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ABSTRACT

Over the last two decades, a new kind of learning programme to promote innovation and 'individual creativity' has seemed to flourish at the global level in numerous universities, engineering and business schools within industrial and emergent countries. If some are really well known, such as the Stanford D. School, many have been created within old institutions. In France, the empirical field of the article, one can count more than 20 innovation/design schools. These 'innovation' training courses are based on participative pedagogical approaches, often mainly related to 'design thinking' methods, linked to new technologies, multidisciplinary projects and prototyping activities. The article aims to consider design or innovation schools in France as a result of the complex interaction between the historical roots of French higher technical education and new education pathways arising from the transfer of an international standardised model that began in Stanford or the U.S.

Keywords: Design Schools, Innovative Education, Business-Education Nexus, Co-Evolution, Knowledge Economy, Engineering Science, History of Technology

JEL Codes: I21, O32, O39, M13

Over the last two decades, a new kind of learning programme, curriculum and diploma to promote innovation and "individual creativity" has seemed to flourish at the global level in numerous universities, technical or engineering schools. From Palo Alto to Paris, from Boston to Aarhus, from Milan to Hong Kong, "design schools", or "formations à l'innovation et à la création industrielle" in French, have been created in order to enhance innovation capabilities in contemporary societies. From the beginning of the 2000s, institutions that deal with the business world, such as Bloomberg or *BusinessWeek*, have published reports about the classification of the main design schools in the world, which are offered both at business schools and design colleges (sometimes jointly)[1]. These learning institutions encompass two major traditions, which are currently often linked: architecture, art and aesthetic schools, on the one hand, and the engineering design tradition in engineering schools. These traditions are distinct but have progressively, if not merged, then at least co-evolved. As pointed out by Richard Buchanan (2009), in the 20th century during their history, traditions of thought and inquiry that have been used since the Renaissance have been conceptualised, without ending in "a single theory or system of design" but, on the contrary, in a pluralism of approaches that is nowadays the ecosystem of the "design culture".

The current development of "design schools" or "innovation and project-oriented programmes" can be considered to be products of this co-evolution of different cultures and approaches. Since the 1960s and the 1970s, this specific and progressive development of design (in a broader sense than the traditional engineering view inherited from the 19th and 20th century) has experienced huge transformations in industry and consumption, where knowledge, innovation, and individual behaviour and uses are essential. Industrial design also encountered art on behalf of new computing devices (Computer Aided Design has been promoted since the end of the 1960s, from the work of former MIT researchers), and gradually consumer behaviour became one, if not the main, driving force in some areas, such as automotive or computing or telecom industries, which shaped design, innovation, and eventually a new kind of innovation/design school from the end of the 20th century (Kônig, 2007). In rankings or in articles by business journalists, the new innovation and design schools are presented as being highly attractive in terms of the job market. Partnerships with the business world are listed as a key value of such training. These training courses are based on participative pedagogical approaches, often mainly related to methods of design thinking (Doorst, 2015).

1. http://www.bloomberg.com/ss/09/09/0930_worlds_best_design_schools (accessed on 16 April 2016). http://www.businessinsider.com/the-worlds-best-engineering-schools-2012-6?op=1&IR=T (accessed on 16 April 2016)

Innovation and design schools are more often linked to new technologies, multidisciplinary projects and prototyping activities. The blossoming of these "new" learning methods aims to meet the "new" needs of business organisations, which are often supposed to adopt new and creative approaches, to cope with the complex challenges of today's society and economy (Boland, Collopy, 2005; Mintzberg, 2004). The creation of these new learning centres, focused on collaborative innovation, interdisciplinary approaches and new technologies, also corresponds to the numerous discourses on innovation in international organisations, especially related to the development of the "knowledge society" or, as defined by Galambos (2012), the "creative society". It also follows the "necessity" to enhance individual creativity in the innovation process (Godin, 2015). All these discourses emphasise the need to develop and reinforce education, learning methods rooted in research on education, or cognitive sciences, like the OCDE (2014) reports on innovation, learning and education or the World Bank (2003), during the same period in which design schools emerged. This can be examined, for example, in the European Commission's Framework programmes and its latest creation, the Horizon 2020 programme, an involvement in innovation and multidisciplinary approaches, to build success in the economy and society of the future (European Commission, 2015).

These institutional recommendations seem to be aligned with the "triple helix theory", which argues in favour of a major shift from dual relationships, in which university and government were the main actors of knowledge, to an industry-university-government matrix, which allows private business to have increased room to grow in the relationship (Etzkowitz, 1993; Etzkowitz, Leydesdorff, 1995). Actually, these new training formations not only encourage new roles for private business, shaping the construction of knowledge into a pro-active situation for innovation processes, but they also contribute to enhancing the so-called "third mission" of universities, *i.e.* their contribution to innovation (Ranga, Etzkowitz, 2013). From another standpoint, the development of innovation training can also be related to the recommendations of the report that Suzanne Berger (2016) recently submitted to the French Ministry of Economy, in which she warned that better interconnections between industry and academia are needed to improve innovation and, subsequently national economic competitiveness. According to this report, for instance, "a dense set of connections along the interface between researchers and industry is what matters most". This point is related to a similar and larger one on the current production system in the United States of America, which works as a model to propose new links between economy and education (Berger, 2013).

The aim of this article is not to embrace the global establishment of design schools and innovation training programmes. At a lower level, it speculates whether their emergence in France is as new as may be thought. We will try to set out some general characteristics of design schools at the global level, before comparing these with what is happening in the French case. We will explore if there is any standardisation of this educational form (Ruano-Borbalan, 2006), wondering if it could be considered to be a mere transfer of an international model or, on the contrary, as a more complex interaction between the historical roots of French higher technical education and these new education pathways. On the one hand, empirical observation indicates that Stanford's Design School (hereafter D-School) could be considered to be a general model for the other Design Schools, including the French institutions belonging to learning institutions, which we put into the category of design schools. The D-School at Stanford is also part of a global network that diffuses its learning formula throughout the world and, as we will see, even in France. On the other hand, these learning institutions are dealing with already established engineering schools and universities, which cannot simply be reshaped following the American fashion. We defend the hypothesis according to which features of today's design schools and innovation curricula are rooted in the same principles or pedagogical devices that belong to the historical establishment of engineering and higher technical schools.

THE DEFINITION OF DESIGN SCHOOLS: REIMAGINING EDUCATION FOR INNOVATION AND CREATIVITY?

In order to explain the topic of our research programme, a deeper exploration of some features of the design schools is required. This model has been used to identify the *écoles d'innovation* in France, which will be described in the article. As epitomised by Bruno Latour (2008), the word "design" is adopted as the common characteristic of this new form of learning, but its meaning could be misunderstood for a French reader: while in French *design* is almost synonymous with aesthetic valorisation and its relative procedures, its connotation in the Anglo-Saxon world is more likely to be linked to a broad approach for the whole activity of conception through innovation, which includes many fields of application in both industrial and organisational projects. In a certain way, it could be pointed out, according to Hatchuel (2001), that a kind of theory of design emerged in order to help the conceptualisation of innovation practices. However, the need to manage

knowledge from different standpoints often creates conflicts between different forms of disciplinary expertise, which suggests the need for a multidisciplinary approach to complex problems (Hatchuel *et al.*, 2002). According to Norbert Alter (2000), one may wonder if the creation of design schools helped the institutionalisation of specific actors in the innovation process. Their creation also epitomises the need for a new pathfinder for innovation that is able to pass from a stage in which innovation is a kind of transgression, according to Alter's concepts, to a stage in which innovation becomes an ordinary activity. Very often, design schools are created with hybrid content, commonly constructed on specific projects and which use the "project approach", as it has developed through management or engineering sciences (Garel, 2011), architecture (Tuffano, 2015), or design (Best, 2010). This is not new: also from a theoretical standpoint, projects are seen as performance models to enhance creativity (Boutinet, 2004, 2012). The debate about the need for design in management and organisations emerged during the 1990s as a way to encourage more responsive management that could inspire innovative and competitive solutions (Barley, Kunda, 1992).

Although a common definition is problematic, if one takes into account the international situation, more than just the French one, design schools can be considered as a rather standardised form of studentship and training method. The didactic activities are more or less common to all these new kinds of learning organisation. If we compare the pictures on the websites of the major design schools, some common attributes quickly emerge: (1) the omnipresent use of "post-its" and white boards as support in creating projects and activities (which are supposed to be as effective in enhancing and sharing ideas); (2) students work collectively on projects and they are seated around large tables, instead of using individual desks; (3) the general ambience is very relaxed, combining food and beverages during the sessions; (4) laptops, tablets and smartphones are the most used technological support, which have replaced pen and paper; (5) finally, the adoption of models and miniatures arising from practical activities and approaches (arts and crafts) are also an essential part of this general ambience, which aims to enhance capabilities through prototypical creation and digital piloting.

Some operative features and justifications are the common background of almost all these kinds of institutions. The hypothesis according to which a model exists can be developed by searching the features of the D-School at Stanford[2]: all Design Schools that are classified or known as such have a

2. See for example http://dschool.stanford.edu/our-point-of-view/ accessed on 13 March 2016.

manifesto and curricula that, even if it is not always pointed out, as a matter of fact are inspired – directly or indirectly – by Stanford. Moreover, the specialised press that reports on design schools in the US and outside the US recognises this school as the first to have been created. This model is formed by three main characteristics, which bring together practice and theory, supporting didactics and organisational choices, in terms of curricula and links with the economic field and with enterprise.

First, design thinking is taken to be the intellectual mainstream or, better still, as the philosophical background to the learning activity. It is shown as a methodology that is able to bring creative and innovative solutions to the complexity of today's society: environmental and green transitions, economic challenges, territorial developments or competition, technological innovation and globalisation, for instance (Lockwood, 2009; Brown, 2008). Design thinking has been presented, by its main creators, such as Rolf Faste, David Kelley, and Tim Brown – all professors in different eras in the Stanford engineering department – as a way to integrate a design approach to management (Cross, 2011). The aims of "design thinking" are to merge technology, business and human values in the same process of creation. This results in a multidisciplinary approach to industrial design. On the one hand, the design approach is able to integrate the user or the customer into the process of creation and, on the other hand, to open the door to multidisciplinary activity, overcoming the implicit difficulty of such knowledge (Jacobs, 2013; Collins, 2010; Bourdon, 2011). The narrative that accompanies the creation of "design schools" assigns specific values to "multidisciplinary approaches" as an economic multiplier and a leverage of knowledge, which are often poorly defined or measurable, or which are difficult to work in practice. "Intellectual flexibility" is often pointed out to be an outcome of this approach, which is judged to be more efficient in carrying out actions encompassing society and economy as an entire "ecosystem", in which innovation and innovative knowledge are considered to be key factors of competition. While links between design and economic performance seem simply not to be explored, despite the institutional claims for multidisciplinarity and innovation that come from the highest level of international organisations, the main endorsements to this narrative come from businessmen or already existing design schools (Martin, 2009; Brown, 2009).

Second, a specific learning method is proposed, in which "project" practice and pedagogy play a crucial role. Often remaining as lectures for classic disciplines, multidisciplinary projects are conceived as the learning core of pedagogy in these institutions, in order to practice the "design thinking" approach collectively. There is a vast literature about project management,

its history and its implications for the evolution of engineering science (Scranton, 2008; Morris, 1994; Soderlung, 2004). There is also a vast literature about project-based learning, but this is still used less in higher education, despite current transformations that highlight some educational thinkers and pedagogues such as, first of all, John Dewey (1897). In any case, the relative novelty of "project-oriented" pedagogy is, in design schools in higher education where knowledge is traditionally transmitted from top to bottom, its supposed value as a learning model. Curiously, the justification does not seem to come primarily from more than a century of active pedagogy and educational reformers, but from a pragmatic synthesis that bounds together engineering, architects or art traditions with new technologies and the makers of counter culture or practices. A project in design schools, as in many industrial cases, is a real project, realised by a multidisciplinary team of students. That is why those learning programmes on innovation are more often linked with local or industrial ecosystems, including firms, local authorities, clusters, start-ups, etc. We already pointed out that the direct involvement of firms is displayed as being a strong point in each of these innovation and design schools. Moreover, the number and the reputation of firms (large corporations, SMEs, start-ups) and even public organisations that are present as "customers" in these schools' projects are essential for their legitimisation and their attractiveness. On the other hand, enterprises find the cultural legitimisation of new and innovative projects interesting, drawing benefits from the scientific and academic reputation of these institutions in a process of legitimisation of academia by the enterprise and *vice-versa*.

Third, a new nexus between business and academia is promoted, according to which the business world is neither a mere funder during the studies, nor a simple employer of students at the end of these, but a "customer" during projects that students carry out according to a specific request formulated by and with the enterprises. Moreover, firms and the business community are also very often part of the faculty, and scholars involved have business links or direct activities. This concept goes hand in hand with the so-called "entrepreneurialisation" of the academic staff, who either attract projects or who, while guiding students, are asked to interact with the business world (Barrier, 2014; Caravol, 2003; Grossetti, Bès, 2001; Pestre, 2013). In any case, a symbiosis between the business world and these schools is promoted as being useful to improve student qualities. One result (and goal) is to transform some students into entrepreneurs during their training, according to the new role that is granted to entrepreneurships during education to enhance innovation and competitive advances (Beylat *et al.*, 2013).

THE *ECOLES D'INNOVATION* IN FRANCE: APPLICATION OF THE AMERICAN MODEL?

Stanford's D-School is not only a reference for other similar institutions, but also served as a channel to diffuse new learning and training models. The first reflection about the links between design and business came from the original inception by Rolf Faste in the 1970s, and the D-School was created in Stanford only in 2004. Between these dates, the foundation in 1991 of IDEO by Tim Kelly, a professor at Stanford, played an important role in the systematisation of design thinking approaches, which, subsequently, were transferred to training activities in the university. After the foundation of the D-School, an alliance was established with the German Hasso Platter Institute in Berlin, showing a link between the American and German design approaches. From this encounter, Tim Brown formalised "design thinking" in the key publication *Change by Design* (2009), which tried to produce a new approach to innovation and conception. As he recounts on his blog, Brown was pushed into formalising the IDEO and D-School approach because of an original request by Bill and Melinda Gates' Foundation, which recognised the importance of new methodologies to cope with complex issues, not only those arising from the business world, but also from society, such as underdevelopment and famines in Third World countries[3]. In 2008, an international network of schools and firms was created to promote the design thinking approach: the Sugar Network. This "design thinking approach" is also patented under the name of the "ME310 Sugar Design Process", which is licensed for other universities around the world. In accordance with the role of enterprises in design school practices, the Sugar network is not developed by universities alone. This gathers together some large enterprises – also some French ones – which are better expressions of the knowledge society, from the automotive industry to computers, from banks to software, from the electrical sector to aeroplanes, these are members of the network[4].

As anticipated, France – as with other countries – has recently been interested in the emergence of a new kind of innovation school and programme, which can be assimilated into the experience of American design schools, even if other experiences are emerging. Following our three criteria (a design approach, learning by multidisciplinary projects, and a new nexus between business and education), about 20 *écoles d'innovation* (see Table 1) now exist in France. The phenomenon is rather unknown from

3. https://designthinking.ideo.com/?p=161 accessed on 15 April 2016
4. http://sugar-network.org/sugar/network accessed on 20 April 2016

a scholarly standpoint and up to now there has been no scientific reflection from this wave of new schools, which are practice-oriented. Only one report, which is part of a special edition of *Entreprendre & Innover*, edited by Witmeur and Silberzahn (2013), about "start-ups and design thinking", accounts on the Idea school of Lyon, which – even if it is not a member of the Sugar Network – was inspired by Ideo's experience and which follows the design thinking approach (Gaultier, 2013)[5]. Without making an exhaustive list here, other similar experiences could be found at the Centre Michel Serres pour l'innovation[6], CPI Ecosystème Schoolab[7], and IDEFI Promising[8], and even in other universities, such as Strasbourg, Rennes, and Bordeaux. INSEAD was not included because, despite its two centres for a design thinking approach, they are based outside France[9].

Without any coordination, the process that created and diffused the form of design schools and their narrative emerged in the French context, following these same considerations to turn academic science into an "economic engine", *i.e.* something useful to enhance economic growth in a post-industrial context. The creation of what Elizabeth Popp Berman (2013) calls the "market university" is already well-known as an historical process which, since the post-World War II period, reveals a new value criterion for the university, in which a certain transition from researching the truth to the search for usefulness is recorded. According to this research, the role of academics in society and in the economy has changed, by means of a more entrepreneurial mood in the conduct of research, in its financing, and in the management of its outputs (such as patents, for instance). Other recent approaches, made from the standpoint of the history of science, have also recorded this transition, claiming that there has been a modification of a paradigm since the post-war era. In this transition, the decline in the weight of the political powers in the dialogue between research and industry seems to have driven academia to seek a new partner in industry, after decades in which the role of the state was overwhelming (Pestre, 2016).

5. Gaultier is director of the IDEA programme at EMLyon business school.
6. http://www.hesam.eu/blog/category/centre-michel-serres/ accessed on 20 April 2016
7. http://creationdunproduitinnovant.com/ accessed on 20 April 2016
8. http://www.promising.fr/formations/ accessed on 20 April 2016
9. Actually, INSEAD participates in a former design venture, the Pasadena ArtCenter, and only recently announced it would open Garage Innovation on its Singapore campus. http://eightinc.com/insights/eight-inc-insead-collaborate-create-new-space-new-way-learn and https://www.insead.edu/executive-education/digital-transformation-innovation/innovation-design

Table 1 – Design Schools in France : les écoles d'innovation

Ecoles d'innovations	Town	Hosting institutions	Design thinking			Multi-disciplinary project as learning	Real customers for projects
			ME310-Sugar	D-Thinking	D-approach		
Centre Michel Serres[10]	Paris	Engineering School, University, Business School, Architectural School and Ecole de Design Industriel*			X	X	X
IDEA[11]	Lyon	Business School		X		X	X
CPI – Schoolab[12]	Paris	Engineering School/ Business School/Ecole de design industriel		X		X	X
DSchool[13]	Paris	Engineering School	X			X	X
Webfactory[14]	Paris	Ecole de design industriel			X	X	X
Master PIC[15]	Paris	Engineering School			X	X	X
Promising[16]	Grenoble	University		X		X	X
FCI Centrale Supelec[17]	Paris	Engineering School			X	X	X
IPI[18]	Strasbourg	University			X	X	X
MPI-UTC[19]	Compiegne	Engineering School			X	X	X
L'Ecole de Design[20]	Nantes	University		X		X	X

10. http://www.hesam.eu/blog/category/centre-michel-serres/
11. http://www.programme-idea.com/
12. http://creationdunproduitinnovant.com/
13. http://www.dschool.fr/
14. http://www.webschoolfactory.fr/
15. http://masterpic.fr/
16. http://www.promising.fr/formations/
17. http://www.fci.ecp.fr/andhttp://www.ecp.fr/home/Formations/Cursus_ingenieur_centralien/la_pedagogie_par_projets
18. http://duipi.unistra.fr/
19. http://www.filierempi.fr/
20. http://www.lecolededesign.com/

Multimedia Sorbonne MMI[21]	Paris	University			X	X	X
MPP[22]	Lille	University			X	X	X
CRED[23]	Bordeaux	University			X	X	X
MAPI[24]	Nice	Engineering School			X	X	X
DESSiiN	Nantes	Engineering School			X	X	X
Living Lab Descartes[25]	Paris	Medical School			X	X	X
DSSA[26]	Villefontaine	Université/ Ecole de design industriel			X	X	X

Notes: * members of the HeSam ComUE.

Studying the French case, it could be pointed out that it is not an "application", *i.e.* a simple transposition of a model, because in only one case was a French "design school" a member of the Sugar network. However, other cases could be considered: the Idea School, for instance, but also some other forms of the diffusion of the "design thinking" approach through the French Association of Management Scholars (FNEGE), which organises specific training sessions about design thinking, directly borrowed from Stanford[27]. In the case of other examples of French design schools, of which there are four in Table 1, we cannot find any direct franchising operation from the Stanford Sugar network, but a use of "design thinking", as it was codified by its mentors in the US, is adopted to explain which methodology is used in these schools. Again, it seems that the adoption of "design thinking" is more likely a consequence of the involvement of business schools and managerial approaches to the innovation issue, passing through the diffusion of this approach by the management units of the universities. In fact, with only one exception (the Nantes Ecole de Design), the implementation of design thinking approaches is the outcome – even when "university" is indicated as the main hosting institution for the design school in Table 1 – of the involvement of departments of management and managerial schools. It is

21. http://multimedia-sorbonne.com/
22. http://www.iae.univ-lille1.fr/formation/master-2-mpp-management-par-projets
23. http://www.iut.u-bordeaux.fr/cred/
24. http://www.polytechnice.fr/electronique/page73.html
25. http://www.medecine.parisdescartes.fr/?page_id=33259
26. http://dsaa.designvillefontaine.com/
27. http://www.fnege.org/assets/backend/javascripts/kcfinder/upload/files/PRG%20FNEGE%20Design%20Thinking.pdf Accessed on 16 September 2016

still not clear what role, if any, exists for the FNEGE in the diffusion of this kind of approach, but this could be examined in further research about the recent developments of this institution. In fact, FNEGE played a central role in the creation of French management as a university discipline from the 1960s onward (Bouilloud, Lecuyer, 1994; Chessel, Pavis, 2001).

The surprising fact that emerges from Table 1 is the current creation of design schools in France from both engineering schools (the majority) and university. Many schools or curricula listed in Table 1 adopt neither the Sugar network trademarked method, nor a more theoretical "design thinking" approach. Their design approach is more likely to come from the project management approach undertaken by engineers, architects or designers. In other words, the presence of a design approach deals rather with the adaptation of a general scheme to the specific innovation system which has historically emerged in France, and in French technological higher education more specifically. This adaptation should not be seen, though, as an "Americanisation" of French or European society in the field of higher education, but rather as an essential part of the legitimisation of this institutional creativity that deals with the historical roots of technological and science education. While, at the highest level, the justification for the establishment of innovative education comes from the economic and social reports of international organisations, and also the fact that "design thinking" is a Stanford product works as a powerful legitimisation of this approach around the world, at a basic level its effective achievements are accomplished using local resources, power and relying on micro-economic opportunities (Ortiz, 2013).

In fact, one interesting point to analyse is the chain of transmission from top to bottom. While different actors are involved in this process (the state, higher education institutions and the business world): it seems that the general assertion that supports the creation of the *écoles d'innovation* is the need, more or less expressed by firms, to use a new kind of knowledge for their innovation processes. While the university, or at least a part of it, accepts this process of reshaping the education system, the state also supports this kind of experience because it is part of the innovation policies of the international organisations. A kind of convergence of these two forces could be found: the state and the business world, or at least a part of it. In the narrative of justification for those processes, normal/university knowledge is often considered to be inefficient and not useful to create and stimulate individual creativity and innovation, while the new kind of knowledge tailored into the curricula and projects of the "design schools" is considered as key to solve complex issues from the standpoint of individuals, firms and communities (Bouchard, Del Forno, 2012; Côme, 2011). But, in this outline, one fact deserves closer

attention. In France – like in other countries – these new approaches are not organised by outsiders to normal legitimate knowledge. The factual creation of these forms of knowledge comes from the cultural establishment. Sorbonne University and the main old-establishment engineering schools – so the institutions that should normally be attacked by these approaches – are on the contrary their creators in France. Likewise, in the US, Stanford and MIT are the key universities in which this approach was designed. The sanctuaries of academic disciplines are now nurturing spaces and discourses for multidisciplinary methods in the name of innovation. The process of the creation and standardisation of disciplines, as it was created from the end of the 19th century by nation-state institutions, mainly on behalf of these same universities and schools, is returning to more creative views which, even though they are difficult to evaluate in terms of academic scores, are considered to be crucial to move forward with real and practical innovations[28]. Broadly speaking, the French "challenge-oriented schools" or "design schools" are also rooted in a strong tradition deriving from engineering schools, business schools and "old-fashioned" traditional universities.

FRENCH HISTORICAL ROOTS OF THE BUSINESS-EDUCATION NEXUS IN INNOVATION

Remi Maniak (2013) provides an illustration of this fact, recalling the current justification narrative of what is now the "new" global kind of engineers and innovation-oriented professionals (innovation managers, architects, designers, etc.). The great value of Maniak's brief paper is the presentation of the "objectives for training for innovation", that summarises the French Ecole Polytechnique experience. It converges in a certain way with all innovations of design schools worldwide, especially those nurtured inside technical or engineering schools, inspired directly or indirectly by Californian innovative techno-scientific ecosystems. Remi Maniak emphasises the essential objectives of a good innovation training approach, deriving from industrial demand, but also from consumer uses, markets, and the ongoing development of techno-sciences.

Formed in a venerable French engineering school, whose curricula are rooted in science and mathematics, Remi Maniak recalls the existence of

28. For instance, the overwhelming need for multidisciplinary approaches prompted an international pool of scholars to redefine the academic evaluations from the standpoint of the knowledge produced by connecting disciplines (Strang, McLeish 2015).

two kinds of innovators: one corresponding to a science-push model, and the other which positively corresponds to innovative engineering, where users' behaviour is the driver. This kind of innovation has to be developed through pedagogical approaches that can help to develop initiative, autonomy, "transgression", and collective attitudes. To do so, the importance of learning in situ, such as during an innovation project, is shown as being particularly useful, also because it also teaches a balance between the interests of socio-institutional actors. According to Maniak, the classical engineering training model is efficient with regard to these goals. At least its pedagogical devices seem to match the objectives. Knowledge (science) comes from lectures; applied sciences are taught (and learned) in tutorials, while internships provide links between enterprises and alumni, and autonomy as innovation is taught or acquired from specific, but separate, pedagogical measures.

Despite the main justification narrative used by promoters of innovation and design schools, that the so-called "traditional form of learning" is entirely compatible with "project-based learning", pedagogy is promoted in innovation and design schools. This is well known, if one considers the history of educational systems. Moreover, the features of innovation training described by Maniak not only belong to today's engineering schools. This is not the first time where the same need for innovation reshaped higher technological education: both the first and the second Industrial Revolutions involved a profound change through the creation of new schools (mainly the engineers' schools), new disciplines (engineering science – or *sciences appliquées* – and management, for instance), and new professional typologies (managers, entrepreneurs and managerial hierarchies) (Pestre, 2015). The current creation of innovation or design schools can be considered, particularly in France, as a part of a new transformation of the nexus between education and the industrial/economic world. This explains part of the outcome of the table about French design schools: the French design approach, which is not very different in its motivations from the design thinking approach, has its roots in engineering, design and scientific national models. Innovation, as Le Masson, Weil, and Hatchuel (2010) have already shown, went through processes of conception (design) and knowledge that evolved together, mutually interacting in each innovation project. Moreover, according to Figuereido (2014), engineering has developed historically as a mix of science, social sciences, design and practice (crafts). This allows us to consider the epistemology of many features of design schools as being closed to engineering science, or at least, as a nexus between different approaches that are part of engineering knowledge.

The capacity of French education to interact with the business world is often considered to be weak; Suzanne Berger recently claimed its inadequateness in dealing with innovation and in promoting a genuine ecosystem with the industrial world. However, this cannot be confirmed by a closer historical scrutiny. The project and design approaches seem to be part of the traditional French education and innovative system, the new links between firms and learning institutions could represent a real novelty. In fact, at the end of the 19th century, innovation focused on the technical system of coal, iron and steam, while afterwards it moved forward, towards other systems. Historical research about one of the oldest French engineering schools showed that the training of mining engineers was a mix of practical actions (such as visits to production sites, laboratory training and work experience), and scientific and "normal" classes (Garçon, 2004). Moreover, a specific institution became the vehicle of the nexus between industry and education: the *conseil de perfectionnement*. Created in many engineering schools, such as the Ecole des Mines de Saint-Etienne, the Ecole Centrale or the Conservatoire Nationale des Arts et Métiers, it was a hybridisation between professors and the business world (represented by alumni, but not only by alumni). In the specific case of Saint-Etienne, whose *conseil de perfectionnement* was created in 1882, the hybridisation was even stronger, because the professors, who were state engineers, in many cases also worked as consultants for private business (Garçon, 2004; Bertilorenzi, 2016). The same thing was true for the Ecole des Mines de Paris (Passaqui, 2015). Thus, both science and industry were involved in the process of reshaping education, adapting it to firms' needs, to the evolution of science, and also to opening the door to practical work (work experience, visits and laboratory projects).

The specific situation of French state engineers, who were both teachers in these schools and consultants for mining-metallurgical groups, produces the idea that the place in which innovation was thought about and practised was bridged by common actors (Garçon, Belhoste, 2010). Without entering too much into the detail of the history of engineering education in France, in a very seminal publication of 1929, which reports on the transformation enacted by French engineering schools since the late 19th century, the prominent American engineer William Elgin Wickenden praised the dialogue between French engineering schools and the business world, showing the existence, in the organisation of many of these schools, of a "*prominent council [which brings together] government officials, industrial and civic leaders, and scientists […]. It provides contact with world affairs and, in very many cases, brings finance and industrial support*"

(Wickenden, 1929)[29]. Wickenden reported that the ability of the French industrial world to interact with both institutions and education was a key cause of the pre-eminence of French technology during the 19th century, being a "valuable asset" of the French economy, and that the excessive penetration of the state and academia into technological engineering education was a partial cause of it ending at the beginning of the 20th century.

In a specific context of economic, technological and social transformations, such as that at the end of the 19th century, the capacity of scholars to interact with the business world emerged as essential for the process of economic development and for the construction of the French style of engineering, and it also constitutes a legacy for the innovation system as a whole (Vinck, 2013). We formulate the hypothesis that the national system of innovation was part of the outcome of the co-evolution of technology, firms and national institutions (such as the engineering schools). In subsequent eras, firms, technology and national institutions co-evolved, due to the specific link that was established in the French system (Le Bot, 2016). The industrial world was brought on board to contribute to the establishment of programmes and school policies in a more consistent way than was often believed. Consequently, the essential features of the modern design schools are in reality part of the long-term tendency of the French nexus between industry and education, and not a full import that came from the US or from international organisations.

The nexus between innovation, industry and education merits a further explanation. From a comparative standpoint, Johann P. Murmann (2003) has pointed out that the German dye industry experienced a great advance over the other two national industries thanks to the dialogue that it was able to establish with academia, shaping programmes to fit the industrial need of high-technological firms in the chemical sector, and determining a kind of co-evolution of industry and science between the late 19th century and the First World War. The co-evolution model is strongly linked to recent work that explains industrial leadership (Nelson, 1995), the link between technological change and economic growth (Mokyr, 2002), and the development of firms (Chandler, 1992). Firms were not mere customers of a national education system, but education and firms interacted and co-evolved in specific times, with mutual contamination. This contamination did not happen in a static ecosystem, in which technology is a given, but it was also linked to technological change, which reshaped the nature of firms and of education,

29. Wickenden was formerly Professor of Electrical Engineering at MIT before becoming President of the Case School of Applied Science in 1929. He undertook this comparative study as a mission for the Society for the Promotion of Engineering Education between 1924 and 1929

determining a co-evolution of these three actors of industrial performance. The specific historical context of technology, firms and institutions plays a central role in explaining how and why some national innovation systems succeeded and others failed (Murmann, 2003). This insight could also be applied to design schools.

In fact, today's experiences of design schools can be compared to what was tried between the end of the 19th century and the First World War. Firms were asked and allowed to participate in the crafting of knowledge, of courses and of training activities as a whole. This is a key issue from our standpoint: this interaction between industry and academia created some key industrial sectors, such as metallurgy and mechanics, in a period in which, on the one hand, firms still did not have their own in-house research laboratory and, on the other hand, technology was evolving faster. Obviously, things are not exactly the same. Mainly because the link with industry and alumni remains within the "traditional" management of engineering schools, and normal classes are still – by far – dominant. Second, the new nexus, enhanced in the current form of innovation and design schools, is strongly rooted in new forms of societal, urban, technological, innovation. Certainly, sharing and orienting projects directly expresses the link between schools and firms, but one can absolutely see that the co-evolution observed during previous phases is still the approach. The state is less directly present but, as seen above, it promotes reports and much discourse on open, flexible, and cooperative innovation, that perfectly suits innovation and design schools. Institutions and organisations like cities, social economy, large firms, and start-ups are involved in using new innovation and design schools.

CONCLUSION

There was a dual central argument to this article. On the one hand, it emphasises the emergence of French design schools, placing them in the context of the broader development of this kind of institution in the US, and on the global scale. On the other hand, it summarises the main features of these institutions, focusing on three main factors that are present in all of them: the design approach, learning by projects, and firm-education direct links. It has been pointed out that, in spite of the general similarity in terms of narration, justification and general scope, French schools are only partially linked to an imagined original American model. Even though this model is supported by international institutions and by a kind of *esprit du temps*, these institutions discovered their roots in the French tradition of engineering schools, and in their evolution. These roots, together with others – such as

the architectural schools, industrial design and the universities, explain how and why *écoles d'innovation* adopted a design approach that is aligned with the historical vision of the French engineering style, which combines firms and academia, and which put forward the importance of projects in enhancing a specific form of intelligence focused on a problem-solving approach.

It could be pointed out that legitimisation for innovation and design schools goes hand in hand with the establishment of a new kind of social and economic structure, in which new needs and complex challenges would require innovative capabilities, and which would reveal new opportunities for entrepreneurial actions. In this context, innovation has become federative and performative, reshaping both public policies and the perception that firms had of their economic environment (Drucker, 1993; Rooney *et al.*, 2003; Rifkin, 2011). The emergence of "design schools" or related innovation-oriented training curricula, should be read within this main political and economic transformation, which is often reported as the "third industrial revolution" or, in a broader view including technological or societal transformations and knowledge production or transfer, as the emergence of the "knowledge economy" (Ortiz, 2013). Firms and educational institutions are obviously the main actors in this transformation or, better, co-evolution.

Drawing attention to the French roots of the blossoming of design schools, we could not justify their existence in today's academic panorama. On the contrary, it serves to explain how and why we can consider their experience to be more or less a standardised one, in spite of only a low incidence of the original model (that of Stanford) in their creation and organisation. Similar and global needs and policies, which could be summarised by the arguments of the innovation narrative, found institutional convergence from different national models. The one that could be linked to MIT or to Stanford is only partially exportable in the French context. In the case of the French design schools, the engineering science and approaches that were established at the end of the 19th century were not only historical antecedents, but part of the mood of performativity that today considers the management of the project and the design approach as viable in order to enhance innovation.

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