When Engineering and Architecture students meet: a French case study

Dr-Ing Christelle Gress[a], Dr Karine Dupre[b]
Strasbourg National Institute of Applied Sciences (France)[a], Griffith University (Australia)[b]
Corresponding Author's Email: christelle.gress@insa-strasbourg.fr

Structured abstract

BACKGROUND
From the beginning of the 18th century onwards, the discipline of Engineering education split away from that one of architect in France. A renewal in both disciplines occurred after World War II and in the early 1970's when the country was under heavy citizen pressure to change its societal ways. Today, as the expectations and demands of government and industry increase with regard to a better quality of life, the challenge on a more sustainable built environment is also increasing. The disciplines of Architecture and Engineering provide two means of regulating, within this scope, through a wide range of knowledge, practice and innovation.

PURPOSE
The purpose of our study is to reflect upon the changes in educational practices, at both national and local levels, of a double-degree engineer-architect curricular; these curricular changes have been reinforced in the last five years and we wish to analyse the implemented strategies, practical skills development, and the outcomes for the graduate students.

DESIGN/METHOD
Our approach relies on the analysis of two types of surveys. The first survey, which covers the national level, is aimed at forming a comprehensive view of the different types of double-degrees in France to date, as well as looking at their quantitative outcomes. The second survey, developed locally in France by both authors, is a two-fold research. The first aspect is to monitor the changes in the curriculum since the implementation of the double-degree, whereas the second aspect is to assess the qualitative impact of these changes on the enrolled students.

RESULTS
Teaching practices observed for several years provide very interesting outcomes in relation to the changing industry requirements and expectations in France and in Europe. Although France is certainly not the only country to provide a double-degrees in Engineering and Architecture, e.g. see Belgium or Swiss, the results of this study show evidence that new ways of addressing this type of curriculum provide a good opportunity for renewal of professionals in both industries since the biggest outcomes are the creation of new qualifications and job profiles, as well as a very drastic recast of Architecture curriculum in some institutions, such as the National Institute of Applied Sciences in Strasbourg.

CONCLUSIONS
Although education in Architecture had always embedded the knowledge of Engineering, which is more or less developed in France depending of the schools of Architecture, the recent incentive from the French government to have a comprehensive view of it was also the opportunity for our research project to size up the actual changes in curricula at both local and national level, as well as to analyse qualitative outcomes. This is important at a time when industry, under increased sustainable principles, is looking for new types of professionals.

KEYWORDS
Double-degree in Engineering and Architecture, teaching practice, France

Introduction

Sustainable development is nowadays a driving economical force and a new way of thinking about our societies' development. As such, it questions our methods and actions, as well as the existing systems, regulations and actors. The built environment is a major concern because its physical evidences refer to several societal outcomes, such as public health, identity and heritage, which are, in short, expressions of human activity. But moreover, the built environment is also the place where experts in design, construction, and management, are experiencing interdisciplinary engagements.

With the changes brought by a strong concern of developing a more sustainably built environment, we were interested in looking more closely at the recent changes in educational practice of the two most important bodies that play a major role for our built environment: engineers and architects. More specifically, the aim of this paper is to present analysis on a recent curriculum, the double degree in Engineering and Architecture, which was created as a direct answer to sustainable development in France. The underlying research questions in this context are: (i) what is the impact of the double degree engineer-architect in the French Engineering and Architecture education landscape, and (ii) what are the teaching and professional outcomes of this double-degree. This is also an unprecedented opportunity to present alternative ways of working and training together.

After a brief survey of the historical context, which explains how training was developed for engineers and architects in France, our paper will present our method and results.

Context

Engineers and Architects in France: a brief historical survey of their education

Today's relationship between architects and engineers are complex and are still evolving but it seems relevant to dress a small portrait of their past relationships, for in many aspects, it explains the present situation.

Until the end of the 17th century, the engineer in France was recognised as a war technician, whose field of expertise was gradually expanding. An important milestone was the creation of a service of Roads and Bridges (Corps des Ponts et Chaussées) in 1669 by Colbert, and another one in 1747 when the King's Council decided to found a specific training course for the state's engineers (Vacant, 2002). The students did not have lectures but were supposed to teach themselves Mathematics (mostly Geometry and Algebra), mechanics and hydraulics in parallel with a very long apprenticeship. In the whole, the formation could last between four and twelve years. For the first time, the profession was identified as such.

Alternatively, architects had witnessed earlier recognition since the Renaissance; they differed from the labour worker by progressively specialising in conception and building design (Choisy, 1899). The creation of the Académie des Beaux-Arts, founded by Mazarin in 1648, formalised the profession further. The education was also heavily based on apprenticeship but the school program focused on classical arts and architecture from Ancient Greek and Roman culture. As such, Architecture became a major science, very distinct from Engineering curricula because a clear distinction was drawn between technical and aesthetical programs. But in the same period, first suggestions of a more holistic approach were claimed e.g. the engineer Belidor (1698-1761) stated: "There will come a time when the Surveyor, the Physicist, the Engineer and the Architect will reason alike" (Guillerme, 2008).

The Industrial Revolution was significant in the development of Engineering and the Ecole Centrale des Travaux Publics (Central Engineering Institution of Public Works) was created in 1793 to fulfil new demands. Calculations and materials sciences helped the flourishing of unprecedented structures and buildings, as well as building up a stronger demarcation between the two professions. Engineers and architects didn't use the same project

databases, nor address the same questions. This was the start of a rising tide of strong demarcation about the architect as an artist (who makes things beautiful), while the engineer is a technician (who makes things work) (Allen, 2009).

An expression of this phenomenon can be seen in the shift observed in the design process after World War Two. Due to the incentive of more productivity in a short period of time, the classical design process of 'project from the architect- feasibility studies from the enterprise-technical consultancy' changed to 'technical consultancy- architectural project- enterprise' (Frapier, 2009). However, the failure of the later system shows evidence for the lack of cooperation and the multiplication of participants and phases, as well as the need to change methods. In the 1960s, more voices for integrative design were heard: "[we need] to unify all that. […] of course, it is not going to happen tomorrow, but we must continue in this vein." (Chalandon, 1969). It was in the same period that education of Architecture was separated from the Beaux-Arts and the new structure was often combined with a heavy introduction of courses that dealt with construction, with, for some schools, representing 35% of the teaching program (Frapier, 2009).

Yet, beyond the divorce between structure and space denounced by Giedion (1967), later decades have proven that the debate is no longer about the status of engineers in relation to that of architects -- with clearly controversial issues (such as social recognition, professional demarcation, due credit given for design, etc.); but rather on the improvement of the built environment. As Jean Prouvé already underlined it in 1971, " Architect? Engineer? Why this question, why the debate? It is all about building."

Change in society and change in education

The former French President Nicolas Sarkozy made a strong statement in 2007 at the grand opening of the Cité de l'architecture et du patrimoine (French Institute for Architecture and Building Heritage): "An architect sociologist or poet, this is fine, but an engineer-architect would be better and it is not by chance that the world's best architects incorporate all these dimensions". Despite the fact that his sentence does not really introduce the wider context, the incentive is clear.

After the Thirty Glorious Years (1945-1975), the oil crisis severely hit France and most of the western countries, consequently rising up environmental awareness and questions about our natural resource management. The major increase of urban areas since the 20th century along with an expectation that 70% of the world's population will be urban dwellers by mid-21st century, doubling the existing urban population globally (UN 2011), has caused consequences on public health and living standards. Admittedly, it is after the Brundtland report in 1987 that states around the world have committed to a body of global agreements and actions. Since then, at different paces, in different places, sustainable development has become a driving force to question anew our lifestyles and ecological footprint. Knowing that urban areas currently account for 60-80 % of global energy consumption, 75% of carbon emissions and more than 75% of the world's natural resources, the built environment is without any doubt facing a great challenge.

In France, the volatility of the government's agencies regarding the environment, housing and sustainable development evidences the difficulty to seize up the problem or even to address it. But maybe most importantly is the fact that, still today, architect and engineer training is not accredited, controlled or reviewed under the same agency. The higher education institutions that educate future engineers belong to the Ministry of Higher Education and Research, while the architects belong to the Ministry of Culture. However, first attempts to foster synergies for a common goal appeared in the 1990s, at a time when the Ministry of Ecology and Sustainable Development was eventually created in 1992 and stabilised (notwithstanding a succession of various appendices to its name until today). Synergies were sought at the administrative and political level by, for example, the creation of new strategies to foster urban growth or the implementation of new building regulations; they were also sought at the educational level. Indeed, it was the start of double-degrees in

France, architect-engineer and engineer-architect. The advantage of this double curriculum is to gain a double-degree in a shorter period than the traditional way of doing the two formations. In short, it takes between an average of seven years to complete an engineer-architect double-degree instead of the five years to become an engineer and then five more years to become an architect.

Twenty years later, we were curious to evaluate the impact of the double-degree engineer-architect in the French Engineering and Architecture education landscape and the teaching and professional outcomes of this double-degree.

Method and results

Method

Our approach relies on the analysis of two types of surveys. The first survey covers the national level, which is aimed at forming a comprehensive view of the different types of existing double-degrees in France, as well as looking at their quantitative outcomes. It was initiated by the Ministry of Culture (in charge of the Architecture training) in 2010 and consisted of a questionnaire that was sent to all twenty-two schools of Architecture in France. It asked about the possible existence of a double-degree, and if so, under which teaching form (organisation, hours and courses per year, credits) and with which results (success, number of drop-out and failed students).

The second survey is a two-fold research, developed locally in France by both authors, at the Strasbourg National Institute of Applied Sciences (INSA thereafter). The first aspect was to monitor the history of the implementation of the double-degree and the changes in the curriculum since then; whereas the second aspect was to assess the qualitative outcomes of this training on the enrolled students, who were also solicited once they became professionals. As such, it has been a ten-year study, relying on the archives of teaching programs, interviews, questionnaires and first-hand experience since both authors were involved into the creation and the teaching of double-degree at INSA.

In both types of surveys, the limitations of the study were the response rates (below 50% in the national survey) and the lack of systematic records that may bias the available documentation and results.

A national portrait

In Europe, several countries have developed education in Architecture with a close proximity to Engineering. An architect-engineer diploma exists in Germany, Austria, Netherlands, Belgium and Greece and national legislation usually regulates the allocation of tasks among professional bodies. Yet, great variety exists in the different form of training and since 2005, the European Commission has requested several criteria to be fulfilled; which in turn grant the European recognition in training as an architect, through double-degree or not. Among them, the length of full-time study is pronounced as: “training as an architect shall comprise a total of at least four years of full-time study or six years of study, at least three years of which on a full-time basis, at a university or comparable teaching institution” (directive 2005/36/EC, section 8/46/1). But content is also a major point, which should “maintain balance between theoretical and practical aspects” and is framed through a list of eleven knowledge sets and skills that future architects should acquire during their training.

In France, the creation of a double degree for engineer-architects and architect-engineers started in 1990, and twenty years later, it was time for assessment. A nation wide study was conducted in 2010 under the governance of the Ministry of Culture and Communications to evaluate twenty years of double-degree curricula existing in nine higher education institutions teaching Architecture, out of twenty two, and in partnership with twelve higher education institutions teaching Engineering. It aimed at assessing the different types of curricula that offer a double-degree in Architecture and Engineering, as well as comparing them in order to forecast a national strategy for the future.

First of all, the analysis revealed heterogeneity of curriculum as the main feature emerging from the study. Admittedly, that can be partly explained by the fact that this training occurred before the Bologna declaration, which in 1999 installed a system of easily readable and comparable degrees (Bachelor Master Doctorate) and the European process of standardised professional recognition. But, despite complying with the French system of accreditation, it also raises questions and challenges regarding the creation of the double-degrees. The study highlights three main types of training for the engineer-architect double degree (Biau, 2010). The first type is full integration: the student follows, in parallel, courses in Engineering and Architecture during five consecutive years. The second type is semi-integration with at least three years of full-time study in Architecture. The last and third type offers specialised training in Architecture after graduation in Engineering and the completion of some architectural electives during the Engineering training.

In the above three cases, the Architecture degree is gained two or three years after graduating as an engineer, with an interval of 1500- 3000 hours of courses compared to the 3400 hours in the sole Architecture degree. It is noted that the double-degree training does not provide uniformity at the occurrence of teaching because it can occur at the undergraduate or postgraduate level, with a clear preference for the later. The inventory of the situation reveals the different experimentations but, most surprisingly, the difficulty of the different institutions to comply with changing national and European regulations. In fact, as of today, only one double-degree in Engineering and Architecture is recognised by the European Commission. This questions the validity of the double-degrees offered in other institutions, while underlining the challenges at stake.

Another interesting outcome of this national survey concerns the amount of students who graduated the double degree. In twenty years, 180 engineer-architects have trained (as opposed to 82 architect-engineers by comparison) (Heyde, 2010). In France this number represents 0.6% of the trained architects over the same period. This is very low, and once again, interrogations arise regarding the difficulty of the training e.g. double workloads, the lack of interest or awareness of its potential, lack of advertisement, and also the lack of incentives to develop the degrees.

Lastly, in assessing the implemented strategies for the engineer-architect double-degrees in France, the study clearly acknowledges that further qualitative aspects were not taken into consideration. For example, the type of courses to be taught or the practical skills developed were not investigated. However, some institutions had already undertaken these aspects, as part of their internal evaluation of the double-degree training or had chosen to investigate it on their own initiative in parallel with the launch of the national study. The following paragraph display one of these contributions.

Qualitative considerations through experimentations, development and maturity

The existing, and almost mature, model of engineer-architect double degree at INSA is the result of several years of experimentation and testing. The main challenges were to define the starting period of training for the engineers, under which form, and whilst complying with national and European legislation. The background of the institution proved to have been a good basis for the earlier experimentations.

Indeed, Strasbourg INSA is the only higher education prestige university-college level in France with competitive entrance examinations that provide education both in Architecture and Engineering with qualifications in the building trade such as Civil Engineering, land surveying, and Climatic Engineering. This characteristic has always been valued through the teaching of Engineering to Architecture students, and since the 2000s the other way around, which, without any doubt reflects the growing interest in a more sustainable built environment. First experimentations concerned land surveying students and Architecture students, with 24 hours of face-to-face and at least 48 hours of collaborative work. It was shortly followed by experimentation with Climatic Engineering and Civil Engineering with

more or less the same teaching principles. The first analysis (Dupre et al., 2008) evidenced that transfer of knowledge was intensive under the collaborative sessions but adaptation to the scientific culture of the other professional body remained the main obstacle. By scientific culture, we mean scientific language, problematisation, conceptualisation, method and approach to deliver 'results'.

Based on these conclusions and the other constraints, a double-degree training was established with a strong emphasis given to student motivation, and design projects at the core of the teaching, collaborative sessions and the recognition of its own identity and demands (distinct from the classical Engineering and Architecture trainings). Although internal fights showed the fear of producing half-skilled professionals in both Engineering and Architecture, the present system today is the only French double-degree recognised at the national and European level.

It could be classified as a type II from the national survey and consists of a program of 450 hours prior to joining the classic Master in Architecture (figure 1). Students need to be very motivated because they undergo two entrance examinations (to start the training and then to enter the masters level), on top of the regular assessments and final exams that punctuate their training. They are also recruited during their last year of their Bachelor in Engineering and despite the fact that only one day a week is dedicated to their double-degree training, it still means more work and the necessity of a certain maturity to take distance from the Engineering training. This is the reason why 20% of the students leave the program after the first six months, which is the same number at the national level. On the whole, 80% of the formerly recruited Engineering students will graduate as architects, after a lengthy period of eight years, instead of seven. This evidences the specific needs for these particular students.

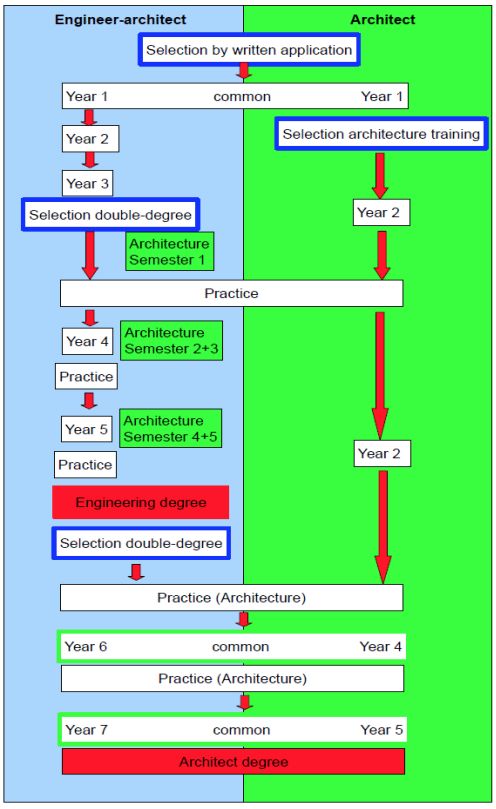

Figure 1: Organisation of the engineer-architect double-degree at Strasbourg INSA.

For example, regular student evaluations suggested an increase in theoretical knowledge, in order to acquire, for example, a better architectural vocabulary and references, which

confirmed our approach. After more than ten years of testing, the training now offers courses with the following emphasis: design project represents 60% of the seven year training; theoretical courses (architectural theory, theory of design, history of Architecture, urban geography) represent 30% and 10% is allocated to develop practical skills such as drawing, software and communication (table 1). As such, and historically, the program went from a 100% design project-oriented to 60%, thus evidencing the importance of the cultural 'sideways' of Architecture training.

Table 1: Main fields of teaching in the engineer-architect double-degree training.

Engineer-architect course
Distribution of teachings

	TOTAL	ARCHITECTURE	CITY and LANDSCAPE	EXPRESSION and REPRESENTATION	STRUCTURE and BUILDING	RESEARCH and OPTIONS
YEAR 1	442			182	260	
YEAR 2	274	56		174	44	
YEAR 3	332	54		118	160	
YEAR 4	530	312	16	84	118	
YEAR 5	312	154	32	66	28	32
YEAR 6	908	144	288	180	234	62
YEAR 7	448	276	104		36	32
TOTAL master	3246	996 30,7%	440 13,6%	804 24,8%	880 27,1%	126 3,9%

Upon deeper qualitative consideration, the 'co-learning method' with landmark moments in all-year round design studio and the 'final year graduation studio' seem to be an accelerated process of learning. In these situations, students learn from their peers but also transversally from older and younger peers, and from those in other disciplinary fields. For their future professional life, it is often a time to create networks, test them and strengthen them, as well as to experiment team management.

Much like surveys that were conducted on other double-degree programs, results concerning the outcomes for the graduated students of double-degrees identified two main aspects (see for example Bousquet, 2010). The first relates more with feelings or impressions gained from the double-degree. Usually, the graduated students assumed a sense of being more skilled and having a wider culture. This allows them more self-confidence while simultaneously having the prospects of more professional opportunities. The second aspect is related to the pragmatic benefits of the double-degree training. Usually it is seen as an added value because these graduates are perceived as having a more complete training in the building industry. It allows more legitimacy, a diversified field of practices and more empowerment in the project management. This is also concretely expressed by higher incomes than the national average (Bousquet, 2010).

But maybe the most interesting finding is the emergence of a new type of profession for which almost all the double-degree engineer-architects felt they were highly qualified for: as an facilitator between the two professions. Furthermore, some of the early graduates have deliberately chosen this path for their professional life. At INSA, it is even more obvious with those holding a double-degree in Climatic Engineering and Architecture. Not only do the graduates play a major role as a facilitator, but they are also at the origin of another type of specialisation concerning the outside envelop of buildings and their energy efficiency. As such, the results of these studies evidence that this new type of training provides a good opportunity for renewal of professionals in both industries since the biggest outcomes are the creation of new qualifications and job profiles.

Conclusion

Although contemporary training in Architecture always embeds the knowledge of Engineering, which has more or less developed in France, the recent incentive from the

French government to take a comprehensive view of the double-degree in Engineering and Architecture was also the opportunity for our research project to size up the actual changes at both local and national levels as well as to analyse qualitative outcomes. This is important at a time when industry, under increased sustainable principles, is looking for new types of professionals. Our research measured the impact of the double-degree engineer-architect in French Engineering and Architecture education landscapes and the teaching and professional outcomes of these double-degrees through a case study. With this concern in mind, the findings clearly underline the innovative and incubating role of double-degree training, despite being in an experimental stage and the very little amount of graduates over a twenty-year period (only 180). Indeed, the creation of new job qualifications in both the Architecture and Engineering industry, e.g. specialist of buildings' outside envelop, and facilitators between architects and engineers, show evidence of the resourcefulness and relevance of such training, as well as its great input to participate to the renewal of both industries.

Yet, this type of assessment also questions the teaching of construction in Architecture. As we have seen in the historical overview, French training in Engineering and Architecture has had a long tradition of being very distinct in France, but should this situation persevere? Should we understand that the double-degree case study suggests the end of such dichotomy? This is what is believed at Strasbourg INSA, for a drastic recast of the architecture training conducted by the institution offers a systematic double-degree in Architecture and Engineering.

Finally, this type of study may be useful to other higher education institutions worldwide because it intrinsically questions our relationship to the built environment and the role of education. The double-degree is one type of answer but when the context changes so much, other innovations might be worth testing. As Biau (2010) analysed it, several factors are today improving the concurrence in the built environment, and they might be considered as paths to explore. They are the increase of digital technologies that break the traditional boundaries where "architects drew what they could build and built what they could draw" (Mitchell, 2001); the globalisation which induces the transformation of marketplace and new types of international relationship with new models shaking the traditional systems and professional legitimacy; the concern and the opportunity of sustainable development and the reshaping of the educational system, which should adapt, forecast, and innovate.

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