializes PhD students into academia (Gardner, 2007), one should also investigate how it may reflect the 'industrialization' of academic work. Second, the work identity and professional commitments of doctoral students have usually been captured via cross-sectional approaches: these are not well suited to analysing changes (Hakala, 2009b, c), and a research design built on temporal comparison may bring new insights into these topics. Finally, most of the literature concerns Anglo-Saxon

country settings, and does not account for the great variety of national settings that might affect the content of doctoral training, their professional expectations, etc. in other environments. Thus a study of doctoral training in the French context can add to a more complex and detailed picture of whether, and how, such training might be becoming 'industrialized'.

We carried out 55 interviews with French doctoral students in the life-sciences and their supervisors to track changes in the evaluation of doctoral training - i.e., what it means for a doctoral student to be effective and successful and for a supervisor to manage what they consider to be 'good' doctoral research. We interviewed supervisors aged from app. 35 to 65 in order to identify changes that may have taken place in this area since the 1970s, when the most senior of these scientists were doctoral students themselves. Drawing on the evaluation frameworks defined by Boltanski and Thévenot (2006), we make two points that challenge the idea of a radical change towards the 'industrialization' of doctoral training, and show, rather, that there has been an interplay between continuity and changes in the evaluation of this training. First, all the accounts of doctoral training gained from our interviews can be interpreted within two evaluation frameworks (Boltanski & Thévenot, 2006) - the 'industrial', concerned with the promotion of efficiency and professionalism, and the 'inspired', emphasizing inspiration, risk-taking and passion – implying that these operate as (sometimes conflicting) imperatives, each of which make demands on both the underlying rationales and the day-to-day practices of doctoral studies. Second, we find that some supervisors have always managed to avoid this balancing act, and evaluate doctoral training via one or other of these frameworks – whether 'industrial'

or 'inspired'. But French doctoral studies in the life-sciences are not immutable: rather, the rationales underlying each of these polarized positions have changed over time. We start by examining the notion of the 'industrialization' of academic work, what has driven it in the life-sciences, and its possible consequences, both for senior researchers and for doctoral training. Our method section then gives a brief presentation of French doctoral studies in the life-sciences and of the interviews we carried out, after which we explain how we came to interpret accounts of doctoral experiences through Boltanski and Thévenot's evaluation framework (Boltanski & Thévenot, 2006). Finally we present and discuss our results on the continuities and changes in doctoral training.

The 'Industrialization' of Academic Work: Its Possible Causes and Consequences

A long-term concern

Concerns about the industrialization of academic work have been expressed for almost 40 years (Ravetz, 1971) and have been revived recently, with the 1980s being seen as a turning point in the process (Hackett, 1990; Kleinman & Vallas, 2001; Ziman, 2003; Hessels, 2008). Kleinman and Vallas (2001: 451) define 'industrialization' as the infiltration of academia by the codes and practices of the corporate world, and (like Hackett, 1990) explain it as the result of isomorphic pressures created by the growing interactions between the worlds of academia and business. They distinguish five developments at the institutional level:

1) Universities and research institutions viewing research organizations as 'profit centres' which they need to bring in high returns, given the context of static academic funding (Ziman, 1994). This leads scientists to seek project-based funding and eventually to cross-subsidize high-risk research with activities that yield positive income.

2) Universities and research institutions facing growing pressures for accountability, relevance, and performance exerted by the state, by industry and by society as a whole (Whitley et al., 2010). This leads scientists to pay increasing attention to the measurable aspects of their activity, and particularly to bibliometric indicators, to standardize and rationalize their work.

3) Universities becoming highly concerned with intellectual property rights, thus putting pressure on academics to seek commercial success (Owen-Smith & Powell, 2002; Owen-Smith, 2003).

4) Universities cutting their expenditure by hiring a 'flexible' scientific workforce. This increases the share of doctorate holders on adjunct or on part-time positions, who no longer gain either job security or the prestige usually attached to scientific work (Stephan, 2005).

5) Finally, universities increasingly linking institutional recognition with market-related activities – such as patenting activities (Slaughter 6 Leslie, 1997).

Consequences for senior life-scientists: a fragmented picture

These drivers of the industrialization of academic science are pervasive, and few fields or institutions have been immune from their effects. In particular, research work has become more and more organized within time-limited projects conducted under contractual arrangements with public and private stakeholders rather than for the 'pursuit of truth' itself, thus sharing many similarities with industrial-style project-based management (Hackett, 1990). Such rationalization is even greater in those scientific areas that use large-scale

and shared instrumentation, such as high-energy physics or genomics.

While there is considerable discussion about if and how this trend affects the practices, values and professional commitments of senior academics in various settings, and if and how their activity becomes industrialized, authors studying the life-sciences seem to agree about the non-determinist character of the process. Comparing the fields of biotechnology and history in the Netherlands and in the UK, Leisyte (2007) shows that senior academics face institutional pressures for productivity and profitability, and that their answers range from *"passive and symbolic compliance"* to *"pro-active manipulation"*. She also argues that factors such as their past scientific achievements will influence the extent to which they change their practices. Other authors agree that changes in practices are not necessarily followed by consequent changes in the values held by the scientists themselves. Morris (2002) notes that UK biologists modify their activities to answer such institutional pressures, but that scientists of all ages and at hierarchical levels still hold to the value statements belonging to what is considered as the traditional academic culture. Again in the UK context, Henkel (2005) concludes that *"major changes in the funding of research and the contexts in which it is carried out have not created major disturbances in academic values or academic identities. At both macro and micro levels the value of academic autonomy remains strong."* (p. 173), but points out that this autonomy must often now be achieved by negotiating with multiple stakeholders and across multiple boundaries. A study of the life-sciences shows that such changes are neither uniform nor mechanical (Louvel, 2010). Research groups experiment in what are becoming more competitive academic labor markets (Robin, 2003; Sabatier, 2010), which have seen a rise of contractual funding (Thèves et al., 2007), and also radically greater use of bibliometric indicators (CNER, 2003). Louvel (2010) shows how these changes are reflected in how some senior scientists exert their authority and ground their legitimacy. In the 1960s and 1970s, they developed an overarching view about their scientific specialty and exerted wide-ranging powers in academia - and were commonly referred to as "*patrons*" (Clark, 1973) or as "*mandarins*". This term from the 19th century originally designated members of an intellectual elite. It became then common in the old French faculties (and in other countries such as Italy), where university management did not counterbalance the powers of the professors (Musselin, 2004). In the 1980s and 1990s, changing conditions for research led to their replacement by highly specialized scientific 'project managers', who collaborated and/or competed with others of their ilk to keep pace with the rapid advance of knowledge and to meet changing institutional requirements.

Finally, studies on the commercialization of life-sciences research have undermined the idea of an overall transformation. Owen-Smith and Powell (2002) show that the changing landscape has transformed the criteria for success and the allocation of rewards in the American life-sciences, and has led to the emergence of "*a new model of the scientist-entrepreneur*". But they also identify scientists whose motivations are a hybrid between 'old school' and 'new school', and other studies into the life-sciences confirm that the commercialization of knowledge is *"still a passion of the few"* in the UK (Morris % Rip, 2006), in contrast to the situation in other disciplines such as chemistry and engineering.

Are doctoral studies in the life-sciences becoming industrialized?

Scholars have already noticed that very few studies document the phenomenon of the industrialization of doctoral training, and we would add that authors tend to focus on the most stable aspects of doctoral training (Hakala, 2009b; Slaughter et al., 2002) such as learning how to master uncertainty (Delamont & Atkinson, 2001), or acquiring a disciplinary identity (Campbell, 2003; Li and Seale, 2008), thus picturing doctoral training as a rather immutable world, with each scientist passing through the same research socialization 'conversion' experience. At the same time (as might be expected) there is no shortage of studies on the political pressures to rationalize higher education and research and on their consequences on doctoral studies across Europe and North America (Delamont and Atkinson, 1997; Kehm, 2006). Kehm notices that doctoral training is "*no longer regarded exclusively as an academic affair. [...] It has moved into the focus of institutional and national policies*" (p.74), and identifies four main changes: the definition of well-structured doctoral programs; the internationalization of doctoral training; its governmental and institutional steering with an emphasis on its relevance for various stakeholders; and a trend towards interdisciplinary approaches. Such broad changes can give rise to one of the two following *"general scenarios"* (Hakala, 2009b: 176-177): science becomes 'just a job', the notion of an academic 'calling' is threatened and students become increasingly less interested in the impassioned 'search for truth'; or the rationalization and institutionalization of research training help redefine its attractiveness.

Empirical examinations of the changes that have taken place over recent decades are obviously needed to find out more in detail how they have affected academic study in the life-sciences. Changes may be especially notable for those doctoral students who work on industry-related projects: studies have indeed shown that academia's links with the biotech industry have impacted both the requirements for and the outcomes of graduate training (Gluck et al., 1987; Jong, 2008). Doctoral students in this field also face conflicting values, given that their future academic careers are likely to encompass both industrial and academic components (Owen Smith and Powell, 2002) - in that respect doctoral training in biotech now shares many similarities with that in the engineering sciences (Enders, 2005; Lam, 2007; Salminen-Karlsson & Wallgren, 2008; Slaughter et al., 2002).

However, are the changes in the doctoral students' experiences so dramatic for those without links with industrial partners? Existing studies provide few answers here, although there are, of course, some notable exceptions: in particular, Delamont et al. (1998) notice that the same contrasting language is used to describe the past and present of doctoral training in biochemistry as in the fields of physical geography and artificial intelligence. Supervisors describe the past (i.e., when they were doctoral students themselves) in terms of implicit and personal working relationships, and the present in terms of more explicitly structured and institutionally organized arrangements. Although one may see this as a consequence of the pressure to rationalize both research projects and higher education curricula, the shift is clearly identified as being less dramatic in the life-sciences than in other disciplines, as life-scientists' doctoral work typically fits into a collective project managed by a supervisor, and follows standard requirements to produce comparable outputs – a situation which has been described as the *"positional mode of socialization"* (Delamont et al., 2000). In contrast, doctoral students in the social

sciences experience a *"personal mode of socialization"* (Delamont et al., 2000): their supervisor considers them as autonomous scholars and sees its own role as an advisor or as a senior colleague rather than as a manager or a boss. But the changes that have occurred within the 'positional' context have not been examined carefully, so there is yet little empirical evidence about the possible industrialization of doctoral training in the life-sciences.

To sum up, studies on senior life-scientists have painted a picture of contrasts of the industrialization of academic work, practices and values, but little is known about the possible industrialization of doctoral training in the life-sciences, except for the experience of those doctoral students who work closely in relation with industry. This study therefore aims to consider changes in the experiences of doctoral students and their supervisors empirically. It focuses on doctoral students in the life-sciences, whose studies are at distance from the commercialization of research results. As they are probably representative of the broad stream of doctoral training - their practices still uphold academic, disciplinary-based values (Morris, 2002; Henkel, 2005) and their career paths are still likely to be strongly oriented toward public research (Fox & Stephan, 2001) - they offer an interesting research setting to analyse continuities and changes.

The Field and Method of Study

Doctoral training for French life-scientists
Since the 1990s in France – as in other countries – doctoral studies have experienced a trend toward more formalized and explicit training, which has most notably resulted in the creation of doctoral schools in 1992. These schools decide which doctoral students will get State grants, and provide a limited number of courses to all

doctoral students (minimum 40 hours per year) that are not necessarily related to their doctoral dissertation, but which focus on such professional skills as preparing for job interviews, etc.. Although attendance is mandatory, students are not marked on these elements, but only evaluated via the examination and public defence of their doctoral thesis. So the direct relationships with their supervisors, and the 'master-apprentice' model of supervision (Kehm, 2006) still predominate in French doctoral training.

Another interesting feature - which differentiates the life-sciences from the social sciences and the humanities - is that most doctoral students in the life-sciences are regarded both as 'students' (who pay tuition fees) and as 'early career researchers', who receive salaries and employee benefits (Gaughan & Robin, 2004): about 77% of them have paid research positions. Research training is traditionally understood as a State responsibility, so funding is mostly targeted to individual students rather than to universities or established researchers (Gaughan and Robin, 2004). Thus 66% of doctoral students in the life-sciences are funded by public institutions (via State grants, scholarships from research councils or regional governments, etc.) whereas only 11% receive funding from industry - some also earn additional income by teaching[1]. Life-scientists are expected to work on their dissertation full-time, and are usually not involved in project-work. Their position as employees explains why 74% of them complete their PhD within three years (a much higher rate than the 40% achieved in social sciences), so concerns about doctoral students spending too much time on contractual research to the detriment of their dissertations seem far less widespread in France than in other countries (Hakala, 2009c). Finally, French doctoral students in the natural sciences still have high

levels of expectation regarding supervision from their supervisor, which apparently differentiates them from their peers in some other countries (Delamont & Atkinson, 1997; Hakala, 2009c), where the scientific workforce is mostly composed of doctoral and postdoctoral researchers, supervisors are overloaded with teaching and administrative tasks, so doctoral students have to seek help from their research group, and in particular from the postdoctoral researchers who work with them on a day-to-day basis. By contrast, the ratio of permanent researchers to doctoral students and to post-doctoral researchers is still high in France (10:1 and 17:1 respectively), so that permanent researchers carry out the daily supervision of doctoral training in the life-sciences[2].

To sum up, "*the doctorate as craft education in small teams (or individual supervision)*" (Probst & Lepori, 2008: 479) still prevails over the "*mass doctorate with larger numbers of students enrolled in graduate schools*" in the training of French life-scientists. An empirical investigation will help us analyze how, in this broad context, the experiences of doctoral studies have evolved over recent decades and if such studies have been 'industrialized' in the life-sciences.

Data collection and analyses
Our research design is based on 55 semi-structured interviews with 20 doctoral students and 35 supervisors from 15 research groups affiliated to two research-oriented universities and to two of the largest French public research institutions (the National Centre for Scientific Research – CNRS – and the National Research Institute for Health and Medical Research – Inserm). Interview data were collected and recorded (and then transcribed) between 2003 and 2006 for two studies on the academic life-sciences in France: one focused on the organization of French research groups (Louvel, 2010), the other focused on academic careers (Dany, Louvel et al., 2011). The research groups under scrutiny were not *"insulated"* from a commercial environment (Kleinman, 1998: 194), but nor were they actively engaged in industrial relations. Their substantial funding and mainstream research interests are in the public sector, but they get an increasing part of their funding from specific research contracts with various public stakeholders (Morris & Rip, 2006). All doctoral students have paid research positions, as a result of their universities' policies of only admitting funded students to doctoral training.

All 20 doctoral student interviews were conducted during the first study (on the organization of French research groups) and the 35 supervisors' interviews were selected from among the interviews carried out for both studies. As these studies did not primarily focus on doctoral training, we chose those interviews in which supervisors gave in-depth descriptions and analysis of their experiences, both in that role and as former doctoral students. We ended up with a relatively well balanced sample between career stages (20 assistant professors or junior scientists – 'chargés de recherche' – and 15 full professors or senior scientists – 'directeurs de recherche'), ages (7 interviewees under 40 years old, 20 between 40 and 50, and 8 over 50), and date of PhD defence (6 interviewees defended their PhD in the 2000s, 12 in the 1990s, 7 in the 1980s, and 10 in the late 1960s and 1970s). The interviewees' academic careers followed conventional French progress (doctoral training, short-term teaching or research positions in the academic sector, permanent academic positions).

We analyzed how informants make their experiences of doctoral training meaningful to identify the associated values. Many studies focus on the 'economic' value of

doctoral studies on the labour market: but our interviewees seemed to find other ways to judge the 'worth' of the doctoral game and defined other criteria for success. Several stated that the 'target' of entering academia was both too far away and too uncertain to give sense to their doctoral training, so we directed our analysis toward the broad principles of the evaluation of doctoral training that give sense to interviewees' daily experiences in order to address the following questions: What makes doctoral training worthwhile? What are the students' and supervisors' objectives, motivations and success criteria? Have their subjective evaluations changed since the 1960s, when the most senior scientists we interviewed were themselves doctoral students? If so, do these changes reflect the intrusion of industrial-style values, and thus support the notion of the industrialization of the doctoral training of French life-scientists?

We conducted our analysis in three stages. We first selected all sentences or paragraphs related to doctoral training (approximately 40 pages of verbatim). At first sight this very rich information seemed to be related to quite disconnected themes: e.g. description of bench work, complaints about work load, comparison between the difficulty and interest of dissertation subjects, reflections on the vocation of doctoral students, analyses of work division between students and supervisors, etc. Nor was there any consensual definition about what constituted 'good' doctoral training - interviewees took divergent positions as to how to define its quality, what made it interesting and valuable, and on how to succeed in it: "*it is hard physical work; one needs to be in good condition*"; "*I had a taste for pure knowledge, I couldn't step into engineers' shoes*"; "*this dissertation project isn't real research. It is more engineering work*"; "*intellectual stimulation was all that counted for me*"; "*some supervisors train researchers, other train knowledge workers*"; "*it's not a job where you can go home at 5 p.m.*" etc. We noticed that the 'positional' mode of socialization of life-scientists (Delamont et al., 2000) encompasses a variety of doctoral experiences. Interviewee's descriptions and evaluations of doctoral training referred – either implicitly or explicitly – to some professional (or other) models (the intellectual, the engineer, the manual worker, the artist, the monk, etc.), and references to such models could evolve during the course of an interview, as did the facet(s) of doctoral training being described.

In the second analysis stage, we searched for a systematic sense of the frames of reference within which the informants valued doctoral training. Were such frames conflicting or compatible? Were they shared by all interviewees? Did they evolve over time? Because of the diversity and the changes noted above in the sources of motivation and criteria for success, we drew on Boltanski and Thévenot's (2006) theoretical framework, rather than on the two modes of socialization described by Delamont et al. (2000). Boltanski and Thévenot posit that evaluation processes do not convey intrinsic properties of people or objects, but are ongoing and are closely linked to context (Hennion, 2004). Valuations of specific situations must also be associated with some general framework: individuals arguing a certain viewpoint do not appeal solely to their personal conviction or feelings, but seek to anchor their position, their sense of the comparative worth of what they are judging, in arguments that others can understand and believe in, and which are somehow related to a general conception of social bounds, which Boltanski and Thévenot (2006: 14) describe as a "*form of generality*" or "*a form of worth that can be used to justify an action*". Such 'forms of generality' are particularly salient in trials or daily disputes, but such

situations rarely "*lead to a systematic demonstration that would make it possible to uncover the principles of worth on which the evaluation is based*". Thus these authors select political philosophers (St. Augustine, Bossuet, Hobbes, Rousseau, Adam Smith, Saint-Simon) whose purpose is to elucidate *"the grammar of political bounds"* or the "*principles of agreement*" (Boltanski & Thévenot, 2006: 65), to help systematize the content of the most common 'forms of generality': "*Each of these philosophies proposes a different principle of order, allowing us to spell out in what the worth of the worthy consists and how a justifiable order among persons is established*" (Boltanski & Thevénot, 2006: 14). From these philosophies Boltanski and Thévenot draw six coherent frameworks within which actions and states of being can be evaluated and justified, and then confront these theoretical constructions with empirical material (notably, handbooks designed to guide business behaviours) to show how these methods of assessing 'worth' play out in ordinary situations. This leads then to define six *"common worlds"* - which they designate 'inspired', 'domestic', 'fame', 'civic', 'market', and 'industrial' - within which social actors' agreements or disputes about questions of worth can be interpreted, and to describe their structure via thirteen categories which define subjects, objects, qualifiers, and relations among humans and things (Boltanski & Thevénot, 2006: 140-144)[3].

In the last stage of our analysis, we started to explore whether our informants' responses could be associated with any of these six common worlds, and found that almost all interview material aligned with either the 'industrial' or the 'inspired' worlds. Some responses (such as the importance of doctoral students building their reputations) could be interpreted as referring to the common world of 'fame', but these were few in number, and the common world of 'fame' did not appear to be a substantial and widely shared framework in this context, and we decided to exclude it from our analysis. Concerned to achieve conceptual clarity we structured the 'industrial' and 'inspired' common worlds into three dimensions[4]:

- The first focused on the definitions of worth which informants used to judge the quality of doctoral training, students and supervisors.
- Secondly, we analyzed the metrics used to classify and order people and things, and to establish or to contest definitions of worth.
- Finally, we looked at the cost of increasing the worth of what doctoral students' were doing.

We found that almost all our informants' responses about doctoral training involved elements from both the 'industrial' and 'inspired' common worlds, despite the intrinsic contradictions between these evaluation frameworks (see below, 3.1). But in a limited number (of both past and present situations), there was a definite sense that one of these worlds held primacy over the other, and identified the different rationales for these situations (see 3.2).

The Eternal Double Face of Doctoral Training

There are strong similarities in how the most senior scientists and doctoral students talk about their doctoral training – and (in most cases) their experiences can simultaneously be characterized as both 'industrial' and 'inspired'.

Doctoral training as an 'industrial style' enterprise

The 'industrial' common world is a very effective interpretative lens through which to view both current and former doctoral training situations in the life-sciences, going back to the late 1960s. One can see here the consequence of the 'positional mode' of socialization which these students have been experiencing for decades (Delamont et al., 2000).

Performance and professionalism as 'industrial' objectives. "*The ordering of the industrial world is based on the **efficiency** of beings, their **performance**, their **productivity**, and their **capacity** to ensure **normal operations** and to respond usefully to **needs**"* (Boltanski & Thévenot 2006: 204, emphasis in the original). Informants' repeated use of such phrases as *"working out experiments",* getting *"high return"* on time and money, being *"good at the bench",* learning to *"manage research",* shows the extent to which industrial notions of worth, based on performance and professionalism, represent an important evaluation framework for doctoral training. Doctoral students progressively acquire professional qualifications to become fully-accomplished professionals, moving gradually up the scale from 'technician' to 'manager'. First, they 'learn the ropes' of experimental work, a process which often entails their first encounter with experimental failure, doubts and frustration (Delamont & Atkinson, 2001). They then take on managerial responsibilities such as managing equipment, and their supervisors also involve them more closely in research project design. Finally, they take on the supervision of undergraduate students, which seems to be a highly symbolic rite of passage for doctoral students.

The realm of metrics. The industrial common world is the realm of metrics, where degrees of worth are particularly measurable. Interviewees (both students and supervisors) measure the 'worth' of doctoral students on three scales, which enable different levels of comparison. First, evaluating bench work remains highly contextualized: informants tended only to compare doctoral students that belonged to the same group (or even those working on the same project) or those who had been (or were being) supervised by the same researcher. They emphasized the highly specialized knowledge and the tacit skills required for bench work in the life sciences: "*I don't know how good they are, I am not working with them at the bench. It is only when working with people at the bench that you can really know what they are worth.*" (Supervisor, 35 years old, PhD defence in 2000.) Second, the acquisition of management skills during doctoral training (and thus, the pace of transition from technician to manager) can be compared across sub-disciplines or research groups. Indeed, informants take the strict and standardized timetable of doctoral training as a stable reference point: a third year doctoral student who has neither supervised an undergraduate student nor published a single conference or journal paper has definitely fallen behind the expected schedule. Those who are ahead of schedule may defend their PhD earlier. Third, an individual's publication record appears as the uppermost and unquestionable metric of 'industrial' worth for doctoral work, and informants use it as a decontextualized measure that allows for comparison across scientific fields. Doctoral students, supervisors and members of recruitment committees adhere to a norm based around two papers published in leading journals: "*A PhD without a single journal article is out of the question. A good target for me would be to publish two papers during my PhD*" (2nd year doctoral student); "*We take into account the candidates' age in assessing their*

CVs. Someone of 29 who has published 2 or 3 papers during his PhD plus one paper during his postdoc is OK." (Supervisor, recruitment committee member, 45 years old, PhD defence in 1990.)

If at first you don't succeed, try, try again. Finally, progress toward the 'industrial' state of worth "*is associated with the operation of investment (in the classical sense of the term) that weighs the 'price of **effort'**, 'heavy in time and in money', and the **'middle-term profitability'** that they ensure.*" (Boltanski & Thévenot, 2006: 208, emphasis in the original.) Informants associate successful doctoral training with a readiness to invest valuable resources – their time and effort - in the enterprise. Above all *"hard work", "discipline"* and *"asceticism"* are expected from doctoral students: "*Becoming a scientist is really hard in biology. It may be quite different in your case; it seems quite nice, walking around and chatting with people. For us it is extremely boring. We are here, all day long, during weeks and months, doing exactly the same thing. You have to be extremely tenacious, and not afraid of repeating things 20 times.*" (Supervisor, 40 years old, PhD defence in 1993.) Supervisors attach great importance to their students' capacity to cope with the boredom and 'sameness' of daily work.

In short, informants describe doctoral training as being ruled by standards and norms that we have related to the 'industrial' common world. But they also express the view that doctoral training should be an opportunity to wander off the 'beaten paths' of science, and that students should acquire the traditional academic ethos of the impassioned researcher developing a 'pure' interest in science 'for its own sake'. In positioning creativity, inspiration and risk-taking as central and enduring values of doctoral research, such responses cannot be seen as aligning with the industrial common world of predictability, conformity

to established rules, and quantitative performance measures. Instead, we must look to the inspired common world to analyze how our informants saw (and evaluated) doctoral training in terms of an intellectual adventure.

… but also as an intellectual adventure

The 'inspired' common world relies mostly on subjective experiences: by definition, it is difficult to find any objective measures of the 'inspired' state of worth (Boltanski and Thevénot, 2006: 159), so it defines itself by rejecting and discrediting other common worlds.

Vocation and imagination as absolute necessities. "*In an inspired world, the state of worthiness has the attributes of **inspiration** itself.*" (Boltanski & Thévenot, 2006: 159, emphasis in the original). The widespread belief among informants was that doctoral study requires embracing science as a vocation (Weber, 1946), where the ultimate goal was the expansion of knowledge rather than a return on investment, or financial rewards, or celebrity, or career progression. This suggests that the informants seek what Boltanski and Thévenot (2006) describe as the 'inspired' state of worth. These responses also suggest that good doctoral students will experience intellectual excitement: "*I remember very well that when I was a young researcher, when I really got an idea – it does not happen that often – then I really got thrilled, feeling that I was just about to find something, to understand something with which I had to struggle during months or even years. And when suddenly a light bulb went off there was this real intellectual excitement.*" (Supervisor, 60 years old, PhD defence in 1963.) So doctoral students must show intuition, imagination and a constant scepticism toward scientific trends, established methods (referred to by interviewees as 'kitchen recipes') and authoritative opinions. Open-mindedness

is not considered as a waste of time (as it is in the industrial common world) but as a driver of fate, and of unexpected discoveries (Merton and Barber, 2004): "*There is a scientist who has really been a model for me when I was a young researcher; I would describe him as a 'Professor Calculus.' This guy always had ideas and brilliant intuitions …. He was a true genius who anticipated what the group would do 15 years later.*" (Supervisor, 40 years old, PhD defence in 1993.) Intuitions and creativity are seen as differentiating the world of science from that of engineering: "*John has been doing the same things for almost two years now. There is nothing creative in this job; he's just repeating the same experiment. For me he's not doing research. It could be done by an engineer.*" (3rd year doctoral student.)

A firm conviction rather than objective metrics. In the 'inspired' world, "*What is worthy is what cannot be controlled or – even more importantly – what cannot be measured, especially in its industrial forms*" (Boltanski & Thévenot, 2006: 159). According to interviewees there are almost no objective metrics that can assess vocation or the inspiration that animates doctoral research – so it is almost impossible to determine from the outside which doctoral work or which student will reach high status in this inspired common world. Industrial measurement scales (such as publication scores) are considered irrelevant – indeed, interviewees even assume a certain decoupling between being creative and having papers published: "*It really gets on my nerves when I hear about so-and-so having published in such and such journals with such and such impact factors… For me, work may not be published precisely because it is really original and risky. I think the most important thing for young researchers is to have ideas. After all it does not matter so much if the ideas are bad, at least they dared to look for something new.*"

(Supervisor, 55 years old, PhD defence in 1978.) It seems that informants are only able to express firm convictions about whether or not they were up to such an intellectual adventure when they reflect on their own practices "*Deep inside of you, you learn to know if you are a good researcher or not. It may take 4, even 5 or 6 years, and the conclusion may be rather cruel. You start a PhD, you defend it, work as a post-doc, you finally get a position at the university and in your early thirties you realize that you are not a good researcher and that you are not made for that job.*" (Supervisor, 60 years old, PhD defence in 1963.) "*I do not consider myself as a researcher. For me, a researcher is imaginative, brilliant, and creative.*" (2nd year doctoral student.)

Leaping into the unknown. To be thought 'worthy' in the inspired world *"calls for sacrificing forms of stabilization and the contrivances that ensure the identity of persons in other worlds*" (Boltanski and Thévenot 2006: 161). Informants state that good doctoral training requires risk-taking and *"not taking the easy way out",* giving up the relative comfort of simply replicating someone else's ideas. In the inspired world, the supervisors' duty is to stimulate talent, stir up curiosity and free creativity: "*One of my doctoral students really likes to search for new ideas. And finally the art of being a supervisor is that of preserving this excitement.*" (Supervisor, 60 years old, PhD defence in 1963.)

Squaring the circle? Compromises that reconcile the two common worlds

How can experiences of doctoral training possibly refer to two common worlds which seem almost incompatible? In fact, informants do not seem to contradict themselves: rather they build "*composite arrangements that include persons and things capable of being identified in different worlds*" (Boltanski & Thévenot, 2006: 278).

They generally have to do so by prioritizing industrial objectives over inspiration (which appears as a *"spiritual complement"*): *"My supervisor really took care that I did not 'go off the road' during my PhD. Because of course, it was really important for my academic career to get some results. However I was not an 'underling' just doing was I was told to. I started studying the S. Cerevisiae genome following his advice, and after a year and a half I got good results and I convinced him to let me switch to bioinformatics."* (Supervisor, 40 years old.) Setting such priorities gives PhD students good publication records, and thus improves their chances of passing the first (CV examination) stage of selection for academic positions. However the second stage (job interview) can also be oriented toward an assessment of the candidate's inspired worth: "*There is always someone on the panel asking 'You've presented your results and that's fine. But we would like to know, what is the meaning of your approach? What do you think of it?' And there are candidates who have good scientific records, with impressive publications, who are completely unable to answer to this question. This proves that they only worked as super-technicians during their PhD."* (Supervisor, recruitment committee member, 40 years old, PhD defence in 1990.) A recurrent dilemma about the direction of research also reveals that security and risk, performance and creativity, can never fully be reconciled: should doctoral work closely follow previous or conventional lines of research as secure options to get results within three years - or should student and supervisor engage in a make-or-break game and work on an original project? Those who favour creativity usually have a 'plan B' - an alternative research strategy in case they reach an impasse: "*We worked on new mutants that were implied in a cellular response. That was really promising. We identified these mutants, which took us more*

than one year, and we only got strange results that made us think that we had probably done something wrong. And after two years we realized that what we thought were mutants were not - so we threw it all in the bin and started from scratch. But not completely, because during the course of our work we had identified other options around which we could reorient our work." (Supervisor, 40 years old, PhD defence in 1997.)

So far in our arguments we have focused on the strong continuity in doctoral training experiences. The two interpretative lenses of the 'industrial' and the 'inspired' common worlds have enabled us to show that quite opposite perceptions and values can cohabitate (even within single experiences), which leads also us to disagree with the idea that doctoral training has recently become industrialized, in the sense of being oriented only towards 'industrial' style values such as profitability and productivity. But some supervisors were (and are) able to avoid compromising between the two common worlds, and promote doctoral training that can be characterized as being 'industrial only' or 'inspired only'. We find that there have been significant changes since the 1960s in the arguments these supervisors employ to justify evaluation of doctoral training within only a single framework.

Holding Doctoral Training in One Common World: Changing Rationales since the 1960s

The changing reasons for 'industrial style' doctoral training

According to the most senior scientists, those supervisors from the 1960s and 1970s denied any mention of the 'inspired' common world were autocrats, driven by the desire to reproduce, extend and diffuse their own ideas and methods. Most of these supervisors held academic power, exerted direct influence on recruitment

and promotion procedures, and took care to retain a monopoly on scientific recognition, with some even appropriating the authorship of their doctoral students' results: "*My former patron did not let his researchers gain international recognition. When I worked in his group he signed every paper that came out and it was he who went to conferences to present the results of my research.*" (Supervisor, 46 years old, PhD defence in 1983.) Such supervisors considered creativity and scepticism as potential threats to their authority. The supervisor's ability to rule the recruitment roost created strong incentives for conformity and compliance, so many scientists from that period, who have since made brilliant academic careers, are torn between resentment for being deprived of their intellectual freedom and gratitude that their career was successfully started: "*My former patron was really authoritarian. Even years after my recruitment, he still introduced me as his student. But at the same time, he has always supported me; he has always been paternalistic with me.*" (Supervisor, 46 years old, PhD defence in 1983.)

Nowadays industrial style doctoral training is defended by other arguments, and informants locate the turning point in the 1980s or early 1990s, depending on the research group. Those who promote this style of doctoral training are mostly concerned about France lagging behind other scientific nations if its scientists do not get rid of 'romantic' visions of doctoral research. Their position is basically pragmatic, and about setting priorities: they argue that there is no time left for doctoral students to express open creativity and inspiration: such attitudes should be postponed, or even totally disregarded as having become irrelevant for academic scientists. Several supervisors take their lead from Anglo-Saxon countries (following a common line of France getting 'left behind',

see Bouchard, 2007). In their view, the high performing research groups are those that employ doctoral students working directly under the command of supervisors, who do not hesitate to reorient their work or to assign them to another project depending on the state of the competition: "*When I was in the States the boss did not have any qualms about telling students what to do. Because he really was the one who managed, who paid the students. So it is quite simple, students do not think about claiming intellectual autonomy because money is at stake.*" (Supervisor, 52 years old, PhD defence in 1975.) Any frustration doctoral students feel at their lack of autonomy is dampened by the knowledge that they need their supervisor's help to stand a realistic prospect of getting a job: "*I am realistic; I know that he can promise things all day long. As long as you agree to work for him it is not a problem, he will dangle carrots in front of your nose. But I know that it is really hard to get a job and I am not sure I can make it.*" (3rd year doctoral student.) Faced with the 'publish or perish' alternative, some doctoral students find this situation to their advantage, as their supervisors reward their subordination by putting their names on papers: "*When they are told 'look, two or three more experiments should finish the work, and if you do them you'll have your name on the paper,' they listen to the argument. I did the same when I was myself a student.*" (Supervisor, 34 years old, PhD defence in 1998.) Finally, the lack of intellectual autonomy also frees those students who fear they might not to be up to the 'inspired' state of worth from the risk of failure: "*My impression is that we are here technicians rather than researchers. When we have ideas, they always seem to be stupid, and we are immediately beaten to the punch. On the other hand, it depends on the students' personality. I don't like wasting my time searching for ideas or documents .... There are people who already have all*

this knowledge in their mind and who can communicate it." (2nd year doctoral student.)

The guardians of science

In contrast, the then supervisors of some of today's senior scientists minimized the industrial dimensions of doctoral training, and fostered intellectual autonomy and risk-taking. They, too, held prestigious academic positions, and were similarly much concerned with training alter egos and commissioning students to help them conduct pioneer work and fructify their personal scientific heritage. They did not appropriate their students' results to increase their own scientific reputation, but rather encouraged students to gain their own reputation (although, of course, they benefited indirectly). Doctoral supervision was considered as an intellectual relationship where the apprentice was a master in the making. Supervisors favoured the exchange of ideas to giving out authoritative opinions, and innovation to orthodoxy: "*You have several ways to supervise students. Some people like Martin really fostered innovation and the search for personal ideas. He let the students do what they wanted and guided them.*" (Supervisor, 44 years old, PhD defence in 1988.) Doctoral students were proud to participate in this intellectual adventure, and, while well aware that their academic career lay in their supervisor's hands, seemed confident that they would do everything in their power to help them gain a position: "*I did not know if he would be able to help me be recruited somewhere but I trusted him, I knew he would not abandon one of his students and I would probably find me something somewhere.*" (Supervisor, 36 years old, PhD defence in 1995.) However, such 'inspired' doctoral training did not go without some downsides. It did not tolerate dilettantism - absolute dedication to work was both proof of a student's worth and a way of living up

to the supervisor's expectations: "*At that time we also worked on Saturdays. The boss was there; sometimes we would do nothing special, we were just here talking with each others, so that I was wondering what I was doing here. But anyway these were useful discussions.*" (Supervisor, 64 years old, PhD defence in 1970.)

Inspired style doctoral training still exists today: "*There is a huge difference between getting results and becoming a researcher and only very few students know that. I am always amazed to see how docile they are, how they always do what they are told to. And they are wrong!*" (Supervisor, 63 years old, PhD defence in 1967.) Its promoters aim to train a new generation of scientists who will not heed the siren song of performance and profitability: they resist quantitative performance measurements which, in their view, confuse means (the publication of results) with ends (the expansion of knowledge): "*Nowadays young researchers publish a lot because everything has to be profitable. And it's impossible in research! So they have this sword of Damocles over their head and you find the same thing in 50 publications. I think it is our duty to keep in mind that publication should not be misused.*" (Supervisor, 58 years old, PhD defence in 1987.) These supervisors also protest against the rise of research contracts, and its consequences on the comparative funding of doctoral work in different fields, with some topics attracting a wide range of public and private scholarships, and others – which neither satisfy political priorities nor promise business applications – getting none. Such supervisors argue, for instance, that doctoral schools should give State grants to the best students, without their funding being linked to specific fields or subjects. Finally they regret the loss of passion among young researchers: the way that the project-based organization of doctoral research, with its standardized

sequences of events and narrowly defined research goals, has diminished students' sense of adventure; how inter-individual rivalry for academic positions has replaced a collective drive towards the advance of knowledge; and how the expansion of the academic world itself has meant science is no longer a passion for the few: "*In the past researchers had a great aura. It corresponded to a romantic vision of science, and the senior scientists still stick to this vision. Whereas the 'beauty of science' makes the junior scientists laugh.*" (Supervisor, 36 years old, PhD defence in 1994.) "*When we started it was like the Wild West, almost everything had to be discovered and it was fascinating. Now things have probably become more difficult and my impression is that the young researchers seek personal recognition more than we did*" (Supervisor, 58 years old, PhD defence in 1964.) "*What strikes me now is that PhD students are no longer ready to make any sacrifices. They want a job, a house, a car, they want to work 35 hours a week. They want what they call a 'balanced life' as they say.*" (Supervisor, 37 years old, PhD defence in 1994.)

Discussion

The 'Industrialization' of doctoral training and generational changes

This paper highlights some continuities and changes in doctoral students' and supervisors' experiences in the French life-sciences. It offers further evidence for the argument that there has been no radical 'industrialization' of doctoral training in the French life-sciences, in the sense that industrial style values - such as performance and profitability - have replaced wholesale those inspired values of passion, creativity, and intuition characteristic of the traditional academic ethos. In fact, the overall historical picture was always fragmented - and remains so. Finally, there are notable changes in the

reasons why some supervisors promoted industrial- or inspired-style doctoral training in the past and why they promote them today. Of course, we cannot be sure our interviews with supervisors do not suffer from retrospective bias, under- or over-estimating certain past experiences. But interviews are an essential tool to reveal subjective experiences and their evolution over time, and previous work shows that reconstructions of past experiences do not necessarily carry the slant of a mythic 'lost golden age', and that supervisors could be trusted to be lucid about the downsides of their own doctoral experience (Delamont et al., 1998).

The interplay between continuities and changes allows us to discuss the idea of generational change while keeping in mind Mannheim's definition - (Mannheim, 1952) - that members of the same generation may not be the same age, nor do they necessarily belong to the same cohort, but rather they share a common set of socio-historical experiences, so that their actions and representations are embedded within the same framework of references. In that sense, are the changes in doctoral students' and supervisors' experiences substantial enough to talk of the training of a 'new generation' of French life-scientists?

The first part of our results tends rather to support the argument of generational continuity, as if all interviewees belong to the same generation of scientists. Indeed, we show that actual expectations about doctoral training do not differ radically from those the most senior scientists held when they were students, and that their various doctoral experiences can be categorized as 'industrial' or 'inspired' with reference to Boltanski and Thévenot's common worlds (2006). It also challenges the myth that senior researchers lived through a lost 'golden age', characterized by the absence of a purely 'industrial' sense of doctoral

training. We show instead that the duality between 'cheap labour' on the one hand and 'true-researchers' on the other has been long-standing.

Our analysis also suggests what gives this generation of scientists its coherence. On the one hand, the characterization of doctoral training of life-scientists as an 'industrial' style enterprise can be related to the fact that (as noted earlier) such training of life-scientists has long belonged to the 'positional mode' of socialization (Delamont et al., 2000) in being characterized by team work, by an explicit division of labour between doctoral students and their supervisor, and by standardized requirements and outputs. This differentiates the natural sciences from the humanities (and also from some social sciences) where the 'personal mode of socialization' is widespread: where doctoral training is solitary work and the production of a *magnus opus* the essential condition for academic recognition. In this respect, the industrialization process has not led to any qualitative change in the experiences of doctoral training, at least for those research groups not commercializing their research outputs or involved in close university-industry relationships. At the most, it can be said to have accentuated some already-existing features, such as the project-based organization of work and the importance of measurable outputs like publication records. On the other hand, the notion of the 'inspired' common world still has great weight: doctoral training remains an initiatory experience where fundamental academic values are transmitted to students. The growing necessity to conduct research that is 'valuable' to a large range of stakeholders has not marked the end of such values as vocation, creativity, imagination and autonomy (Henkel, 2005).

The second part of our results aligns more with an argument of generational discontinuity - that current doctoral students and senior scientists do *not* belong to the same generation. Generational changes are reflected not so much in how doctoral training is evaluated as in the underlying rationales for valuing specific aspects of doctoral work. Henkel (2005) comes to similar conclusions about senior life-scientists in the UK: she shows that they still regard autonomy as a core value, but that its definition has changed radically from "*freedom from external interference*" to *"the power to manage multiple relationships*" (Henkel, 2005: 170) within and beyond scientific communities. We show that both industrial and inspired styles of doctoral training used to be justified by supervisors' interpretation of their need to retain complete authority over their scientific specialty, but are now justified instead by 'publish or perish' imperatives, and by the fierce competition inherent in keeping pace with the rapid advance of knowledge. Previous research on changes in the French life-sciences (Louvel, 2010) enables us to specify further which shared experiences, expectations and meanings characterize different generations of doctoral students, and which changes delineate them. Indeed, in the past, the most senior supervisors could be described as 'patrons', controlling access to scientific recognition, and to career progression (Louvel, 2010). Their small number of doctoral students were destined to succeed them and – whether their training could be considered 'industrial' or 'inspired' - belonged to the same generation: indeed they were protégés, whose employment prospects depended on their patrons' influence, at a time when personal links mattered much in the academic world. The changed conditions of the research context have put an end to the patron–protégé relationship, and limited the direct influence (most) supervisors have over whether their doctoral students are recruited into academia. More significantly,

the number of French doctoral students in the life-sciences increased massively in the 1990s; publications in leading journals and postdoctoral work (elsewhere in France, or abroad) became prerequisites for landing permanent positions; and research institutions and some universities banned academic 'inbreeding' (the recruitment of their own doctorate holders as permanent researchers). Although there is no clear turning point (some doctoral students were clearly still considered as protégés into the mid-1990s), the emergence of a new generation can be observed, which shares a different set of experiences and expectations. Both industrial and inspired styles of doctoral training aim at teaching the rules of international competition and of institutional requirements, and beyond these at advancing scientific knowledge and increasing student's chances of being recruited as professional academic researchers. Within these common constraints, the difference between the two styles lies in supervisors' interpretation of the legitimacy of some changes (pressure to 'publish or perish', adaptation of the research topic to various stakeholders' requirements, etc.) and of the appropriate reactions (compliance or resistance).

Implications for further studies on doctoral training

Our analysis has three main implications. First, it shows that values attributed to doctoral training depend on divisions which appear beyond disciplines and institutions, the two main categories traditionally put forward to analyze academic cultures (Clark, 1987). We found that whether supervisors adopted (or defended) the inspired or industrial style of doctoral training depended on their individual convictions, which in turn stemmed from their personal experiences (e.g. work experiences in other institutions, or abroad, their previous

scientific success or failures, their own doctoral training, etc.). Consequently, the changes in practices and values depend on several factors: further studies are obviously needed in contrasting disciplinary, sub disciplinary and institutional settings, as 'general scenarios' of change need to be fleshed out, and confirmed or disproved by detail. Our study shows that the opposition between the 'positional' and the 'personal' modes of research socialization (Delamont et al., 2000) - which was primarily designed to contrast the 'hard' and 'soft' sciences - can also be understood as a continuum that can be found in all disciplines. Indeed, although life-sciences might be thought to be aligned with the 'positional' mode, 'inspired' French life-science doctoral students are closer to the 'personal', close interpersonal relationships being essential to help them express their creativity.

Second, our analysis contributes to the policy debate on the need to develop 'professional doctoral education' that would specifically prepare doctoral students for positions outside academia (Kehm, 2006). This issue is raised by the concern that the increasing proportion of doctorate holders who do not get an academic position may lack the skills and competences required to get jobs in industry. However, some qualitative studies have shown that doctoral training already serves several purposes, and is flexible enough to prepare students for various career options (Probst & Lepori, 2008), a flexibility which may be more appropriate than an early differentiation between two career tracks (research vs. professional). Our distinction between the 'industrial' and 'inspired' styles of doctoral training shows that students involved in the same doctoral program (and even doing research in the same department) can experience their doctoral studies in very different ways. There is thus a strong differentiation between the skills and

professional identities of doctoral students, but it remains implicit: while well-known among scientists, it is not mentioned in any official doctoral program.

Our study also suggests that this implicit differentiation has two downsides. First, 'inspired' doctoral students tend to be those who are already considered as future colleagues by their supervisors, although they cannot be certain that they will find a permanent position in academia (there is, in fact, some empirical evidence that some students considered as 'inspired' fail to enter academia, whereas 'industrial' style students do succeed in finding positions). Secondly, supervisors play the leading role in creating a balancing act between the 'industrial' and 'inspired' values of doctoral training, since doctoral students are not really able to negotiate their roles with their supervisors, and so adapt the content of their training to their personal aspirations and professional expectations. To take advantage of the flexibility offered by the current organization of doctoral training, doctoral students would need to be able to enter into bargaining processes, but these would probably be seen as being incompatible with the professional culture of the life-sciences, which is rather based on a strict obedience to hierarchy.

Third, our analysis brings new evidence to fuel the well-established debate about the motivation of doctoral students. As finding academic positions becomes more and more difficult, there is indeed growing concern that the motivation they gain from their day-to-day research work no longer compensates for the stress and uncertainty about their academic future (Gaughan and Robin, 2004; Robin and Cahuzac, 2003; Stephan, 2005). However, our study records the remarkable persistence of doctoral students' daily motivation, despite the threats weighting on their future career, and our results show that, for most French

doctoral students in the life-sciences, it relies on their ability to alternate between 'industrial' and 'inspired' modes of thinking. This has several virtues: it dampens the relative frustration (Merton, 1965) arising from the distance between the industrial routines of their work and their idealized picture of research as an intellectual profession; and conversely it also calms their worries about not being up to the high requirements of the intellectual adventure of research. In a sense, it prepares them for the 'real world' of compromises, which they will find whether they enter academia or industry.

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Notes

1   The remaining 23% work part-time (outside academia) or their source of funding is unknown.
Source: science and technology indicators 2006, OST, downloaded from http://www.obs-ost.fr/fileadmin/medias/tx_ostdocuments/OSTComplet_01.pdf

2   Source: report from the Observatoire des Sciences et des Techniques (OST): http://www.cpu.fr/uploads/tx_publications/OST_etude_RH_pers.non_permanents_recherche.pdf

3   See graph 1 in annex.

4   See graph 1 in annex how these three dimensions relate to the 13 categories which originally define the structure of each common world.

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Graph 1. Synthesis of Boltanski and Thévenot's (2006) framework and of its use in the paper

| Six common worlds within which actions and states of being can be evaluated and justified | … Each defined by 13 properties | … And structured in the paper into three dimensions |

Six common worlds within which actions and states of being can be evaluated and justified

Fame

Civic

Inspired

Domestic

Industrial

Market

… Each defined by 13 properties

- The "higher common principle"

or the convention for establishing equivalences among beings

- The "state or worthiness"

or how are the states of worth - and of deficiency - defined

- The "human dignity"

or how is humanity characterized – physically and emotionally

- The "list of subjects"

being worthy or unworthy

- The "state of deficiency and decline of the polity"

- The "list of objects and arrangements"

which objectify the worth

- The "relation of worth"

- The "natural relations among beings"

- The "harmonious figures of the natural order"

- The "model tests"

or situations where proofs of

… And structured in the paper into three dimensions

The **definitions of worth** which informants used to judge the quality of doctoral training, students and supervisors

The **metrics** used to classify and order people and things, and to establish or to contest their notions of worth