People place process: a self reflection tool to become a professional in design thinking, based on Pedagogical Action Research

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The nature of design thinking projects requires a great capacity to solve situated-inquiry problems (versus technical problem solving, Schön). Design thinking requires practitioners to become reflective professionals. This piece of research provides a protocol and tools to guide their journey of self-reflection:

- A new action research protocol (derived from Pedagogical Action Research) for design thinking practitioners.
- A conceptual framework (People Place Process) to guide design thinking development, in both academic and business environments.
- A scale-up model to develop design thinking pedagogy at the scale of an individual educator, a university and a government.
- An activity framework for both academic and business users to identify competences developed with (and required for) design thinking projects.

Pedagogical action research represents the oldest strand of action research. It has roots back in the Science of Education movement in the late nineteenth century (Bain, Boone). It has then revived in the early twentieth century by the work of John Dewey. The ultimate goal of reflective teaching is to develop teachers’ skills in "reflection-in-action", i.e. their ability to frame and reframe problems, find solutions instantly on the basis of their interpretation and analysis of the situation, and construct new meanings and directions for future actions (Schön). The protocol and tools developed in this research have been adapted to design thinking projects, both in academics and companies.
People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research

Véronique Béatrice Hillen
People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Dit proefschrift is goedgekeurd door de promotoren en de samenstelling van de promotiecommissie is als volgt:

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Amazing students who were inspiring

Thank you all of you
to make our dreams happen every day!
To all the people who inspire me
“When we love, we always strive to become better than we are. When we strive to become better than we are, everything around us becomes better too”.

Paulo Coelho, The Alchemist
Foreword: How to read that piece of research?

Pedagogical action research represents the oldest strand of action research, reaching back to the Science of Education movement in the late nineteenth century (Bain, 1879,1 Boone, 1904)2 and revived in the early twentieth century by the work of John Dewey (1910,3 1929,4 19385). Its aim is to improve the teaching practice of faculty by reflection in and on action.

The ultimate goal of reflective teaching is to develop teachers’ skills in “reflection-in-action”, i.e. their ability to frame and reframe problems, find solutions instantly on the basis of their interpretation and analysis of the situation, and construct new meanings and directions for future actions (Schön, 19836): “An artful teacher sees a child’s difficulty in learning to read not as a defect in the child but as a defect of his own instructions” (p. 66). Each student is unique and faculty need to practice reflection-in-action in order to adjust their pedagogy to students’ reactions, especially in difficult contexts.

The nature of design thinking projects requires a high capacity from both students and faculty to solve situated-inquiry problems: on one hand, such projects require an inquiry into a problematic situation, which turns into a frame experiment; on the other hand, they generate unexpected reactions from students that faculty has to deal with in real time. As a consequence, design thinking pedagogy requires the development of skills in situated-inquiry problem solving: such skills are required not only from students to solve wicked problems and problematic situations, but also from faculty, who should explore such problems with them and deal in real time with students’ (and possibly partners’) reactions.

Situated-inquiry problem solvers face other challenges than technical problem solvers:

Table 1. Technical versus situated-inquiry- problem solving enriched and adapted from Schön, 1983

<table>
<thead>
<tr>
<th>Professional problem-solving</th>
<th>Situated-inquiry problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Professions based on...</strong></td>
<td>... science</td>
</tr>
<tr>
<td><strong>Problem inquiry is...</strong></td>
<td>... reflection on a given situation (people, time, location)</td>
</tr>
<tr>
<td><strong>Main questions are...</strong></td>
<td>... a manipulation of available techniques to achieve chosen ends in the face of manageable constraints</td>
</tr>
<tr>
<td><strong>Main questions are...</strong></td>
<td>... an inquiry into a given problematic situation, which turns into a frame experiment</td>
</tr>
<tr>
<td><strong>Consequences are...</strong></td>
<td>Have I selected the right problems from my stock of known problems? Have I selected the right problem-solving techniques from my stock of known techniques?</td>
</tr>
<tr>
<td><strong>Consequences are...</strong></td>
<td>Have I inquired enough into the problematic situations to understand its uniqueness and different components? Have I reframed in the appropriate manner for the context and in an actionable way? Have I found appropriate solutions with a positive expected impact on the given situation?</td>
</tr>
<tr>
<td><strong>Consequences are...</strong></td>
<td>Reliability when problems are well defined with known techniques of solving but limited in contexts of ambiguity and uncertainty.</td>
</tr>
<tr>
<td><strong>Consequences are...</strong></td>
<td>Validity when ill-defined or super wicked problems with unknown solutions, but time consuming and limitations in scaling up.</td>
</tr>
</tbody>
</table>

As a consequence, faculty, especially in design thinking, needs to become reflective professionals. Research cycle starts with a need identified by the teacher: how “to identify, clarify and resolve a problematic situation in practice”. The pedagogical action research protocol suggested is a reflective process to improve their practice. It is derived from McKernan (1996), Norton (2009) and Kemmis and McTaggart (1982). Norton (2009) and McKernan (1996) defined a set of assessment criteria for PAR, which seeks to improve some aspect of practice: it should be cyclical, reflective, participative, determined by practitioners; it needs systematic enquiry and rigor. McKernan (1996) suggests to define and use a conceptual framework, in order to analyze data. He is the only one who has extensively formalized all the relevant qualitative methods in PAR with his seminal books (1991, 1996). Observational and narrative research methods in the form of narrative case studies with a conceptual framework were chosen for this piece of research.
The rigorness and access to data collection is a key criteria of quality for such research. That is the reason why data records have been created and are available online. Data collection through data records include different types of data (students’ reports, presentation, field notes, videos, etc.) and are structured as follows:


For narrative case studies, the transparency of self-reflection and the rigorness of analysis thanks to a rigid five-step process (situate, plan, act and observe, reflect, improve) for each project and each academic year are key criteria of quality for such a research. All of them are available in appendices (chapter 7, 125 pages, with one section for each historical era: 7.1, 7.2, 7.3). Overviews per academic year are available in chapter 3 with one page for each academic year. For each historical era, reflection according to the conceptual framework is given.

McKernan (1996) advised to carry out longitudinal reflection according to a conceptual framework. This piece of research has identified the following framework in the course of pedagogical action research: People / Place / Process. Such framework represents a guidance tool for teachers to develop design thinking pedagogy and to analyze students’ outcomes. New tools to develop and improve design thinking pedagogy represent scholarship contributions of this piece of research:

- A new PAR protocole adapted to professors in DT pedagogy
- A conceptual framework to guide DT pedagogy development: PPP framework
- Scale up model to develop DT pedagogy at the level of a university
- An activity framework to identify competences developed with design thinking

Limits of this piece of research lie in the imperative to adapt design thinking to local cultures, types of produced artefacts, users for which such artefacts are created. The importance of making such adaptations reinforces the importance of pedagogical action research: Self-reflection in and on action is a key factor of success to improve one’s practice.

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Different types of action research for different purposes

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Seven main characteristics of pedagogical action research
Three main models specific to pedagogical action research
Model 1 theories as scientific action research
Model 2 theories as practical-deliberative action research
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My journey of practice: three historical eras combining three types of purposes

Pedagogical Action Research Procedures

Three relevant models: McKernan, Deakin, Norton
The choice of a relevant method: narrative case studies

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Learning from practice through iterative cycles and pedagogical action research
A research procedure adapted for design thinking pedagogy
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PLAN: The how for the what
CHAPTER 01 > The why and the what

ACT & OBSERVE: The what and how in action
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Consequences: stage gates for product development processes in companies

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Quick overview of lessons

Conclusion: Is it useful? Is it adaptable? Is it transferable?

Second historical era: developing an international program (2009/2012)

Data presentation of ME310 Paris

Quick overview of lessons

Conclusion: Is it useful? Is it adaptable? Is it transferable?

Third historical era: Creating a d.school (2012 to now)

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Quick overview of lessons

Conclusion: Is it useful? Is it adaptable? Is it transferable?

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Building my culture of design thinking

Contribution to PAR on DT: The PPP conceptual framework

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Sitatue: The oldest French engineering school with an inspiring expedition at Stanford
Plan: French multidisciplinary projects
Act & observe: Dream or hell teams?
Reflect: A need of a common language
Improve: No talk, action is needed!
Epilog to my second year in pedagogy at ENPC

Learning about a culture of design thinking

PEOPLE
PROCESS
PLACE

2008/2009: A stay at Stanford with a new track at ENPC
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Which hope for sustainability? How to combine it with design thinking?  
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Back to ENPC  

Plan: First edition of Innovacteurs  
Act & Observe: Concept generation, with (almost) no tangible outcome  
Reflect: Emerging pedagogical issues for the teaching of design thinking  
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Learning about a culture of design thinking  

PEOPLE  
PROCESS  
PLACE  

Conclusion: Is it useful? Is it adaptable? Is it transferable?  

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Design fiction is not design thinking  
In emerging countries, extreme innovation may have a big impact  
Design thinking in a hospital is promising  
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Innovacteurs: Teaching design thinking should be a focus for all disciplines  
Improve: Sense making and implementation, the core of design thinking
Learning about a culture of design thinking

PEOPLE
PROCESS
PLACE

2010/2011: Briefs matter to do design thinking or not!

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Plan: The 2nd edition of ME310 and mono teams for Innovacteurs
Act and observe: How can implementation happen
   Innovacteurs 3: Brief and access to the field matter
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Learning about a culture of design thinking

PEOPLE
PROCESS
PLACE

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Learning about a culture of design thinking

PEOPLE
PROCESS
PLACE

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CHAPTER ONE

The why and the what

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Why a PhD? Why this subject?

Summary of the section

After seven years of international business and a corporate strategic renewal, the challenge of creating the first curriculum on intrapreneurship in a top French engineering school based on the combination of supply chain management and product design, gave me the opportunity to discover a new kind of pedagogy at Stanford University, based on empathic making. From knowledge dissemination to experiential learning, this new emerging transdiscipline called design thinking requires faculty to learn how to become educational practitioners of a different kind, able to stage the best conditions for their students to innovate. The ability to reflect on one’s practice through an appropriate pedagogical action-research protocol has emerged, from my experience, as an efficient way to learn how to become a reflective educational professional in teaching and developing design thinking pedagogy.

From a business background in corporate strategy to academia

During my seven years as CEO of Euroconsult, the global satellite industry think tank, I faced the operational challenge of resuscitating a near-bankrupt business. Despite my success in doing so, I had no idea how I did it. Relying on instinct to be successful in business was frightening. Would I be able to do it again? I felt the need to reflect and to learn more. Despite two Masters degrees (one in business from ESCP Europe and one in innovation management from Centrale Paris), I had to do a Masters in research before tackling a PhD.

My research Masters at CNAM was linked to my practice of strategic rejuvenation. I drew extensively on the work of Charles Baden Fuller (1994, 1995). I wrote a case study on the strategic shift of a state-owned

company (SCIC Gestion owned by Caisse des Dépôts et Consignation, transformed into ICADE Patrimoine from 1998 to 2005 by its CEO, Jean-Claude Leullier).

The opportunity to teach corporate strategy at École des Ponts (ENPC), France’s one of the oldest engineering school, led on to the opportunity to become academic director of one of its 6 departments (Industrial Engineering Dept.). The challenge of renewing it jeopardized my initial PhD plan and offered an unexpected adventure in academia.

An attractive challenge: How to educate intrapreneurs

My motivation in joining ENPC was based not only on its historical values, a balance between the pragmatism of my family and the intellectual path of my studies, but also on the expected benefit to my country in the creation of the first curriculum in intrapreneurship.

Educating future French captains of industry became the new mission of the Industrial Engineering Dept. at ENPC. Given the need for French companies to rejuvenate their mature businesses (Stopford and Baden Fuller, 1994), the question is how to educate future leaders who are able to combine exploitation and exploration (March, 1991; Martin, 2009), i.e. the administration of existing businesses and the creation of new ones. My plan was to develop a curriculum based on the combination of product innovation and supply chain management, which also incorporates the dimension of sustainability.

I quickly discovered that – after 20 years of success in technical expertise for offshore platforms and the automotive industry – the department was experiencing a dramatic fall in student applicants. It was no longer at the heart of the school, which had been positioned in civil engineering for over 250 years. With no title, no budget and no team, could I achieve a strategic renewal in an academic environment? It would mean hard work, dedication and ingenuity, with little probability of success. If I could achieve it in these conditions, I could achieve it anywhere…

ENPC’s values, a source of inspiration for leaders as makers

The values of an ENPC engineer, as laid down by its founder Perronet 250 years ago, were a strong source of inspiration in defining the desired profile of an intrapreneur:

- capacity to both conceive and produce;
- capacity to communicate, whether with a minister or a site worker, whether in writing or verbally;
- capacity to incorporate into the completed work state-of-the-art techniques, the environment, aesthetic qualities and benefits for users;

• capacity to use mathematics to solve technical problems and find aesthetic proportions;
• capacity to organize work to produce both quantity and quality;
• capacity to include aesthetic criteria and to be both engineer and artist;
• values of solidarity, community, mutual respect, intergenerational transmission;
• importance of practice and self-learning through the completion of projects;
• importance of the competition and the workshop as a source of collective emulation and individual improvement;
• importance of proven multidisciplinary to in order to create a “nursery of young talents practicing all forms of production, from French essay writing to artistic drawing”, including along the way stone cutting and woodcarving.

Such values still represent a perfect manifesto for today’s pedagogy in innovation.

My move from business to academia was motivated by the feeling to achieve a national mission (the education of a generation of future leaders, both entrepreneurs and intrapreneurs, who would foster a new wave of growth) and to contribute to the renewal of an old French Grande École, which was a sleepy beauty historically wired for this challenge (see appendix 8.6: “ENPC, an old engineering school founded on experimenters and makers »). I knew that the journey would be long and challenging.

First experiments with multidisciplinary teams: is it worthwhile, or even possible?

As an academic director and professor, I was in charge of creating a curriculum in innovation for the Department of Industrial Engineering. The curriculum plan was for a class in the first semester, and the collaboration between multidisciplinary teams and other schools in the second semester. I was responsible for teaching the Masters-level class for industrial engineering students (ecobootcamp) and for co-organizing the multidisciplinary teams.

The class was satisfying in terms of its goals of disseminating knowledge about innovation and providing a practical exercise. On the knowledge side, I gave lectures on broad innovation topics. On the practical side, I asked students to conduct case studies on sustainable innovation. I adapted a creativity workshop developed by a colleague at ENPC into a practical assignment for the design of a collective game, including needfinding, prototyping and testing in class.

Apart from this practical exercise, this first year of pedagogy in innovation at ENPC was modelled on lectures in the style of Marc Giget, holder of the Chair in Innovation at Conservatoire National des Arts et Métiers, founder of Euroconsult and the Innovation Directors Club (including an online platform of over 250 videos of global best practices). Together, Marc and I have written a book on corporate strategy (Giget, 1998)12, and have developed many workshops for companies in

innovation and corporate strategy. Our school of thought was influenced by the study of innovation dynamics in the Universal Exhibitions during the Belle Époque.

After two multidisciplinary “chaîne de l’innovation” team sessions in collaboration with five schools from different disciplines and two consulting companies (see appendix 7.1: Overview on my first multidisciplinary courses in 2006/2007), I felt depressed by the mismatch between the high investment of resources and the low level of outcomes (powerpoint presentations with no sense-making and little if any team collaboration between disciplines) and by my students’ disappointment with the collaboration between different disciplines. I decided that if I couldn’t find other ways of teaching multidisciplinary teams, this kind of organization was not worth the effort, either in terms of delivering a learning experience or in terms of project outcomes.

**Hope: my 2007 encounter with Larry Leifer**

I met Larry Leifer and his team in Paris in the summer of 2007. Larry Leifer was a tenured professor at Stanford University’s mechanical engineering school and in charge of a global innovation program with leading companies, at the time called ME310 Design Entrepreneurship (and now labelled Design Innovation). I was organizing an Innovation Award Ceremony with a consultancy company (BearingPoint) and a French economics journal (L’Expansion). I told them about my difficulties in teaching multidisciplinary teams. He invited my school to come and visit them at Stanford, in order to discover what they were doing, and how they went about it. The learning trip was inspiring and energizing: the quality of the projects and partners was impressive. The curriculum was based on project learning, with almost no lecturing. It embodied the shift from knowledge dissemination to experiential learning. Making was the core of the pedagogy.

After this first learning expedition to Silicon Valley, I compared Stanford’s d.school movement with MIT’s FabLabs movement: the former focused on empathic design for people, the latter on creating artefacts with digital workshops. The first seemed a more fruitful way to foster innovation and more ambitious – even if riskier – in terms of learning objectives for an engineering school. I decided to join the global movement Stanford’s d.school because of its human-centric approach and aspirations for major societal impact.

What impressed me most during that learning expedition was how Silicon Valley was consciously or unconsciously driven by a common culture based on empathic making. I was also struck by Larry’s view that: “Our job as academics is to create the best possible conditions for our students to innovate.” As a former CEO, I could understand this level of responsibility. In order to learn my job as an academic, I employed the same three lenses (place, people, process) as a CEO, in order to analyze how to do things and identify what needed to be done.

“*Our job as academics is to create the best possible conditions for our students to innovate.*” This statement by Larry Leifer at Stanford in February 2008 has become an inspiring motto for deciphering and staging the culture of design thinking.
Definitions of pedagogy, course, curriculum, learning experience

Pedagogy is the discipline that deals with the theory and practice of education; it thus concerns the study and practice of how best to teach. Its aims range from the general (full development of the human being via liberal education) to the narrower specifics of vocational education (the imparting and acquisition of specific skills). A class or a course is a series of periods where students study a subject under the supervision of a teacher. The term curriculum refers to the lessons and academic content taught in a school or in a specific course or program. An educational program is a program written by the institution or ministry of education, which determines the learning progress of each subject in all the stages of formal education. By extension, a program can be defined by a series of courses on a specific subject, which is developed by a department of an university or school.

Learning experience refers to any interaction, course, program, or other experience in which learning takes place, whether it occurs in traditional academic settings (schools, classrooms) or nontraditional settings (outside-of-school locations, outdoor environments), or whether it includes traditional educational interactions (students learning from teachers and professors) or nontraditional interactions (students learning through games and interactive software applications).

Objectives: how faculty can learn to develop design thinking pedagogy

As presented in Banerjee and Ceri Eds, 2016, a global movement in both universities and companies has been initiated on the assumption that multidisciplinary teams can solve complex, large-scale problems and design thinking represents a promising way to tackle the following needs identified:

- The need to tackle wicked problems differently than by linear analytical thinking (Banerjee);
- The need for companies to create Blue Ocean strategies (Kim, Mauborgne), which means developing brand-new offerings of products/services with potential for a growth wave;
- The need to foster a culture of exploration in order to create new businesses and to rejuvenate existing companies (Martin, March, Baden-Fuller, Volberda);
- The need to renew a curriculum driven by abstract thinking, by reconciling the right and left brains (Pink, Martin) in higher education in a way that combines the hand, the mind and the heart (Junginger, Buchanan);

References:

• The need to foster creative confidence (Kelley) in order to generate solutions.

I quickly realized that delivering high-quality education in design thinking was of paramount importance in the growing global university movement. A central element of my quest was our ability as a faculty to achieve professionalism in the pedagogy of design thinking: how could I develop the skills needed to develop and teach this specific kind of pedagogy? This question is of course crucial to delivering high-quality education. In my experience, a number of factors make this kind of pedagogy very different from traditional pedagogies.

It represents a move:

- From knowledge acquisition to learning by doing and reflection, which includes state of mind and know-how;
- From well-defined problems to ill-defined and wicked problems;
- From right/wrong answers to appropriate solutions for a given context;
- From briefs given by teaching teams to real-world challenges with partners;
- From problem analysis to solution generation;
- From analytical thinking to pragmatic and abductive thinking;
- From thinking and creativity to doing and implementation;
- From a positivist epistemology to pragmatism;
- From individual to team evaluation;
- From concept generation to outcomes with real impact and implementation;
- From reframing to creating positive impact in a real context;
- From sales pitch to learning story.

This kind of pedagogy constitutes a radical paradigm shift not only for learning but also for teaching. It requires new skills from faculty involved in real projects with real impact on society: faculty members teach innovation by real practice and engage with students by conducting hands-on projects in the field.

All these specific elements create the need for faculty to learn new ways of teaching. How can faculty acquire those new skills, given that such teaching is based on practice with real projects and students in the field? How can they develop such pedagogy without an official educational program? There is no identified educational program available for faculty interested in developing design thinking pedagogy, so they need to develop one from scratch, to experiment and improve. One can learn design thinking from books. One can have the privilege of attending workshops with experts from consulting companies. One can have the good fortune to join a teaching team
with expertise in that field, such as those at Stanford’s d.school, and to learn as a participant-observer. Some tipping points can be identified through such courses, which then need to be adapted to one’s own context.

Even with such privileges, such a pedagogy (be it a course, a program or a d.school) presents great challenges for faculty, including:

- Defining an appropriate brief for students and a partner,
- Staging a space,
- Developing a curriculum,
- Dealing with corporate partners with real stakes in companies,
- Managing the dynamics of student teams,
- Managing the variation in terms of student performance each year,
- Adapting to new projects and partners each year.

This kind of pedagogy is full of challenges and therefore highly risky in terms of student satisfaction, outcomes and skills development. It is a new type of education, which involves different departments. In the face of such challenges, the initial enthusiasm of interested faculty may quickly fade after the first experiment, in favor of traditional pedagogy, especially where there are other professional commitments, such as research and publication.

After a first year of teaching design thinking, I realized that what might work with Masters-level students at Stanford did not work with the Masters-level students from a top French engineering school. I needed to self-reflect and adapt my teaching: for example, explaining the why, the what and the how was a prerequisite in convincing students to go hands-on. After a couple of years of practice, I also became aware of other risks, including the risk of repeating the same mistakes year after year and failing to adjust sufficiently to the context and students. The question I faced, therefore, was how to improve my practice of teaching design thinking from year to year. I was very struck by my reading of Schön (1983), which offered another way to develop knowledge from practice. I started considering how I could become a reflective educational practitioner. Unable to find any case studies or specific literature, I decided to dig into the literature of action-research, especially in pedagogy. Even if applied to different contexts and purposes, pedagogical action research – as exemplified by Bain, Boone, Dewey in the early 1900s, then Taba, Brady and Corey in the 1950s, and more recently McKernan, Norton and Kemmis in the 90s – offered promising avenues to improving the teaching of design thinking.

Our research question meets the seven major characteristics of pedagogical action research (PAR) as described by Norton (2009) from Kember (2000): Education is a social practice; PAR is aimed towards improvement of some aspect of the practice, as well as contributing to knowledge
(added in 2012, Norton)\textsuperscript{17}; it is \textbf{cyclical}, with a successive number of spirals which should progress in a logical way (Kember, 1997)\textsuperscript{18}, but are more likely to diverge in the practice (Norton, 2009), \textbf{reflective, participative} and determined by the practitioners; it needs \textbf{systematic enquiry} and rigor to be recognized as a research strand.\textsuperscript{19}

The use of appropriate pedagogical action-research protocols was very helpful in improving my practice. I am therefore firmly convinced that Pedagogical Action Research is an efficient way for faculty to learn how to develop design thinking (DT) pedagogy and to become professionals in DT pedagogy, by systematically analyzing one’s practice and drawing lessons to improve the student learning experience and project performance.

From knowledge dissemination to project developer, my conviction is that faculty interested in design thinking pedagogy need to learn from reflecting in and on action (Schön, 1982)\textsuperscript{20}, in order to make the transition from experts in a given field to reflective educational practitioners with real projects. Pedagogical action research offers faculty a framework for improving their practice and becoming professionals of teaching design thinking. It also offers a unique opportunity to combine teaching and research objectives.


Three contributions to scholarship on design thinking pedagogy

Summary of the section

Teaching innovation based on design thinking requires teachers to make dramatic changes in pedagogy, a transition from knowledge acquisition and dissemination to the “ability to create the right conditions for students to innovate” (Leifer, 2009) from teacher-centered instruction to student-centered learning (Vinke and Hummels, 2010) through personal transformation based on learning a new culture.

My global research question is how to help academics to develop design thinking pedagogy, with one more specific question for teachers interested in such an adventure: How to become a professional practitioner in teaching design thinking? This piece of research’s hope is to demonstrate that pedagogical action research is an efficient way to become a professional practitioner.

In the long run, the underlying aspiration of my research is to renew the way we educate future leaders, on the basis of the culture of design thinking as practiced with multidisciplinary teams in Silicon Valley, which aims to achieve substantial real-world impact. This piece of research suggests two models of dissemination, one at university level, the other at government level.

My journey as a practitioner

After a stay at CDR (Center Design Research at Stanford) during the academic year 2008/2009 in order to gain personal experience of a program called “ME310 Design Innovation”, I set up a series of courses and programs between 2008 and 2012 at ENPC’s Industrial Engineering Department. My experience as a professor of teaching design thinking, both at local and international levels, has shown how teaching design thinking needs to be adapted to one’s specific cultural situation (in my case, the culture of a leading French engineering school). What works at Stanford did not work in France, for the French need to be fully convinced of the “what”, the “why” and the “how” before going into action. My experience of setting up such courses and programs in France suggests that it is of paramount importance for teachers to construct their own culture in design thinking, in order to it to their context (including types of students, culture, pedagogical formats,


topics, local resources…). My experience as a dean shows that the capacity to build one’s own culture and better one’s practice as a teacher relies on the ability to reflect upon one’s experiences.

Reflection on my practice has led me to develop a metaphor suited to European culture, as a way of eliciting and raising awareness of the culture of exploration: in order to face the ambiguity and risks of innovation, we need to embark on a journey of exploration which requires preparation of a boat, a crew and navigation tools. This kind of culture of exploration is different from a culture of exploitation. The culture of exploration has its own tipping points, which differ dramatically from those of the culture of exploitation and are usually less explicit. Design thinking provides a number of milestones in a culture of exploration (Hillen, 2014) 23, which safely guide a crew through its journey of innovation, in order to create something that makes sense for the people one wants to innovate for.

In order to make the design of my pedagogy more robust, I reflected each year on my practice as a developer and professor of design thinking pedagogy (please see chapter 7 for detailed data collection and analysis). This self-reflection has helped me to develop a conceptual framework (“PPP framework”) based on the metaphor of exploration and on my experience as a manager, in order to guide the development of such courses: people (how to stage people), place (how to stage the place where teams will innovate), process (which tools and methods should be used).

My experience of global teams within the framework of Stanford’s ME310 program gave me the experience and legitimacy to submit and get the green light for the project of creating a d.school in France. In building a d.school, the long-term objective is to inspire as many professors as possible, in France and abroad (beyond d.school Paris’ five academic institutions), from different disciplines and different cultures, to develop such a pedagogy, in order to bring about a fundamental transformation in the way future leaders are educated to become change makers. d.school Paris supports the long-term objective of dissemination among academics worldwide through pedagogical action research. d.school Paris’ mission is to become a model of innovation pedagogy based on design thinking, a long-term project that is financially supported by France’s Agence Nationale de la Recherche 24. It is currently developing resources to help professors become professional practitioners of design thinking pedagogy, which include the following elements:

- An international community based on connections with academic networks such as SUGAR, Como summit and Ashoka;
- A platform with pedagogical resources available for use by teachers;
- The publication of international editions of books that spread the culture of design thinking (such as the 101 milestones for Latin America), which are edited with different professors in different countries and languages;


24 ANR = National Research Agency
An activity-framework, in order to elicit pedagogical activities and competences through education in design thinking;

Pedagogical action research with teachers involved in developing this pedagogy, including a symposium and a published book.

My practice encompasses my experience as a professor of design thinking, both at national and international level, as well as my experience as a dean of a d.school. I have drawn on this experience to develop a scaling up model for universities, which explains how to develop design thinking pedagogy at different levels.

My journey as a researcher

I adapted a procedure from pedagogical action research to reflect on each academic year of practice, with the aim of improving it and reaching higher level of ambition for the development of design thinking pedagogy (a course as a teacher/a program as an academic director/a d.school as a dean). Through 8 years of practice and self-reflection based on this pedagogical action research protocol, I hope that I have become a reflective professional in teaching design thinking from the creation of a course (first historical era of French multidisciplinary teams), to a global program (second historical era of global teams), to a d.school (third historical era of national dissemination). The purpose of the proposed research project is to understand how pedagogical action research is an efficient means to become a professor of design thinking through self-reflection on one’s practice.

My experience from a longitudinal study shows that becoming a professional in teaching design thinking requires:

- self-reflection on practice over time, through
- a structured pedagogical action research protocol (situate/plan/act & observe/reflect/improve),
- a conceptual framework (people/place/process).

Each academic year, I discovered milestones in the culture of design thinking, formalized them according to the conceptual people/place/process (PPP) framework, and reflected on how to disseminate them in a way appropriate to the target audience. Through 7 years of discoveries, practice and self-reflection, I have built my own culture of design thinking which is suited to my situation (people, objectives, artefacts). My hope with this piece of research is to pave the way for other researchers and teachers to embark on a similar journey to becoming a professional in developing design thinking pedagogy.
My longitudinal study demonstrates that becoming a professional in teaching design thinking requires:

- building one’s culture in design thinking over time, through
- identifying, testing and reflecting on “tipping points”, suited to
- one’s objectives, capacities and context.

This piece of research makes three types of contributions to scholarship, set out in the paragraphs below.

**Contribution to theory: two pedagogical action research tools for design thinking pedagogy**

The first contribution is theoretical, with the development of two research tools adapted to design thinking projects, in order to allow faculty to self-reflect on their practice of teaching design thinking:

- A tailored pedagogical action research protocol, structured in 5 steps: situate/plan/act & observe/reflect/improve (Fig. 1.a); this tool is derived from the literature review on pedagogical action research as described in section 2.1.

![Fig. 1.a. 5 steps for an adapted Pedagogical Action Research Protocol for faculty to reflect on design thinking projects](image-url)
• The development of a conceptual framework based on three core categories: people/place/process (Fig. 1.b); this tool emerged from reflection on my practice through pedagogical action research, as described briefly in chapter 3 and in detail in Appendix 7.

Contribution to practice: three historical eras of practice and research

The second contribution is practical, with a longitudinal study of eight years of practice, 74 projects and over 500 students at Masters level. The reflection on practice shows how this practitioner evolved from teaching a course to the position of a dean of a d.school tasked with dissemination, to the role of creating an international ecosystem. The three historical eras identified in that longitudinal study define three levels in the development of design thinking pedagogy:

• Designing a curriculum with multidisciplinary teams of engineers and designers;
• Developing an international program with a global network of over 15 universities and partnerships with worldwide companies;
• Creating a d.school to disseminate practice through the training of professors.

The adapted pedagogical action research protocol, with narrative case studies, has been tracked so that each academic year can be analyzed and measures taken to improve the development of design thinking pedagogy. As a result, “tipping points” in the culture of design thinking were discovered and experienced for each academic year. They are classified in relation to the three categories of the conceptual PPP framework. The “People Place Process” (Fig. 1.b) conceptual framework, which emerged in the first years of reflection as a tool to guide the development of design thinking pedagogy, has guided my practice and reflection over the years through the different historical eras (a curriculum, a program, a d.school). This process of how to build a culture of design thinking thanks to an adapted PAR protocol and the PPP conceptual framework is drawn in the following table 1.
A full analysis of data collection is carried out in Chapter 7.

The identification, experience and reflection relating to tipping points show how a culture of design thinking has been built up over eight years of practice (Fig. 2). This qualitative analysis demonstrates how a reflective practitioner (Schön, 1983)\(^{25}\) becomes a professional in action through an appropriate pedagogical action research protocol and a guiding conceptual framework, the PPP framework. Those two tools are recommended to any design thinking faculty wishing first to learn about this new culture, and second to become a professional. The self-reflection represents both a professional development through research, as well as a transformative personal journey.

The quantitative analysis of how tipping points evolve over time according in each category (Fig. 2) clearly shows two kinds of evidence:

- Firstly, the two peaks in terms of number of tipping points identified in the culture of design thinking match two specific and unique periods in the journey: on one hand, an academic stay at Stanford in 2008/2009 contributed to the identification of most tippings points (33 out of 101) in the culture of design thinking thanks to a full immersive experience, a lot of interviews and observation; on the other hand, after two years with a teaching assistant from Stanford, 2011/2012 was a year of new experiments and new discoveries (23 out of 101) in terms of people and process, in order to adapt my teaching to local stakes, partners, artefacts and students.

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Secondly, the observation over years shows different trends in each category: at the beginning, a lot of tipping points are discovered and experimented in terms of people and place, then the emphasis shifts to process with the development of new tools appropriate to different artefacts and contexts.
Societal impact: two dissemination frameworks

The third contribution is societal, with the development of two reference frameworks, which aim to make an impact on national education systems:

- An activity-framework clarifies the different competences and activities developed by design thinking pedagogy.

- A scaling-up model is a sense-making path to the development of design thinking pedagogy, from a course to the transformation of national education at university level.

![Fig. 4a 10 activity-framework for design thinking](image1)

![Fig. 4b. A scale-up model to develop DT pedagogy based on the PPP framework](image2)

The 10 activity-framework (Fig.4.a) identifies 10 competences developed by and for design thinking. It is a promising tool for evaluating or making students reflect on their own skills development, as well as for structuring curriculum development. The scale-up model (Fig. 4.b) is a tool that can guide faculty in identifying the right path in terms of levels of ambition for design thinking pedagogy. Chapter 5 provides a detailed analysis of the two tools.
Overview of this piece of research

After an introduction (Chapter 1) which describes how the research question emerged from practice, a literature review (Chapter 2) is carried out firstly on pedagogical action research, which results in the adaptation of a research protocol for design thinking pedagogy, and secondly on the expansive scope of design thinking, which results in the identification of the main different strands in product design (design to engineers with a focus on functions and technologies, design to artists with a focus on style and form, design to multidisciplinary teams with a focus on business and experience). The global movement of design thinking is placed within a historical perspective, especially in the academic world, and some tipping points are explained in terms of people and process.

After this literature review, the longitudinal study of eight years of practice and over 90 projects is presented in three parts: Chapter 3 gives an overview of the data collection, which is broken down into three historical eras of practice: designing a curriculum, developing an international program and creating a d.school. Chapter 7 (appendix) describes each historical era in detail, in terms of the adapted pedagogical action research protocol: situate/plan/act & observe/reflect/improve. This protocol has been used for the year by year construction of a culture of design thinking. Each historical era, which represents a higher level of ambition in terms of design thinking pedagogy, will be assessed against three main questions: Is it useful? Is it adaptable? Is it transferable?

Chapter 4 draws the conclusions of this longitudinal study: the construction of a conceptual framework around three categories (People/Place/Process) as a way of guiding the analysis of design thinking pedagogy through pedagogical action research, as well as changes in outputs, place and process over the eight years of practice.

Since its lessons drawn from practice, this research is expected to have an impact on society, with two tools of dissemination as described in Chapter 5: 1) An activity-framework for design thinking, to structure the development of design thinking pedagogy; 2) A scaling up model to develop design thinking pedagogy, from a course to national educational programs, through an international program and a d.school.

In conclusion (Chapter 6), the tipping points identified in the culture of design thinking will be assessed in terms of their impact on universities and companies: Is it useful? Is it adaptable? Is it transferable?
People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
2.1. Pedagogical Action Research: How to reflect on design thinking pedagogy

Summary of the section

This section demonstrates how pedagogical action research can help faculty to become a professional in design thinking pedagogy: only reflection in and on action can help such teachers to learn the culture of design thinking and improve their teaching.

The history of the action research movement shows that education has been one of the main areas of inquiry. This section reviews the history of action research movements that have influenced the emergence of pedagogical action research, the different types of action research and their purposes, as well as existing models for pedagogical action research (McKernan, 1996\(^{26}\), Masters, 1995\(^{27}\) and Norton, 2009\(^{28}\)), in order to define an appropriate research procedure for design thinking pedagogy, as well as appropriate research methods with a longitudinal study, narrative case studies and data records.

This section describes, the first contribution to scholarship of this piece of research, which consists in a research tool to help faculty develop design thinking pedagogy: an adapted pedagogical action research protocol (situate/plan/act & observe/reflect/improve) for reflecting on narrative case studies. In addition, a conceptual framework (People / Place / Process) is suggested from both the literature and first experiments as a structuring research tool. It structures data collection and analysis for this longitudinal study over 8 years of practice.

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Historical background of Pedagogical Action Research

*Kurt Lewin, a father of action research*

Many (starting with Chein, Cook and Harding, 1948) argue that social psychologist Kurt Lewin of MIT was the ‘founding father’ or the main pioneer of action research through his work in the Group Dynamics movement of the post-war reconstructionist period. In the mid-1940s, Kurt Lewin coined the term to refer to a form of experimental inquiry based on the study of groups experiencing problems (1946, 1948). Lewin endeavored to show that democratic participation is an alternative route to greater productivity gains to the autocratic coercion propagated by Taylor through The Principles of Scientific Management. His fieldwork started with providing support for one of his students in dealing with moral problems in the family factory and then extended to a wide range of experimental projects involving social and practical problems such as prejudice, group relations, eating habits, industrial unrest (Marrow, 1969), and military training programs (leadership, techniques of psychological warfare, morale) in post-World War II conditions. He focused on group decisions as a means of effecting social and cultural change. He described himself as a ‘practical theorist’ with a strong belief in the value of interweaving theory and facts. He first conceptualized a graphic model for action research with a series of action steps including planning (a general idea or a difficult problem requiring resolution), fact-finding (or reconnaissance), execution (how to solve the problem) and analysis (an attempt to evaluate the effectiveness of the first action step, to plan the next step and to modify the overall plan). He worked closely with the Tavistock Institute and the related socio-technical school (with researchers such as Trist, Rice, Emery).
Pasmore (2001)\textsuperscript{36} considered the practical and theoretical contributions of these currents to be so closely aligned that the two groups can be described as one school of thought: Lewin’s Field Theory, McGregor’s Theory X and Theory Y, Emery’s principles of work design, Emery’s and Trist’s causal texture of environments. Lewin’s field theory states that the behavior of an individual is a function of both personality and environment. “This theory and related findings became a central tenet of the socio-technical school as well, as it allowed for the possibility that by changing aspects of the workplace, behavioral changes could be produced. It would not be necessary to change the deep-seated personalities of workers in order to produce new behaviors; the potential for a wide range of behaviors, triggered by different environmental stimuli, already existed in the individual” (Pasmore, 2001, p. 40). Both workplace and work influence the behaviors of workers.

**Education as a first root of action research**

McKernan (1988)\textsuperscript{37} shows by careful study of the literature that action research existed before Lewin’s works as a root derivative of the ‘scientific method’, reaching back to the Science of Education movement in the late nineteenth century (Bain, 1879\textsuperscript{38}, Boone, 1904\textsuperscript{39}) and revived in the early twentieth century by the work of John Dewey (1910,\textsuperscript{40} 1929,\textsuperscript{41} 1938\textsuperscript{42}), who applied the inductive scientific method of problem solving as a logic for the solution of problems in such fields as aesthetics, philosophy, psychology and education. Dewey’s stages of reflective thinking contain all the features of scientific action research: suggestion, intellectualization, hypothesizing, reasoning and the testing of hypotheses in action\textsuperscript{43}.

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\textsuperscript{40} Dewey, J. (1910). How We Think, Boston, MA: D.C. Heath


\textsuperscript{43} “The stimulus of thinking (the suggestion) was a practical problem of concern to the scientist. After thinking about the problem in order to understand the dynamics at play, the researcher could begin formulating hypotheses regarding the nature of cause and effect operating among variables that shape the situation. Reasoning comes into play as the researcher identifies and creates theories regarding actions that can be taken to change the outcomes of the system by manipulating the variables. These theories are then tested through experimentation ad observation to determine if the hypotheses are confirmed. For Dewey, practical problems demanded practical solutions. A solution to a problem could only be regarded as viable when it was demonstrated to produce desired outcomes in practice” (Pasmore, 2001, p. 38).
McKernan (1991, 1996) demonstrated that the post-war reconstructionists, such as Hilda Taba and Stephen Corey in the 50s, paved the way for educational action research. There was very strong interest in the 1950s in using action research as a general strategy for designing curricula and tackling complex problems, such as intergroup relations and prejudice, through large curriculum development projects (Taba et al., 1949; Taba, Brady and Robinson, 1952; Corey, 1953). Towards the end of the 1950s, action research fell into decline due to the shift towards the establishment of expert educational research and development laboratories. This reflects the separation of theory and practice, and was manifested through the top-down development strategy of the research, development and dissemination RD&D model, which insulated professional researchers from the teaching ranks. This separation had the negative consequence of preventing researchers from studying problems in the field, particularly innovative practices (McKernan, 1996, p. 11).

A brief history of the main movements which have influenced PAR

Pedagogical Action Research has evolved over time according to the following movements:

- The Science in Education movement (19th century): Bain, 1879; Boone, 1904
- The experimentalist and progressive educational work of John Dewey (1910, 1928, 1938)
- Kurt Lewin’s group dynamics movement (1940s) for social changes in companies and in the army: Lewin (1946, 1948) in cooperation with Tavistock Institute (Trist, Rice, Emery)
- Post-war reconstructionist curriculum development in American education (1950s): Taba et al., 1949; Taba, Brady and Robinson, 1952; Corey, 1953
- The teacher-researcher movement in the UK (1970s) revived by Stenhouse (1971, 1975) and the seminal book by Carr and Kemmis (1986) which is based on critical theory and the philosopher Habermas’ idea of critical social science (1970, 1972, 1974) with the practical aim of emancipating the oppressed

CHAPTER 02 > Literature Review


- Pedagogical Action Research focused on being a practitioner doing action research in higher education (Norton, 2009)

My research question is anchored in the pedagogical action research strand, with a twofold objective as stated by Norton (2009): “Not just to change student learning and individual teaching, important though that is, but to bring about more radical change in which the very nature of higher education should open to critique and fresh perspectives” (p. 50).

Different types of action research for different purposes

The review of action research strands in Adler and Shani (2001) shows that none of them as a research design strategy fits with our research, because of the nature of the research or because of their inclusion of collaboration between researchers and an outside organization: - Action Science (Argyris, 1971, 1999) and Clinical Field Research (Schein, 1987) are forms of behavioral research based on controlled experiment; - Intervention Research (Hatchuel and David, 2008) entails the selection of a pioneering company and the study of its best practices; - Appreciative Inquiry (Cooperrider, 1997) also called Cooperative Ecology Inquiry (Heron, 1996, Reason, 1994)

53 Adler, N., & Shani, R. (n.d.). In search of an alternative framework for the creation of actionable knowledge: Table-tennis research at Ericsson. In Research in Organizational Change and Development (pp. 43–79). doi:10.1016/s0897-3016(01)13002-8
Bravette, 1997; Bradbury, 1998) or Developmental Action Inquiry (Torbert, 1999), seeks to value and recognize the best as a constructive mode of practice, in order to create and maintain change in human systems, and entails intense and interactive collaboration between researchers and a collaborative company; - Participatory Inquiry (Reason, 1995) entails the participation of the researcher as a member of the local within which problems need to be solved.

Adler and Shani (2001) also drew on the ideas of the German critical theorist Habermas (1986) to compare different action research approaches in terms of their purposes:

- Technical purpose: information that expands our power of technical control/manipulation and control of the environment, both natural and social;
- Practical purpose: interpretations that enable action to be orientated within common traditions/meaning to be understood in a specific situation, so that a decision can be made and action taken;
- Emancipatory purpose: analyses that free consciousness from its dependence on hypostatized power/generating knowledge that furthers human autonomy and responsibility.

Even more broadly relating to action research, Kemmis and McTaggart (2005) have given a history of action research divided into four generations (p. 272). The first three generations correspond to the three purposes provided above by Adler and Shani (2001). The fourth generation corresponds to participatory action research, which is not pedagogical in the literature reviewed. In terms of principles, challenges and quality criteria (Kidd and Kral, 2005) focus on process rather than outcome, with an emphasis on replicability. In terms of content, their research domains concern social problems in local communities. This strand of social science may be linked with political movements for greater justice and democracy in the tradition of 19th century social science, where political action and social reform were taking place against the background of social and political upheavals created by the industrial revolution.

References:

Table 3. Different schools of thought in action research

<table>
<thead>
<tr>
<th>School of thought</th>
<th>Raison d’être</th>
<th>Main authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical/positivist (or empirical-analytic)</td>
<td>Essentially oriented towards functional improvement measured in terms of its success in changing particular outcomes of practice. It is a form of problem-solving and it is regarded as ‘successful’ when the defined goal of the project has been attained.</td>
<td>Education: Dewey 1910, 1929, 1938, Taba 1949, Corey 1953</td>
</tr>
<tr>
<td>Practical (or hermeneutic/interpretive)</td>
<td>Has technical aspirations for change, but also aims to inform the (wise and prudent) practical decision-making of practitioners. Practitioners aim not only to improve their practices in functional terms, but also to see how their goals and the categories by which they evaluate their work are shaped by their way of seeing and understanding and changing themselves in that situation.</td>
<td>Design: Schön, 1983, 1987 Education: Stenhouse, Elliott, Elbutt, McKernan</td>
</tr>
<tr>
<td>Emancipatory (or critical)</td>
<td>The aim is not only to improve outcomes, and the self-understanding of practitioners, but also to assist practitioners in making a critique of their everyday social and educational work processes in order to reconstruct not only the practice and the practitioner, but also the practice setting (or, one might say, the work, the worker and the workplace).</td>
<td>Social science: Habermas: 1970, 1972, 1974 Education: Kemmis &amp; Grundy 1981, Kemmis and McTaggart 1982, Carr and Kemmis 1983,</td>
</tr>
<tr>
<td>Participatory</td>
<td>Seeks to resolve prejudice in local communities.</td>
<td>Kemmis &amp; Mc Taggart 2005, Kidd and Kral 2005</td>
</tr>
</tbody>
</table>

Pedagogical action research is a sub-strand of action research, which needs more detailed characterization in terms of theories and protocols in order to position this piece of research within the different schools of thought.

Pedagogical Action Research theories

Seven main characteristics of pedagogical action research

Education is a social practice, as is design thinking pedagogy which takes place within a complex ecosystem (students, partners, the field), with an ill-defined brief as a start for the project. Our research meets the seven major characteristics of pedagogical action research (PAR), as described by Norton (2009)\(^6^9\) from Kember (2000)\(^7^0\): it seeks to improve some aspect of practice (the student learning experience, project outcomes, the relationship with partners, the practice of academics), as well as contributing to knowledge (added in 2012, Norton\(^7^1\)); it is cyclical, with a successive number of spirals which should progress in a logical way (Kember, 2000), but are more likely to diverge in practice (Norton, 2009), reflective, participative and determined by the practitioners; it needs systematic enquiry and rigor in order to be recognized as a research strand.

Three main models specific to pedagogical action research

McKernan (1996, p. 3-34\(^7^2\)) defined three models specific to pedagogical action research, a brief and enriched overview of which is provided below.

Model 1 theories as scientific action research

Model 1 theories are referred to as scientific action research, with Lewin’s and Taba’s models respectively in the field of social problems and of curriculum, and Lippitt and Radke (1946)\(^7^3\) in the field of social prejudice. The scientific method of problem solving for social problems and the curriculum is based on induction and a series of steps, guided by Dewey’s five stages of scientific reflective thinking—the scientific method. With Stephen Corey’s works (1949, 1953)\(^7^4\) mainly focusing on justifying action research within the context of the USA’s prevailing positivist ideology, it is considered to be the first generation of educational action research (Dewey, Lewin, Corey, Taba), often labeled ‘scientific’.

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The research needed for social practice can best be characterized as research for social management or social engineering. It is a type of action-research, a comparative research on the conditions and effects of various forms of social action, and research leading to social action. (...) Research that produces nothing but books will not suffice. (Kurt Lewin, 1948)

Model 2 theories as practical-deliberative action research

Model 2 theories are referred to as practical-deliberative action research, with Stenhouse, Elliott and Ebbutt’s models which were developed in the framework of the Ford Teaching Project (1972-1974), led by Elliott and Adelman (Elliott and Adelman, 1973), and in line with the British tradition of action research in organizational development championed by researchers at the UK’s Tavistock Institute of Human Relations (Rapoport, 1970). The object of study is to engage teachers to link practice and theory by reflective self-development: the action researcher develops a personal interpretive understanding of theory by working on practical problems, and that theoretical understanding is constitutive of practical action and discourse. In place of Elliott’s image of a spiral for this process, Ebbutt prefers to refer to a series of successive cycles. Type 2 models correspond to the second generation (Stenhouse, Elliott) and may be labeled ‘practical’.

Action research is the process through which teachers collaborate in evaluating their practice jointly; raise awareness of their personal theory; articulate a shared conception of values; try out new strategies to render the values expressed in their practice more consistent with educational values they espouse; record their work in a form which is readily available to and understandable by other teachers; and thus develop a shared theory of teaching by research practice. (John Elliott, 1991)

Model 3 theories as critical-emancipatory action research

Model 3 theories are associated with critical-emancipatory educational action research as in the Deakin model developed by Kemmis and his colleagues (Carr, Grudy) in the Australia in the 1980s. The aim is to help people recover and release themselves from the constraints of “irrational, unproductive, unjust and unsatisfying social structures that limit their self-development and self-determination” (emancipatory) and from the constraints embedded in the social media through which they interact “by deliberately contesting and reconstituting

ways of interpreting and describing their world” (language, discourses), ways of working and ways of relating to others (power). It may be called ‘critical’ in that it leans heavily on the Frankfurt School of philosophy’s critical theory and Habermas’ theory of knowledge-constitutive interests (Freire, Habermas).

**Action research is simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out.** (Carr and Kemmis, 1986)\(^79\)

**My journey of practice: three historical eras combining three types of purposes**

McKernan (1996, p. 28\(^80\)) pointed out that the journey towards the design of a curriculum could be guided by different purposes at different stages of maturity: “The curriculum contains elements of practical as well as technical and critical endeavor, in which means and ends are negotiated through complex human interaction and decision-making is shared by a wide range of participants: teachers, administrators, parents, policy makers and others. In such a system, the practitioner needs technical skills (e.g. how to define instructional objectives) as well as practical skills (e.g. skills in small group work and critical skills (e.g. making judgment, self-reflective monitoring), but most especially curriculum development and research skills”.

“As (a curriculum designer and) a change agent, the practitioner has a problematic situation to consider. What is proposed here is that (curriculum) action research be considered as a practical, technical and critical reflective process”.

The pedagogical action research explored here is divided into three different historical eras, which match three different levels of design thinking pedagogy (course, program, d.school). Each historical era also reflects the different stances described in the literature review. Each stance reflects a different level of maturity of practice:

- At the beginning (2007/2009), the purpose was **technical**, as conditions—in terms of people and processes—were explored in order to help teams to navigate in the early phases of innovation.
- With the setting up of an international program (2009/2011), my aim became **practical**, as I sought to educate myself as a practitioner through pedagogical action research with the hope that my personal self-reflection could inspire other academics.

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• In setting up the d.school and thus disseminating design thinking across many disciplinary fields (2012-now), the aim has become emancipatory in the sense that it is to understand how both particular people and settings are shaped and re-shaped discursively, culturally and contextually.

I hope that in the future my research may become participatory, with the emergence of a common, skill-centered educational model in design thinking pedagogy. The competency-centered educational model (Hummels and Vinke, 2009) developed by the department of industrial design at Eindhoven University of Technology has inspired this framework of activity, which has been defined on the basis of years of practice.

The ultimate goal of reflective teaching is to develop teachers’ skills in “reflection-in-action”, i.e. their ability to frame and reframe problems, find solutions instantly on the basis of their interpretation and analysis of the situation, and construct new meanings and directions for future actions (Schön, 1983). “An artful teacher sees a child’ difficulty in learning to read not as a defect in the child but as a defect of his own instructions” (p. 66). Each student is unique and faculty needs to practice reflection-in-action in order to adjust their pedagogy to the level and responses of students. Each design thinking project is unique and is based on situated-inquiry problem solving (in opposition to technical problem solving). Therefore, teachers of design thinking face a dual challenge: they need to reflect-in-action not only on the projects given to students, but also about the way students respond, learn and pursue those projects.

From the dominant model of technical rationality to the unrecognized model of reflection-in-action, “the dilemma of rigor and relevance may be dissolved if we can develop an epistemology of practice which places technical problem solving within a broader context of reflective inquiry, show how reflection-in-action may be rigorous in its own right, and links the art of practice in uncertainty and uniqueness to the scientists’ art of research” (Schön 1983, p. 69). That is the reason why adopting a structured pedagogical action research procedure is of paramount importance to the legitimacy of reflective practitioners, in showing how professionals in teaching design thinking think and take decisions in action.


Pedagogical Action Research Procedures

Three relevant models: McKernan, Deakin, Norton

McKernan (1996)\(^83\) gives a detailed description of each educational action research procedure (p. 17-32), which aims at helping faculty to reflect on their practice of teaching. Two of them are of particular interest for my question research:

- McKernan’s model (1988)\(^84\), originally developed in Ireland and subsequently in America, which employs a time-process cycle to bring about curriculum change (Fig. 5);

- Deakin model (Fig. 6) in critical-emancipatory educational action research, which was developed at Deakin University, Australia in the 80s and reported by Kemmis and McTaggart (1982)\(^85\).

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Deakin’s simple structure (plan, act, observe and reflect) provides an interesting starting point for research in the field (McTaggart et al., 1982)\(^{87}\), though it is noteworthy that the model does not start with problem formulation, a stage emphasized as of paramount importance by Kemmis and pertinent to my research purpose: “Kemmis is concerned with focusing the problem. To achieve this he poses three questions: What is happening now? In what sense is it problematic? What can I do about it?” (…) “The theory of critical action research is bound up with issues of control of education and the avenues by which political action can be taken” (McKernan 1996, p. 27).

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Norton (2009) suggests a simple process for carrying out action research, which is known by the acronym: ITDEM’D (first published in Norton, 2001 and adapted in 2012):

Step 1: Identifying a problem/paradox/issue/difficulty
Step 2: Thinking of ways to tackle the problem (your chosen method)
Step 3: Doing it (your collecting of data)
Step 4: Evaluating it (analyzing, interpreting your finding)
Step 5: Modifying future practice (how will you improve your students’ learning?)
Step 6: Disseminating research findings (opening your work to peer scrutiny)

Compared to previous models, McKernan’s (1996) presupposes scope for total curriculum planning, which suits my research question. An adaptation of the three research procedures (Deakin, 1982, McKernan, 1996, Norton, 2009) will be used to answer my research question: how to develop and improve design thinking pedagogy. As PAR models apply to any issue in education, there is no detail on what should be taken into account, for example, for capstone projects.

**The choice of a relevant method: narrative case studies**

Among all the references identified, McKernan is the only one who extensively formalized all the relevant qualitative methods in PAR with his dedicated seminal book (1991, 1996): *Curriculum Action Research*. Its richness and positioning as a resource (by comparison with “how to…” books) “to identify, clarify and resolve a problematic situation in practice” have been appropriate to my research question. That is why, despite the fact that the target of his research is primary school teachers, the methods he outlined have been a methodological milestone in my research journey. In addition, the purpose he gives for doing action research as a teacher is congruent with mine. It is “to achieve educationally worthwhile changes, and at the heart of this enterprise are considerations of curriculum and pedagogy. To be ‘educational’, action research needs to address concerns about the educational quality of students’ curricular experiences, and the pedagogical conditions under which they are accessed” (introduction by J. Elliott in McKernan, 1996).

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Observational and narrative research methods in the form of narrative case studies have been chosen for this piece of research among the different research methods presented in PAR (Norton 2009; McKernan 1996).

Case study in education presents a number of advantages (McKernan 1996, p. 76):

1. Reproduces phenomenological world of participants through detailed description of events
2. Presents a credible and accurate account of the setting and action
3. Uses multi-methods to corroborate and validate results
4. Tells a story in language layman and practitioner can understand
5. Data are ‘representative’

All three types of observation data have been used: narrative mainly through case studies based around participation, stream-of-behavior recording, anecdotal records and journal; structured protocols through checklists of pre-specified conditions; and rating scale through skill development ladders. The advantages and disadvantages of such methods have been carefully studied, especially guidelines for the conduct of participant observation (McKernan, 199692, p. 64), which is close to ethnographic research, though different. Particular attention has been paid to three criteria considered worth tackling in an action research study:

- keeping a record of events and activities,
- describing the research setting,
- analyzing the data thematically in terms of frequency of occurrence.

“The essential character of the case study suits it to rendering an account of all pertinent aspects of an event, thing or situation, employing as the unit of study an individual, institution, community or any group considered as a unit. The case consists of some phase of the life history of the unit, or the entire life process, whether the unit be a person, family or social group” (McKernan, 1996, p. 77).

In order to avoid the pitfalls of this kind of case study (no generalization, researchers may have a priori assumptions which bias interpretations, idiosyncratic and interpretative nature, to name a few (McKernan, 1996, p. 76), a collection of case studies were studied over time. This longitudinal study, coupled with triangulation (Denzin, 1970)93 from the different research methods to secure data, complete case records and open access to the field data, should minimize the bias introduced by the style of a case study to tell a story as it has evolved, with data selected and constructed by the researcher.

“It is phenomenological in that it represents the world as the participants and researcher experience it. It is therefore more than a description of characters and setting—it seeks to disclose the ‘milieu’, which itself influences an innovation, systems, etc.” (Denzin, 1970, p. 77).

“The principal purpose of case study is to appreciate and understand an innovation from the inside, and to convey this understanding to others. A separate point concerning case study refers to the style of writing, which should be less scholarly or formal and more like the approach of an investigative journalist or literary critic” (Denzin, 1970, p. 81).

Learning design thinking as a Faculty

Learning from practice through iterative cycles and pedagogical action research

Learning design thinking, both as a practice and a discipline, requires time and self-reflection. Pedagogical action research is a promising way for academics to improve their practice of developing design thinking pedagogy and to become professional practitioners.

Academics become designers when they engage in design thinking pedagogy. The first version of such a course should be considered as a prototype: it is a way to learn how to do it. The use of a prototype as a data collection mechanism is unusual in traditional research, but common in the design culture (Lofthouse, 2001)94: "Prototypes are a fantastic way of evoking new insights and builds, and of checking what works and what doesn’t. As soon as one prototype is finished and has been interrogated, a new one can be started… The real value comes from looping the loop” (Allan et al, 2001,95 quoted in Lofthouse, 2001). Those research loops are in line with the strand of action research and its reflective process. McKernan’s model (Fig. 5) shows how this process is bound up with a series of cycles in time.

Action research is the reflective process whereby in a given problem area, where one wishes to improve practices or personal understanding, inquiry is carried out by the practitioner—first, to clearly define the problem; secondly, to specify a plan of action—including the testing of hypothesis by application of action to the problem. Evaluation is then undertaken to monitor and establish the effectiveness of the action taken. Finally, participants reflect upon, explain developments, and communicate these results to the community of action researchers.

Action research is systematic self-reflective scientific inquiry by practitioners to improve practices. (McKernan, 1996, p. 5)96

In the pedagogical action research movement, an interpretative social science paradigm is contrasted with a positivist paradigm modeled on empiricist natural science: “A positivist social science appeals to those who plan and engineer the organization of the society. An interpretative social science appeals to the social practitioner, because of its power to develop discursive self-awareness” (J. Elliot in the introduction to McKernan, 1996). This piece of research positions itself within the second research strand because “this transition between being self-aware and self-consciously or discursively self-aware, enables people to achieve a measure of autonomy over their social conduct” (idem).

This kind of self-awareness and capacity for improvement in the development of DT pedagogy answers my research question: the aim of reflective thinking in these qualitative research methods is to provide a method for new university academics to connect their knowledge of design thinking with a process of teaching and learning, as well as to enhance the quality of teaching and learning in design thinking. Those objectives are in line with the mainstream purposes of pedagogical action research as analyzed by Norton (2009, p. 59-60).
A research procedure adapted for design thinking pedagogy

After reflecting on the different models presented in the previous section, the following steps have been chosen in order to define our research procedure:

- **Situate:** “The where and the why”
  
  Kemmis and McTaggart (1982) do not identify that step and the procedure starts with the next one “plan”. Norton (2009)’s first step is to identify a problem or issue. McKernan (1996) starts with “problem situation”, which implies a problem definition. Even if that step is not clearly mentioned for some models, all of them describe in the practice of research the initial situation for the reasons mentioned below.

- **Plan:** “The how of the what”
  
  Each model, even if labeled in different ways, recommends that step for the reasons mentioned below.

- **Act and observe:** “The what and how in action”
  
  Norton (2009) clearly mentions the combination of doing and observing (“Doing it - your collecting of data”). “Act” and “observe” are dissociated for Kemmis and McTaggart (1982). It is not clear in McKernan’s model, but when looking at the research done with case study, it is clear that observation is carried out at the same time as acting. The first time I carried out the research protocol, I thought it would be more efficient to dissociate the two actions: I quickly realized it was not! Firstly, observing (which means to collect data in real time on how students behave with what is done) was the only way to remember what happened because of the time line (one or two semesters), the high number of teams and courses, the high number of parameters to observe. Secondly, observing action in real time was very efficient to adjust quickly to projects’ development and students’ behaviours. This step is at the core of true reflection in and on action.

- **Reflect:** “The why on the what and the how”
  
  All models mention that step, even if sometimes included in action evaluation.

- **Improve:** “What’s next”
  
  Decisions to improve future practice are clearly mentioned in McKernan and Norton, not in Kemmis and McTaggart. The first few years, I did not clearly define what to improve and I did not write the decisions. After two years, I repeated some mistakes and decided to do it: written decisions are necessary for future improvements.

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98 A blank template is available in appendix 8.7

99 Chapter 3 presents the 5 steps of the procedure with one page for each academic year. Chapter 7 describes in detail each step for each academic year (between 10 and 20 pages for each academic year).
**SITUATE: The where and the why**

SITUATE (the where and the why): Description of the initial situation, with the identification of a research focus in terms of need assessment on how to develop design thinking pedagogy (problem/paradox/issue/difficulty).

“At this stage the internal (school-situated) and external (community) constraints that impede progress are established and ranked in order of priority.” (McKernan, 1996^100, p. 28).

For design thinking pedagogy, the stage “situate” describes the context in which one develops such a course. It can include a description of the university and departments where it happens, traditional pedagogies (epistemology, objectives, curriculum, outcomes), planned objectives of design thinking pedagogy, type of students (disciplines, levels), pedagogical formats and constraints. It also describes the means at disposal (space, team, partners, budget). As a result, a need or problem is identified for research purposes.

In the case of my research, each academic year, the question was the same one: which tipping points in the culture of design thinking could I identify and experiment? In which category (People / Place / process) should I classify them?

Expected length: half a page to half a dozen.

**PLAN: The how for the what**

PLAN (the how for the what): Thinking of ways to tackle the identified problem in order to develop design thinking pedagogy, with all the decisions taken (chosen direction/method/‘intelligent’ idea) in regard to expected results, together with the identification of an action plan, including a curriculum.

“The plan will detail who reports to whom and when; specification of roles and goals; schedule of meetings, etc.” (McKernan 1996, p. 28).

For design thinking pedagogy, “plan” can include what is set up: -- not only at the level of “student learning and individual teaching” (in terms of the setting up of an ecosystem and its stakeholders (student team, teaching team, potential involvement of

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partners), places where teams will carry out their project, as well as process and tools given to students, including the definition of briefs and syllabus (objectives according to the format, lectures, assignments, toolkits...)—but also at the level of the university (in terms of priorities, governance, people involved, including the change agent, resources available to academics, and more broadly in terms of expected impact “to bring more radical change in which the very nature of higher education should be open to critique and fresh perspectives” (Norton, 2009, p. 50).101

In the case of what is described in my research, “plan” includes the numbers of teams, courses, partners, as well as the type of projects and courses. Full syllabus are available online.

Expected length: half a page to a dozen.

**ACT & OBSERVE: The what and how in action**

ACT & OBSERVE (the what in action): Chronological observation of the way the action plan is implemented in practice, on how teams behave and perform/what they produce, on how teaching teams (and possibly partners) behave and react, given the fact that adjustments are needed in the course of action for such capstone projects, in order to optimize team dynamics and project outcomes.

“This is the stage of installing the plan in the setting and taking action”

(McKernan, 1996, p. 30)

For design thinking pedagogy, the act stage will highlight and record: - first the way teams behave and perform; - second all the new decisions taken in the course of action, including the adjustments needed for the process in terms of curriculum (assignments, lectures, coaching, pedagogical resources at disposal), for people involved, or for the re-organization of the space, for the sake of tackling and solving problems linked with real-world wicked projects (such as lack of time and resources), given the purpose of this pedagogy which is not only to develop skills but also to achieve project outcomes that make sense and can be implemented in reality.

Expected length: half a page to a dozen.

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**REFLECT: The why on the what and the how**

REFLECT (the why on the what and the how): Reflect, explain and understand research findings from action (the why on the what), in order to modify future personal practice.

“Evaluation of the action steps taken follows. At this stage the critical research group seeks to understand what the effects have been and what has been learned as a result of action. By carefully reflecting on the action the practitioner becomes a ‘self-monitoring’ teacher-researcher. The data and conclusions should be shared within the group which will make decisions about the acceptability of the steps” (McKernan, 1996, p. 30) 102

For design thinking pedagogy, reflection can be articulated in relation to the three types of conditions that need to be set for such a course to happen: the effect of the setting up of an ecosystem of **people** (including students, teaching team and potential partners for which the project is carried out), the effect of the organization of **places** (including the studio and the field), the effect of the **process** and tools that have driven teams in the development of the project. Reflection can take into account initial conditions.

Expected length: half a page to a dozen.

**IMPROVE: The what’s next**

IMPROVE (the what’s next on the how and the what): All the decisions taken to modify future practice, depending on the structure of the course and how it is run (by an individual or a teaching team in an ecosystem), in order to implement actions which are required to improve the following year’s curriculum.

For design thinking pedagogy, a description of how such conclusions for future action should be shared, discussed and sometimes negotiated with stakeholders (university, teaching team, partners) can be included.

Expected length: half a page to a page.

The adapted procedure (Fig. 7) for the analysis of design thinking pedagogy represents a contribution to the scholarship on pedagogical action research.

Fig. 7. An adapted Pedagogical Action Research Protocol for faculty to reflect on design thinking projects.
Learning about design thinking, learning about a culture: how?

One expected outcome of rigorous reflection-in-action by teachers in design thinking is to learn about the culture of design thinking in order to become skilled professionals. Why? What is a culture? How do you acquire it?

Why? Teaching design thinking represents a paradigm shift, from technical rationality to reflection-in-action. A shift of this kind has an impact on a teacher, not only in the content of the curriculum (autonomous learning by doing with projects based on wicked problems and unknown solutions, through a process based on activities in the field), but also in the way it is taught (away from lectures and exercises in application with individual assessments based on right and wrong answers, to projects and activities with appropriate solutions and real impact with team self-assessment and feedback from real users).

The range of activities for teachers in design thinking is broader, more uncertain and more complex than in traditional ways of teaching. In different roles from curriculum designers to stage directors, teachers not only have to define the content of the curriculum with unusual activities and materials, but also to “stage the conditions for their students to innovate”. These conditions should provide the best possible learning experience inside and outside the classroom and class timeframes. The learning experience depends on familiar curriculum elements (syllabus, series of pedagogical activities, assignments, pedagogical resources, including presentations and bibliography, objectives and modality of assessment…), together with less familiar components, such as access to a studio containing project spaces (and 8 other types of space, which offer students symbolic, functional and emotional support), access to prototyping machines and materials, access to the observational field, which includes ecosystem preparation, identification of people, organization of visits, to additional communication resources (camera, experts, dropbox…), to a handbook for action in the field.

It is of paramount importance for faculty to build their design thinking culture in order to become professional practitioners in a given context: they need to learn about the culture of design thinking so that they can adapt it to their own cultural context, purposes, targeted artefacts and disciplines, levels of students, available resources… Faculty needs to learn about the culture of design thinking so that they can develop their own adapted culture of design thinking.

Students need to learn the culture of design thinking. Teachers need to learn the culture of design thinking. What is a culture? How do you learn a culture? Defining what a culture is and how to learn it represents a difficult but important challenge in the context of a global economy.

What is a culture? The Cambridge English Dictionary states that culture is “the way of life, especially the general customs and beliefs, of a particular group of people at a particular time.” Macionis and Gerber (2010) define the constitutive elements of a culture: “some aspects of human behavior, such as language, social practices such as kinship, gender and marriage, expressive forms such as art, music, dance, ritual, religion, and technologies such as cooking, shelter, clothing

[... are said] to be cultural universals, found in all human societies. The concept material culture covers the physical expressions of culture, such as technology, architecture and art, whereas the immaterial aspects of culture such as principles of social organization (including, practices of political organization and social institutions), mythology, philosophy, literature (both written and oral), and science make up the intangible cultural heritage of a society.” (p. 53)

**How do we learn about a culture?** Two reference points are worth investigating in the attempt to answer this difficult question:

- How does an individual adopt changes and experience cultural development?
- How do anthropologists learn about cultures?

In his analysis of the differences between French and Americans, Baudry (2005) studies how individuals can undergo “cultural development” in the same way as one speaks of “personal development”. After citing modern authors (Edward T. Hall, Ruth Benedict, Claude Lévi-Strauss, Geert Hofstede, Fons Trompenaars, Joseph Campbell, André Laurent) and classical authors (Descartes, Pascal, Montesquieu, Voltaire, Rousseau, Stendhal et Tocqueville) on approaches to the study of intercultural differences, he explored the process of individual change, citing Kübler-Toss’s study of life’s (1997) terminal stages as adapted by the American consultants Cynthia Scott and Dennis Jaffe (1989). According to this analysis, a triggering event may initiate a four-step process: denial/resistance/exploration/commitment (Fig. 8).

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When a possible new direction of progress is identified, cultural development can be articulated as a sequence of seven levels of cross-cultural awareness:

1. Ignoring cultural differences
2. Restricting ourselves to criticism or praise
3. Explaining another culture in terms of our own
4. Understanding a culture from the inside
5. Seeing our own culture from the outside
6. Communicating across cultures where “it becomes possible for us to view things from the perspectives of others”
7. Effecting cultural change, i.e. “the level at which it becomes possible to act upon a culture in a conscious manner in order to change it”

The objective for faculty is to reach levels 6 and 7. They need to conduct the exploration and make the commitment to change the culture of design thinking in ways that suit their local context and purposes.

O’Neil (2006) gives an interesting analysis of how anthropologists learn about the culture of another society: fieldwork and first hand observation of that society, which is called ethnography, are prerequisites: “Since it primarily relates to the way people interact with each other, it is not possible to adequately observe it in a laboratory setting.” Participant observation is considered the best way to learn about a culture: “The best way to really get to know another society and its culture is to live in it as an active participant rather that simply an observer.” (…) “By physically and emotionally participating in the social interaction of the host society, it is possible to become accepted as a member. In practice, this requires learning their language and establishing close friendship ties.” Time is also a key factor of success. Learning a new culture requires long immersion in a community: “It is rarely possible to grasp much of another culture during a short visit. Anthropologists have learned that long-term residence lasting years is necessary to see the range of cultural behaviors.” How long is long? “There is no simple answer. It depends on the focus of the study.” Learning the culture of design thinking should be approached as an ambitious field of study, which requires years of exposure to real communities that practice design thinking, such as those of Silicon Valley. This kind of long exposure lowers the risk of misinterpretations between ideal, actual and believed behaviors. O’Neil (2006) gives insightful recommendations on learning about a new culture. “Ethnographers can collect reliable data and develop a realistic understanding of the culture patterns in another society through a combination of five things”:

1. Proper mental preparation (including adopting the cultural relativity perspective)
2. Participant-observation
3. Competence in using the host culture’s language
4. Long-term residence
5. Luck in being at the right place at the right time.

The need for a conceptual framework

Data collected in the field may be overwhelming and difficult to analyze afterwards. “The researcher uses a ‘conceptual framework’ to make sense of the rich detail and evidence. This framework may be borrowed from existing social science or developed as constructs which are grounded in the particular case” (McKernan, 1996, p. 76). That is why one of the purposes of our early experiments (2006-2010) was to define such a conceptual framework.

The PPP framework one of the contributions to scholarship of this piece of research, fully described in Chapter 4. It is built on the metaphor of exploration. In the 15th century, the so-called age of discovery, would-be explorers needed to be careful and thorough in their attention to three key elements: a crew (people), a boat (place) and navigation tools (process and tools).
Conclusion

This section has demonstrated that pedagogical action research is needed in order to become a professional in design thinking pedagogy: only reflection in and on action can help teachers in this field to acquire the culture of design thinking and improve their teaching.

The history of the action research movement shows that education has been one of the main areas of inquiry. This section reviews the history of action research movements that have influenced the emergence of pedagogical action research, the different types of action research and purposes, as well as existing models for pedagogical action research, in order to define an appropriate research procedure for design thinking pedagogy, as well as appropriate research methods, entailing a longitudinal study, narrative case studies and data records.

This section represents the first contribution to scholarship of this piece of research: the literature review has helped to define a protocol for design thinking pedagogy. This pedagogical action research protocol to reflect on one’s practice has been built on three main models: McKernan (1986)\textsuperscript{109}, Masters (1995)\textsuperscript{110} and Norton (2009)\textsuperscript{111}. It includes five steps: 1: situate, 2: plan, 3: act & observe, 4: reflect, 5: improve. It is an instrument for reflecting on narrative case studies, which are also chosen as a research method.

McKernan (1996) also suggests the need for a conceptual framework as a tool of data analysis. Based on the image of exploration, such a conceptual will be defined and experimented in the first years of this longitudinal study in a way to identify and experiment tipping points in the culture of design thinking (see chapter 3).

In conclusion, it is of paramount importance to bear in mind that learning design thinking, both as a practice and a discipline, requires time and self-reflection, in order to acquire the language and the culture. Pedagogical action research is a promising way for academics to improve the way they develop design thinking pedagogy and to become professional practitioners.


2.2. The widening scope of design: From product design to experience design

Summary of the section

In this section, we will enquire into the definitions of the word “design”, whether used as a verb, a noun or an adjective. A literature review also indicates two dominant paradigms for product design, each of which depends on the disciplinary background from which it emanates: Liberal Arts versus Science. Design thinking as practiced in Silicon Valley has emerged in universities as a possible new transdiscipline for multidisciplinary teams since the creation of the Stanford d.school in 2005 (Banerjee, 2016).112

Each of the paradigms reflects underlying assumptions with their own intrinsic values and purposes, and implicit consequences in terms of how design is perceived, especially in the corporate world:

- The linear step-by-step process from conception to realization, for the guideline school derived from the Science paradigm: the value lies in achieving efficiency with a series of defined steps;
- The triangle between form/function/symbol for the black box school in the Liberal Arts paradigm: the value formerly lay in achieving the highest aesthetic level, nowadays it lies in reframing;
- The overlapping of three circles (user desirability/technological feasibility/business viability) for the Silicon Valley school in the business paradigm: the value lies in creating a desirable new experience and delivering it quickly.

The section ends by focusing on design thinking as a promising transdiscipline for multidisciplinary teams to innovate in complex and uncertain environments: key milestones in terms of place, people and process will be reviewed and analyzed, especially in the realm of education.

Definition of design: noun, adjective, or verb? Which correlated stance?

Design is a source of ambiguity because it has more than one common meaning, depending on whether it is viewed as a noun (outcome), an adjective (judgment) or a verb (process) (Walker, 1989),113 and depending on historical period (Margolin, 2002)114 and cultural background (Flusser, 2002)115.

Buchanan (2001)116 identified the problem of a common definition for design both as a weakness—because it has “caused discussions to become unproductive and wasteful of time and energy” and “efforts to establish a new field of learning requires a definition of the field”—and as one of its great strengths: “Fields in which definition is now a settled matter tend to be lethargic, dying or dead fields, where inquiry no longer challenges what is accepted as truth. However, I believe that definitions are critical for advancing inquiry, and we must face that responsibility regularly in design, even if we discard a definition from time to time and introduce new ones.” Depending on whether the word is used as a noun, an adjective or a verb, it can refer to:

- **The result of the process** (a sketch, plan, model, products manufactured with the aid of a design and a designer, called designed goods). In this case, the word is used as a **noun** (a design) (Buchanan, 1992117).

  Visiting any Design Centre Bookshop (London or Georges Pompidou for instance) may add to the confusion! The variety of subjects covered by the volumes on display indicates the range and heterogeneity of the field: architecture, town planning, housing, interior design, famous designers, the grammar of form and color, furniture, styles such as Art Nouveau and streamlining, packaging, graphics, fashion, ceramics… This perspective is derived from art history and architectural history.

- **A judgment** on the degree of novelty, originality and the look or overall pattern of the product; the word is used as an **adjective**. In popular usage, many French people use the word design to express whether an object is trendy: “It’s design”.

  This practice is reinforced by the trend for objects to be signed by designers who behave as artists, so that their value is enhanced through belonging to a “designer” brand. This kind of use of the word usually annoys designers, since it reduces its meaning to the esthetic dimension of the object. This approach is derived from Liberal Arts.

- **The process** (“the act or practice of designing”); here, the word is used as a **verb** (to design), mostly by designers, architects and engineers. In terms of definition, the word “design”

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combines both intent (objective, plan) and form (drawings, artefacts).

Most academic definitions (Heskett, 1980\textsuperscript{118}, Buchanan, 1992\textsuperscript{119}, Simon, 1969\textsuperscript{120}, ICSID\textsuperscript{121}) refer to design as a verb (see all definitions in appendix 8.3).

Given the historical evolution of industrialized countries from the 19\textsuperscript{th} century to today, the first two paradigms—Liberal Arts design and Engineering design—have often been contrasted, both in practice and in the literature. It is of paramount importance to unpick them, even at the risk of caricature. In the 19\textsuperscript{th} century, during the Belle Epoque era, artists and engineers were closely associated, to the point that many people were both, seeking to transform their artworks and inventions into products through industrialization. Achieving a merger between Arts, Science and Business was a common goal, with the objective of creating large industrial companies. After World War II, the dynamics changed as society’s needs changed. Each strand has evolved differently at different historical moments. Today, all three strands influence product design. The aim of design thinking, as an emerging global movement, is to transcend each of them and to create a transdiscipline.

Stappers et al. (2009)\textsuperscript{122} summed up the three paradigms by identifying three distinct forces of innovation:

- The technology push, in which new products come about through a technical possibility and which can lead to “technological tricks in boxes with a button”;
- The market pull, which “caters only to the needs of people on the level of explicit needs” and in which new products come about through visible demand from buyers; The contextual push, “in which new products which address tacit and latent needs come about (…) through increased insights in the needs and dreams of possible future users. These insights can, of course, pertain to existing products and their buyers, but more often lead to new products for which no buyer existed yet”.

It is essential to bear in mind that from a user’s perspective, a product’s attractiveness is often the result of the combination of an appeal to the mind (the functional attractiveness stressed in the engineering approach), the heart (the emotional appeal stressed in the arts approach) and the hand (the practical appeal stressed in a contextual approach).

\textsuperscript{121} The International Council of Societies of Industrial Design. (2009). \textit{About Us}. Retrieved from http://www.icsid.org/about/
\textsuperscript{122} Stappers, P.J., Van Rijn, H., Kistemaker, S.C., Hemmink, A. E., & Sleeswijk Visser, F. (2009). Designing for other people’s strengths and motivations: Three cases using context, visions, and experiential prototypes. \textit{Advanced Engineering Informatics}, 23 (2), 174-183
Design to engineers (Science/linear process)

Design as an expertise: design theory

Engineering design research, embodied in the creation of the Design Research Society in 1966, derived from the attempt to apply rational scientific methods and knowledge to the design of the artificial with a mechanized, quantified view of design as a problem-solving and decision-making activity. In this perspective, design would no longer be an ad hoc practice, perceived as a black box governed by intuition. Boundaries with engineering and industrial production could be identified (Maldonado, 1976; Marglin, 2002). Cornell University, MIT, The University of Sydney (Cowan), Carnegie Mellon University (Simon and Newell) and the University of California at Berkeley (Rittel) were centers for the leading theorists of design science and computer-aided design. Artificial intelligence, operational research, architecture and ergonomics were the roots of engineering design, all founded on analytical reasoning and mathematics. The need for the standardized production of domestic goods and mass housing favored improvements in production and product performance through statistical processes.

Seminal works in this field include:

- “Introduction to Design” (1962) by Morris Asimow, a chemical engineer, as the first attempt to define engineering design;
- “Community and Privacy” in architecture by C. Alexander (the first PhD in architecture, at Harvard, 1963, to break down design problems into solvable small patterns and to use information theory to tackle the interactions between user requirements resolved and components of pattern language), who resigned from the movement in 1971 because of its neglect of user concerns and its tendency to convert everything into mathematics;
- “Systematic Methods for Designer’s” by B. Archer (an industrial designer from the Hoschule für Gestaltung at Ulm and founder of the Dept. of Design Research at the Royal College of Art, becoming the first professor of design research) on critical path analysis, a model of operations research;


• “Engineering Design: A Systematic Approach” by Pahl et al. (2007; first published in German in 1977\textsuperscript{127}).

Before Simon, engineering design was synonymous with analysis (determining the dimensions of parts based on the analysis of forces, stress, fatigue...). By recognizing that information processing in different fields follows same general design procedure, he helped to legitimize the study of the artificial (i.e. all human productions) and its design as a form of scientific inquiry. Academic recognition was therefore possible, both in research and education. The basic premise of the Pahl & Beitz\textsuperscript{128} framework is that design should be carried out as a structured and systematic activity. From the late 1980s to today, various authors (including Cross, Pugh, Dieter, Ullman, Ulrich and Eppinger, Dym, and Otto and Wood) have adopted Pahl and Beitz’s high-level, systematic, function based approach (Maier and Fadel, 2009).\textsuperscript{129}

In the 1990s, an important school of thought in engineering design emerged from the study of economics and decision-making processes: Decision-Based Design is based on a mathematical framework in which the quest for an optimum is based on the maximization of utility, in the light of known customers’ preferences. Axiomatic design (Suh, 1999, 2001)\textsuperscript{130} forms part of the same strand of mathematical developments, based on abstractions and indifference to human intention: decisions are considered to be algorithmic, and the objective is to achieve the optimum. Last but not least, French theorists took up the same approach with C-K theory: outlined by Hatchuel\textsuperscript{131}, the theory was developed in the 2000s with his colleagues from Mines de Paris, Benoit Weil and Pascal Le Masson.\textsuperscript{132} It provides a theoretical basis for the description of how designers think, how they navigate between knowledge and concepts. Le Masson, Weil and Hatchuel (2006, 2010) also demonstrated that the strategic management of innovation must be based on innovative design activities, instead of relying on traditional R&D and project management techniques. This French approach based on C-K theory analyzes and explains new management principles and techniques that tackle these activities, including innovation fields, lineages and C-K (Concept-Knowledge) diagrams.


The guideline school of thought derived from Science

Nowadays, the “engineering design” school, which advocates the position of “design to experts”, tends to predominate in large companies and universities. Lerdhal (2001)\textsuperscript{133} refers to Stoltermann (1994)\textsuperscript{134} in his description of “this guideline approach”:

“The design process can be described rationally. It is possible to formulate the guidelines as generic design principles that can be transmitted and therefore do not depend upon a specific designer or design situation. The guideline approach is process-oriented, in the sense that it is assumed that by controlling the design process it is possible to control the result. Jones (1981)\textsuperscript{135} described viewing the design process as a ‘glass box’ with a set of clear and well-defined tasks and steps along the way.”

Technology-driven projects are dominant and considered as potential breakthrough triggers. Gaining specialized knowledge with a process managed by experts and objective reasoning is crucial and functionalities/specifications are stressed. Science is the reference point for engineering design.

Cross (2007)\textsuperscript{136} identified the object of study of the sciences as the natural world, the appropriate methods as controlled experiment, classification, analysis, and the values as objectivity, rationality, neutrality, and a search for “the truth”. Science is about the quantification and measurement (“hard side”) of what exists and its methods are inductive and deductive reasoning, observation and analysis. Science aims to describe the world we live in. Science is based on a positivist view of the world. Causation and prediction are reference methods. In the 19th century, science made such outstanding progress as to surpass technique and experiment, with the result that technologies came to be considered as applied science. Technologies, materials and machines helped and continue to help human beings to bypass natural laws and physical phenomena.

Consequences: stage gates for product development processes in companies

The engineering literature of product design is based on the search for objective design theory founded in cognitive reasoning and methodologies, as well as the assumption that design is for experts, meaning that abstract knowledge and thinking are superior to practice. Science is a reference point for engineers.


As a summary, the “engineering design” school:

- is derived from an engineering perspective with Science as a reference;
- has as its goal to understand and describe physical phenomenon;
- is characterised by technology-driven projects;
- stresses functionalities/specifications;
- is the outcome of a managerial process run by experts/the art of objective reasoning;
- considers conception theory as a formalized methodology and tools, with a guideline approach;
- considers that design belongs to experts.

In practice, it would appear that the emphasis in the engineering paradigm is on the planning aspect of design (leading to project management based on a series of steps and tasks) and that prototypes are used only to test feasibility and functionality. Product development processes (Ulrich and Eppinger, 1995) and stage gate processes (Cooper and al. 1997) are the consequences of these paradigms, which are efficient for the market launch of industrial products with clear specifications. They do not provide any insight on how to find to work with users to develop ideas and overstep logical thinking based on abstract and linear reasoning.

Engineering design approaches were challenged as far back as the late 1960s, especially in architecture and urban planning: in 1967, there was a confrontation during an Architecture Symposium between behaviorists, who represented a mechanized, quantified view of design (Archer, Jones, Markus, Struder) using operational research models and systems theory in a very abstract way to tackle every problem, and phenomenologists (such as Wand, Alexander, Rittel, Cross), who were primarily concerned with the ‘humanness’ of human beings. In 1971, C. Alexander released a manifesto against computer use, behaviorism and ‘continued attempts to fix all of life into logical frameworks. The same year, the Design Participation Conference organized by Cross was an official attempt to listen to Rittel’s ideas for second-generation design methods, which would include user involvement and the identification of user goals in design decisions. Simon famously contended that human decision-makers are content with “satisficing” solutions (Simon 1996: 27–30, 119–121), and that decisions

about the artificial world are made by human beings for human use. In 1979, to keep pace with change, the Design Research Society (created in 1966 by Jones and Archer) initiated a new journal, *Design Studies*, edited by Cross.

Stappers (2009)\textsuperscript{142} emphasizes the risks associated with “product design relying exclusively on the (technology push, which) can lead to ‘technological tricks in ‘boxes with a button’”.

The functional attractiveness of products is only part of their perceived value, since people also make choices based on emotional attractiveness. Products should appeal to both the heart and the mind.

**Design to (industrial) designers (Liberal Arts/reflection)**

The industrial design literature in product design focuses on the quest for self-reflection in exploring situated contexts and creating new artefacts, as well as the assumption that design is for practitioners, in other words that practice is superior to theoretical considerations. The Liberal Arts represent a reference point for industrial designers. In the Renaissance, ‘disegno’ (which in practice meant drawing) was considered by art theorists such as Vasari as be the basis of the visual arts: it referred to the inventive, conceptualizing phase which generally preceded the making of paintings, sculptures and other works of art (Walker, 1989)\textsuperscript{143}, a combination of ‘intent/project/plan/objective’ and ‘form/structure’.

Since the nineteenth century, the industrial design culture has evolved from external perspectives on an object (esthetics and emotional attractiveness) to the way people experience it in situated contexts, representing a shift from material artefacts to user experience, from Liberal Arts to ethnography (Buchanan, 2001).

**Design as a practice: a conversion with situated contexts**

Beginning with a Design Policy Conference at the Royal College of Arts in 1982, an opposing movement to engineering design research emerged in the 1980s. It was based on the opposition between inductive and deductive reasoning in theory building. The seminal 1983 book that challenged Simon’s technical rationality was ‘The Reflective Practitioner’, written by Donald Schön MIT’s Department of Education:

It sought to establish “an epistemology of practice implicit in the artistic, intuitive processes which [design and other] practitioners bring to situations of uncertainty, instability, uniqueness and value conflict”, Schön (1983)\textsuperscript{144}.

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Milestones in the development of design as a discipline

1984: Publication of Design Issues
1986: The first PhD on the development of the cognitive faculties of expert designers by O. Akin at Carnegie Mellon University: ‘Psychology of Architects’
1986: Design Processes Newsletter published by Charles L Owen at the Illinois Institute of Technology to focus on ID, design management and design policy
1989: Publication of Research in Engineering Design
1998: Doctoral Education in Design, the first research appeal for education in industrial and graphic design at Ohio Conference

The black box school of thought derived from the Arts

Lerdhal (2001, p. 49)\textsuperscript{145} cited Stoltermann (1994) in describing “this aesthetic approach”: “It has an approach based primarily on intuition, personal experience and is based on the idea that a designer can only be ‘guided’ through the design process by his own ideals and values. It is a product-oriented approach, focusing on the physical product. This description can be related to the school that Jones (1981) describes as viewing the design process as a ‘black box’, which cannot be understood rationally. No external rational methods can be used; the process is individual and personal. This school has originally its background and basis in art, handcraft design and industrial design”.

Industrial design is the product of two historical roots: Liberal arts and industrialization. The common reference in industrial design was preliminary visual artefacts (more commonly called drawings), be it for a painting, a sculpture, a machine, a product or a logo. In the Renaissance, ‘disegno’ (which in practice meant drawing) was considered by art theorists such as Vasari as be the basis of the visual arts: it referred to the inventive, conceptualizing phase which generally preceded the making of paintings, sculptures and other works of art (Walker, 1989), a combination of ‘intent/project/plan/objective’ and ‘form/structure’. At the end of the 19th century, interior design and object design were seen as applied arts for people (‘art manufacture’, ‘applied art’, ‘industrial arts’, ‘decorative art’, ‘ornament’, ‘commercial art’). Today, the “artist” school of thought still survives among product designers, defending a position of “design for designers.” Expressions such as ‘designed goods’ or ‘designed by’ still reflect this approach. The main goal is to create something new, original (and, for some designers, even provocative, as a way to achieve maximum impact and exposure), with the stress placed on esthetics, freedom, and unbounded creativity. The result is a style embodied by an individual—an art of subjectivity.

**Design history, a discipline for the Liberal Arts paradigm**

Design history is a discipline that reflects the Liberal Arts paradigm.\(^{146}\) It has emerged in the last forty years, following the creation of the Design History Society in 1977. It is derived from the Arts and Crafts tradition (with William Morris), focusing on individual styles and object collection, as well as on craftsmanship as production techniques. Margolin (2002)\(^{147}\) traces the first major impetus of design history as an academic subject back to the early 1970s in Great Britain, with the encouragement for all students in arts and design to follow new curricula, including the history of their own subjects, with a study of historical styles from the Arts & Crafts movement to the present day (Art Nouveau, Art Deco, Bauhaus, Bel Design, Dada, Deutscher Werkbund, Futurism, Streamline, Good Design, International Style, Memphis, Modernity, Postmodernism, Radical Design Retro Design...).

Design history courses were also established in the United States, Scandinavia and elsewhere. Books such as Guidot (1994, 2005)\(^{148}\) became references for design education in France. A series of international conferences and new scholarly journals gave design historians a place to publish their research. The big names in design history include Bony, Midal from ENSCI—Les Ateliers and ECAL, Whitehouse from Swinburne University of Technology in Australia, Forty from London University’s Bartlett School of Architecture; Dilnot, Bhagat, Brody, Lichtman, Yelavich and Hazel Clark at Parsons School; Margolin from the University of Illinois; Walsh and Williamson from the University of Delaware. The reference point is the Liberal Arts.

In Cross’s classification (2007),\(^{149}\) the arts are close to the humanities: the object of study is experience of the world, the appropriate methods are analogy, metaphor, evaluation, and the values are subjectivity, imagination, commitment and a search for ‘justice.’ The arts represent the world of individual genius and the creation (“soft side”) of the object of desire, and should exist through sense and sensitivity, creativity and imagination, abductive thinking. The aim of the Liberal Arts is to imagine a desired world. Symbols, values and artefacts help human beings to achieve spirituality and to make sense of life. Art is founded on a genealogical view (a thing, process or action has a purpose). The mode of knowledge creation is effectuation.

**The rise of industrial designers with the consumer society**

To some extent, the industrial design profession broke free of the liberal arts with the rise of industrialization and the consumer society. During the first industrial revolution in the 18th century, the economy was transformed by new technologies like the steam engines; engineers

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rose to prominence by designing new forms of transportation (train, boat); it represented the ability of human beings to bypass the laws of the Nature (Flusser, 2002).

During the 19th century industrial revolution, which saw the transition from a feudal to a capitalist mode of production and the growth of industry, design emerged as distinct from arts and crafts as well as from engineering production. “Engineers design the machines which make the products other designers design” (Walker, 1989). At that time, the distinction between industrial designers and engineers was not so clear, as was noted by Maldonado, who defined industrial design as the planning of objects that were manufactured industrially, i.e. by machines, and in series, as well as in Margolin’s translation of his work.

After the Second World War, the growth of capitalism and mass consumerism shaped design as a specialist practice, profession and disciplinary field. In the 70s and 80s, design practitioners defined the role of designers in response to demand from new industrial sectors, such as printing, advertising, packaging, and manufacturing, shaping specialist work practices and career paths that became institutionalized through the development of unions, trade journals, education and training, and professional regulations (Whitehouse, 2009, p. 57). People wanted to own things: goods are tangible and made; services are intangible and delivered.

The Bauhaus movement (1919-1930) through Walter Gropius and Johannes Itten, stressed that the Liberal Arts can be functional and that forms can create functions. The Bauhaus movement stressed functionalism. Their school valued prototypes made for industry but completely unconnected with the market. User perception was seen as potential bias. Their style was marked by a total absence of ornamentation. Their philosophy was anchored in a strong belief that form-giving and esthetics can resolve all complex problems, by discovering the universal answer in the ideal object (De Mozota, 2003).

In summary, the “artist approach” embodied in industrial design:

- considers that “design is for designers”,
- is derived from an artistic perspective with a history of styles (Art Nouveau, Art Deco, Arts & Craft, Bauhaus, Bel Design, Dada, Deutscher Werkbund, Futurism, Streamline, Good Design, International Style, Memphis, Modernity, Postmodernism, Radical Design Retro Design…),
- has the goal of creating something new,
- is characterised by creativity-driven projects,
- emphasizes esthetics, freedom, unbounded creativity,
- is the result of a style embodied by an individual/the art of subjective feeling,
- considers conception theory to be a black box: Inspiration comes from gods.

Consequences: styling for design in companies

Given its historical roots, there is a big emphasis in this kind of design paradigm on form, the visualization of concepts (with different degrees of refinement, from drawings to CAD and films). As a consequence, in the corporate environment, design may commonly be viewed as being about style: executives ask industrial designers to make products beautiful. This view is a legacy of the principle that “form follows function” promoted by the architect Louis Sullivan and the slogan that “Ugliness does not sell” coined by Raymond Loewy, the French American designer who is a founding father of “styling”.

In the last twenty years, industrial designers have tried to escape from the syndrome of form-giving only, to make the transition from drawings to intent, and to claim their roles as pathfinders through their ability to question, reframe and create something brand-new.

Designers themselves challenge this esthetic view of design by citing:

- Mounted objects displayed in museums as symbols of turning points in style (Brown, 2009)\(^\text{156}\)
- A “pseudo art history in which the task is to locate great individuals such as Raymond Loewy and Norman Bel Geddes and portray them as the creators of modern mass culture” (Miller, 1988)\(^\text{157}\)
- The history of objects that are well-known because they are signed by designers who behave like artists with no consideration for users and business viability (Esslinger, 2009)\(^\text{158}\)
- A failure to understand current issues of professional concern and to take a “long view”


The generation of only incremental innovation (Verganti, 2009) when design is based only on style, which is one of two common views on design amongst executives.

As a consequence of the evolution in industrial design culture, some scholars define a company’s level of design maturity by the way it views design: none, style, functions and forms, problem solving, framing. Problem solving and framing are based on design as a process, rather than as an object or a description (Fig. 9).

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Mutanen (2008) has identified in the design literature four basic approaches to how design is disseminated in business organizations (Fig. 10):

1. **In the expert-centered approach**, design is viewed primarily as a professional skill possessed by individual industrial designers (see Heskett, 1980, 2001; Papanek, 1984; Cross, 1995; Racine and Findeli, 2003) in the context of business development. There are particular ‘designerly’ ways of knowing, thinking and acting, and specialist design professionals possess more of these abilities than others. This view is also represented in the works of Bruce and Jevnaker (1998), Ainamo (1996), and Gemser and Leenders (2001) who have studied the correlation between investment in design and the company’s perceived competitive advantage. Developing design is often seen as a matter of recruiting skillful experts, sometimes well-known ‘design stars’, into a firm and managing them successfully.

2. **In the tool-centered approach**, the primary focus is individual professional ability in the context of product development. Essential to its development is the idea of systematizing design work by constructing specific tools and methods. This approach dates back to the design methods movement of the 1960s, in which the goal was to turn design into a science (Simon, 1969; Bayazit, 2004). It was in this vein, for example, that Fraser et al. (2002) developed the idea of a design maturity model.

3. **In the process-centered approach**, design is seen as not so much about building particular design methods, but rather as the development of the overall coordination and division of labor between multiple experts involved in the process of product development or innovation. The process models developed by Cagan & Vogel (2001) and Ulrich &

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Eppinger (1995), for example, suggest that design (among other functions) develops through the creation of the right kind of interaction between experts at different phases of the product development process.

4. In the **strategy-centered approach**, design is viewed as systematically managed collective activity in the context of brand management (Karjalainen, 2004) and business development (Ainamo, 1996; Cooper et al., 2002) as a collective product design capability held by various organizational actors (Bucciarelli, 1994; Henderson, 1999; Bechky, 2003). This essentially means that design is more than the sum of individual designers: it is embedded in the ways in which organizational actors work, think and communicate (Blaich & Blaich, 1993). It is based on the broader idea of design activity as distributed, multidisciplinary, situated, and subject to change.

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Design councils worldwide, and especially the British Design Council, have for the last 20 years promoted design as a key strategic advantage for companies and for a country’s overall competitiveness. De Mozota (2003)\(^{178}\) analyzed 20 studies (p. 58-74) that demonstrated the positive impact of design on economic growth through increased competitiveness. She demonstrated the value of design for marketing, innovation and strategy. She also advocated for global design management as a key factor of success.

**Design for multidisciplinary teams (impact/iterative and reflective process)**

*From product design to experience design: sense making for users first!*

According to times, practices and contexts, the word ‘design’ has held different meanings in the West. Depending on society’s economic priorities and needs, the definition of design and the role of designers have evolved as previously described: initially linked with the genesis of conception, usually with reference to preliminary visual artefacts (more commonly called drawings), be it for a painting, a sculpture, a machine, a product, a logo, today’s design is increasingly associated with the felt experience of users.

The question of the designer’s role in shaping meaning is central: is it the user who creates the meaning of the object or does the designer “ensure that people’s needs and desires (…) are met by visual and material images and artefacts that enter the market place and help us define who we are?” (Sparke, 2004)\(^{179}\) The late 1990s and the early 2000s saw the emergence of the concept of economic function (Pine II and Gilmore, 1998;\(^{180}\) Myerson, 2001; Rifkin, 2003)\(^{181}\):

- In terms of the nature of economic function, goods are made, but experiences are staged;
- In terms of user attributes, goods are standardized, services are customized, experience is personal;
- In terms of method of supply, goods are inventoried, services delivered on demand, but experiences are revealed over time;
- In comparing factors of demand, goods have features, services have benefits and experiences have sensations.

With changes in the needs of contemporary societies, the focus of design has shifted from industrialized goods to experiences, from the design of products to the design of “memorable”

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experiences that engage all five senses. This shift has an impact on design methodologies and tools, which have come to include research on contextual factors and user perceptions, as well as experience prototyping.

Buchanan (1992, 2001\textsuperscript{182}) stressed this fundamental shift from an external to an internal perspective on design, from early theories of design expressed in grammars and logics (in forms, functions and materials), to the emphasis on rhetoric and dialectic in the internal perspective on the design, production, and use of artefacts:

“In design theory of the early and middle decades of the twentieth century, products were often understood from an external perspective. By this, I mean that the focus of attention was on the form, function, materials and manner of production and use of products. This is why form and function loomed so large in theoretical discussions of both graphic and industrial design, and why materials, tools, and techniques figured so prominently in the early phases of design education, as in the “preliminary” or “foundation” courses of the Bauhaus and the New Bauhaus.

With the move away from visual symbols and things as the focus of attention, designers and design theorists have tried to understand products from the inside—not physically inside, but inside the experience of the human beings that make and use them in situated social and cultural environments. While form, function, materials and manner of production continue to be significant, we have an opportunity for new understanding through an investigation of what makes a product useful, usable and desirable.” (2001, p. 13)

From a similar position, Buchanan (2001) defined four orders of design (Fig. 11), which “are ‘places’ of discovery, rather than categories of fixed meaning”:

- **Symbols**: “Graphic design grew out of a concern for visual symbols, the communication of information in words and images. That the name of this profession or area of study has changed over the years only serves to emphasize the focus: it has evolved from graphic design, to visual communication, to communication design”;

- **Things**: “Industrial design grew out of a concern for tangible, physical artifacts—for material things”;

- **Action**: “We call this domain “interaction design” because we are focusing on how human beings relate to other human beings through the mediating influence of products. And the products are more than physical objects. They are experiences or activities or services”;

There are two schools of thought on the nature of “experience design”:

1. The experience of a user at all stages of interaction with the product and service, from the earliest (choice, purchase) to the latest (end-of-life), including the phase of enjoyment. In the business context, its most popular instrument is the “customer journey” (Frazer, 2012; Newbery and Farnham, 2013; Diller, Shedroff and Rhea, 2008). Storyboards, value curves (Kim and Mauborgne, 2005) and the curve of experience are also tools that are currently used to understand and re-invent experiences.

2. A user’s sensory experience of a product or service at a given moment: the senses (hearing, sight, touch, and taste) are analyzed with the aim of enhancing the user’s experience (Minvielle & Minvielle, 2010).

We explore the position of the first score in this research on design thinking projects.

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**Historical perspectives of design thinking**

A concept can be initiated by a person but is usually disseminated by a community and through mass communications, whether TV, the press, websites, books, or academic articles. In general, it is TV that has the biggest impact, and often a whole community “becomes a convert and evangelists of design thinking”.

Design thinking first came to mainstream attention in 2004 with the front cover of *BusinessWeek*: “The Power of Design Thinking”. Today, it is closely associated with IDEO and Stanford University’s d.school. Like many designers, David Kelley, the founder of IDEO and a professor at Stanford, has always rejected the idea of writing about his practice, but in reality the concept is the outcome of his observations. Tim Brown (2009) explains how IDEO tried to move beyond the sculptural object displayed in lifestyle magazines or on pedestals in museums of modern art, by speaking of design with a small “d”:

“One day I was chatting with my friend David Kelley, a Stanford professor and the founder of IDEO, and he remarked that every time someone came to ask him about design, he found himself inserting the word “thinking” to explain what it was that designers do. The term “design thinking” stuck. I now use it as a way of describing a set of principles that can be applied by diverse people to a wide range of problems”

(Brown, 2009, p. 6).

The article aroused a lot of attention in the business community. Stanford University’s Larry Leifer, who runs the ME310 Design Innovation program, likes to tell how Hasso Platner, founder of SAP, was one day reading the magazine just before making a presentation to hundreds of employees. He was immediately convinced and announced that this would be the direction to take in order to foster innovation in his company. He (Hasso) made a large endowment to Stanford University, supervised by David Kelley and six other professors, to create the Hasso Platner Institute of Design at Stanford, worldwide known as the d.school. It gave a boost from 4 in 2004/2005 to 20 courses in 2009/2010 through 12 courses offered in 2008/2009.

Before 2004, there was barely any trace of the concept of ‘design thinking’ in the mainstream media. Most of the emphasis was on the IDEO process, which had already come to public attention with the ABC TV channel’s broadcast of a program called “Deep Dive” on the evening of February 9, 1999, which is still the video on design thinking most watched by the community. The IDEO process was formalized in a book by a British journalist called Jeremy Myerson (2001), who knew Bill Moggridge (one of David’s associates), by David

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Kelley’s brother Tom who published a book the same year\(^{189}\) as well as by IDEO’s corporate communication and Stanford academics (mainly David’s friend Bob Sutton\(^{190}\) and his doctoral student Andrew Hargadon\(^{191}\)). There is no doubt that in the business world IDEO paved the way for the emergence of design thinking, and also forged specific processes and tools for the design of products and services.

**The Story of IDEO (Myerson 2001)\(^{192}\)**

Myerson (2001) dedicated an entire book to describing the genesis and development of IDEO, as well as its achievements and culture (space, spirit, process and tools...). IDEO was formed in 1991 through the merger of three studios: Matrix Product Design owned by Mike Nuttall and David Kelley Design in Palo Alto, which specialized in product design, and ID Two owned by Bill Moggridge in London, which specialized in interaction design. David Kelley explained the reasons for this merger: “I was so far ahead of the game that I had no competitors in engineering design. But when I talked to business people, they told me that I was top of an industry that didn’t exist. Clients didn’t want to referee a fight between engineers and designers in developing a new product. They wanted an integrated one-stop design consulting firm. So I decided to give up my unique position and merge with Bill Moggridge and Mike Nuttall. I also wanted to join an industry with a higher profile, with award schemes. Industrial design provided all of that” (Myerson, 2001, p. 22). This multidisciplinary organization rode the wave of high-tech innovation in a unique ecosystem, a combination of entrepreneurial spirit, academic institution, early success, good weather... “Our chief characteristic has been that we constantly reconfigure what we do in order to catch the wave of what is new in the industry.” David Kelley explained (p. 23) the success of IDEO through the years, from a combined offering of engineering and design, through to computer interface design, experience design, and upstream services in the development process with business strategy design. Investing in start-ups (IDEO Ventures), manufacturing its own products (IDEO Toy) and negotiating licensing deals were other items on Tim Brown’s agenda when he took over in 2001. “How can we make our company more innovative on a routine basis? That has become the big management question.” (Meyerson, 2001, p. 30) “That ability to bottle the creative fuzzy front end and sell it back to large companies is a hallmark of IDEO” (Meyerson, 2001, p. 33).

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In executive and academic publishing, design thinking reached an international audience in 2008 with an article by Tim Brown, CEO of IDEO, in *Harvard Business Review*: “Design thinking—Thinking like a designer can transform the way you develop products, services and even strategy”\(^{193}\). In 2009, he published his long-awaited book “Change by Design—How Design Thinking transforms organizations and inspires innovation” and many other authors followed suit.

A Google search (Fig. 12) shows the development of the phenomenon, with a take-off in 2011\(^ {194}\):

![Google Trends for Design Thinking](https://www.google.com/trends/

The most popular books on design thinking are those published in 2009 by Roger Martin, Dean of the Rotman School of Management at the University of Toronto, by Hartmut Esslinger\(^ {195}\), founder of frog design, and by Dev Patnaik\(^ {196}\), founder of Jumps Associates, as well as a collection of articles by 30 scholars with global reputations published by the Design Management Institute. In the academic literature, the research done on IDEO by Bob Sutton and Andrew Hargadon, initially focused on brainstorming, was published in a major academic publication in 1996\(^ {197}\).

Whereas the term “design thinking” was introduced to the business world by David Kelley, IDEO and the like, the idea that designers have and use ‘designerly’ ways of knowing

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and thinking can be traced back in the academic literature to the 1960s and emerged in the 70s amongst researchers in design engineering, such as Archer, Simon, Lawson, and Rowe, and with architects like Christophe Jones and McDonnough. New approaches to design education were first clearly articulated by Nigel Cross (2011). In contrast with the sciences and humanities, the goal was to understand how designers think and act, or ‘the designerly ways of knowing’, taking design as a ‘third area’ of general education: as a fundamental form of human intelligence, design capacities constitute “abilities to resolve ill-defined problems, to adopt solution-focused cognitive strategies, to employ abductive or appositional thinking and to use non-verbal modelling media”. This third culture was first highlighted in a 1979 report by Archer and his colleagues at the Royal College of Art, but the focus of this movement was how designers think and act, not design thinking as a transdiscipline that drives multidisciplinary teams in the early fuzzy front end of innovation.

What about a definition of “design thinking”?

Brown (2008) gave this simple but now popular definition: “Put simply, it is a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.” Other definitions are listed in appendix 8.3.

It is very important to note that, while this is the most popular sentence, 149 pages of the book’s 245 pages are dedicated to defining what design thinking is: from team to process, from tools to place, the description clearly shows that design thinking is a culture.

The graphic representation below represents the brief in design thinking (Fig. 13):

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**Potential benefits of design thinking**

Design thinking offers large companies three kinds of opportunities:

- To tackle wicked problems which represent challenges for the future;
- To design new offerings which are desirable and delivered more quickly to the market;
- To create a culture of exploration and empathic makers in large organizations.

It is a transdiscipline that drives multidisciplinary teams to tackle wicked problems, including the design of new experiences based on product, service and system design.

**Tackling super wicked problems**

Complex future societal challenges, including overpopulation, climate change, biodiversity loss, mass urbanization, are described as wicked or super-wicked problems (Rittel and Webber, 1973)\[^{200}\]. They represent classes of challenge (Banerjee, 2016)\[^{201}\] that are open-ended medium-scale design challenges and scale transformation challenges. Such challenges require empathic makers who want to make an impact in the world.

Tackling such challenges requires different disciplines: “This new field (of sustainability) integrates industrial, social, and environmental processes in a global context. The skills required for this higher level discipline represent a metadisciplinary endeavor, combining information and insights across multiple disciplines and perspectives with the common goal of achieving a desired balance among economic, environmental, and societal objectives” (Mihelcic and Al., 2003)\[^{202}\]. The need to hybridize different fields of knowledge in order to tackle future challenges is widely acknowledged.

Such complex problems also require a new generation of innovation leaders, characterized by a shift from power to inspiration, from risk-aversion to impact-driven, from efficiency to inquiry-focus, from decision-making to paradigm-shifting, from thinking to action. “The job of an innovation leader is to amplify impact with the greatest sphere of influence possible, and raise innovation capacity within the system, whether it is in the context of a project, a team, an organization, an institution or a large transformative initiative” (Banerjee, 2016).\[^{203}\]

Human-centered innovation processes are a valuable source of the innovation skills, mindsets and impact frameworks required to tackle such challenges.

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Creating and quickly delivering attractive new offerings

Design thinking brings clarity to the “Fuzzy Front End” (Rhea, 2003). In the academic literature, the early stages of product development process are described as the fuzzy front end of innovation: What to make? For whom? Why? What benefits? How does it fit my business strategy? These are the core questions. The fuzzy front-end process often appears to be a random process whereby ideas are refined into a product that (magically) emerges from the end of the funnel. Without questions about where it comes from, it enters the new product pipeline, passing through what is commonly known as the “stage gate process” in which management periodically reviews the product’s progress and determines whether it meets their criteria for allocating additional development resources. Since the selection of ideas is unstructured, the focus of progress is primarily on internal operations. However, through the development of a unique and proprietary understanding of who the customers are and what they want and need, it becomes possible to identify the right problems to solve and the right questions to ask. Design thinking provides a systematic and rigorous approach to defining the inputs into the funnels: “With the customer as our guide, there is no need for the fuzzy front end to remain fuzzy” (Rhea, 2003, p. 154).

Creating new product and service offerings by means of design thinking can be a big factor of market differentiation. Verganti (2009) noted how: “In the pursuit of differentiation, products have to be desirable: either because they better answer people’s needs (by eliminating constraints and problems and enhancing the experience of users, which is the root of user research based on antropologists’ and sociologists’ approaches in humanities) or because they appeal to emotions (by branding, which is the root of research on design management, based on marketing and behaviorism)”. In order to achieve breakthrough innovation, Verganti called for executives, scholars, artists, scientists, and of course designers themselves, to become radical researchers: “Experts who envision and investigate new product meanings through a broader, in-depth exploration of the evolution of society, culture, and technology.”

Design thinking drives multidisciplinary teams to innovate thanks to a common language. The limitations of stand-alone designers in the early phases of innovation are observable (Lofthouse, 2001), as are those of single champions in the literature of innovation, as noted by O’Connor (2008): “Much of the RI literature highlights the critical role of the single-minded, impassioned champion (Chakrabarti, 1974; Greene, Brush, and Hart, 1999; Howell and Higgins, 1990; Kuratko, Montagno, and Hornsby, 1990; Maidique, 1980; Pinchot, 1985; Shane, 1994; Sharma, 2000). While persistent, skilled, visionary champions are critical to


RI, organizations will never maximize their resources and advantages if they do not move from relying on champions to a dynamic capability that includes them as one element of a system. Design thinking represents an alternative way of designing products and services in multidisciplinary teams (Owen, 2006)\textsuperscript{207}: “The innovation process can be improved significantly with design thinking: a team can use it as an alternative way of thinking”.

**Building a culture of empathic makers with an impact on society**

In addition to the capacity to bring better designed offerings to the market, design thinking represents an opportunity for organizations to change their culture and acquire new sense making opportunities for society, in other words to move from making products to achieving societal impact through strategy. In her 2006 dissertation at Carnegie Mellon University, supervised by Buchanan, Sabine Junginger demonstrated how design thinking has changed the values and actions of organizations. Junginger (2006)\textsuperscript{208} demonstrated how product design can have an impact on a company’s strategy and on the society: empathic making can create organizational changes through human-centred product development to such a point they have an impact on the company’s strategy and the society’s vision which is developed. She defined three levels of change in an organization brought about by human-centered product development: operational, strategic, visionary (Fig. 14).

Martin (2009) described how P&G renewed its culture by means of design thinking, with a shift from exploitation to exploration, from reliability to validity, from heuristics and algorithms to the discovery of mysteries about people and technologies, all of which fueled the company’s innovation capacity for the next ten years. For his part, Patnaik (2009)\textsuperscript{209} showed not only the impact of empathy in repositioning product and service offerings on unexpectedly promising markets, but also in creating a unique and attractive culture: “Creating widespread empathy helps executives to reframe how they see the world with emotionally charged memories to stay true to the vision, and with the hidden payoff of creating high motivation for employees and a sense of mission.”

Junginger’s (2006) three case studies represent three possible scenarios for disseminating design thinking within an organization:

- from inside (by building internal capacity);
- by hiring a design company;
- by collaborating with a university through capstone projects.


Running multidisciplinary teams as a transdiscipline

Future societal challenges and new offerings need multidisciplinary teams in the early phase of design. “The biggest hope of a multidisciplinary team is that they are able to construct a common, comprehensible definition of the problem, an explanatory view of relevant mechanisms and processes, and a manageable set of problem solutions.” This kind of collaboration should be present in the early stages of innovation: “Multidisciplinary research collaboration may best be started in the problem formulation and planning stages of a project. Questions about the what, why, how, with whom, and for whom need careful discussion, as well as the usefulness of expected results” (Uiterkamp and Vlek, 2007). The question that then arises is which transdiscipline should be employed.

Banerjee (2016, p. 9) explains the differences between multi-, inter- and trans-disciplinarity:

- Inter-disciplinary is where the thinking and the tools from one discipline can be leveraged for another discipline or the work is at the intersection of two fields.

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Multi-disciplinary is where members from different fields come together to solve the problem, but each representative of a discipline operates strictly within his or her disciplinary domain.

Trans-disciplinary is when members of different disciplines come together to “surround” a challenge and use their different disciplinary perspectives to “co-create” solutions in a manner that requires them to transcend the confines of their disciplines.

He then explains that when trans-disciplinary co-creation is done well, it is difficult to discern which discipline might have been responsible for which component. Trans-disciplinarity is a particularly important method for addressing complex, multi-dimensional challenges. The more advanced innovation methodologies focus on making sure that trans-disciplinary co-creation is achieved.

It is of paramount importance to recognize design thinking as an emerging transdiscipline for the tackling of ill-defined problems (such as sustainability, digital transformation and new product offerings), and the need for its dissemination through national education systems.

Teaching innovation through design thinking: Where, Why, What, How

Global perspective on transdisciplinary programs

In the last 10 years, two basic principles—multidisciplinary teams and human-centered design—have been responsible for the transformation of many innovation curricula around the world, constituting the first two foundational values of design thinking. Bertola, Harfoush and Vacca (2016) have offered an international perspective on how universities have developed “new programs not anymore centered on creating experts in specific domains of knowledge but rather centered on problems”. The Como Innovation Summit initiative created a platform for a number of higher education organizations to share their early experience and lessons. One of its activities was to survey the participants with the aim of identifying patterns in the emergent phenomenon and codifying possible new paradigms for education. The chapter offers an overview of trends. The book provides an in-depth description (history, mission, community, learning type and future evolution) of ten best practices in higher education (four North American programs, one in China and five in Europe, including the d.school Paris): “The goal of education is to enable individuals to be responsible for their future role in society and/or its positive transformation”.

Since 2005, the d.school at Stanford has paved the way for a definition of the pedagogical


principles of design thinking:

- “hands-on real world projects”
- “radical collaboration between faculty, students and industry”
- “a methodology of innovation that combines creative and analytical approaches”
- “learning by doing”
- “bias toward action”
- “to learn the process together and then personalize it, internalize it and apply it to their own challenges”
- “we don’t just ask our students to solve a problem, but to define what the problem is”

The hope is that design thinking should become and be recognized as transdiscipline, different in its characteristics (in terms of purpose, format, type of problems, process, skills, place), for example, from engineering and business education.

Table 4. Differences between engineering, business and design thinking education

<table>
<thead>
<tr>
<th></th>
<th>Engineering education</th>
<th>Business education</th>
<th>Design thinking education</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>Understanding the natural world</td>
<td>Business development</td>
<td>Improving quality of life</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Technical performance</td>
<td>Sales and margins</td>
<td>Value creation for people</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Problem analysis oriented</td>
<td>Case analysis oriented</td>
<td>Solution and action oriented</td>
</tr>
<tr>
<td><strong>Stance</strong></td>
<td>Descriptive</td>
<td>Prescriptive</td>
<td>Proactive</td>
</tr>
<tr>
<td><strong>Competence</strong></td>
<td>Knowledge acquisition through analytical skills</td>
<td>Analytical skills</td>
<td>Know-how and “savoir être” (life skills)</td>
</tr>
<tr>
<td><strong>Pedagogical format</strong></td>
<td>Lectures, case studies, simulation, controlled environment experiments</td>
<td>Lectures, case studies</td>
<td>Real issue projects with real partners, fieldwork, coaching, activities in staging space for teams</td>
</tr>
<tr>
<td><strong>Epistemology</strong></td>
<td>Positivism</td>
<td>Positivism</td>
<td>Pragmatism and constructivism</td>
</tr>
</tbody>
</table>

215 Stanford University (n.d.) A 90-minute video-led cruise through our methodology.
<table>
<thead>
<tr>
<th>Students</th>
<th>Disciplines in engineering</th>
<th>Disciplines in business: marketing, finance, law, human resources</th>
<th>Many disciplines including engineering, design and business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>One discipline professor</td>
<td>Multidisciplinary teams</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Applied theory problems defined by faculty</td>
<td>Case studies</td>
<td>Situation based brief discussed between partners and faculty</td>
</tr>
<tr>
<td>Problem</td>
<td>Well defined problems</td>
<td>Defined customer targets</td>
<td>Ill defined/wicked/messy problems</td>
</tr>
<tr>
<td>Mode of thinking</td>
<td>Deduction</td>
<td>Deduction</td>
<td>Induction and abduction</td>
</tr>
<tr>
<td>Outcomes</td>
<td>One solution to a problem</td>
<td>Market studies and business plans</td>
<td>Solutions appropriate to a given situation</td>
</tr>
<tr>
<td>Activities</td>
<td>Data collection, analysis, modeling, presentation</td>
<td>Case studies</td>
<td>Inspiration/ideation/implementation</td>
</tr>
<tr>
<td>Process</td>
<td>Step-by-step linear process</td>
<td>Stage-gate linear process</td>
<td>Cycle and iterative process</td>
</tr>
<tr>
<td>Skills</td>
<td>Mathematical modeling, simulation, prototypes, analysis tools, case studies, PowerPoint presentations</td>
<td>Use of quantitative marketing tools, relying on survey data and demographics</td>
<td>Empathy, ethnographic research, real world observation, sources of inspiration, brainstorming, many types of prototypes according to objectives, user feedback, storytelling, video and real outcome presentations</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Exams, out-of-the world problem solving</td>
<td>Learn public speaking and employee messaging, received personal coaching</td>
<td>Self-reflection, outcomes in the real world</td>
</tr>
<tr>
<td>Location</td>
<td>Classroom, theater, lab</td>
<td>Classrooms</td>
<td>In the field and project space with rooms staged for activities</td>
</tr>
</tbody>
</table>

Common characteristic of this kind of pedagogy is that innovation is taught in context, through enquiry and learning experiences, in order to foster initiative and proactivity. It often requires an epistemological shift, from positivism to constructivism and pragmatism.
As shift from knowledge acquisition to experiential learning based on situated enquiry

A dominant pedagogy, lecture-based learning no longer meets the needs of students, who are connected to online sources of knowledge: “When content is available everywhere, anytime, learning is no longer dependent primarily on an instructor ‘transferring’ their deep current expertise to masses of uninformed students. Lectures are no longer sufficient. Research on how people learn has shown that ‘active’ pedagogies, those that allow students to ‘construct their own knowledge’ are more engaging and effective than passive lectures alone” (Corcoran, 2014). The lecture is no longer an adequate means of project-based learning in innovation, in which new knowledge is produced through situated enquiry and artefact building. Buchanan (2001) recognized the importance of this shift, even for design education, which is normally more practice-oriented: “Instead of teaching (the materials, tools, techniques of design as the primary subject matter), the new course focuses on projects and problems that are situated within the experience and motivation of students. Having a reason to design gives focus and purpose to student development”. Design thinking education represents a shift from traditional knowledge acquisition to experiential learning with authentic problems and results that matter.

Project-based learning, capstone projects, university/industry partnership

Project-based learning implies that students work in teams and are given a “driving question” to respond to, and are then directed to create an artifact to present the knowledge they have acquired. It combines knowing and doing. Students solve authentic problems and produce results that matter (Blumenfeld and al., 1991; Markham 2011).

A capstone project is a multifaceted assignment that serves as a culminating academic and intellectual experience for students, typically during their final year.

A capstone project with industry means that the company gives the project’s brief.

ME310 projects consistently and uniquely unite three approaches for student learning:

- problem-based learning
- immersion and simulation

The debate between traditional and experiential education dates back to the 19th century with seminal works by John Dewey: “Learning here means acquisition of what already is...”


221 including Democracy and Education, Experience and Education, How We Think, Art as Experience, Experience and Nature
incorporated in books and in the heads of the elders. Moreover, that which is taught is through
of as essentially static. It is taught as a finished product, with little regard either to the ways
in which it was originally built up or to changes that will surely occur in the future. It is to a
large extent the cultural product of societies that assumed that the future would much like
the past, and yet it is used as educational food in a society where change is the rule, not the
exception” (Dewey, 1938, 1997\textsuperscript{222}, p. 19).

The knowledge of the past is of limited use in the quest for new solutions for the future.
That is why traditional education is inadequate for the teaching of radical innovation. “Since
the subject-matter as well as standards of proper conduct are handed down from the past, the
attitude of pupils must, upon the whole, be one of docility, receptivity, and obedience. Books,
especially textbooks, are the chief representatives of the lore and wisdom of the past, while
teachers are the organs through which pupils are brought into effective connection with the
material. Teachers are the agents through which knowledge and skills are communicated and
rules of conduct enforced” (Dewey, 1997, p. 18). Radical innovation requires breaking free of
past design decisions to imagine possible new futures, more appropriate for the reconciliation
of ecological, aspirational, technical and economic priorities. Dewey was already advocating
for this kind of education based on life-experiences as far back as the beginning of the 19\textsuperscript{th}
century. In his theory of experience, he relied on two fundamental principles—interaction
and continuity—as two criteria for the value of experience.

The teaching of design thinking is in the tradition of education in design. A review of the
literature shows that competence in designing can only be gained through experiencing the
design process as a problem-solving practice. Practical exposure is essential to the learning of
design methods and the experience should be as real as possible. Design learning is typically
based on action and reflection. The paradigm underlying this approach is that of discovery
learning (Christiaans and Venselaar, 2005\textsuperscript{223}).

\textbf{How to develop design thinking pedagogy with specific learning environments}

Beckman and Barry (2007)\textsuperscript{224} showed how the innovation process based on design thinking
(observation to understand contexts/frameworks to identify insights/imperatives to generate
ideas/solutions to create experiences) matches the different learning styles observed by Kolb
(1984)\textsuperscript{225} for experiential learning, a highly iterative process that consists of the repetition of
four steps: experiencing, reflecting, thinking and acting (Fig.15).

\textsuperscript{222} Dewey, J. (1997). \textit{Experience and Education: the 60th anniversary}. West lafayette, IN : Kappa delta pi.
\textsuperscript{223} Christiaans, H., & Venselaar, K. (2005). Creativity in Design Engineering and the Role of Knowledge: Modelling the
Management}, 50 (1), 24-56.
\textsuperscript{225} Kolb, D. (1984). \textit{The experiential learning: Experience as the source of learning and development}. Englewood Cliffs,
NJ: Prentice-Hall
Creating such learning experiences requires different modes of learning. Design thinking pedagogy is complex in that it incorporates three (affective, perceptual and behavioral) of the four learning styles (Table 5) described by Kolb (1984)\(^226\).

**Table 5. Learning models, adapted from Kolb (1984)**

<table>
<thead>
<tr>
<th>Emphasis</th>
<th>Affective</th>
<th>Perceptual</th>
<th>Symbolic</th>
<th>Behavioral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source of information</strong></td>
<td>Experiencing what it’s actually like to be a professional in the field under study.</td>
<td>Understanding something: to be able to identify relationships between concepts, define problems for investigation, collect relevant information, search a question.</td>
<td>Solving a problem for which there is usually a right answer or a best solution.</td>
<td>Actively applying knowledge or skills to a practical real life problem.</td>
</tr>
<tr>
<td></td>
<td>Students are encouraged to reflect upon an experience to generate insights and feeling about themselves.</td>
<td>Students are encouraged to view a topic from different perspectives and in different ways.</td>
<td>Abstract information, meaning removed from the present and presented via reading, data, pictures, lectures...</td>
<td>In attacking the problem, the focus is on doing.</td>
</tr>
</tbody>
</table>

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Assessment

Expressions of feelings are seen as productive inputs.

Learners should define criteria of success.

The right or best solution, expert opinion, or rigid criteria in the field.

Success is measured against criteria associated with the task.

Learners’ activities

Vary from any prior schedule in line with the learner’s needs.

Planned time on looking back at previous steps, events, or decisions to guide future activities.

The learner is guided and constrained by externally imposed rules of inference according to a plan.

Periodic checkpoints for which reports or other information are required, with time managed by the learner.

Teacher’s role

Role model for the field

Mirror or process facilitator

Accepted representative of the body of knowledge

Coach, but primarily at the learner's request.

Teachers’ feedbacks

Personalized with regard to the learner's goals and needs. Critiquing.

Reward system to emphasize methodology of inquiry. Suggesting.

Plan of analytical activities. Judging and evaluating.

Make decisions about what to do next or how to proceed. Advising.

“To conduct the educational process in universities in a manner that attends to the individual learning styles of students and fosters student development requires identification and management of those aspects of the educational system that influence the learning process” (Kolb, 1984, p. 196). 227 “Any educational program, course design, or classroom session can be viewed as having degrees of orientation toward each of the four learning modes in the experiential learning model, labelled, affective, perceptual, symbolic, and behavioral, to connote the overall climate they create and the particular learning skill or mode they require (Kolb and Fry, 1975). Thus an affective environment emphasizes the experiencing of concrete events; a symbolic environment emphasizes abstract conceptualization; a perceptual environment stresses observation and appreciation; a behavioral environment stresses action taking in situations with real consequences” (Kolb, 1984, p. 197).


Fry (1978)\textsuperscript{229} and Kolb (1984) acknowledge the fact that some courses can be highly orientated towards more than one style. Design thinking pedagogy can leverage all four of them or be more orientated in one way than the others, depending on the personality of the teachers and/or type of students and/or culture. A consistent pattern of environmental orientation for design thinking pedagogy has emerged from this piece of research in the following combination:

- **Behaviorally** complex learning environments are nonetheless the closest to design thinking characteristics and should remain the dominant paradigm: “The problem need not have a right and best answer, but it does have to be something the learner can relate to, value, and feel some intrinsic satisfaction from having solved” (Kolb, 1984, p. 199). The focus is to foster pride in delivering something real and useful for someone in a given context.

- In the attempt to achieve that goal, the learners need to solve their problems and are immersed in perceptually complex learning environments: They need to investigate for themselves to understand something (what is useful and how to do it) and are “free to explore others’ ideas, opinions, and reactions in order to determine their own perspectives”. “If a task is being done, the emphasis is more how it gets done” (Kolb, 1984, p. 198).

- In the course of their investigation, the learners are engaged in activities that stimulate insights and feelings about themselves as professionals, which may require affectively complex learning environments where they can express their feelings with peers and teachers in accepted discussions. The purpose is to encourage self-reflection and personal growth, as well as better team dynamics and social interactions with the given context. The development of emotional intelligence (Goleman, 1995)\textsuperscript{230} is cultivated.

- Depending on the reframing capacity and autonomy of students, symbolically complex learning environments may also be necessary to enforce methodology and the scientific rigor of design thinking. “The teacher is a timekeeper, taskmaster and enforcer of schedules of events in order that the learner can become immersed in the analytical exercise necessary to reach a solution and not worry about having to set goals” (Kolb, 1984, p. 198)\textsuperscript{231}.

Given its process and the cultural context, design thinking pedagogy requires all four learning modes and environments. To create such complex learning environments is a challenge. The question, therefore, was how to do it.


How to create learning environments for design thinking

This question about how to create this kind of learning environment was behind my stay at Stanford in 2008/2009 and my interviews with more than 30 designers in the Silicon Valley: these learning environments were the result of the chemistry between people, place and process, a kind of sub-ecosystem of Silicon Valley itself. I combined these findings from the field with a literature research.

PEOPLE: Multidisciplinary teams as a dogma

The d.school’s manifesto hung on a billboard at CDR where my office was during my stay at Stanford and reflects the values of the Stanford d.school community (Fig. 16). The doctrine of multidisciplinary teams was as powerful in practice as in the literature, whether in design thinking (Sutton and Hargadon 1997, Kelley 2001, Beckman and Barry 2007, Brown 2009, Frazer 2011)\textsuperscript{232} or innovation (Banerjee 2016)\textsuperscript{233}.

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The T-person is the profile that students are expected to show after a course in design thinking. Interviewed by Adam Bryant on October 24, 2009, Brown\textsuperscript{234} pointed out that “there’s this idea that McKinsey first articulated many years ago of the T-shaped person, which is somebody who’s got some deep craft — a great writer or a great designer or a great architect, engineer or whatever they might be — and that’s the vertical stroke of their T. But then the horizontal is that they’ve got clear empathy and interest in engaging with other disciplines and doing other pieces of the process or playing other roles”.

The Harvard psychologist Howard Gardner’s theory of multiple intelligences relates mental capabilities to domains of behavior—intrapersonal, linguistic, logico-mathematical, spatial, musical, kinesthetic, interpersonal—not to an integrated process of productive thinking such as designing.\textsuperscript{235} Charles Burnette, from the University of the Arts at Philadelphia, noted that many models have been advanced to establish objectives for education,\textsuperscript{236} but perhaps none has been more influential than Bloom’s Taxonomy of Educational Objectives (Bloom, et al 1956).\textsuperscript{237} That is why he interpreted the cognitive, affective and psychomotor domains of learning defined by Bloom in terms of the IDEeSIGN model of design thinking to define the educational objectives associated with each dimension of the model.

Analytical and intuitive ways of thinking are combined to achieve both exploitation and exploration, with deduction and induction on the one hand and abduction on the other.

As reported by Bob Sutton on May 7, 2010,\textsuperscript{238} at the opening Gala for the new building that houses the Hasso Plattner Design Institute of Design also called the d.school, together with the Mechanical Engineering Department’s Design Group and its ME310 Design Innovation Class, David Kelley stressed the contribution that the d.school makes to people: creative confidence, which is the combination between identifying opportunities in the real world and making real things happen. It represents a paradigm change with traditional education. He went on to explain that the “main tests used to decide who gets into Stanford and who does not, as well as the bulk of training in the technical aspects of engineering, math and the sciences, are constructed so that there is a right answer to the question and it is the student’s job to find that answer and report it back to the teacher.”

\begin{itemize}
\end{itemize}
**Why a d.school?**

Bob Sutton at the opening ceremony for the new building, May 13, 2010: “Certainly, such definitive technical knowledge is crucial. I want engineers who can calculate the right answers so that bridges don’t fall down and airplanes don’t crash. As valuable as it is, however, such training—with its focus on individual achievement under conditions under which the right answers are already known—means that a lot of the people who come to the d.school for classes lack both the skills and the confidence to work on messy problems where the faculty don’t know the answer (…) and the only hope is to keep pushing forward, observing the world and the people in it, identifying unmet needs, brainstorming solutions, and trying to develop prototypes that work—and failing forward through the disconcerting process. The thing I liked most about David’s emphasis on “creative confidence” is that I think he nailed the single most important thing that the d.school does when we are successful.”

Considering the fact that our students have been selected for their outstanding analytical skills, particular stress has to be placed on the development of intuitive reasoning based on empathy and sense making for others. At a symposium in March 2010 on the Future of Design at Stanford University, a group of design/innovation practitioners and educators came up with the concept of Design Intelligence/Creativity Quotient, with the hope that it would take design thinking and the conversation around innovation to the next level. The concept really came home to Nussbaum when Bill Burnett, Executive Director of the Stanford University Design Program, said he wanted to add an additional screening measure to the SATs and GREs that students submit for admission to the school. “We measure math, verbal and writing capabilities, why not creativity?”

It is generally assumed that there is a conflict between the engineer and the artist. Each wants to describe a world or create new worlds in a different way, one analytically, the other intuitively. To reveal the synthesis between the two in each of us, so that we can simultaneously adopt both mindsets in order to create innovative products, is a possible initiation process that requires an individual and collective transition.

The main challenge in teaching design thinking to highly analytical people is first to develop abduction skills and then to help them navigate empathically between and intuitive thinking. The objective is to set the stage for people to feel safe in exploring targeted values, attitudes and reasoning:

- **A shared vision:** create a new experience, which is desirable, feasible and viable

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239 This text is inspired by a conversation in 2010 with Fabien Paris, a former co director of studies at ENPC, who passed away at a very early age. He was inspired by our studio and created a similar room for professors, where his spirit remains.
• **Core values** (adapted from Cross, 2007):  
  - “Ill-defined or wicked problems” versus “pre- or well defined problems”  
  - “Sense making for users” versus “new and original”  
  - “Possible solutions appropriate to a context” versus “a single solution”  
  - “Solution-focused mode of problem solving” versus “analysis-focused mode”  
  - “Constructive mode of thinking” versus “individual critical mode of thinking”  
  - “Combination of conception and execution” versus “conception only”

• **Core attitudes:**
  - Optimism: “We can change the world by what we do”  
  - Idealism: “We want a better world”  
  - Empathy: “We care for others”  
  - Creative confidence: “We can solve problems based on what we feel make sense for others and what we can do for them”  
  - Pragmatism: “We want to deliver something useful for someone”

• **Cognitive stance:** T-man profile, the combination (Table 6) of analytical reasoning (inductive and deductive) and intuitive reasoning (Martin, 2009).  

<table>
<thead>
<tr>
<th>Analytical thinking</th>
<th>Intuitive thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis in fragments</td>
<td>Synthesis at a glance</td>
</tr>
<tr>
<td>Exploitation</td>
<td>Exploration</td>
</tr>
<tr>
<td>Intellectual intelligence</td>
<td>Emotional intelligence</td>
</tr>
<tr>
<td>Rigidity, rationalism, conformism</td>
<td>Passion, optimism, originality</td>
</tr>
<tr>
<td>Inductive and deductive</td>
<td>Abductive logic</td>
</tr>
<tr>
<td>Honing and refining the past</td>
<td>Inventing the future</td>
</tr>
<tr>
<td>Reliability</td>
<td>Validity</td>
</tr>
</tbody>
</table>

Table 6. Intuitive versus analytical thinking, Adapted from Martin, 2009


**PROCESS: Historical perspective**

In addition to shared values and a common brief as explained, the process and tools are considered as the “glue”\(^2\) between disciplines: “a glue that brings teammates together around a common goal: make the lives of the people they’re designing for better.”\(^2\) IDEO is widely recognized as a pioneer in defining the process of design thinking. The following historical perspective shows the process’ development from a linear process with an iterative loop to a cyclical process transiting between three “spaces”.

Deep Dive (1999), Meyerson (2001) and Kelley (2001) characterised the first historical period in the IDEO process. In the 1990s, under the influence of David Kelley, IDEO was a linear process with an iterative loop focused on testing tangible artefacts with users in real contexts (Fig.17).

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**The IDEO process from 1991 to the mid-2000s (Myerson 2001, p. 31-33)**\(^3\)

1. **Understand**: Understand the market, the client, technologies, customers, perceived constraints.

   “The Understand phase of any project kicks off with team meetings and brainstorms which aim to get a handle on the problem and get inside the minds of potential users of a product. This stage is all about grasping the business, marketing and technical issues at the heart of the project, about setting out initial insights and product ideas that can be fleshed out later. Who are the competitors? Who are the customers? What technologies can be utilized? What profit margin does the client want to achieve?”

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242 Design Thinking as providing “a glue that brings teammates together around a common goal: make the lives of the people they’re designing for better.”: http://dschool.stanford.edu


What is the lifecycle of the product? This first phase also enables the IDEO team to work out which users should be observed.”

2. **Observe**: Observe people in real life to identify frustrations, likes, dislikes, unmet expectations

“The second Phase—Observe—entails getting ‘out there’ to conduct observation studies of existing and potential users of the product. (…) Joint teams of designers and human scientists undertake assignments (…). From the information gathered, user profiles and usability requirements are created and functional specifications defined.” Lead and extreme users are first identified and observed with video ethnography tools.

3. **Visualize**: Visualize concepts through tangible prototypes, user scenarios and videos

“The third step of the process—Visualize—is where industrial design shines. IDEO develops detailed scenarios in the form of storyboards or videos showing how people might use a product or a service, and creates physical models and rough working prototypes to elicit feedback. Fictional characters are invented with real names, personalities, jobs, hobbies, passions and phobias that everyone can relate to. Designers adopt those characters during a narrative storytelling process which stimulates rapid-fire design ideas. The most promising of these ideas are swiftly translated into rough 3D models you can touch and hold, which are valued much more than 20 sketches. (…) We are in multiple realizations of what the future can be.”

4. **Evaluate**: Evaluate and refine ideas with iterations with users and clients

“The fourth step—Evaluate—enables the development team to review options and refine the working design. Often this involves going back to the user groups observed at stage two for their comments, as well as undertaking lab and field tests. (…) The project returns again to the viewpoint of the client (…): We look again at whether the client should be producing it and whether the right distribution is in place.”

5. **Implement**: The phase of engineering design and manufacture

“Once the business decision has been made, then the detailed design work for production is done. The Implement phase takes up 90% of the cost and the time of any project (…) IDEO puts great emphasis on strong, well-documented implementation which maintains the design integrity by referring back to initial user requirements.” (Myerson, 2001)
In 2005, the d.school at Stanford started global dissemination amongst academics, which has had a big influence on how design thinking is perceived in the business world as well. Its initial process (Fig. 18) has disappeared from its website and has been replaced by a new one (Fig. 19) with 5 steps (instead of 6) and the following modifications: “Understand” and “Observe” have been replaced by “Empathize”, “Point of View” by “Define”. The three last ones (“Ideate”, “Prototype” and “Test”) remain the same.

Since 2012, it has been replaced by a simpler version (Fig. 19), which has become the design thinking process best known around the world because of its simplicity, ease of understanding and use, based on methods clearly explained in a free-of-charge CC toolkit “bootcamp bootleg”. This simple process is not appropriate when the objective is implementation, i.e. delivering something of value in a real context. Since the process stops with a test activity, it does not involve implementation. That is why the d.school Paris has not used it since 2013 (see chapter 5, the evolution of process), in order to avoid a museum of dead prototypes.

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Tim Brown, CEO of IDEO since 2001, changed the initial IDEO process, as a HBR article in 2008 and the release of his book in 2009 demonstrated it. It became a fully cyclical process with three “spaces”: inspiration – ideation – implementation (Fig. 20). Brown (2009) also stressed how social events are part of the process and should be organized as rituals at each step.

The use of the words “ideation” and “ideate” is a common source of misunderstanding about the IDEO and d.school processes, which ascribe different meanings to the two concepts. The activity called “ideate” at the Stanford d.school refers to brainstorming / bodystorming activities in which one “aims to generate radical design alternatives”. In the IDEO process, “ideation” phase encompasses three activities (Brown, 2008, 2009): brainstorming, prototyping and testing.


For the sake of clarity, the d.school Paris has merged the two processes, with some modifications in two activities, in order to be more efficient in implementation, whether with the market launch of a new product in a company or with the building of structures or objects in public space. As well as the three spaces (inspiration/ideation/implementation), d.school Paris has added a fourth, which is dissemination, not only during the ideation phase, but throughout all the steps of the process, in order to facilitate implementation (see Fig. 28 in Chapter 4, section “evolution of process”).

In 2008/2009, interviews with around a hundred students, lecturers, coaches and academics at Stanford, as well as with practitioners and consultants in Silicon Valley, gave a picture of their stances, motivation and practice, including process and tools. In terms of process, four slightly different stances stood out at Stanford in 2008 associated with four different courses.

- **Concerning the d.school’s stance at Stanford**, the emphasis is on needfinding, reframing and concept generation. Here is a description of the process: “Students start in the field, where they develop empathy for people they design for, uncovering real human needs they want to address. They then iterate to develop an unexpected range of possible solutions, and create rough prototypes to take back out into the field and test with real people. Our bias is toward action, followed by reflection on personal discoveries about process. Experience is measured by iteration: students run through as many cycles as they possibly can on any project. Each cycle brings stronger insights and more unexpected solutions” (Kembel, 2013). Students came from Stanford University’s 7 schools and the courses were elective, with or without credits, and were available to hundreds of students.249

- **Concerning the course “Design for Extreme Affordability”** run by Jim Patell, a professor at Stanford business School, the emphasis is on implementation in real conditions, as well as the creation of start-ups. Here is description of the process: “Needfinding, user empathy, rapid prototyping and iteration (...) Teams gain empathy with all stakeholders in order to develop solutions that fit into the culture, aspirations, and constraints of their target customers. Teams will iterate on their designs and business models through a rapid sequence of prototypes, user tests, and design reviews”250. Amongst the 40 participants, 25% were business students, 25% engineering students and 50% from other programs across campus. The duration of the course was two quarters.

- **Concerning ME310 process at the School of Mechanical Engineering**, the emphasis is on a series of 6 main prototypes (CFP/CEP, darkhorse, funky, functional, design to X, final prototype as a proof-of-concept), which help students to think divergently and convergently in the process: “Teams observe and interview users to better understand their needs, benchmark existing technologies and products to identify the design opportunities, extensively brainstorm to discover the obvious, crazy, and novel ideas, and iteratively prototype to quickly test their


ideas and get a better understanding of their designs. The end result is a refined design concept backed with key insights”. Most of the 40 students come from the mechanical engineering school. This course is a major with on average three days a week spread over three quarters.251

• **Concerning the Stanford design program**, the emphasis is in 2009 on reframing and generating innovative solutions: “We work simultaneously in the creative framing of the problem domain and generating a wide array of innovative solutions. We dive deep into the human condition, using ethnographic research methodologies and behavioral sciences to discover latent needs. Our methodology combine intentionality, design expression and an questioning of the larger implications, allowing us to arrive at innovative solutions to appropriately framed problems”252. Students are selected on their design portfolio, regardless of their background, for around 12 slots each year. The course is a full-time program leading to a Masters degree. It is led by Bill Burnett and David Kelley.

Last but not least, the design thinking process requires a huge set of tools for each activity (ethnographic research, visual thinking, prototyping including experience prototyping, storytelling, creativity techniques…). A literature review between 2008 and 2016 identifies up a dozen design thinking processes, in the academic world (e.g., Kumar 2012253, Luma 2012, Fraser 2011254, Hillen 2014255, Uebernickel et al. 2015256, K12 movement,257 the movement for libraries,258), in consulting companies (including IDEO for ethnographic research259 or experience protopyes260,

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Frog design\textsuperscript{261} and Numa Institute\textsuperscript{262}, in social businesses (including Human Centred-Design for social innovation under extreme conditions in emerging countries\textsuperscript{263}) and in industry (including SAP, GE, P&G). Some represent adaptations of earlier versions. Some interpretations missed the point.

\textit{PLACE: From lecture hall to field, with 9 landmarks in the studio}

\textbf{From the classroom to the studio.} The traditional spatial learning environment meets the needs of a pedagogy primarily based on lectures, which delivers predigested knowledge to large cohorts of obedient students, with a focus on individual assignments that require analytical skills to discover single answers to predefined problems. Design thinking pedagogy is project-based learning with a focus on solving real problems with a specific process and activities. It requires a radically different learning environment, as particular physical spaces foster targeted activities and behaviors. George Kembel (2010\textsuperscript{264}), Director of Stanford University’s d.school, described this change in educational approach and its spatial consequences: “In 2020 we will see an end to the class room as we know it. The lone professor will be replaced by a team of coaches from vastly different fields. Tidy lectures will be supplanted by messy real-world challenges. Instead of parking themselves in a lecture hall for hours, students will work in collaborative spaces, where future doctors, lawyers, business leaders, engineers, journalists and artists learn to integrate their different approaches to problem solving and innovate together.”

The importance of the learning environment in its spatial dimension can be undervalued by decision-makers in education, as noted and explained by Corcorran (2014)\textsuperscript{265}: “Without an awareness of the connection between physical space design, and human behavior in these physical places, educators may be unaware of the importance of designing spaces to foster activities and behavior that lead to better engagement, and better learning.”

After visiting around a dozen sites and interviewing a hundred people in Silicon Valley in 2008/2009, my main findings were about how to stage an innovation space for design thinking methodology, and I discovered a lot of “landmarks”.\textsuperscript{266} Even if messy at first sight, lofts, studios or garage-style spaces are structured in such a way as to incorporate a certain number of symbolic


\textsuperscript{266} Hillen, V. (2014). Place. In Hillen, V. \textit{101 Landmarks I’ve discovered to innovate thanks to design thinking}. CC
and functional facets, which create the right emotional and mental conditions. Most people on a learning tour tend to find these places “crazy” and are unable to identify any structure. My findings included the discovery of a global structure around 9 “landmarks”\textsuperscript{267}, which embodied the spirit of design thinking and facilitated design thinking activities. The more places I visited, the more landmarks I identified, the better I was able to decipher their logic and impact. Those landmarks have also been described in works, such as Kelley (2001), Myerson (2001), Brown (2009) and Doorley & Witthoft (2012)\textsuperscript{268}.

The spaces of design thinking pedagogy look like studios. Studio environments are the signature pedagogies of design education: “\textit{Studio-based teaching of the ‘studio’, as a central pedagogy, is utilised in art, design and architecture education and was until recently typically found across all design disciplines (e.g. fashion design, communication design, product design.” (Daniel and Fleischann, 2014).\textsuperscript{269} The studio is seen as both a physical space and a teaching approach, which is centered around the pedagogical concept of learning-by-doing (Schön, 1983\textsuperscript{270}), and grounded in Kolb’s experiential learning model (1984\textsuperscript{271}). The team (Doorley and Witthoft, 2012),

\textsuperscript{267} Idem


who designed and developed the d.school space, offered original strategies for manipulating the space to enhance the ways teams innovate.

Daniel and Fleischann (2014) provide a full description of the components (space, community, mode of learning and a program of projects and activities), which include:

- a large space in which each student has a desk or area as a dedicated workplace,
- space available to personalize or to pin ‘work-in-progress’,
- space for exhibition,
- flexible opening modes of learning including one-to-one, group work, seminars, formal lectures, workshop” in the spirit of a “dialogical learning and teaching”,
- events to showcase work to the wider design community,
- size between 12 and 20,
- critiques of student work from educators, tutors, peers, or visiting professional,
- knowledge used for decision making,
- an important social dimension with the establishment of communities.

**From studios to real fields.** In some design thinking studios, individual spaces may be replaced with project space. The major difference between studio-based learning and design thinking-based learning is not inside the studio, which is considered as a safe boat in which to explore the field outside, where users experience and interact with objects, products, services and places.
**How to develop DT pedagogy with an activity framework**

Vinke and Hummels (2010) described this shift in epistemology paradigm, from positivism to constructivism: “Students’ learning can be characterised as individual, context-related, experiential, self-directed, reflective, collaborative, exemplary and integrative”, as well as the shift for teachers, “from being an authoritative source of knowledge to a facilitator of students’ learning”. They demonstrated that these kinds of constructivist curricula, “where it is the learner who creates meaning, affected by and reflecting his or her socio-cultural environment”, require specific assessment processes based on a competence framework. The design learning process at Eindhoven University of Technology (Hummels and Vinke, 2009) is captured in an Industrial Design competence framework (Fig. 21).

**Fig. 21 Industrial Design Competence Framework**

(Hummels and Vinke, 2009)

“Students perform learning activities that yield competency development (process) and particular deliverables (results).” (Hummels and Vinke, 2009) Five stages of development are expected: blank/awareness/depth/expertise/visionary. The competency framework is used as a

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reference for a Personal Development Plan. Students in the Industrial Design Department at Eindhoven University of Technology “are assessed on the development of their overall competency of designing, vision on designing and growth as a designer: it is the student who has to prove or demonstrate what (s)he has achieved in the semester as a whole”.

The Reflective Transformative Design Process (Hummels and Frens, 2008),274 based on a reflective practice, can be applied to design thinking projects: “Developing design solutions, which are placed in the center of this model, can be seen as a process of taking decision based on too little information. (…) “The decisions are not necessarily correct decisions, though it is possible that further insight into the design challenge invalidates a decision, forcing the designer to rethink certain solutions and come up with more appropriate solutions.” Decisions are taken “to the best of one’s knowledge and experience” at a given time and place.

Design thinking projects involve reformulating the order of priority set by Hummels and Frens (2008), in terms of information drives, as follows:

- The first drive is information gathering to explore in a real life context with users.
- The second drive is information gathering from making experienceable prototypes “to open up new solution spaces that go beyond imagination”.
- The third drive comes from analysis (from large to small) and abstraction (from small to large issues), “which produces a more formal kind of information that (again) feeds into the connecting activities”.
- The fourth drive is information gathering to direct the design decisions through a vision, which “focuses obviously on development of disruptive, innovative solutions to transform the behavior and experience of users and society as a whole”.

Hummels and Vinke (2009)275 described 10 competencies linked with the practice of design at Eindhoven University of Technology: team and communication, self-directed and continuous learning, descriptive and mathematical modeling, integrating technology, ideas and concept, form and sense, user focus and perspective, social and cultural awareness, business process design, design and research processes. The literature and syllabus review indicates seven learning activities for design thinking: needfinding, reframing, creativity, prototyping, storytelling, reflection, teamwork. This piece of research has reflected on the practice of design thinking in order, if need be, to modify the set of competencies identified through the literature review. The results are included in chapter 6: An activity-framework for design thinking pedagogy.


Conclusion

This section provides two literature reviews with two kinds of benefits:

- The first one on pedagogical action research demonstrates how faculty can become a reflective practitioner by building a culture of design thinking thanks to a specific pedagogical action research protocol and a conceptual tool (People Place Process).

- The second one on different schools of thought in design demonstrates the widening scope of design as a practice, in terms of people, process and place: from single designers to multidisciplinary teams, from a black box to a semi structured process of exploration with precise tools for each activity, from the studio’s and the amphitheater’s environments to the field with real contexts and real users, from product to experience design.

Throughout the history of product design, different strands have been identified in terms of the who, the why and the how of design. In reality, those accumulated “layers” culminate in different schools of thought, which may compete with each other in business and/or academic environments. It is essential to be able to unpick them, in order to understand individual perceptions and to avoid unproductive conflicts. Which school of thought should be chosen depends on the purpose and the context (Fig. 22).

![Fig. 22. Schools of thought in design](image)
Given the importance of strategic renewals for companies in uncertain and complex environments, my focus on the paradigm of design thinking for multidisciplinary teams aims at educating future leaders as empathic makers, in order to foster new waves of growth. That is the reason why the last section of chapter 2 is a literature review of design thinking mostly in education, in terms of people, process and place. The chapter ends with a demonstration why experiential learning requires a specific learning environment and assessment practice (Kolb, 1984; Vinke and Hummels, 2010).

The following chapter presents the data collection and analysis through a longitudinal study form 2006 to 2015 with 74 projects in design thinking.
A longitudinal study from 2006 to 2015 with 74 projects

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Summary of the chapter

Chapter 3 provides a quick overview of data collection, the adaptation of the pedagogical action research protocol to design thinking projects and lessons drawn from each historical era of practice. Appendix 7 presents a full and detailed data analysis, broken down into the three historical eras of practice. It details the adaptations made to pedagogical action research (situate/plan/act & observe/reflect/improve) for each type of pedagogy and each narrative case study:

- 2007/2009: French Multidisciplinary Teams, with a stress on differences between different schools of design and design thinking, both in practice and in the literature;
- 2009/2012: Global Multicultural Teams with Stanford, with a stress on the development of an adapted process and assignments, in order to increase sense making and implementation;
- 2012/2015: Local and Global Dissemination with the creation of d.school Paris, with exploration of how to train faculty and disseminate design thinking.

Reflection on practice contributes to the definition of strategic staircases in a roadmap for design thinking education. Reflection on my practice helped me to define the first three levels of aspiration for design thinking pedagogy. The fourth level is based on my reflection on the experience of the former provost of the University of Philadelphia, Randy Swearer, who led such a transformation from 2008 to 2015. A reflection on how to transform a university is published in a joint book on how to create innovation leaders for large-scale complex problems. Reflection on the experience of such countries

as Finland, which created Aalto University and the Design Factory, has given me insights on how to reach level 5.

The following roadmap sets out the key steps in developing design thinking pedagogy:

1. Designing a curriculum
2. Developing a program
3. Creating a d.school
4. Transforming a university
5. Disseminating through national programs

Each step represents a set of objectives, which require a higher level of innovation, resources and commitment. It is essential to keep in mind that the dissemination of design thinking, either as a leader or as a teacher, should begin with a personal transformation in order to embody the values, the knowledge and the practice. Recommendations in terms of decision-making for each level of design thinking pedagogy are detailed in chapter 5.

The question on how to train faculty to deliver high quality education in design thinking should be on the agenda of faculty, provosts and presidents who engage their universities in such a direction. Pedagogical action research is a promising path of exploration to achieve such an objective: reflection in and on action creates the structure for people in an organization to learn, to transform themselves and to deliver high quality outcomes in terms of learning experience.

Design thinking today is a global movement, both in universities and companies. The quality of projects and learning experiences, as well as the development of expertise and ecosystems to tackle future challenges, are key differentiating factors in the competitive global sphere of higher education.
Global data overview from 2007 to 2015

Our data consist of a collection of narrative case studies, which describe how design thinking pedagogy has been developed for Masters-level students over a long period of time from 2006 to 2015, with different levels of ambition, first as a course, then as an international program, and finally as a d.school (Table 7):

- From 2007: Curriculum of the ENPC’s Department of Industrial Engineering for Masters-level students, with two core elements in innovation (a course and projects) in addition to a learning trip and other related courses (marketing, patents, buying, project management);
- From 2009: ME310 Design Innovation Program in Paris for Masters-level students from all disciplines, schools and countries, in cooperation with Stanford University and its SUGAR academic partners;
- From 2012: d.school Paris as a national demonstrator of future pedagogies in innovation based on design thinking, with a consortium of 5 schools; The bid to create such a d.school was won in 2012 from a hundred other projects submitted to France’s national research agency.

Each academic year is covered through narrative case studies of the development of courses and structured with the appropriate pedagogical action research procedure: situate/plan/act & observe/reflect/improve. It ends with an analysis of how I, as a reflective practitioner, have developed a personal culture of design thinking by identifying, experiencing and reflecting on tipping points in that culture. Each tipping point is analyzed in terms of each category of the PPP (people, place and process) conceptual framework. It demonstrates its effectiveness in guiding faculty in both the development of design thinking pedagogy and through a personal transformative journey on the way to becoming a reflective practitioner and ultimately a professional.

The longitudinal study provides a basis for the analysis of the evolving practice of developing design thinking pedagogy with different levels of ambition: a course, an international program, a d.school. For the practitioner, this entails two shifts: first, design thinking faculty need to make the shift from a teacher-focused to a learner-centered approach, from being an authoritative source of knowledge to a facilitator of student learning (Hummels and Vinke, 2010). Secondly, my posture evolved as the pedagogy developed, from course leader to international program director.

277 ME310 Paris was put on hold in 2014/2015, in order to develop d.school Paris. 2012/2013 was a year of transition and only the innovation curriculum at ENPC Industrial Engineering Department was implemented.

278 The tender was called IDEFI (Initiatives d’Excellence à la Formation Innovante) and was launched within the framework of a national initiative dedicated to research. Focused on higher education. It was one of the last tenders issued: http://www.enseignementsup-recherche.gouv.fr/cid59599/37-projets-de-formation-labelises-idefi.html

to dean of a d.school, from the domestic to the global stage with international recruitment of students, companies and academic partners, from staging director to French think-tank to dean of the d.school Paris.

Artefacts emerging from courses have evolved from product design to process, service and strategic design leveraging local, national and international ecosystems. The quest to engage students with sustainability challenges has evolved to the quest to adapt design thinking to a broad range of subjects and the development of user expertise in the elderly.
**Table 7. Project overview per year and per course**

<table>
<thead>
<tr>
<th>Academic year</th>
<th>EcoBootcamp (3 ECTS)</th>
<th>Innovateurs (6 ECTS)</th>
<th>ME310 (38 ECTS)</th>
<th>Others (3 to 9 ECTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>Collective game</td>
<td>1. Re-invent the bottle for sustainability (ENPC/ENSIC)</td>
<td>No course</td>
<td>No course</td>
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<td></td>
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<td>2. Re-invent luxury packaging (ENPC/SCA)</td>
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<td></td>
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<td>3. Re-invent household water uses (ENPC)</td>
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<td>2008/2009</td>
<td>No course</td>
<td>4. Re-invent railway experience (ENPC/ENSIC)</td>
<td>No course</td>
<td>No course</td>
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<td></td>
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<td>5. Re-invent urban light for sustainability (Idem)</td>
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<td>6. Re-invent grocery for sustainability (Idem)</td>
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<td>7. Re-invent the kitchen for sustainability (Idem)</td>
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<td>8. Re-invent the shower experience at students’ (ENPC)</td>
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<td>9. Stress and communicating (ENPC)</td>
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<td>10. Re-invent a training space for decision makers (ENPC)</td>
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<td>11. Valorization of the pork industry (ENPC)</td>
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<td></td>
<td></td>
<td>2. What if the fridge does not exist (ENPC/ENSIC)</td>
<td>2. Invent civil applications for drones with Thales Underwater Systems</td>
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<td></td>
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<td>3. Project: transparency (ENPC/ENSIC)</td>
<td>3. Invent a new device at home for social networking with Pioneer</td>
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<td>4. Improve the life in a poor Moroccan village (Idem)</td>
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<td>5. New services for student’s union (ENPC)</td>
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<td>6. Stress at work (ENPC)</td>
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<td>7. Photovoltaic in highly turbulent zones (ENPC)</td>
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<td>8. A new waiting experience in a hospital (ENPC)</td>
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<tr>
<td>2010/2011</td>
<td>(...)*</td>
<td>9. Improve the life in a poor Moroccan village</td>
<td>4. Invent a civil application for a military technology</td>
<td>No course</td>
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<td>10. Create energy with human movements</td>
<td>with Thales Optronics</td>
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<td></td>
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<td>11. Electricity and behaviors</td>
<td>5. Airport 2014 with EADS</td>
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<td></td>
<td>12. Improve waste recycling in buildings</td>
<td>6. New water and water services for Suez Environment</td>
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<td></td>
<td>13. Improve waste recycling industry</td>
<td>7. A new prototyping with Amplitudes Technologies/INRS</td>
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<tr>
<td>2011/2012</td>
<td>Sustainability at students' residence 1</td>
<td>14. Seniors and photography (ENPC/ENSIC)</td>
<td>8. New energy services for GDF SUEZ</td>
<td>No course</td>
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<td></td>
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<td>15. Ambassadors of Marrakech culture (ENPC/ENSIC)</td>
<td>9. A new experience of TV with Panasonic</td>
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<td></td>
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<td>16. French retired people in Morocco (ENPC/ENSIC)</td>
<td>10. Re-invent the zoom for high quality images in</td>
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<td>17. Panasonic 1: Reinvent the fridge (ENPC)</td>
<td>movement with Angénieux</td>
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<td>18. Panasonic 2: Reinvent the fridge (ENPC)</td>
<td>11. No course</td>
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<td>19. Open Data for Suez (ENPC)</td>
<td>12. No course</td>
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<td>20. Recycling Cloth Box for Suez (ENPC)</td>
<td>13. No course</td>
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<td>21. Video animation for Stupellix (ENPC)</td>
<td>14. No course</td>
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<td>22. Oxygen bottles in hospitals for Air Liquide (ENPC)</td>
<td>15. No course</td>
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<tr>
<td>2012/2013</td>
<td>Sustainability at students’ residence 2</td>
<td>23. Re-invent the fridge for seniors (ENPC/ENSIC)</td>
<td>No course</td>
<td>No course</td>
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<tr>
<td></td>
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<td>24. Re-invent the shower for seniors (ENPC/ENSIC)</td>
<td>25. Re-invent the sport for seniors (ENPC/ENSIC)</td>
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<td></td>
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<td>25. Re-invent the telephone for seniors (ENPC/ENSIC)</td>
<td>27. Improve the village life with an NGO in Togo (ENPC)</td>
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<td></td>
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<td>26. Re-invent the sport for seniors (ENPC/ENSIC)</td>
<td>28. How to guide tourists in a RER station for RATP (ENPC)</td>
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<td></td>
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<td>27. Improve the village life with an NGO in Togo (ENPC)</td>
<td>29. Solar Decathlon challenge with 9 schools</td>
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<td></td>
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<td>28. How to guide tourists in a RER station for RATP (ENPC)</td>
<td>30. User experience in an eco efficient building (ENPC/SSS)</td>
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<td>29. Solar Decathlon challenge with 9 schools</td>
<td>31. Improve agriculture's tolls in a village in Togo</td>
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<td></td>
<td></td>
<td>30. How to guide tourists in a RER station for RATP (ENPC)</td>
<td>32. Improve pineapple crop in a village in Togo</td>
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<td>31. Improve agriculture’s tolls in a village in Togo</td>
<td>33. TunisiaOpportunity: Improve a school in Tunisia</td>
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<td></td>
<td></td>
<td>32. Improve pineapple crop in a village in Togo</td>
<td>34. invent an APP for Campus Life</td>
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<td>33. TunisiaOpportunity: Improve a school in Tunisia</td>
<td>35. invent an APP for Campus Life</td>
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<td>34. Improve pineapple crop in a village in Togo</td>
<td>36. Re-invent the coffee experience for students for Nestlé</td>
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<td>35. invent an APP for Campus Life</td>
<td>37. invent an exercise area in a retirement home (Favier)</td>
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<td>36. Re-invent the coffee experience for students for Nestlé</td>
<td>38. Improve the village life in Ecuador: heat pumps</td>
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<td></td>
<td></td>
<td>37. invent an exercise area in a retirement home (Favier)</td>
<td>39. Improve the village life in Madagascar: accounting books</td>
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<td>38. Improve the village life in Ecuador: heat pumps</td>
<td>40. Improve the spectator's experience for a theater in Paris</td>
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<td>39. Improve the village life in Madagascar: accounting books</td>
<td>41. Improve commuting services for disable for a transporter</td>
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<td>40. Improve the spectator's experience for a theater in Paris</td>
<td>42. Which services for quality air measured locally in real time with a research lab</td>
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<td>41. Improve commuting services for disable for a transporter</td>
<td>43. Re-invent small greave shuttles for a small company</td>
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<td>42. Which services for quality air measured locally in real time with a research lab</td>
<td>44. Communication outside the fire for a start-up</td>
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<tr>
<td>2013/2014</td>
<td>Users’ experiences in Coriols</td>
<td>39. Improve the village life in Ecuador: heat pumps</td>
<td>No course</td>
<td>No course</td>
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<td>40. Improve the village life in Madagascar: accounting books</td>
<td>41. Improve the spectator's experience for a theater in Paris</td>
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<td>41. Improve the spectator's experience for a theater in Paris</td>
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<td>43. Re-invent small greave shuttles for a small company</td>
<td>44. Communication outside the fire for a start-up</td>
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<tr>
<td>2014/2015</td>
<td>(Urban ecology in a town)**</td>
<td>38. Improve the village life in Ecuador: heat pumps</td>
<td>No course</td>
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<td>39. Improve the village life in Madagascar: accounting books</td>
<td>40. Improve the spectator's experience for a theater in Paris</td>
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<td>42. Which services for quality air measured locally in real time with a research lab</td>
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<td>42. Which services for quality air measured locally in real time with a research lab</td>
<td>43. Re-invent small greave shuttles for a small company</td>
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<td></td>
<td></td>
<td>43. Re-invent small greave shuttles for a small company</td>
<td>44. Communication outside the fire for a start-up</td>
<td></td>
</tr>
</tbody>
</table>

No of teams: 74  Around 30  44  13  8
No of ECTS taught: 15  48  232  Ca. 12

* The course was run by Sushi Suzuki  ** The course was run by Aurelie Delemarle newly in charge of the Dept.
What data collection and records for narrative case studies?

As recommended by Stenhouse (1975)\textsuperscript{280}, the content of case records will be kept as a valuable archive available to future research and researchers under a number of conditions.

\begin{quote}
For the narrative case studies, data were recorded on multiple elements of the research and incorporated into a global database\textsuperscript{281}. As recommended data collection was adapted to my research question from the contents of case records as given by McKernan, 1996\textsuperscript{282} (p. 82, p. 150):

An account of negotiations in a project acquisition (field notes, emails, record of conversation...).

Log note of vital conversations or visitors or events relating to the project.

Extract of videos: lectures, student presentations.

Collection of pictures: space, students, project outcomes (prototypes, products, implementations).

Descriptions of settings (behavioral and activity spaces).

Background dossiers and information on people included in the project (such as application forms and CV).

Sequence of events charting project developments in the order they transpire.

Observation with field notes and sessions with actors.

Fieldworkers’ reflections: factual and evaluative.

Samples of students’ work, with artefacts produced by students: documents (project reports, exams, presentation in two formats: videos, ppt), prototypes, products/final outcomes.

Teaching team’s debriefings and transcripts of important meetings, especially with partners and students at crucial moments of project development, minutes of assessment committee reports.

Official school reports on assessment and evaluation.

Official curriculum guides.

Government documents (e.g. policy documents).
\end{quote}


\textsuperscript{281} Data records are available on: www.datarecordofparisestdschool.fr

Student assessment records, for example reflexivity journal
Student satisfaction questionnaires
Transcripts of face-to-face interviews with students and partners
Past examination papers
Track record of project outcomes in terms of their real-world impact, demonstrated with pictures, interviews or videos
Official reports, newsletters, articles, communication artefacts such as videos

Observation is obtrusive because of my status as a participant. That is why multiple observation techniques have been used to enhance objectivity. Field notes consist of four types: - observational field notes (ON) about the 6 Ws (what, who, where, when, why, how); - conceptual field notes (CN) with interpretations and inferences mainly formalized in quick drawings; - procedural field notes (PN) with aide-memoires, action and behavior check-lists; - interview notes (IN) with accounts of conversations with key actors and participants. Check-lists are particularly appropriate when evaluating students’ performance skills: they were drawn up from observation of a small group of students in the early years and have been used to guide students in developing the appropriate behaviors as projects develop. McKernan (1996, p. 110) recommended maintaining a distinction between “action lists” (which examine behaviors) and “static lists” (where objects are observed, such as space setting). He believed that these elements have an impact on the ‘hidden curriculum’.

Until 2013, these field notes were recorded in notebooks, which was a practical and discreet way of taking notes anywhere and in real time. The drawback is the difficulty of structuring and filing them in such a way that they can be shared and are easy to analyze for research purposes after the class. During academic year 2013/2014, field notes were recorded either on a computer or in a notebook. For the sake of clarity and exchanges with peers, word documents are more practical and should be encouraged.

I have felt that photography and videos have been an underdeveloped resource in the conduct of my pedagogical action investigation: photographs have always been taken randomly because of the lack of additional resources for photography during lecturing or coaching, and for storing and recording them with appropriate comments. Since 2014, a picture database has been available for each class and year, which is a source of evidence that needs to be further developed in the future, focusing on specific areas of concern and better structured for the purposes of pedagogical action research. It is obvious that not all courses can be fully recorded at all times. Even as things stand, the amount of data collected can quickly become excessive and time-consuming to process. The recording of this kind of data needs to focus on specific issues. My status of an active agent has made the use of such valuable data collection challenging, valuable as it might be.
Three historical eras to discover and learn how to develop design thinking pedagogy

This piece of research capitalizes on three historical eras in the use of design thinking approaches to teach multidisciplinary teams. In the course of the literature review on pedagogical action research (chapter 2.1), I realized that my stances on pedagogical action research changed as this research project matured. As a consequence of growing maturity through many years of practice, the type of action research carried out has evolved in its purposes from technical, to practical, to emancipatory (McKernan 1996), with the hope that in future it will become participatory. Three schools of thought on approaches to design have also influenced each historical era:

- **2007 - 2009:** Designing a curriculum
  
  **Stance.** The purpose of our research was technical, as we looked for the right conditions in terms of people and processes to help teams navigate in the early phases of innovation.
  
  **School of reference.** The first historical era was initially influenced by two opposite schools of thought: design to designers with a research strand from the 70s, which analyzes how designers think and act (Cross, Lawson, Dorst, Rowe), versus design to engineers (Simon, Eppinger, Hatchuel), which analyzes how engineers solve problems through a step-by-step process.

- **2009 - 2012:** Developing an international program with global teams and companies
  
  **Stance.** As my research progressed, the stance became practical, as action research became a process of self-education, with the hope that my personal self-reflection could inspire other academics.
  
  **School of reference.** The second historical era is influenced by design thinking as an emerging research strand in the 2000s, which formalizes the practice of multidisciplinary teams in Silicon Valley, both in the industry and academia (Kelley, Moggridge, Fulton, Brown, Junginger, Martin, Frazer, Beckman, Barry, Pavnaik, Fraser).

- **2012 - now:** Creating a d.school in Paris with dissemination at the local, national and international levels
  
  **Stance.** At the end (2012-now), it is emancipatory in the sense that it seeks to understand how specific people and settings are shaped and re-shaped discursively, culturally and contextually: not only for teachers, but also for students and for partners.
  
  **School of reference.** The third era is influenced by the activity-framework and RDTP model (Reflective Design Transformative Process) from the department of industrial design at
Eindhoven University of Technology, which considers self-reflection to be a core aspect of learning design (Hummels and Vinke, 2009; Vinke and Hummels, 2010).

- In the future, my hope is to foster participatory research in order to disseminate pedagogical action research for design thinking projects in universities, as an indicator of high quality education in that field.

Each historical era examined below is structured into three parts:

1. first a presentation of data,
2. second a quick overview of the pedagogical action research protocol,
3. third a quick overview of lessons drawn from analysis.

**NOTA BENE:** It is essential to note that these brief overviews derive from a long and detailed analysis, which has taken years of practice, reflection and writing. This long analysis is also based on a long history of data collection and recording. A full description of the protocol is given in chapter 7, Appendix 1 (100 pages), where each student project is described as a narrative case study – which is not the case in the brief overviews below – with a detailed account of the best and worst outcomes for each academic year. The tipping points identified and experienced in the culture of design thinking, are also fully described in terms of the what, the why and the how, as well as structured according to the PPP framework at the end of each academic year. The next chapter (Chapter 4) opens with a section analyzing the evolution of such tipping points and how their identifying, experiencing and reflecting on them has helped me to learn about this new culture and to build one such a culture appropriate to my context and practice.

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283 Data records are available online: www.datarecordofparisestdschool.fr
First historical era: designing a curriculum (2007/2009)

Presentation of the data on ecobootcamp and Innovacteurs

In the first historical phase, the PAR procedure will be used to analyze only two out of the seven academic years of which I was in charge. The next five following academic years will be analyzed either in the second historical era (international program) or the third (the d.school Paris). Self-reflection on the practice was carried out for each academic year. As a consequence, practice and lessons from pedagogical action research are interwoven between the different types of pedagogy.

This section gives a global overview of the data on these multidisciplinary projects, Innovacteurs (Table 8), as well as a short analysis employing the PAR procedure (Tables 9a and 9b): *situate* at ENPC, *plan* the first French multidisciplinary teams, *act & observe* team dynamics and outputs, *reflect* to understand why and *improve* to take decisions.

My core mission as an academic director of the industrial engineering department at ENPC was to set up a curriculum in innovation from scratch. I started with a course and projects. I added a field trip and one-week workshop on the basis of the main observations from previous experiences. I also created the curriculum for a double degree between two elite French schools, one in engineering (ENPC) and one in design (ENSCI), which was approved in 2009 and implemented over the next two years. In addition to Innovacteurs, another multidisciplinary
course in innovation – “Chaîne de l’Innovation” – was offered to M2 GI students from 2006 to 2008, organized by the consulting firm Accenture and involving 5 schools from three disciplines. I started my journey with a strong belief in multidisciplinary teams as the ideal organizational form to generate outstanding results in terms of sense making and outputs for innovation. That was why I endeavored to create this double degree for engineering students from ENPC and design students from ENSCI, as well as multidisciplinary teams for capstone projects.

In addition, I researched and reflected on how to incorporate sustainability into product design. I interviewed over 30 designers in Paris and in Silicon Valley who claimed to practice design thinking and sustainability, in order to assess the consequences. I was a PhD candidate in sustainability and product design. I made sustainability an integral key part of most of the teams’ briefs from 2006 to 2012. I did research into this kind of pedagogy.\textsuperscript{284}

Table 8 sets out the attributes of the Innovacteurs program between 2008 and 2015, in terms of the type of students and a quick overview of the teaching process, tools, space and outcomes. Short narrative case studies are described in Tables 9.a and 9.b. Full narrative case studies are appended in Chapter 7.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>First historical era</th>
<th>Second historical era</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td><strong>PEOPLE</strong></td>
<td></td>
<td></td>
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<tr>
<td>Total class size</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Students in</td>
<td>16</td>
<td>31</td>
</tr>
<tr>
<td>engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students in</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coach</td>
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<td>none</td>
</tr>
<tr>
<td>Number of teams</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Multidisciplinary</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROCESS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching process</td>
<td>3 milestones = 3</td>
<td>3 milestones</td>
</tr>
<tr>
<td></td>
<td>project reviews</td>
<td></td>
</tr>
<tr>
<td>Duration of</td>
<td>A couple of</td>
<td>A trip to Silicon</td>
</tr>
<tr>
<td>exposure to</td>
<td>sessions in a</td>
<td>Valley, a few hours,</td>
</tr>
<tr>
<td>design thinking</td>
<td>class in the 1st</td>
<td>1 full week class</td>
</tr>
<tr>
<td>before the class</td>
<td>semester</td>
<td></td>
</tr>
<tr>
<td>Specific tools</td>
<td>None</td>
<td>Forecast DT process</td>
</tr>
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<td></td>
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<tr>
<td>Expected</td>
<td>Presentation</td>
<td>Presentation and</td>
</tr>
<tr>
<td>deliverables</td>
<td></td>
<td>report</td>
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</tr>
<tr>
<td><strong>PLACE</strong></td>
<td>No space at ENPC,</td>
<td>A dedicated empty</td>
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<tr>
<td></td>
<td>individual spaces</td>
<td>room at ENPC; ditto</td>
</tr>
<tr>
<td></td>
<td>and machine shops</td>
<td>at ENSCI</td>
</tr>
<tr>
<td></td>
<td>at ENSCI</td>
<td></td>
</tr>
</tbody>
</table>
The first historical era (2007/2008, 2008/2009) of my longitudinal study was mainly influenced by the conflict between different schools of thought concerning design. That is the reason why the literature review covers the issue in chapter 2.2: does product design belong to (former industrial) designers or engineers? With regard to the words “design” and “product design”, two main schools of thought are indeed in opposition, both in the literature and in my practice during that era: the guideline school derived from Science, which was at the heart of the culture of engineers and engineering design, and the black box school derived from the Arts, which was at the heart of the cultures of designers in industrial design.

My findings show that in these circumstances, where ideas and practices are characterised by two opposing schools of thought, the only solution is to endeavor to foster interdisciplinary approach in multidisciplinary teams, with possible reframing and concept generation as outcomes. This quest for interdisciplinarity can at best be fostered in multidisciplinary teams if the underlying assumption is that fruitful outcomes come from a confrontation between the culture of engineers and the culture of designers. My experience with French multidisciplinary teams, combined with my stay at the Stanford d.school from August 2008 to February 2009, reveals a difference between the culture of design and the culture of human-centered design as practiced and taught with multidisciplinary teams in Silicon Valley. It shows the difference between driving multidisciplinary teams with the objective of multidisciplinarity, and a transdiscipline such as design thinking. The multidisciplinary team doctrine can lead to tension, conflict and desertion when not handled with a common transdiscipline.

Last but not least, in addition to the pedagogical action research protocol, another outcome to emerge from that first historical era was a conceptual framework for reflecting on action: People Place Process. This conceptual framework has proved very effective not only for identifying tipping points in the culture of design thinking, but also for reflecting on how to develop design thinking pedagogy.

A short pedagogical action research protocol is presented in Tables 9.a and 9.b for those two first years of practice. It should be noted that a full and detailed description of the protocol is provided in Appendix 1, Chapter 7.1 for the first historical era (35 pages). While further ideas are developed after Tables 9.a and 9.b, the full protocol describes the year-to-year improvements that were introduced into the learning experience, projects outcomes and implementation.

I was appointed as an academic director in the Industrial Engineering Dept at ENPC. It was my first academic year. I was in charge of teaching corporate strategy and innovation. ENPC is France's oldest Engineering school, dating back more than 250 years. My mission was to reposition the department (which, at 20 years old, was still new in the school) on intrapreneurship, with a combination of product design and supply chain management. I had to redesign the whole product design curriculum and develop a compulsory course and a project for all M1 students. My ambition was to create national multidisciplinary programs. I developed many partnerships with French design schools (ENSCI, Strate).

My course consisted of a series of lectures on general principles of innovation and a small project, with the brief of designing a family game (adapted from a colleague's workshop in creativity and communication). 3 projects for 12 students in total were developed in partnership with design schools: 2 multidisciplinary teams (ENPC/ENSCI and ENPC/Strate), 1 mono discipline team. * Reinvent the bottle for sustainability * Reinvent luxury packaging * Reinvent household water uses. The teaching team consisted of a designer, researchers and myself. One classroom was available for GI students. Students were to apply the theory from the first semester's course. They had one-page guidelines for the brief. Two project reviews (problem statement and solution generation), coaching between sessions on request and final presentations were organized. No report was expected from students.

**Act:** The course was run as planned. No adjustment was made during action.

**Observation:** - High level of satisfaction for the course. Interesting prototypes produced and tested in class. – Very divergent levels of satisfaction and outputs for Innovateurs: Two were unsatisfied and frustrated (one because of no prototype which was their expectation, the other because of no commitment from Strate designers). 1/ The refocus of teams on what makes sense in households was too harsh and killed the prototype phase, as the team was completely demotivated. 2/ The team on packaging had no feedback from the expert (faculty in the design school) and engineers were demotivated by the lack of commitment from students in design. 3/ The team on the bottle was very committed and performed excellently: the project was considered as outstanding (sense making, great storytelling, very realistic pictures, very detailed descriptions on the “what” in all aspects: design/technical/communication/business); students were motivated to create a company; outcomes included a ppt presentation, drawings, but no prototype.

- One team was strongly demotivated at being asked to start the analysis phase again in order to make sense for households and to better understand water issues. They did not prototype anything as expected.
- It was difficult for the teaching team to give feedback with such different perspectives; it was difficult for students to synthesize feedbacks from a very different stance than they were used to. It was a source of high tension in teams.
- It was a miracle that one team performed excellently: this was due to the commitment of all students on both sides. Instructions given were too loose. The combination of design, engineering and business with multidisciplinary teams (for both students and academics) does not drive teams. It is a factor of divergence, not efficiency. People from different backgrounds are not a sufficient condition to make it happen.
- No industrial engineering students worked in the dedicated classroom. The bottle team set up an ad hoc space at ENSCI. They found the space inspiring and exciting. They only worked over there.

### Table 9a PAR on 2007/2008: dream teams or hell teams?!
• Multidisciplinary teams create divergence and conflict, neither efficiency nor a condition for success.

• A lot of efforts and respect is needed from both sides (students & TT) to understand each other. Understanding each other and respecting each stance are pre-requisites to drive students efficiently.

• Commitment and hard work are key to success.

• Analysis may kill action: they represent different epistemologies (positivism versus constructivism and pragmatism); even if the analysis is not accurate and lacks sense making, students should move forward with the prototyping phase in order to experience action through prototyping. The more students want to prototype, the more the TT should downgrade the expectations in terms of analysis.

• Dedicated space is not enough to impact team generate dynamics: the space should be inspiring.

• Creativity is not enough to create sense making or implementation.

Reflect

• Still believe in what I do, with a rational and neutral attitude, be resilient and smart.

• Explore new ways of teaching innovation other than lectures, with more practice and more pragmatism than lectures to teach engineering students emotional intelligence; explore new ways of generating and teaching innovation.

• Find a community outside France.

• Find a dedicated space.

• Kick-off, project reviews and final presentations to be organized equally for both schools.

• Drop industrial feasibility as an assignment, and maybe market feasibility.

• Create mono disciplinary student teams.

• Keep only one committed design school and one committed teacher of design.

• Understand better how designers think and work.

• Find a committed engineering teacher to create a multidisciplinary teaching team.

• Discover Silicon Valley with direct experience: I should learn design thinking as a personal experience.

• Understand the way Stanford teaches innovation especially in the ME310 program.

• Drop teaching if only ppt presentations and sales pitch after a few attempts at new curriculum!
Innovation curriculum for M1 engineering students included a field trip to Silicon Valley, a one-week workshop between the first and second semester, a course in the first semester, and projects in the second semester in cooperation with ENSCI only. The course was run at a business school (ESCP Europe) and focused on entrepreneurship. Students did not like it. After the field trip to Silicon Valley with industrial engineering students, I spent the first semester at Stanford: I discovered ME310, the d.school, design companies in Silicon Valley and reflected a lot on an emerging conceptual framework: People/Place/Process. I also reflected on sustainability and DT practice. I returned and ran projects (called Innovacteurs) for the second semester with a teacher-designer from ENSCI. At the request of 3 departments (mechanical engineering, civil engineering, industrial engineering), the dean of studies from ENPC was prepared to create a common space with a workshop and different project space: half a floor was dedicated to those projects with a prototyping room and 50 m² dedicated for GI students. The space was empty with traditional furniture.

I started with a one-week workshop including a project search by students and a talk by B. Cockayne (Stanford). Students could customize the space and run mini projects of their choice. Teaching team included three instructors: a researcher in mechanical engineering from ENPC, one in design from ENSCI and 1 in business. We run 5 multidisciplinary teams (design and engineering) and 3 mono teams (with only engineering students). Briefs were redefined by students among a series of broad topics “for a better world”. Briefs chosen: * Reinvent city light for sustainability * Reinvent the kitchen for sustainability * Reinvent luxury grocery for sustainability * Reinvent the shower experience in international student residence * Reinvent the train with airplane standards * Reinvent a space for decision making in a consulting company * Stress and commuting * Valorization of pork industry. The syllabus included 3 milestones with project reviews as well as team coaching in between and detailed performance criteria for each phase. Students in engineering received recommendations in respecting DT’s values and principles. Expected deliverables included a final presentation and a report. Students were provided with two project rooms at ENPC and individual spaces at ENSCI.

- The choice of projects by students was too time consuming. Asking students to choose their projects is risky in terms of framing and time consuming. It is not a factor of motivation as expected.
- Concerning team dynamics, two types of behaviors could be observed among GI students: interested versus skeptical. Multidisciplinary teams were initially highly motivated to work with different backgrounds. Team dynamics between engineers and designers were very different during projects, from desertion to high commitment and great cooperation. Three mono French teams were demotivated and provided poor results in terms of sense making and deliverables. One international mono team was committed and delivered interesting results. One multi team provided interesting results (despite the desertion of designers), one multi team provided average results (with average commitment on both sides) and another outstanding dynamics and results (with high commitment). Commitment of students is key to team dynamics and the quality of outcomes.
- There was no common language between designers and engineers (no agreed process or tools), which was a source of conflict. The culture of design is different from DT. DT was not understood enough by engineering students, who could not explain to design students who did not believe in key concepts (the value of getting into the field and testing prototypes for instance). It was a source of frustration for them.
• Concerning students' outputs, the criteria of sense making (versus none) emerged. Except for the packaging team, students did not deliver any prototypes, but only ppt presentations of various qualities. Students provided very different outputs and levels of quality (in terms of sense making, detailed description of the “what” and reflection), from outstanding to very poor. Four projects (pork, space, commuting, eco kitchen) did not make sense in the “what” and the “why” to the point it was embarrassing at final presentations. For the best projects (train experience/shower experience/grocery/city lights), a lack of resources and possible areas of implementation prevented them going further.

• TT learned how to work and coach together. Too many projects with too many briefs represent a high risk for the quality of coaching (too long reviews, no expertise, no insightful feedbacks). A new TT member with a mechanical engineering background and no training in design or DT was again a challenge in terms of giving insightful feedback from different perspectives with a common direction. Organizing and running multidisciplinary teams with a multi TT is time-consuming and difficult. Space with no specific staging is not attractive and functional enough.

• Teaching design and design thinking is different, which should be acknowledged from the very beginning.
• Space should be “staged”, in order to be attractive and functional.
• The better framed a project is, the fewer students are lost in reframing, the better the output.
• In French culture, students need to understand design thinking before action.
• Pragmatism is a core value of design thinking and should be pivotal.

• Stage dedicated space with 9 milestones discovered in Silicon Valley.
• Scale up in terms of pedagogy development with the creation of an international ecosystem with worldwide companies and universities: create ME310 Paris! (ambitious capstone projects with real partners and stakes, explore the ME310 Design Innovation syllabus based on a field trip, paper bike competition, a series of prototypes and three phases: make it up/make it real/make it happen, sponsorships, multicultural partnerships, recruitment of an alumnus).
• Develop further resources (instructions, new lectures to explain DT more: convince first, then action, prototyping) and a more coherent curriculum (a field trip/a course/capstone projects), in order to discipline skeptical or poor students.
• Drop thinking of business models and concentrate on exploring design thinking activities.
• Work on briefs to be adapted to the pedagogical formats and objectives.
• Do it with people who want to do it, instead of pitching to people who do not believe in what we do.
• Keep learning, exploring, practicing design thinking.
Quick overview of lessons

Reflection on practice has led to many insights and lessons, as demonstrated in appendix 7.1. Here are the four key lessons, with a key insight:

First, teaching innovation with multidisciplinary teams should not take as its starting point the idea that innovation will be fostered by the confrontation of different points of view associated linked with different backgrounds and disciplines, that is to say in the case of Innovacteurs, engineering and design: if it does, there is a high probability of conflict and tension, which ends in demotivation, inactivity and even desertion. This confrontation does not drive multidisciplinary teams. On the contrary, it is a big risk factor.

Second, the culture of design is different from the culture of design thinking, as are civil engineering and industrial engineering in an engineering school, or finance and marketing in a business school. Some French designers see design thinking as a threat and as design for dummies. It should not be assumed that designers and design schools will easily adopt and teach design thinking. Resistance and confusion are often observed.

Third, design thinking should not be taught as a patchwork of different lectures/courses or exercises from each discipline, which are merged in a global process, handbook or curriculum: the conceptual stance of designers to reframe and their creative skills to generate ideas; then the engineering side for prototyping; finally the business model, marketing approach and sales pitch for implementation. This way of creating a design thinking curriculum will usually miss the core aspect of design thinking – designing for and with target users – let alone sense making and implementation with real impact in a given context.

Multidisciplinary programs do not teach innovation better than a transdiscipline

Curricula with a patchwork of courses from different disciplines do not help students to understand and practice innovation better. As an example, the double degree (two years in engineering and two years in design for Masters-level students) between an engineering school ENPC and a design school ENSCI required a huge amount of time, politics and energy. It only attracted one student a year with poor results, as dissatisfaction was observed from both sides: engineering students were attracted by design thinking more than design and were disappointed by design studies at ENSCI which they found as abstract as their own, with no link to innovation processes in a company; the teaching team at ENSCI was not satisfied by engineering students’ thinking and outcomes because of a lack of style; both types of students found it too long and demanding; they all dropped out before completion. They did not have the feeling that they were learning innovation better than with the curriculum in innovation designed with a transdiscipline such as design thinking.
Fourth, space has an influence on mindsets and should be inspiring in order for teams to work efficiently. The setting should be different from traditional classrooms. It needs specific staging to be attractive and functional enough, as described in Hillen and Levy (2013) and Hillen (2015). It requires attention and effort. The proximity between workshop and prototype is an encouragement to move from analysis to action.

In conclusion, teaching design thinking is about teaching a transdiscipline with its own values, process and tools. That is why a d.school and transdisciplinary curricula have often been created in a department and space that are different from the design engineering and business schools, in order to welcome professors and students from all disciplines into a neutral and inspiring space.

Key insights - With the practice of French multidisciplinary teams, my experience has been a) that teaching design thinking is different from teaching design, and b) faculty should recognize and teach design thinking as a transdiscipline, not as a multidisciplinary approach.

Conclusion: Is it useful? Is it adaptable? Is it transferable?

Design thinking is useful in changing course outcomes, values and students’ activities. As presented in Hillen and Levy (2013), student outcomes have been transformed from concepts emanating from abstract analysis and presented with ppt presentations, into tangible prototypes based on needfinding and tests with users, as well as possible implementations that generate value in real contexts. The use of design thinking to educate multidisciplinary teams creates a common language – the “glue”\textsuperscript{286} – in which the focus is on making sense for the people for whom one wants to innovate, and a bias towards action in delivering something useful to them very quickly and cheaply. A DT course represents a shift from problem solving and function analysis to the concept of affordance and relational design theory (Maier and Fadel, 2009)\textsuperscript{287}.

A Design Thinking course represents a shift from knowledge dissemination with right and wrong answers to situated inquiry for appropriate solutions with a positive impact, from positivism to constructivism (intent driven with a positive impact), phenomenology (situated inquiry in interaction with people in a given context) and pragmatism (action biased with quick delivery). It can represent a paradigm shift for higher education in terms of epistemology, and a shift in the position of faculty, from authoritative experts to learning facilitators (Hummels and Vinke, 2009)\textsuperscript{288}.

\textsuperscript{286} Design Thinking as providing “a glue that brings teammates together around a common goal: make the lives of the people they’re designing for better”: http://dschool.stanford.edu


The main lesson I have learnt (Hillen and Levy 2013) is that developing DT pedagogy entails becoming a self-reflective practitioner in order to become a professional (Schön, 1983). Two additional lessons are that design thinking should be explained as a transdiscipline (and not as a compilation of multidisciplinary approaches) and be taught with cultural adaptations.

The conditions of success for the possible transfer of a design thinking course to cultural contexts other than Silicon Valley should nonetheless be taken into consideration:

- A need to adapt the pedagogy of design thinking as taught at Stanford and practiced in Silicon Valley, not so much in terms of content (values, process or tools for instance), but more importantly in terms of how to teach it. In France for instance, people need to thoroughly understand the what, the why and the how before moving into action;
- A need to protect oneself from the emotional reactions of skeptics people by developing professionalism and self-reflection through a structured protocol;
- A need to carefully set up the conditions (people, place, process) in order to lower the risk of failure for students and create an attractive experience for possible further exploration;
- No need to set up multidisciplinary teams for basic courses;
- A need to label it “design thinking” in order to avoid confusion with multidisciplinary approaches that do not convey the spirit, method and tools of design thinking. Design thinking should be recognized and taught as a common transdiscipline, not a multidisciplinary approach.

Last but not least, the People Place Process conceptual framework is useful and transferable to the development of a design thinking course: it obliges faculty to think about the conditions needed and to stage an adequate learning experience for innovation teams.

As presented in Hillen and Levy 2013, it is useful for faculty start by setting up a course in order to gain the skills they need as stage directors, curriculum designers and course instructors. For one course, the recommended conditions are as follows: 50 m² of dedicated and staged space with 9 points of reference, ideally a maximum of 5 teams of 5 students with 2 instructors, no partner or a local partner with direct access to the field and no stake, brief on defined objects, context and users, use of existing tools and teaching materials.


Second historical era: developing an international program (2009/2012)

This section gives a global overview of data from 2009 to 2016 for the international ME310 program in Paris, brief overviews on pedagogical action research protocols for just three academic years (including Innovacteurs), as well as lessons gained from that period.

Data presentation of ME310 Paris

The second historical era covers pedagogical action research on three academic years (2009/2010, 2010/2011, 2011/2012), including the first three years of developing an international program (ME310 Paris) in cooperation with Stanford University. The fourth year of ME310 Paris is analyzed in the third historical era. Data presentation nonetheless includes five years of ME310 Paris for the period 2009 to today, although PAR for the fifth year is not included as our longitudinal study ends with academic year 2014/2015.

I was in charge of developing ME310 Paris (curriculum, pedagogy, project and student acquisition, administrative processes). In addition to developing a full-time international program in design thinking in cooperation with Stanford University and its affiliates, I was responsible for running the Industrial Engineering Department at ENPC. I also taught a course in corporate strategy for Masters-level students at ENPC. In addition, during the third academic
year of this historical era, in November 2011, I submitted a bid to the French Ministry of Research and Education to create a d.school in Paris.

When I was at Stanford in 2008/2009, I interviewed Philip Skogalt, executive director of ME310, in order to understand the key factors of success for such a program. He replied that the first factor is the recruitment of companies and students: “It is the strength and the weakness of ME310. You have to recruit the best students to attract the best companies. You have to recruit the best companies to recruit the best students. You need both elements in a very specific timing and it is very hard. It takes as much time as to run the class.”

ME310 Paris started with three projects, thanks to the generosity and trust of Thales and Larry Leifer, director of ME310. Networking and communication brought projects for the following years. Project acquisition requires long-term action to find the best briefs and partners.

Design principles for ME310 include:

- A structure based on worldwide teams of teams: two student teams and two faculty teams in two different universities and countries work on the same brief, provided by a company which also creates an in-house team (Fig. 23)
- A brief given by a company focused on future growth: how might we reinvent (a product or a service)
- Faculty trained by a stay at Stanford (6 months or one year)
- Dedicated space for local teams with project and prototyping spaces
- Number of students per team: 4
- Kick off and final presentation/exhibition at Stanford
- Three phases (make it up/make it real/make it happen) and 6 prototypes
Additional principles for ME310 Paris (Fig. 24) include the following observed key factors of success:

- 3 or 4 projects to drive emulation between students, a real learning experience with a curriculum including lectures, a community and minimum baseline resources, such as dedicated space, prototyping room, teaching team;
- 1 project at least in collaboration with Stanford;
- Partnership with other universities according to the quality of the teaching team, resources, space and past achievements, experience in ME310 and/ or DT, number of projects, expertise linked with the topic, global dynamics linked with DT;
- Hiring experts for a series of exchanges to accelerate knowledge and building.
The teaching team was limited from 2009 to 2014 with one teaching assistant. Two teachers (mechanical engineering and English) joined project reviews from time to time during the first two years. Experts were hired for 6 sessions of exchanges with students in the subsequent years. One administrative assistant helped on a part time basis.

Table 10 describes attributes of ME310 in Paris from 2009 to 2016, in terms of corporate partners and types of students. All the ME310 briefs entail the renewal of the product/service range of large worldwide companies. They cover a large spectrum of topics. Briefs always start with the idea of reinventing products and services.
### Table 10. Data presentation of ME310 Paris

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<td>Aalto/Finland, Stanford/USA, Stanford/USA, Swedenburn/ Australia, Unimore/ Italy</td>
</tr>
<tr>
<td>Briefs</td>
<td>Home device for social media network/helicopter dashboard/drones for civil uses</td>
<td>Airport in 2040/proton therapy against cancer/a civil use for a military technology (LSA)/water services to enhance the brand</td>
<td>Eco efficiency services in a building/Image capturing for the film industry/TV experience</td>
<td>Bathroom for seniors/dashboards for autonomous modes in traffic jams/a camera for firefighters</td>
<td>Kitchen for seniors, dashboard for seniors/bottles for baby care/coffee vending machines in offices</td>
</tr>
<tr>
<td>No of students</td>
<td>12</td>
<td>12</td>
<td>16</td>
<td>12</td>
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<tr>
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<td>No of disciplines</td>
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<td>3</td>
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Tables 11.a, 11.b and 11.c provide a short description of the pedagogical action research protocol. For the sake of clarity, they only focus on ME310 Paris in terms of observation, reflection and improvements, although the reflection on practice was influenced by the “Innovacteurs” course. A full description (50 pages) is provided in section 7.2, including narrative studies on all the projects for ecobootcamp and Innovacteurs.
A new president, CEO of a supply chain consultancy company, was appointed at ENPC’s Industrial Engineering Department. I set up the first cohort of ME310 Paris, thanks to a partnership with Thales for two projects (in addition to one project provided by Stanford with Pioneer) and the recruitment of a ME310 alumnus with an engineering background. A double degree agreement was signed between ENPC and ENSCI. In addition, I was in charge of three courses (ecobootcamp, Innovacteurs and strategy).

9 projects for Innovacteurs, with around 40 students in engineering and design. TT included three members representing design, business (but in practice design thinking) and mechanical engineering.

3 projects for ME310 Paris with 3 companies (two business units from Thales and Pioneer), 12 students from three disciplines (8 in engineering, 2 in business, 3 in design) and 2 nationalities:
- Redesign a helicopter cockpit;
- Redesign a swarm of drones for civil use;
- Redesign a home device for social networking.

A dedicated space (150 m²) was customized by ME310 students and included: a living room, a project room, a workshop, a storage room, a brainstorming room. It was available for all students. The manifesto and learning objectives were described in a 30 page document, which convinced a first corporate sponsor.

**Act - TT:** There was a tension between the ME310 alumnus and myself in driving the teams. The ME310 alumnus focused his feedback on what was done for Stanford assignments on a series of prototypes, whereas I focused on making sense and finding a promising direction at the overlap between desirability, viability and feasibility, sometimes without worrying about prototype assignments. He complained that I was thinking too much and students should “do” more (that is to say prototype). I argued that doing without sense making posed a risk of irrelevance and providing no value for the company: no desirability for users, no viability in terms of the business model. We agreed on a 50/50 (thinking/doing) sharing time at project reviews. I also felt that TT should help more in preparing needfinding and interacting with companies (which my colleague did not agree).

**Observation -** Team dynamics for ME310. Needfinding was hard for students: getting access to the field was the first hurdle. When facing users or experts, students did not ask the right questions, did not listen carefully enough and did not take enough notes. What they heard and observed was biased with preconceptions. It was easier to prototype but it was hard to test with users: students either failed to find users or were biased in collecting feedback. The principle of creating “a non product for a non user” was very fruitful for Pioneer. ME310 teams performed very differently (understanding/needfinding/prototyping), but all ended up with presentations and final prototypes of good quality compare to other ME310 teams. Kick off and final presentations involved more than the corporate liaison within Thales. The Finnish did not appreciate the confidentiality measures requested by Thales. It was a huge source of tension and misunderstanding.

Students helped to create the space. It is theirs.
• Partnerships between universities and companies are challenging: references and values are different (concerning confidentiality, IP, nature of discourses, objectives, state of mind). I feel closer to companies’ references than the university’s. My focus on creating value for companies comes from my past experience as a CEO. It is essential for me, which creates a gap with other academics and students. Concerning partnerships with universities, communication at distance needs time to create trust on both sides (students and TT).

• Prototyping without sense making focuses on doing, but may not create value.

• Multidisciplinary teams with different levels of commitment are sources of conflict.

• Access to the field is key for needfinding and testing with users.

• Collaboration with the company is key to make it happen.

• International collaboration requires time and communication.

• Increase sense making for projects which should be at the crossroads of desirability, feasibility and viability, with three actions: 1/ Prepare access to the field for students to do user research and go with them in the early phases 2/ Ask students to focus on finding and testing incremental solutions in real contexts to gain relevance and trust, then to look for breakthrough innovation: no breakthrough before incremental! 3/ No prototyping without testing with users in real contexts.

• Find a balance between teaching and creating value for the company.

• Find actions to create momentum inside the company.

• Recruit students with the same expected level of commitment.
Table 11.b PAR on 2010/2011: briefs on users, not on technologies nor topics

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<tr>
<th>Situate</th>
<th>Plan</th>
<th>Act and observe</th>
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| 2nd edition of ME310 Paris with the same resources in terms of people and place. In addition to Thales, more French companies from different sizes and sectors joined ME310 Paris (EADS, Suez Environment, Amplitudes Technologies). | 5 projects for Innovacteurs. 4 projects for ME310 Paris, with 16 students from all disciplines and 7 nationalities: Redesign the airport of the future - Redesign the cancer laser treatment business model - Find a civil market for a military technology - Create a new service offering in water and waste. A professor of English from the language department joined the TT. | Act - I could not officially experiment with new pedagogical ideas because of opposition from the ME310 alumnus. Openness and enthusiasm from the English professor were refreshing.  
Observation - Most students were committed and smart. Briefs were too broad and ambitious. It was hard for them to understand their topic, to do needfinding and to test with users, if any. Access to the field for such briefs was too difficult for students: it is possible but difficult for needfinding; it is impossible to test with users in real context. Futuristic projects require months of reframing to the detriment of ethnographic research and tested prototyped. Concerning corporate partners, their commitment was different, with a huge impact on students’ motivation and likelihood of future implementation. Communication with the Finnish TT and students was difficult for both sides, even painful: Finnish TT sought to provide a fun experience for students whereas I my goal was to provide value to companies that trusted us. Ideas and prototypes produced by the two Finnish teams did not make sense and were not presented to the companies at EXPE Paris. The two other teams with Stanford and HPI worked efficiently. The fact that French students had more time made them more empowered. |
CHAPTER 03  A longitudinal study from 2006 to 2015 with 74 projects

- When a brief starts with a broad topic or a technology with no targeted users, it takes a lot of time for students to do user finding, instead of needfinding. If reframing takes more than a quarter, there is a risk of downgrading in the level of definition of the final prototypes and non-preparation for implementation. The best expected outcome is thus sense making in reframing, concept generation and simulation.

- The ME310 Stanford curriculum does not stress needfinding, with no assignment given in that area. Making without sense making is a waste of time and value for companies.

- Reflection from students is key to create sense making from action.

- Corporate partners who do not embark people from inside their company create limitations for implementation, because they have to sell the project afterwards with no support from students and TT.

- The definition of briefs has a huge impact on teams’ exploration and learning of design thinking. Briefs should be carefully discussed between partners and teaching teams: it is the TT’s responsibility, not the students’, to frame a feasible brief to learn design thinking.

- Preparing access to the field from partners and TT is key for a good learning experience in needfinding and testing with users: it is time consuming and risky.

- The notion of partnership, not clients, is key in such pedagogical contexts.

- International collaboration requires courses to better learning experience.

Reflect

- Briefs: Define potential users and customers from the beginning. Never take projects with no access to the field or when the brief is too close to design fiction.

- Find committed partners to make it happen, never clients.

- Prepare access to the field for user research and testing.

- More personalization for students’ space through challenges (space contest games), in order to develop their skills and to increase emotional commitment.

- Communicate as much as possible with international TT to create trust and drive students in the same direction.

- Develop ME310 syllabus further, especially on sense making, dissemination and ethnographic research.

- Recruit committed and passionate students.
This was the third session of ME310 Paris, with the departure of ME310 alumnus to Panasonic and the recruitment of ME310 Paris alumnus with a design background. Three projects were run with three French companies: Angénieux Thales, GDF SUEZ, and Panasonic Germany, in cooperation with Stanford and HPI. After bidding, the project of creating a French d.school was approved with a grant of €4 million over 8 years.

10 projects for Innovacteurs and 3 projects for ME310 Paris with GDF SUEZ, Angénieux and Panasonic: * Reinvent energy services * Reinvent zooms for high quality images in motion * Reinvent the TV for Europeans. I plan a lot of pedagogical innovations in ME310 program.

Act – I can experiment a lot. The Panasonic and GDF SUEZ teams are not able to do user research, so I decided for the first to switch to ideation more quickly, which is a great success for them to move ahead, and for the second to go into the field myself: first I found a path, second students were inspired by my way, third I discovered I was using a systematic approach that I formalized into a tool for ethnographic research.

Observation - Most students were smart and team dynamics performed very well, even if some students were less committed than others. One of three teams outperformed in each step with full autonomy and professionalism despite the ambition and the difficulties of the brief. Thanks to first introduction from corporate liaison, they managed to gain trust in the film industry thanks to incremental innovation that led to a breakthrough idea and a functional prototype with a lower level of definition than reality. The two others failed in reframing and ethnographic research in the first quarter. I helped one of them and the other found its path thanks to ideation (prototyping and testing with users). All teams found very promising directions. Even with communication actions and expressed interest, all projects failed in terms of implementation after the course, because of the lack of operations generated inside the company. Corporate partners did not know how to make it happen. Briefs were again ambitious but the facilitation by two corporate partners to give access to the field with users and experts helped to reframe with sense making. Some students had difficulties in being independent and performing activities. A lot of additional coaching was needed for them to perform. I came up with the concept of episodic reframing versus continuous reframing.
Briefs can be classified by type of artifacts with a degree of increasing complexity: product/service/systems.

In order to reduce the risk of students going astray, two basic rules can be applied: start with an object in the system and then expand step-by-step to the level of a system; start with incremental making and then enlarge to envision a breakthrough innovation with a wizardoz prototype.

Divergence of two teams enriched the project if mutual respect and understanding.

A performance criterion for a team is to reach a level of continuous reframing versus episodic reframing.

TT should go hands-on and temporarily take charge. When some students are very bright, the role of TT is different: trust and encouragement are more important than anything else.

Pitching the project at the end of the program has a limited impact in terms of dissemination and implementation. Pitching does not mean that operations are generated inside the company to launch the product and/or service. First dissemination measures are promising, but not effective enough. Operation generation is more important than business model generation for effective implementation inside the partner company. Corporate liaisons should involve a lot of people (and the right people!) inside their companies, in order to implement the project afterwards: creating collective momentum should be more efficient than selling outcomes internally after the project is complete. First incremental innovation, then breakthrough, in order to gain insights and trust. Product, service and system design are different.

Close collaboration with companies increases the probability of implementation. Coaching corporate partners from TT has a positive impact on projects.

Avoid broad subjects: the subject needs to be reframed to the point that the TT knows what to do and how to do it from the start.

Create training and dissemination events inside the company: a global kick-off with as many stakeholders as necessary for implementation and lectures on DT, an open door event to discuss findings in terms of feasibility and viability, events in the company in the development team and marketing team, an exhibition show.

Support the corporate partner in analyzing its environment and creating momentum.

Create an ecosystem that is committed to make it happen.

Find partners that can make it happen inside the company.

Make a clear distinction between Stanford syllabus based on prototypes and Paris syllabus based on ethnographic research and dissemination.

Develop further lectures and pedagogical resources for students.

Be clearer on instructions.
Quick overview of lessons

Reflection on practice has led to many insights and lessons, as set out in appendix 7.2 (50 pages). Key factors of success for the development of an efficient international program with global companies in a prestigious network such as ME310 are identified in terms of three topics: defining the brief, sense making, dissemination in the corporate partner’s company.

Defining briefs to allow a learning experience in design thinking

Brief definition has a strong impact on the learning experience of students. It requires a great deal of time and thinking from faculty, who has to deal with the corporate partner. The brief should involve real stakes for the company. I faced three main challenges for defining briefs: too broad topics (reinvent a military technology for civilian use with no target user given in the initial brief), complex artefacts and no easy access (if any) to the field.

First challenge: when topics are too broad, they take too much time to reframe. The brief should open up a path for exploration, which means a journey into the unknown and ambiguity for all. Nonetheless, the broader the topic is, the higher the risk of students losing their way. If neither the corporate partner nor faculty have any idea about the final destination, reframing will be time consuming, to the detriment of learning the different activities and tools of design thinking, especially needfinding and testing with users. Briefs, which provide no target user, oblige students to find users. The biggest risk is that students may reframe in a direction that does not make sense for the company. Lack of time and expertise in the teaching team, as well as a lack of time and conviction on the part of the corporate partner, may allow students to pursue dead-end paths. If the students are unable to reframe, faculty should be able to indicate a safe path that makes sense in terms of desirability, technical feasibility and viability for the company. Framing for a great learning experience in DT should the TT’s responsibility.

Second challenge: no easy access to the field for needfinding is time consuming and poses the risk that students do not do any ethnographic research and do not go into the field. The pace of prototype production is intense. Students need to deliver one type of prototype every two weeks. Students may lack networks or ideas about how to access the field and users. In some countries, introductions are needed to facilitate connections and access. That is why I consider that faculty and the corporate partner are responsible for facilitating access to target users and real implementation conditions.

Third challenge: overall, the ME310 briefs in Paris were too ambitious for students, in that they entailed reinventing systems with complex technologies and super wicked problems that nobody in the company knew how to tackle. Prototyping complex technological systems can quickly become unfeasible for students. Faculty and corporate partners should anticipate what prototyping means within the framework of the project and whether it is reasonably feasible for students with the available resources.
**Key insights** - Briefs should be defined to secure the learning experience of students in design thinking. Key success factors include a brief, which reinvents a specific object for a specific target user, an easy access to target user, as well as artefacts which can be prototyped by students.

**Sense making to develop high-quality projects**

Sense making is at the core of faculty responsibilities. I have also learned what it means to find a sense-making direction: a sense-making direction combines what makes sense for target users and what makes sense for the company’s business model. This is the priority in the first quarter. ME310 students usually demonstrated more commitment and proactivity than students from other classes: they want to be proud of what they have achieved. Despite that commitment, they may be not skilled enough to find a sense-making direction through ethnographic research and they usually do not understand the priorities, development processes and business models of the company they are working for. That is why faculty should play this role.

The first lesson I have learned about sense making for users is first to predefine the target users in advance with the corporate partner and to prepare access to the field before the class, second to carry out ethnographic research with students as soon as possible, in order to collect relevant data, show students how to do it and to find a sense-making direction without the bias of students’ data collection and analysis. This prevents them pursuing irrelevant paths that faculty cannot evaluate. It preserves the feeling of project ownership for students: when students are convinced of user desirability, but are on the wrong path, it is harder for faculty to get the project back on the right track without frustrating students.

The second lesson I have learned is that understanding user desirability for target users is not enough to set a sense-making direction for a new product and service offering in a given company. Faculty and the corporate partner should conduct repeated discussions to assess the consequences for the company: should this new offering be launched on the market? Is it at part of the core business model? If not, how could such an offering be produced and distributed? Who would be involved? How should the project be taken forward after the class? How to connect the existing development with the existing development process? These are the core questions that should be asked. Student findings should match what makes sense for the company: this has a strong impact on the development of a project. If not, the project is doomed to be dropped after the class.

The third lesson is that this kind of program with global companies is highly demanding for faculty. It requires a broad spectrum of skills, notably the following: - teaching design thinking; - leading an innovation project with design thinking by practice; - building an international ecosystem incorporating different stakeholders (academics, global companies,
necessary resources such as labs and access to the field of users and experts); - project acquisition with companies; - knowledge and practice in facilitating the market launch of a new offering in a large company. Faculty skills have an impact on the quality of a project and its implementation in the company.

**Key insights** - Faculty and the corporate partner are as responsible as the students for finding a sense-making direction for the project, which is a combination of what makes sense for target users and what makes sense for the company’s operations. Their skills and commitment have a significant impact on the quality of projects.

**Dissemination inside the company to foster implementation**

Dissemination within the corporate partner’s company dramatically increases the likelihood of real implementation, that is to say the launch of a real product/service onto the market. I have observed two types of corporate partners: those that have already launched new products and services on the market and those who have not. Some are skilled, empowered and legitimate. Others are not. In both cases, the more faculty communicates with the project leader inside the company, the better they both understand how to make it happen, the greater the chance of a launch on the market. Dissemination measures are also key factors of success for implementation and should begin with the kick-off and continue to the final presentation and exhibition.

The first lesson I have learned regarding dissemination is the importance of an ecosystem within the company. The ecosystem can be described as an internal community, which believes in the project’s direction and wants to make it happen. Either such a community already exists or it should be built. It should include the core functions for a market launch and the various levels of hierarchy needed for both approvals and operations. Faculty and the corporate partner should involve the people required from the kick-off to the pilot. The core objective is to build a common vision, enthusiasm and trust.

The second lesson I have learned about dissemination is the importance of a series of communication actions, from the kick-off to the final presentation of the learning story, through the phases of inspiration and ideation. The first quarter focuses on the sharing of insights on users. The second quarter focuses on finding a sense-making direction at the crossroads of user desirability, technical feasibility in the time available and organizational viability for the company. The ultimate goal is to create a pilot and gear up the company’s operations for launch in the third quarter before the end of the project.

The third lesson I have learned about dissemination is the importance of the final event, which should include a “show”, in addition to an exhibition and final presentations. Three
key factors of success are observed: first, the quality of all projects should be very high and demonstrate the process (in-depth ethnographic research, testing with users, high level of definition for final proof of concept); second, a “show” (for instance an international conference including guest speakers, TED format talks, professional organization) should be run to create a unique, informative and attractive event for executives; third, during that event, formal meetings should be organized company by company in order to answer the question of implementation.

### Key insights

Faculty and the corporate partners are responsible for creating the conditions for implementation within the company. They should guide students in their actions. Two pivotal measures for leveraging this process are the creation of an internal ecosystem in order to generate the operations required, and a series of dissemination actions in order to foster decision-making for a market launch. Showing projects with a high level of quality at an attractive networking event is key to attracting new companies with exciting briefs and strong commitment.

### Conclusion: is it useful? Is it adaptable? Is it transferable?

Developing a full-time international program in cooperation with Stanford University was useful in gaining experience and legitimacy in design thinking, as well as impact with projects involving real-world stakes and global companies. Was it worth the effort? Larry asked me this very wise question many times at EXPE in June. The level of effort, commitment and ambiguity is so high that the responsibility has an impact on one’s personal life. Beyond the first reasons given, such a program represents a personal challenge, which leads to personal development. The dream is to contribute to the launching of breakthrough innovations onto the market with global companies. I think I share this dream with all the corporate partners, students and faculty. The dynamics with students when successful are also very rewarding, especially when students undergo a personal transformation that has a powerful impact on the rest of their lives: Pierre Valade, graduate from the first cohort, founded his own company which was sold to Microsoft in April 2015 for $100million, and was kind enough to recognize that ME310 was a turning point in his life. Amine Bellakrid, from the same cohort, has told me many times that ME310 opened up new opportunities for him that he would have never imagined.

I adapted the ME310 curriculum, which is mainly based on a series of prototypes, with two main objectives: first, to increase the level of sense making and second to increase implementation by companies. I developed and tested numerous pedagogical innovations to match user desirability and company viability, notably the following:

- In order to increase sense making, the focus in the first quarter (which is called “make it up”) is on ethnographic research: faculty prepare access to the field (with or without the corporate partner) by identifying places and negotiating access for students. They
go into the field with students until they have built their own understanding and judge that students are good enough. I developed lectures and assignments in ethnographic research: how to prepare the field, how to collect, analyze, and present data. The second quarter (which is called “make it real”) focuses on testing all the prototypes with real users in a given context.

- In order to increase implementation, a key point is between the second and the third quarter (which is called “make it real”), with discussions within the corporate partner’s company. In the first quarter, dissemination measures begin in order to share insights from the field; in the second quarter, they demonstrate how users react to prototyped solutions; before entering the last quarter and developing a proof of concept through a pre-industrialized prototype, we organize open door events within the company in order to understand the degree of collective conviction in the company on what to do and how to do it.

ME310 is highly demanding: it is very difficult to set up (company and student recruitment) and to run (administrative processes for operations, competences in design thinking, leadership, project management, dissemination in companies, creating and running a worldwide ecosystem, expertise in corporate strategy and how to make things happen in a company, ability to decipher a company’s priorities and operations, as well as to trigger an internal dynamic). It is transferable provided that resources are available (Hillen and Levy, 2013291, see chapters 5 and 6 for more details). A great deal of attention should also be paid to ensuring to ensure a consistent level of quality in the network, especially in a period of development. Sharing additional pedagogical resources and developing faculty competences through pedagogical action research constitute promising avenues of enquiry for tackling such challenges.

In the third historical era, pedagogical action research covers three academic years (2012/2013, 2013/2014, 2014/2015), marked by the creation of a d.school. The first curriculum was still offered during that period, with the ecobootcamp course transferred to a faculty and Innovacteur projects (without partnership with a design school) delivered by my team. The ME310 program is run every two years, first in order to accommodate my new dual role and second to scale up the d.school. Data presentations in table 12 include all programs, both existing and new. Short PAR overviews (in tables 13.a, 13.b, 13.c) for this period focus on how to disseminate design thinking among different schools, with two new courses and two different training models, but still, when necessary, include reflections on previously developed programs and courses (full analysis in appendix 7.3.).
When I was at Stanford in 2008/2009, I interviewed David Kelley about his experience of creating a d.school. Walking from the guru room to the white room in the newly refurbished Peterson building, he confessed: “It almost killed me. I never thought it would have been so difficult with faculty.” He explained that he even organized cooking sessions at his home to build team spirit and trust. Despite all his efforts, nothing happened the way it happened when he founded IDEO. When I started the d.school, I many a time remembered his words of wisdom: “It is a very long and difficult journey.” I am grateful to him for this advice. First his confidence that I could do it (even with no prospect of a national grant) energized me for years. Second, the fact that such an icon in design thinking found the experience so tough was a strong signal of the potential difficulties on the path: forewarned is forearmed.

### Table 12. Masters-level students and executives according to level

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<td>ME310 Design Innovation</td>
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<td>Innovacteurs++</td>
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<td>Integrated Urban Systems</td>
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The third historical era in this longitudinal study was influenced by the Reflective Transformative Design Process (Hummels and Frens, 2008)\textsuperscript{292} concept, which was created and deployed for students in the department of industrial design at Eindhoven University of Technology. The same concept is applied to faculty to help them to become reflective practitioners, in order to develop design thinking pedagogy.

Faculty needs to shift their educational goals from teaching a specific body of knowledge to facilitating students’ ability to learn and develop continuously in a context of rapid transformation. “It requires a shift in educational paradigm” (Vinke and Hummels, 2010\textsuperscript{293}). Students need to be taught to reflect on what they do, think, explore, and envision, especially in a context of designing intelligent systems, products and related services for societal transformation (Hummels and Frens, 2008). The competency-centered educational model (Hummels and Vinke, 2009) at Eindhoven University of Technology’s Industrial Design Department requires students to select learning activities geared to their individual learning needs and as part of a Personal Development Plan, to perform those design activities and to self evaluate and “reflect in, on and for learning, supported by feedback from the staff members involved (…) It is intended to generate a meaningful learning experience: learning to determine what to perform, how to achieve this performance and why to achieve this”. This new educational model requires pedagogical action research not only from faculty, but also from students themselves.

This self-reflective inquiry, both from students and faculty, is a prerequisite for success in the practice of design thinking. The framework of competence in design thinking (see chapter 5) differs from that of industrial design, as defined by Hummels and Vinke (2009), both in content and developmental stages. However, the learning environments and educational model (Kolb, 1984)\textsuperscript{294} are similar. This Reflective Transformative Design Process concept is explored for design thinking pedagogy, with the expected result of defining a competence framework for design thinking.

The bid submitted for the creation of a d.school included a faculty training model divided into four steps: immersion and exposure of teachers to the theory and practice of design thinking, co-development and co-teaching of a course, course transfer, sharing practices during a symposium. Firstly, faculty had the opportunity to attend a series of “events” (including a field trip to Silicon Valley, various workshops, including full theory or full practice or both) and had access to a dedicated website with resources, such as a scoop-it, and a specific design thinking library. They carried out a two-day project, to redesign the ENPC library's entry and


exit in full collaboration with the staff. The toolkit for educators was slightly modified to suit this purpose. The initial bid also indicated volunteer faculty numbers, type and number of students per school – 5 to 10 students for the school of architecture and the school of urbanism; one Masters for the school of telecommunications and for the university of social sciences; a whole class of M1 students for ENPC, which submitted and run the project.

In the first year, teachers from four schools attended the training program with various levels of attendance: one from the school of architecture, one from the school of urbanism, 2 from ESIEE, 2 to 4 from ENPC. None from the largest social sciences institution attended this first year. All of them were satisfied with the program and decided to set up a joint course. Matching academic timetables across four schools to find a common slot in the first semester was a struggle in itself. My suggestion of a partnership with a retirement home was appreciated. While I was setting up ME310, my teaching assistant visited retirement homes on the recommendations of a friend of mine who created an ecosystem of players in the silver economy. We discussed two brief directions: reinvent the garden and improve the nurse experience.

Despite interesting learning outcomes, the second phase of co-development and co-teaching was a catastrophe: none of the teachers attended the full course, let alone co-teaching. Only one teacher felt she could take over the course. During the debriefing, most of them were unsatisfied and even aggressive: I guess it was a way to cover up their lack of engagement and the inability to take over, as my teaching assistant and I had to take the full control of the course. At the same time, I was struck by the capacity of a teacher of English to set up a new course including a real project in the garden she created next to our new building: she attended a couple of sessions, I suggested a few pedagogical resources, we bought her garden supplies and she was able to refurbish an entire course without our involvement. Students and teacher were fully satisfied and outcomes were very promising. This contrast sharply challenged the initial training model. I decided to change it dramatically for the following academic year, as it was unsatisfying in many respects: the pace of transformation for just one course was so slow, resource intensive and risky that it risked jeopardizing the whole project.

On the basis of a first year of experience, I made two decisions: the first entailed a dramatic change in the training model for faculty; the second was to develop new courses for one or two targeted schools only. For the second year, the course d.seniors was maintained and co-taught with a new member of the d.school, who created her start-up designing products for seniors. A series of 6 workshops on design thinking were offered to all faculty from the 5 schools. Three levels of courses were developed (awareness, basic, advanced), with a focus on awareness and basic levels. One course targeted students in architecture and civil engineering, with the creation of a wooden structure for a better outdoor coffee experience.

During the second year of operations, a series of discovery workshops for faculty attracted a lot of attention with over 100 faculty attending one or two sessions. Courses, which targeted two types of students from two schools, also drew a lot of attention, with the building of
distinctive structures on campus, and were much easier to set up. Innovacteurs increasingly focused on emerging countries and start-ups. In 2012/2013, a half-time course over one semester was set up in cooperation with a team from the Stockholm school of entrepreneurship in cooperation with Ronald Jones, dean of Konstfack University College of Arts, Crafts and Design. However, it was too time-consuming and was not repeated. In 2013/2014, I decided to stop the partnership with a design school, as the Innovacteurs project had never been presented to design students as a course in design thinking, which was a source of permanent tension between disciplines.

In each academic year, specific pedagogical resources and engineering were developed for the different pedagogical formats and levels (awareness, basic, advanced). As the d.school team and the interested faculty community grew, developing an online platform for pedagogical resources emerged as a need. The launch of an international conference, as well as a free book available online, were two turning points in creating momentum, both in academia and the corporate world.
It is the first academic year for the d.school. A multidisciplinary team of 4 permanent staff is recruited, with 3 designers, 1 engineer and 1 business person (me!). Except one person, the d.school team did not perform well and cause internal problems. The team was located on two different floors and student spaces on another one. ENPC’s director of studies, who did not believe in our mission, objectives and the resources needed, blocked our operations until December 2013, on grounds of administrative procedures relating to the budget. Students of the d.school were still only industrial engineering students. I was in charge of the d.school and the department, as well as three courses (ecobootcamp, innovateurs, corporate strategy) and the training program for teachers. The bid provided a roadmap of actions for the d.school’s creation and development in terms of operations (team, space, communication, training process for faculty) and objectives (number of students, professors, courses/school, pedagogical action research, international network).

**Course** – We planned Innovateur with 7 projects with 4 multi-teams and 3 mono-teams. The multi-team briefs were focused on redesigning precise objects for seniors. The extreme innovation project was set up in Togo/Africa. We set up a new course, intermediate between ME310 and Innovateurs, half-time over a semester, with one international team in Paris and one team at the School of Entrepreneurship in Stockholm under the supervision of the dean of Konstfack design school. ME310 Paris is on hold.

**Faculty** - The initial training model for professors is structured into 4 phases (immersion, co-development and co teaching/transfer/sharing), as planned in the bid. The first started with a series of workshops and hands-on projects.

**Act** – The ENPC Director of Studies and the d.school’s subordination to the Department of Studies restricted all operations and were factors of resistance and demotivation. Understanding how the administrative system works is hugely time consuming. Courses (Innovateurs and training for faculty) are run as planned. Innovateurs include one HCD project.

**Innovateurs** - Students were interested and smart. They all had a great learning experience. All teams produced interesting outcomes. In multi-teams, engineers complained that designers did not understand design thinking and were not willing to carry out the different activities, to the point that designers soon deserted. The extreme innovation team outperformed in terms of sense making, trust generation and implementation, thanks to the teams’ proactivity, a new way of teaching and coaching. This kind of experience transformed students and created a collective sense of pride. A lot of lessons were learned (see Appendix 7.3 p. 239). 100% briefs allowed teaching design thinking. Innovateurs ++ performed well, but the fact it was a single team did not create the ambiance and stimulation found in ME310 with 3 or 4 teams.

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295 Detailed data analysis according to the PAR protocole is carried out in chapter 7: appendices 7.0, 7.1, 7.2, 7.3.
Faculty training – The pool of volunteers was limited to 7 faculties from 4 schools. Professors had limited time to live the experience and learn. They did not show up to all sessions. They all enjoyed it, but sometimes they thought they understood and did not, and sometimes they wrongly doubted their understanding: I do not know I do not know versus I do not know I could know. The pace of transformation is too slow: It has taken a year to plan a common slot for a course to accommodate around 20 students from four schools out of the five from the consortium. The initial process of training is inefficient and unreliable.

- Teaching design thinking with projects in emerging countries has a huge impact on students’ experience and the real world. Social innovation projects create the ideal conditions to learn design thinking for basic and intermediary levels. The process is very different that involved in developing a new offering for companies.
- A class of 40 students (without partnership) ideally requires 3 or 4 faculties.
- Partnerships need an assigned coach, in addition to collective project reviews. This coach has to combine expertise in both DT and the targeted users/situation/topic, in order to give relevant feedbacks.
- An international class with two teams in two different countries should consist of at least 3 or 4 teams, in order to create the right conditions for a class and the right stimulating ambiance in the studio, as well as to justify resources.
- Permanent student teams in the studio create a soul, an ambiance and a dynamics, which are of paramount importance for the dissemination of design thinking in both companies and universities. It is a lively demonstrator.
- Teaching team should agree to teach design thinking as a transdiscipline, not as a multidisciplinary approach.
- The initial training model for faculty is slow, time consuming and inefficient.

- How to create trust in communities from the very beginning when HCD projects (more lessons in Appendix 7).
- Define a new process to train faculty for wider and quicker dissemination.
- Change operational conditions: the team, the positioning in the university’s organigram in order to be in control of budget expenditure and execution, someone to replace me as an academic director.
- Learn administrative procedures to run operations (buying procedure and space refurbishment).
- Improve internal interfaces to gain trust and support.
The d.school’s operations changed dramatically: - team (departure of three designers; recruitment of an ethnographer and an administrative coordinator); - space in a brand-new ecoefficient building (with a studio, an open space and shared facilities, such as classrooms, prototyping hall, amphitheater); - new administrative positioning (independent department, with its own budget planning and execution); - new hierarchical positioning (report to the central management). I was no longer academic director of the Industrial Engineering Department. I was still in charge of ecobootcamp, Innovateurs and ME310 Paris, as well as the new d.seniors course, which is the first multi school course in design thinking at the d.school. I was obsessed with implementation as a driving factor to justify all the efforts: making an impact is key for motivation and pride.

<table>
<thead>
<tr>
<th>Situate</th>
<th>Plan</th>
<th>Act and observe</th>
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<tbody>
<tr>
<td>Innovateurs</td>
<td>10 projects are set up with 6 in emerging countries (Togo, Tunisia, Ecuador), 2 with partners (a retirement home and a global coffee company) and 1 at the request of students to improve campus life.</td>
<td>Act – A class in design thinking was successfully and efficiently set up an English teacher, which was not expected. Teachers did not attend the multi school class and did not co-teach. They even complained, which was unexpected.</td>
</tr>
<tr>
<td>ME310</td>
<td>Three ME310 projects are set up with three companies (Lapeyre, Valeo, Thales TOSA) and three academic partners (Stanford, HPI, Aalto). The ME310 Paris syllabus is enhanced with 30% additional assignments, especially in user research and dissemination inside the corporate partner’s company.</td>
<td>Innovateurs: Students were diverse in terms of proactivity, openness and enthusiasm. Extreme innovation projects provide a fabulous learning experience, even if students are less proactive than others and sometimes skeptical. Coaching in the field made the difference in engaging reluctant students in DT activities: making changed their attitudes.</td>
</tr>
<tr>
<td>d.seniors</td>
<td>The first multi school course is run and should be co-taught with 4 instructors, my teaching assistant and me.</td>
<td>ME310: Students were proactive, modest and efficient. Dynamics with their international team varied from one partner to another one (great/neutral/negative). Arrogance among students abroad killed mutual respect and listening, which led to demotivation. It also created a risk of irrelevance. Corporate partners could either be part of the team, give regular feedback or intervened for reality checks only from time to time.</td>
</tr>
<tr>
<td>d.garden</td>
<td>The professor set up and ran the class very efficiently with interesting results: 20 students, real outcomes.</td>
<td>d.senior: Student outcomes and learning experiences were very promising. Professors did not attend the class regularly and did not co-teach; only one educator felt she could take over a class afterwards.</td>
</tr>
</tbody>
</table>
Dissemination actions are fundamental to making the links between project outcomes and internal changes for implementation inside the company. It demands a broad range of specific activities and events to generate internal operations for implementation. The more people are on board, the earlier, the better for implementation.

An obsession with making it happen from the very beginning and a commitment from all the stakeholders (TT, students, partners) are prerequisites for successful implementation. The dream becomes a reality when everyone feels that they actively contribute to a successful dynamic to make it happen: it is hard to achieve this state of grace. People feel they are living a unique human adventure that they will remember for the rest of their lives.

The training model for teachers should be changed dramatically, in order to scale up.

Professors have limited time to explore design thinking and to develop a new course. Most of them do not have the skills to develop intermediate or advanced levels. The existing training process, objectives and resources should be dramatically changed in order to scale up and disseminate. New training programs should offer a path from basic to advanced levels, with an accreditation system and competence development.

Space is a demonstrator and a disseminator, not only of DT, but also project results.

d.seniors/d.garden: Do the same!

Training of faculty:

- Change the training model for teachers: from “haut de couture” (luxury format) customized follow-up services to broad open formats, from volunteering to an accreditation process with 3 levels (awareness/discovery/expertise).
- Change the design principles: a small part of a course can be changed; students can have a class in regular classes; an entire class can be run without a real project or partner.
- Change the objectives: basic courses are the first target, given the easiness of implementation and impact on students.
- Change resources available to faculty: - organize a series of discovery workshops; - develop ready-to-use pedagogical supports for basic levels.
- Disseminate pedagogical action research protocols to faculty of the d.school Paris.
- Define a skills framework for DT.
The d.school’s operations are under control: - a bigger and every efficient team; - donation of furniture by Steelcase for the studio; - compliance for budget execution; - high level of satisfaction from all internal interfaces. Broad actions of communication (including an international conference, Facebook campaign, a free digital book) are launched to create momentum in France and to make d.school Paris a recognized name, especially for its user expertise (seniors, d.buildings, extreme innovation, public sector) and its capacity for implementation.

Courses included the existing options (ecobootcamp, d.seniors, Innovacteurs, d.garden) and new options (d.structure, MS Urban Integrated Systems), as well as a new training model for teachers with a series of workshops. A new session of ME310 Paris is not set up, in order to scale up activities and support previous projects into implementation in three ways: a start-up, an innovation center inside a company, a new subsidiary in a large company.

**Act** – All courses were run as planned, except the integrated urban systems course, which was time and energy intensive with little impact in terms of outcomes and student numbers.

- **d.senior** is an efficient way to teach DT in terms of learning experience, outcomes and resources.
- For the class on integrated urban systems, the teaching team lived through hell in terms of managing student expectations, communication with management, and developing adapted new tools and lectures. Hopefully the corporate partner was interested, involved and supportive. Results were good enough for an experiment, not for implementation.
- **d.structure** was a class between civil engineers and architects with the brief to create a new wooden structure on campus for a better coffee experience. Teaching ethnographic research was difficult. Students kept their discipline references (small scale-up models, drawings, 3D modeling…). They did not find a promising path for exploration so I had to inspire one. They did not want to build, so I had to provoke them and hassle them with project management. The structure was a huge success on campus: form, aesthetics, use of mathematics, and last but not least high frequency of use!
- Support for the implementation of ME310 projects was efficient and led to the development of each new structure.
- The new training format for professors is efficient, in terms of attendance and momentum.
For a topic such as integrated urban systems, further development should be done before the class, in order to create the best conditions (ethnographic research, reframed directions, access to the field and a pilot, stakeholders’ approvals…). Otherwise, risks (no sense making, no scale prototyping, no testing with users) damage the learning experience and expectations. High exposure can lead to disappointment.

User expertise is key to scale-up and greater efficiency: it attracts interest to enroll new faculty; it helps the teaching team in all its responsibilities (brief, partnerships for access to the field for ethnographic research and testing, reframing…); it increases sense making and implementation; it fosters specialized ecosystems.

Adaptations to the process and developments of new tools are needed to tackle different types of artefacts: object/product/service/process/public space with or without furniture/application/system.

A system of accreditation, as well as pedagogical action research, should guarantee a high level of quality for courses delivered. Further pedagogical tools should be available online in a ready-to-use format. Adapting DT to specific disciplines and topics creates an impact in terms of dissemination and transformation.

For all courses:
- Develop specific DT pedagogy for different artefacts (public space/service/app/process/system).
- Develop different user expertise (such as citizens in the city, seniors, poor villages in emerging countries) and ecosystems for access to real infrastructures in order to run tests and pilot.
- Explore different new tools for specific artefacts and contexts (such as participatory videos to co-design with citizens).

Faculty training:
- Develop an accreditation system.
- Disseminate PAR as a tool for TT debriefings, student assessment and decision sharing.

For all courses:
- Communicate more towards students to facilitate recruitment and course development.
- Test and evaluate the DT skills framework, with self-assessment by students.
- Explore solutions to help projects to cross the valley of death and get implemented (launch product, scale up, building…) with two scenarios: either inside a company with support to corporate partners (through the setting up of an in-house studio, training programs, workshops, communication actions, projects and coaching) or for start-up with support to entrepreneurs (through contract searches, place, communication and coaching).
Quick overview of lessons

Reflection on practice produced many insights and lessons, as set out in Appendix 7.3. (22 pages). Key factors of success to develop a d.school efficiently are divided into three areas: operations, dissemination and adaptations.

Operations to manage such a project

The management of operations is key to the success of such a project. First, the PPP framework was an efficient management tool to guide identification and reflection on relevant actions, not only in the setup phase, but also in the period of development. It structured the roadmap right through from the bid to government, to exchanges with the administration, to communication with the operational team. Second, management behavior had a strong impact on scaling up, for example providing incentives for teachers to get involved (time allocation, reduction of research targets, recognition…). The commitment of the directors of the consortium schools was also a strong factor accelerating or impeding progress. Third, it is of paramount importance to gain the trust of stakeholders inside the system, in order to facilitate daily operations and to solve problems. Fourth, the structure, which develops such a project should be as independent as possible from conventional administrative processes: creating a start-up in a public administration can quickly become so hellish that people cannot resist the pressure. Last but not least, such a project needs a great operational team.
Dissemination, both in the university and beyond

Creating and developing a d.school requires dissemination. Two forms of leverage have been identified and tested: communication and the identification of different levels of pedagogy.

As regards communication, the objective is to create and maintain momentum, both in academia and in industry, in order to raise awareness and attractiveness. A series of communication actions was launched, both inside and outside the university. Internal communication is as important as external communication. Targets include administrative staff, faculty, students, research centers and companies.

Concerning pedagogy dissemination, this is facilitated by offering discovery workshops to as many faculties as possible and by providing the resources to deliver high quality pedagogy at basic levels. The experiment of “a luxury format” for just a lucky few faculties proved to be inefficient in terms of transformation rate. With over a hundred faculty attending workshops and ready-to-use materials for basic levels, the transformation rate is quicker and broader. Over time, natural selection of interested faculty and an accreditation system favor the development of faculty skills to teach higher levels in design thinking pedagogy.

The setting of four types of course was a key finding of the first two years of experiment. It drives development not only in resources and operations, but also in dissemination and an accreditation system. Each type of course requires a different format and pedagogical resources, with different individual’s development stages (Table 14, Hummels and Vinke, 2009)\(^296\) and different needed key factors of success, as briefly explains below:

1. **Type 1: Workshops** of half a day to one day with no credit are a traditional format for arousing interest and maybe arising awareness, either about the whole process or a specific activity. An efficient formula does not require a lot of time from a faculty and includes an introduction to the studio, a short lecture and a short exercise.

   When people enter a workshop, most “are like blank” (Table 14).

2. **Type 2: A weekly course** over a quarter or a semester is a traditional format for basic level (between 1,5 and 4 ECTS). Basic formats are the most easily scaled-up and efficient format: with ready-to-use pedagogical materials and very little training, any faculty can run them with classes of around 40 students. Such classes require no project with real stakes and partners, but only a series of practical exercises. Basic levels require development time to create an optimal learning experience with ready-to-use materials, which should be available online. Once developed, updating is efficient.

   In terms of individual developmental stage, students are starting their journey of awareness according to Hummels and Vinke (Table 14).

3. **Type 3: Advanced courses** (between 6 and 15 ECTS) are usually a core course in a given program. They include a real project and our experience shows that it should be local: the transformation of part of the campus was the most efficient brief; it requires administrative authorization and interfaces, which is time consuming; it makes implementation easier; it is a factor of pride and publicity when achieved, for students, faculty and the administration. Advanced levels require time to develop and run partnerships with local players (administrative authorization and coordination meetings) and to guide students in their work, from the field to sense making, through prototyping and evaluation of implementation. Faculty should be efficient coaches with an expertise in the given situation, in order to avoid naivety in dealing with partners and real users.

In terms of individual developmental stage, students are between the stage of blank and awareness according to Hummels and Vinke (Table 14).

4. **Type 4: Programs** (over 30 ECTS) represent a full dedicate course in innovation and design thinking. They usually include a series of courses and a partnership with industry: this requires faculty to be able to deal with innovation and business issues, partners’ attitudes and skills, and to deliver high quality outcomes; it requires balancing the learning experience and value creation for the partner. It requires skills in innovation and business, as well as deep understanding how industry works. It is risky, stressful and difficult for both students and faculty. Time allocation and financial compensation should be proportionate to the stakes. Programs with financial partnerships with the industry require business development skills and project leadership in addition to pedagogy and design thinking. At that level, faculty should be professional practitioners of design thinking.

In terms of individual developmental stage, students are between the stage of awareness and depth according to Hummels and Vinke (Table 14). It depends on the level of self-reflection which is required from students and their ability. Without previous background in such a pedagogy and self-reflection, they do not reach that individual stage of development.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
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<tbody>
<tr>
<td>Blank</td>
<td>“The design process is probably just a phrase, a set of unknown activities: one big blur”</td>
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<tr>
<td>Awareness</td>
<td>Students have performed a number of assignments and projects. They have received their first feedbacks, and have written their first reflections on their learning experiences within learning activities, deliverables and competency development achieved. They have built a showcase twice, in which they reflect on their overall competence of designing, on their design process(es) and their growth as a designer. At the end of their first year, students demonstrate awareness of what the ten ID competency areas entail as related to their own work, what their own overall competence of designing is, what their own growth as a designer is, how competency development contributes to overall development, and what a design process may constitute”. (p. 85)</td>
</tr>
<tr>
<td>Depth</td>
<td>“The stage of depth is characterised by knowledge and skills building, including experiential knowledge as well as theoretical knowledge. Students demonstrate depth in particular competency areas and in their academic skills as a designer: making (synthesising and concretising) and thinking (analysing and abstracting), next to emotional and social skills. (…) In their reflections they connect competency areas to one another and establish connections between competency areas, the overall competence of designing and growth. They have gained experience with the activities within the reflective, transformative design process, and with jumping from one activity to another while reflecting on the previous one. They demonstrate understanding of this design process as a whole.”</td>
</tr>
<tr>
<td>Expertise</td>
<td>“Expertise in the overall competence of designing is reflected in their ability to integrate various approaches in their design process (design, engineering and social science). It also shows in their ability to jump comfortably back and forth between the activities within the reflective transformative design process, reflecting on the steps they take, and trusting their senses.”</td>
</tr>
<tr>
<td>Visionary</td>
<td>Dorst (2004) is quoted to define this stage as follows: “The world discloser or ‘visionary’ consciously strives to extend the domain in which he/she works. The visionary develops new ways things could be, defines the issues, opens new worlds and creates new domains. To do this a visionary operates more on the margins of a domain, paying attention to other domains as well, and to anomalies and marginal practices that hold promises for a new vision of the domain.”</td>
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Cultural adaptations?

Two factors of attractiveness and dissemination have been identified in the d.school Paris over the years: user expertise and implementation.

User and context expertise breaks the ice with teachers and researchers interested in this topic. The knowledge, the projects and the partners around this subject attract them. Design thinking is discovered in the course of action through projects, lectures and workshops. User expertise is also a factor of efficiency and security for faculty: first, briefs are better refined and operational; second, sense making is secured by faculty; third, access to the field is facilitated through faculty networks. The more advanced the course, the greater faculty involvement and expertise should be, both in design thinking and user expertise. In the case of a partnership with industry, faculty should have the right language, skills and business references to increase mutual understanding and the likelihood of implementation. It is a key factor of success.

Real implementation attracts French teachers and researchers, as it demonstrates the efficiency of this pedagogy. It also demonstrates the ultimate learning experience and the ultimate dream of the design thinking paradigm. Although a bias towards action is highlighted in the initial design thinking manifesto, implementation for all courses and all faculties is always a difficult challenge. 100% implementation requires the following specific conditions:

• First, the framing of the brief has a key impact on the feasibility of this goal: it should be tailored to the competencies of faculty and students, as well as the course format. Implementation can be experienced outside a partnership with a company.

• Second, the process as implemented at the Stanford d.school should culminate in implementation, the last phase of the IDEO process, even in the case of a basic or intermediate course and even if adapted to the nature and context of the project;

• Third, implementation should be an obsession for faculty, which would be transmitted to students. I have pitched the 100% rule for d.school Paris: 100% convinced, 100% responsible, 100% committed to make it happen.

• Fourth, the level of ambition should match the level of faculty expertise on how to implement in different contexts. In the case of a market launch, the more faculty and the corporate partners know how to implement in a company, the more implementation will happen.

Creating a d.school is highly demanding, it requires a lot of energy, conviction and serendipity. It requires you to envision a project and defended, usually both in writing and verbally, in order to obtain the resources (space and money). It requires a lot of management skills to create and develop it (management of the project, the administrative processes, people


298 October 23, 2015, Stanford, 300 people from SUGAR network
such as internal and outside stakeholders, a team, faculty, partners, reporting capacity...). It requires great capacity for exploration in order to adapt it to various contexts and artefacts (product/service/process/system/public space). It requires a great deal of flexibility and responsiveness to adapt to the reactions of local ecosystems. A key factor of success is to embody the culture of design thinking first through self-transformation, and then by developing design thinking pedagogy step by step: a course, a program, a d.school...

**Conclusion: Is it useful? Is it adaptable? Is it transferable?**

A d.school constitutes a high-impact demonstrator for a university: it attracts a lot of attention from stakeholders, including academic partners, companies, staff, faculty, the press, and students. The first impact is therefore in communication: the d.school represents pedagogical innovation, which answers today’s imperative to generate solutions to wicked problems in uncertain conditions, and to do it quickly with a studio, a space that bewilders any visitor and makes a good tour destination where, as happened in our case, the director of communication was able to bring two ministers. It represents a factor of differentiation and a competitive advantage to attract students, companies and partners. A course at the d.school offers a different learning experience for students and potential personal transformation. From pitching ideas to making something tangible for someone, student outcomes are also useful for the people we innovate for. In the long run, the hope is to educate a new generation of empathic change makers with an impact on the society.

A d.school needs to be adapted to one’s context and culture, in terms of curriculum design and artefacts. It provides a behaviorally complex learning environment (Kolb, 1984), where skills, attitudes and knowledge can be developed through experiential learning. Learning by doing and from doing should be appropriate not only to the initial characteristics of the target learners in their specific cultural environment, but also to the targeted learning outcomes and profiles. The balance between knowledge, practice and reflection needs to be adapted within a course. Similarly, the balance between the different learning modes (behavioral, perceptual, affective, symbolic, as described by Kolb, 1984), should be adjusted to the local culture.

A d.school needs to be adapted to the profile of its educators, in order to get them on board and disseminate design thinking through a variety of courses. Engaging faculty in developing design thinking pedagogy is a huge challenge anywhere. People resist paradigm shifts. In addition, not everyone is able to develop this kind of pedagogy, based as it is on the creation of behaviorally complex learning environments. However faculty who are willing to embark on such a journey can deploy faster with ready-to-use pedagogical materials, project definition and development (including partnership and negotiation for access to the field),

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material resources, teaching assistants and time allocation. Suitable training sessions and pedagogical resources should be developed and made available. Pedagogical action research should be organized to help faculty to better their own practice class after class and to publish. Faculty should be recognized for the efforts and the skills that such pedagogy requires, with appropriate compensation (financial benefits, time allocation, revised research objectives).

A d.school can be transferable to any university or country, provided that certain resources are made available. The balance between space, people and process should be maintained through a scaling-up model, as described in chapter 5. Success depends on the skills of the project leader, which include their ability to adapt design thinking to the local culture, to build a competent team and to leverage the initial resources. The more support the project leader receives from management (resources, priority, commitment), the easier, the faster and the more impactful the d.school is. Transferable though it is, creating a d.school is a big challenge with many risks, hurdles and pitfalls.

Is it worth the effort? If Larry asked again… I guess it depends on one’s ambition and motivation… For me, it is definitely worth the daily effort! ... It nourishes my thinking, experiments and practice everyday… It opens up a new and broader range of opportunities for transforming a corporate culture and creating strategic renewals…
Final reflection from a longitudinal analysis (2007/2015)

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Building my culture of design thinking

Contribution to PAR on DT: The PPP conceptual framework

A conceptual framework emerged from our first experiments (2006-2010), based on the idea that the voyage of exploration necessary for innovation requires three structural elements, which are a crew (people), a boat (place) and navigation tools (process and tools) (Fig. 25). The PPP framework is suggested as a conceptual framework through which to analyze the narrative case studies. It is a contribution to pedagogical action research adapted to design thinking pedagogy.

For each academic year, the process of pedagogical action research (Table 15) was carried out in detail as described in Chapter 7 / appendix 1 (110 pages). Short analyses are provided in Tables 9.a/9.b, 11.a/11.b/11.c, 13.a/13.b/13.c. For each academic year, the tipping points I discovered and practiced in the culture of design thinking were recorded and analyzed in chapter 7 (which means 8 sections “learning about a culture of design thinking” for 8 academic years). Table 16 gives an overview of which tipping points were discovered and when. It has taken years to learn about the culture of design thinking and I am still learning (see section “making my culture of design thinking evolve” in section 7.3).
Such a long journey of research shows that learning about a culture of design thinking can only be achieved over time with a rigorous method of self-awareness, practice and self-reflection through pedagogical action research. This longitudinal study is an invitation for any practitioner to learn about design thinking with the following steps:

- first discover relevant milestones in the culture of design thinking,
- second experience them, and
- third reflect and commit to improve your practice.

Table 15. Building a culture of design thinking thanks to PAR

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Situate</td>
<td>Plan</td>
<td>Act and Observe</td>
</tr>
<tr>
<td>People</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Place</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Process</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 16. Track record of tipping points in design thinking

<table>
<thead>
<tr>
<th>Place: 22</th>
<th>Process: 43</th>
<th>People: 36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stanford University, project spaces, 7 s shop kitchen, loft/studio</td>
<td>Constraints and dialectics, creativity</td>
<td>Multidisciplinary teams, risks with high IQ, emotional intelligence, engineers, constructivism</td>
</tr>
<tr>
<td>d.schools, space and mindset, 9 spaces, fun space, zen space, brainstorming room, library, material library, living room, red sofa</td>
<td>Context of ambiguity, well defined versus wicked problems, brief definition, DT briefs, user center design, foresight, affordance, the art of observation, visual thinking, rules for brainstorming, post it generation, idea selection, failures or learning</td>
<td>Manifesto of values, epistemologies, pragmatism, T-man, designers, David Kelley, Larry Leifer, Banny Banerjee, community, technology brokers</td>
</tr>
<tr>
<td>Living labs, design factory/Aalto, this belongs to you</td>
<td>Ethnographic research, frameworks, benchmarks, the art of prototyping, different prototypes for different purposes</td>
<td>Empathy, kindness, optimism, I do therefore I am, radical collaboration</td>
</tr>
<tr>
<td>The school of design thinking (Potsdam)</td>
<td>Mystery/heuristics/ algorithms, reflexivity</td>
<td>Cultural interpreters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Place</th>
<th>Process</th>
<th>People</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2008/2009</td>
<td>10</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>2009/2010</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>2010/2011</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Intuitive and analytical skills, intuition, creative detour, abduction, multiple intelligences, ten faces of innovation, anthropologist, deduction and induction, cross-pollinators, storytelling, experimenters, a real human adventure, divergence and convergence.

Experience design, imagine the ideal experience, storyboard.

Transdisciplinary teams

Creative confidence
The evidence for the number of landmarks per academic year and per category (people, place, process) is described in Fig. 26. The variation over time can be explained as follows:

- From 2007 to 2009, most landmarks discovered and experienced concerned space. 2008/2009 represents a peak because of my stay at Stanford;
- From 2010 to 2012, most landmarks discovered and experienced concerned people and process. 2011/2012 represents a peak because my teaching assistant from Stanford left. This meant that I could experience new tipping points in the culture of design thinking beyond the ME310 Design Innovation curriculum;
- Since 2012, most landmarks identified and/or developed concern new tools in the process, so that our culture of design thinking can be adapted to many different users, contexts and artefacts.

For each historical era, the way to develop design thinking pedagogy at different levels has been analyzed and recommendations for interested faculty has been structured in terms of People/Place/Process (chapter 6). This demonstrates the practical effectiveness of the PPP framework in developing design thinking projects for different levels of ambition. It demonstrates the importance of starting small, learning from doing and developing a step-by-step approach as an individual and as a university. Key recommendations per objective are detailed in Fig. 27.
Contribution to design thinking literature with a book: 101 Landmarks

The discovery of tipping points in the culture of design thinking has prompted me to pursue practice and self-reflection through pedagogical action research since 2008. Another outcome of this research is the publication of a book on design thinking: 101 Landmarks I’ve discovered to innovate thanks to design thinking. After a series of lectures to explain design thinking, and a couple of years of practice, I realized that it was easier to explain design thinking as a culture of exploration. While no one can give a strict definition of what French culture is, everyone can experience it. That is why I decided to explain design thinking through the image of a culture.

Extract from the digital book on my culture of design thinking

The book “101 Landmarks I’ve discovered to innovate thanks to design thinking” retraces my apprenticeship: my searches, my explorations, my prototypes, my experiments, my discoveries.

When we start telling people about our world, the first question is always: but what exactly is design thinking? Too often, I hear people who think they know reduce it drastically to three variables at best: it is creativity and prototyping, plus possibly the idea of multidisciplinary teams. It’s a bit like saying that France can be reduced to the beret and the baguette. Or Germany to sausages and beer. True, these are (perhaps) dominant characteristics (though I’m not entirely sure about the beret!). But this runs the risk of painting something of a caricature and missing the subtleties of a much richer, deeper and more inspiring universe.
Design thinking is like a culture: when you visit another country, you encounter all its riches, its architecture, its food, its national costumes, its heritage... You can either travel through like a tourist in a hurry, see only a minuscule part and make uninformed value judgments. Or you can live there like a native, though even more curious, amazed and eager to learn, in which case you experience all its richness, sometimes more deeply and subtly than the inhabitants themselves. Because you have an outsider's view, the curiosity to understand and to learn, the pleasure of discovery and the desire to stay.

For me, design thinking is like another country's culture. When I encountered it, it felt like coming home: “This is my world. I have found it at last.” The richness of this world inspired me and continues to do so. I looked for the codes. I interpreted them. I play with them to set the stage for a world that is faithful to the canons of design thinking but reinvented to match specific objectives and conditions.

The standard view is usually that exploration is a positive act and exploitation a negative one. According to Wikipedia, exploration is the act of searching or traveling across a terrain (including space) for the purpose of discovering resources or information. As for the term exploitation, it can convey two distinct meanings: - The act of using something for any purpose (in this case, exploitation is a synonym for use); - The act of using something in an unjust or cruel manner. After the Age of Discovery, major explorations continued from the 17th century through the 18th and 19th centuries into the modern era. In scientific research, exploration is one of three purposes of empirical research (the other two being description and explanation). Exploration is the attempt to develop an initial, rough understanding of some phenomenon. This view is somehow based on a positivist assumption that reality – or a new territory – is already there, waiting to be discovered.

When I started to read about early exploration in the 15th century, I quickly realized how cautious explorers were before embarking on such a risky journey: they made thorough preparations with a boat, a crew and navigation tools. When I started to explain design thinking using this historical reference, it was clear that the French reacted much more positively than if I said that it was a culture from Silicon Valley. As a former CEO, I had identified tipping points in terms of people, place and process in order to develop design thinking pedagogy. These two trains of thought were close to each other. The book is built on the image not only of culture, but also of exploration. It is structured into three categories (place: a boat, people: a crew, process and tools: navigation tools).

PEOPLE: The crew (“people”) symbolizes the innovating project team. Like explorers on the great expeditions of the past or today’s long-distance races, every crew member contributes to every aspect of on-board life, while still having a specific role appropriate to their expertise and personality. Assembling a team is key to any adventure. Each person has their own point of view, experience, sensibility, skills, ways of doing things, desires, dreams.

PLACE: The ship (“place”) symbolizes the place where innovation takes place. As it was for explorers on the great fifteenth century expeditions, the boat is the vessel that carries us to unknown lands, to explore, to discover and bring back discoveries. More than a workplace, it is a living place. It needs to be a part of every stage in our explorers’ journey. It needs to provide emotional security from the dangers of the outside world of exploration. It needs to isolate in order to foster analysis. It needs to inspire in order to foster creativity. It needs to facilitate the implementation of ideas for subsequent testing in the outside world.

PROCESS: The navigational instruments (“process”): Portolan charts, Toscanelli maps, globes, provide a picture of the territory of exploration, always approximate, reflecting the current state of knowledge. To produce navigational charts by exploring unknown lands was one goal of the early expeditions, but the ultimate goal of exploration was to find and bring back new riches from these early voyages. After the phase of exploration comes the phase of exploitation. Artefacts like backstaffs, quadrants, astrolabes were navigational instruments used by mariners to find their way on a voyage of exploration.

The first edition of the book is in French, published under a common creative license. It is available for download free of charge, in order to disseminate the culture of design thinking in France. From May 2015 to June 2016, almost 2000 people downloaded it. For the last two years, the momentum has been created in French higher education and companies, given the growing number of projects that can be identified.

The evolution of OUTPUTS: From concepts to real impact through sense making

*From a pitched idea to change making through useful artefacts*

*First historical era: Designing a curriculum*

From 2007 to 2009, most of the French mono- and multi-disciplinary teams produced PPT presentations at the final presentation. A lot of projects did not make sense. The worst and the best outcomes from students are strong indicators for key factors of success in teaching design thinking (Table 17).

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Innovacteurs</strong></td>
<td>A beautiful ppt presentation that realistically presents the user’s experience, technical feasibility, communication plan and a possible business model.</td>
<td>Beautiful presentations that cover users’ experience and technical feasibility with low-definition prototypes.</td>
</tr>
<tr>
<td>Best outcome</td>
<td>Ppt presentations with no sense making in terms of understanding the context and possible solutions.</td>
<td>Ppt presentation with no sense making and a clear arrogance from students who pitched ideas despite an obvious lack of work.</td>
</tr>
<tr>
<td><strong>Ecobootcamp</strong></td>
<td>Prototyping of family games tested among students</td>
<td>Outsourced to a business school</td>
</tr>
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</table>
In 2007/2008, the process of design thinking was taught through material found in the literature, including websites (mainly IDEO and Stanford). The best student outcomes in 2007/2008 were ppt presentations with an ideal suggested solution, shown through a series of beautiful slides: The team working on the bottle was very committed and performed beyond expectation, presenting a project that was judged outstanding: sense making, great storytelling, very realistic pictures, very detailed descriptions of the “what” in all aspects (design/technical/communication/business). However, nothing tangible was produced and nothing happened in reality, despite students’ motivation to set up a company. In 2007/2008, a very good student from another team said: “We could have gone further” in developing the concept both in its content and presentation. There was frustration on both sides. The worst student outcomes were pitches for ideas, which came out of the blue and made so little sense as to be embarrassing (Table 17).

In 2008/2009, my stay at Stanford allowed me to experience the process, with the emphasis on prototyping and testing. Engineering students experienced a field trip to Silicon Valley in September 2008. Multidisciplinary teams were organized for the second semester. Conflicts between designers and engineers, as well as targets that were too ambitious and briefs that were too broad, with no detailed process and precise assignments, explain the fact that only two (out of eight) teams produced an untested prototype. Good engineering students felt frustrated that design students
valued neither needfinding nor prototyping and testing. Two teams were unable to prototype because of their subjects (train travel and lights in the city). They were not able to explain the process of design thinking. Poor teams, which presented projects made no sense pitched many of their ideas so arrogantly that it was embarrassing and irritating. The teaching team was not in the best position to evaluate whether the project made sense: students with poor results used it as an opportunity to pitch ideas, instead of demonstrating the value based on end-user feedback.

Three key factors of success in teaching design thinking for multidisciplinary teams are: first, the process of design thinking should be recognized and respected as a transdiscipline for all disciplines; second, the brief should be realistic in terms of access for needfinding, prototyping and testing; third, end users should be part of the process in order to increase appropriateness and pragmatism and avoid pitching with no sense making.
Second historical era: Developing an international program with companies

From 2009 to 2012, in addition to the French curriculum including Innovacteurs, I set up a full-time international program called ME310 Design Innovation, which included multidisciplinary and multicultural students and teaching teams, as well as corporate partners from global companies. Most teams produced solutions that made sense to varying degrees, with no real implementation (except maybe one team). The worst and the best outcomes from students are strong indicators for key factors of success in the teaching of design thinking (Table 18).

Table 18. Students’ outcomes from programs

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Innovacteurs</td>
<td>Best outcomes: The mono team created sense making solutions implemented in a given context and built trust with stakeholders who expected even more (hospital).</td>
<td>Students imagined a solution (with both a tangible prototype and a simulation) to a complex problem, which helped the corporate partner to win a bid (waste recycling).</td>
<td>A multi team created outstanding outcomes (presentation, report, prototypes) from a broad topic (seniors and photography) with no partner.</td>
</tr>
<tr>
<td></td>
<td>Worst outcomes: The three multidisciplinary teams were lost in design fiction with abstract concepts and no sense making.</td>
<td>Two multidisciplinary teams were lost in reframing from a broad topic. The one in Morocco was lost in empathy.</td>
<td>A mono team got lost in understanding the subject (open data).</td>
</tr>
<tr>
<td>ME310</td>
<td>Best outcomes: Students produced a lot of sense making prototypes with one close to the iPad just released at the same time (family flip, Pioneer).</td>
<td>The corporate partner used students’ work and the partnership as part of his due diligence to raise money from investors.</td>
<td>The solution was demonstrated with a low definition prototype and attracted attention inside the company and the target industry (Angénieux): “It represents a revolution for our industry”.</td>
</tr>
<tr>
<td>Worst outcomes</td>
<td>The outcome did not make sense for the corporate partner. The final prototype’s definition was low and not tested with users (drone, Thales).</td>
<td>The suggested solution was simulated with no tangible prototype, and was not tested by any stakeholder outside the corporate partner (EADS and Amplitudes), especially end users.</td>
<td>The project, even with a final prototype of good definition which demonstrates a proof of concept, was not disseminated in the company beyond the corporate partner (Panasonic).</td>
</tr>
</tbody>
</table>
As the table shows, even the best student outcomes from ME310 projects did not generate any development process after the program. Only one student project led to real implementation within the Innovacteurs framework, as the corporate partner won a bid to implement the recycling system in a building, which is still under construction in 2016.

Whenever students get lost in reframing, they struggle to find a sense-making direction, let alone promising solutions, which could be implemented. The culture of design in France values giving students abstract topics: reframing is considered to be the designer’s most important activity. The risk is that students get lost, and never get into the field or prototype anything. With this kind of journey, implementation is doomed to fail.

From 2009 to 2012, ME310 projects were disappointing in terms of real implementation inside the corporate partners’ company. Nothing really happened despite full satisfaction with student outcomes. Collaboration with a corporate partner should lead to sense making in the way students think and act. Unfortunately, this kind of partnership does not necessarily bring that result, for many reasons: low level of commitment by the corporate partner, failure to undertake professional follow-up; a low level of access to the field and end users; the corporate partner’s lack of understanding of the subject.

Collaboration with a corporate partner should bring a better level of implementation. Unfortunately, this cannot be taken for granted, for many reasons: the corporate partner may not know how to implement, one is unable to engage people in the partner company or stakeholders who are needed for the implementation phase, because of a lack of experience or power or technique of dissemination and product development.

Three key factors of success in teaching design thinking with real implementation include: first, a sense making solution that has emerged from needfinding and prototyping with end users; second, a shared conviction of a sense making solution across the ecosystem (students, professors, as many people as possible inside the corporate partner’s company and extended partners needed for implementation), which has emerged from extensive exchanges to understand the corporate partner’s interest and ability to make things happen; third, a change in the process, which cannot end with prototyping and testing, but should take into account the implementation phase (including storytelling, pilot and business model generation) and the need for dissemination within the company throughout the process.
Third historical era: Creating a d.school

In addition to Innovacteurs and ME310, the first course between four schools was dedicated to design for seniors. The change in the final objective (as well as in the process and assignments) had a marked impact on student outcomes: Instead of producing a low definition prototype at the end of the course, students were able to find ways to implement a real and useful artefact in a given context. The quality of outcomes was now measured in terms of impact on reality, and no longer in terms of sense making and whether students had prototyped and tested with users (Table 19).

Table 19. Students’ outcomes at d.school Paris

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<tr>
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</thead>
<tbody>
<tr>
<td>Best outcome</td>
<td>Real...Africa</td>
<td></td>
<td>All teams outperformed: needfinding, prototyping, testing and real implementation. One team built an impactful path for seniors in only three weeks.</td>
<td>All teams outperformed: needfinding, prototyping, testing and real implementation.</td>
</tr>
<tr>
<td>Worst outcome</td>
<td>Students did not influence the group of 80 architects and engineers to be driven by a sense making concept for users. They only did project management.</td>
<td>Some implementations will not last in the long term.</td>
<td>One team struggled to find potential users and clients for a product already developed by a start up. They developed a functional prototype anyway and tested with users. One team failed to present needfinding.</td>
<td></td>
</tr>
<tr>
<td>ME310</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best outcome</td>
<td>Successful...students’ work. Creation of a start up.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worst outcome</td>
<td>No implementation inside the company and no dissemination beyond the two corporate partners.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### d.seniors

<table>
<thead>
<tr>
<th>Best outcome</th>
<th>First edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>An emergency lamp for doctors’ trolleys was delivered.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Worst outcome</th>
<th>First edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>The solution should be implemented by the retirement home.</td>
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</table>

### d.structure

<table>
<thead>
<tr>
<th>Best outcome</th>
<th>First edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students converged for a real implementation of a structure which is still in place and used every day on campus.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Worst outcome</th>
<th>First edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students did not carry out good needfinding. Some students produced small scale intermediate prototypes which were ugly and would never have created a good experience.</td>
<td></td>
</tr>
</tbody>
</table>

In 2012/2013, the d.school Paris started to offer training sessions for faculty. ME310 was on hold, as I was still in charge of the department while starting the d.school. The only course was Innovacteurs, with 8 projects and 3 teaching assistants. The overall quality of Innovacteurs projects was high in terms of outputs. Such a high level of quality had never been reached before. Apart from one team, which was involved in a big project with over 80 engineers and architects as part of an international competition to build a 110 m² house (solardecathlon), all the teams were carrying out needfinding, developing prototypes and testing them with users. The engineers were disappointed that the designers did not want to perform design thinking activities and had no interest in such outcomes. A HCD team in Togo was able to raise funds to build a mill, which was constructed over the summer. With good preparation (brief, partners, logistics, trust), HCD projects offer the opportunity to make a real impact on people’s lives. They justify and warrant any effort, creating a sense of pride for both students and faculty. They contribute to personal development, self-esteem and self actualization (Maslow’s hierarchy of human needs): the need to do good, to be fully alive and to find meaning in life.
In 2013/2014, I set up ME310 again with a strong aspiration to make an impact on the companies we work with, that is to say to trigger internal development processes for a real market launch. I looked for partners and briefs that showed promise of achieving that goal. I developed a dozen actions to disseminate the project, the philosophy and the methodology inside the corporate partner’s company. I selected Innovacteurs projects with potential for implementation. I set up the first multi-school course in the same spirit: local needs in a specific place with people available to interview and to make decisions for implementation. With this obsession and some changes in the curriculum, all the projects triggered real implementation, with different degrees of impact and success. It was the best year for implementations.

In 2014/2015, I decided to put ME310 on hold and to follow up ME310 projects from the previous year, in order to increase the chances of implementation. I carefully selected projects for Innovacteurs with
I continued to deliver d.seniors, started a new course between the school of civil engineering school and the architecture school, and another new course for a specialized executive Masters in integrated urban systems. What had seemed impossible for students and my colleagues at d.structure was delivered: a beautiful and useful structure for a coffee experience on campus. This structure sparked questions: I am not an architect or a civil engineer, but I run the only class that achieved the objective of building a real and useful structure in only thirteen 3 hour sessions (in addition to extra weekend work by the students).

I ran d.seniors with an alumnus who specializes in seniors. d.seniors students delivered very different outcomes with limited impact. We may have underestimated the need for faculty to communicate extensively with the retirement home staff. The outcomes for students in the executive Masters were limited in terms of the potential for implementation: either the user cases and solutions did not make sense, or the nature of the artefacts (in this case an urban lighting system) did not allow permit prototyping and testing in real-world conditions, and would have required a high level of commitment and investment from multiple stakeholders (the company, the municipality) and more time allocation for students and faculty.

Three new key factors of success in implementing projects with design thinking education: first, making it happen should an obsession for faculty, before, during and after the class; second, the partners and briefs should be selected at student level and the course format should reflect this; third, all the stakeholders (faculty, students and partners) should be 100% responsible and committed to making it happen. The habit of achievement (Roth 2016) should drive our efforts, thinking and making.

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Students’ satisfaction: from grades to pride in making

There is a big difference between students who perform and those who don’t. Students who perform are highly satisfied and driven by what they achieve and their impact on the real world. Students who do not perform are dissatisfied, highly critical and can only be managed by rigorous grading in order to generate a satisfactory level of quality.

Students who do not demonstrate high proactivity, strong commitment and growing conviction in what they achieve through the project, need assignments and grades in order to produce consistent quality. Projects produced in this way are not outstanding and usually have no impact. But the overall quality of outcomes is acceptable. Assignments and grading should based on clear guidance on what has to be done. It prevents the risk of not delivering anything that makes sense. Poor students provide an opportunity to better the curriculum design: it pushes faculty to refine assignments, lectures, practical exercises, preparation of the context. It pushes them to bridge student inadequacies, to step in and to contribute significantly to the work. It demands a much greater investment of time from faculty. There is also an emotional impact on teachers as such students are a constant source of demoralization. They usually do not recognize the instructors’ skills, argue about everything and always find excuses to avoid responsibility for events.

Students who demonstrate strong conviction and commitment are driven by what they want to achieve and, at the end of the project, are very proud of the real-world impact they have had. Grading is not necessary.
Assignments and grading should reflect the endeavor to make sense and deliver implementation. Such students reinvent assignments by going one step further. They are a source of inspiration: they develop new concepts, new tools that match their artefacts and contexts, and new ways of doing things more efficiently. They are a powerful source of motivation, to the point that faculty no longer feel that they are teaching but collaborating with delightfully surprising young professionals. They help teachers to save time in running the program by contributing to resources and methods that usually depend on faculty input.

Creating something useful for someone in a given context should create a sense of pride in both faculty and students. It justifies the mutual efforts and endeavors. Making it happen is the purpose of design thinking and fosters a sense of achievement and pride.
The evolution of PLACE: from classrooms to the field

A class, a floor, a building

From 2006 to 2008, an empty classroom was available to ENPC students on the Innovacteurs course and individual spaces for ENSCI students. The ENPC classroom was in a remote location in the main building and almost empty apart from some traditional furniture. None of the students used it. The teams met and worked at ENSCI. Depending on the location of the project reviews, one discipline would dominate: students of the school where project reviews were held felt more responsible for taking the lead in the project, and design values (such as esthetics, altering perspective, originality of solutions) dominated design thinking values (pragmatism, user needs, quick and dirty prototypes and user testing).

From 2008 to 2012, half a floor was made available for Innovacteurs and ME310 projects. ENPC painted the space green, to differentiate it from the white color of the building. Furniture was laid out in the 9 spaces identified in the 101 landmarks, in garage style. ME310 students were involved in setting up the space and naming each room. The students all used the space constantly, even for personal meetings. Three components of the space drew the attention of ENPC employees, to the point that the unions asked the school director why students had the privilege of enjoying such a setting and not them. Those three components were the red sofa, the red fridge and the Nespresso coffee machine. This incident shows the importance of thinking about possible reactions when creating a space. The setting should strike a subtle balance between boldness and acceptability, in order to create change without arousing anger and strong resistance. It should reflect the culture of exploration and be bold enough to distinguish it from a culture of exploitation, but at the same time, it needs to be acceptable to most people, to avoid arousing envy and attracting criticism on the grounds of expense. My experience has been that the way to make this happen is to start with a garage style: cheap, small and comfortable. The space is structured according to the 9 landmarks identified during my stay in Silicon Valley in 2008/2009. As discussed in the following section, it is essential to justify each element of the space in terms of the tipping points of a culture of exploration.

Space has a strong influence on mindsets. In entering a different kind of space, students more easily follow a set of rules associated with the mindset of exploration. The space creates a territory within which people can change their behavior. The values of the d.school are posted on the wall as a constant reminder, which contributes to self and group discipline.

I discovered the spirit and energy of these spaces at Stanford (1) and the d.school (3), as well as the studio/garage/loft space (8). In 2008/2009, I learned to understand the link between space and mindset (7). I identified nine milestones (9) for staging innovation space through visits to a dozen places in Silicon Valley: 7s shop (10), project space (11), fun space (12), kitchen (13), Zen
space (14), brainstorming room (15), library (16), material library (17), living room (18), red sofa (19). In 2009/2010, I visited half a dozen living labs in Europe (2) and started to understand the differences and similarities. I visited the Design Factory (5). I recognized the value of letting students customize their space (21): Make it yours! I reflected on the connection between space and mindset, as well as the 9 milestones: although symbolic, they have an influence on student mindsets. I first experimented with the garage style: it was efficient; it gave students an entrepreneurial spirit: they were proactive, they never complained and greatly contributed to the development of the program. In 2011/2012, I experienced the value of going into the field with students (22): first I could observe them in action; second, I could mentor them on the spot or afterwards with clear examples of what to do or not to do; third, I could collect data if necessary, and students could directly observe how to do it. The learning experience continues beyond the class space.
In 2012, the d.school moved into a new, eco-efficient building with two dedicated floors and other types of spaces available (amphitheater, classrooms...). After two years in operation, the studio is overbooked with students and classes. It is also used for regular meetings of ENPC staff, “in order to change the way they conduct meetings and the way they think”. It acts as a demonstrator for all the schools, especially for ENPC and ESIEE, which organize regular tours with VIP visitors. The quality of the building and its innovativeness in terms of eco-efficiency benefit both brands, ENPC and the d.school. It creates a neutral space for students and faculty from the different schools in the consortium. The access to different types of space, such as a big amphitheater, a hall and a huge prototyping room, makes it possible to organize big events, such as the international conference on the future of design thinking on May 6, 2015, which helped to promote the spread of design thinking, both in academia and in industry. And to conclude the positive effects, the new building offers a new learning experience for students and faculty and a better way of demonstrating innovative teaching methods to visitors.
ME310 students have a dedicated project space available to them and others have access to the facilities during and after the course. In 2013/2014, ME310 students had three separate project spaces, instead of dedicated space in a shared open area as in previous years. As a result, it was observed that there was less student communication between teams. However, the project spaces provided more of a demonstration for visitors and other students, to the point that they were used as showrooms for the design thinking process. Their visits became parts of curriculum. More resources (in terms of furniture, more space, prototyping materials and machines, a logistics team) have killed the garage spirit where students were hands-on, pragmatic and helpful. In 2013/2014, the students were conscious of the privilege of being in such a space. In early 2014, a debriefing with faculty clearly showed that they were taking the d.school’s high level of service and availability for granted, to the point that they were showing signs of this respect towards the organizing team. In 2015/2016, the students behaved like spoiled children: they complained about the size of their space, despite the fact that there was more than 20 m² for a single team of three students and that they were mostly able to use the entire studio. They complained of not having an enclosed space. Most of them did not work as hard as previous cohorts and took for granted the material and human resources at their disposal. This kind of attitude calls for reflection and improvement measures, to restore the garage style spirit. And to conclude on the negative effects, the spirit of entrepreneurship among full-time students and faculty is at risk, since they can behave like spoiled children.
In 2013/2014 and 2014/2015, I experienced the importance of dissemination within a company. The experience of creating the Valeo CarLab show how a new place in the company can initiate a change in the culture with DT tipping points (20). A different spatial setting attracts attention, making people think that “something different and new is happening over there”. Examples of creating a space in companies show that it is of paramount importance to start small and to grow step-by-step, keeping pace with the number of people attending events (workshops, number of projects in progress, slightly unorganized design sessions where people share feedback about a project…) and the success of projects. This prevents criticism and strong resistance. It makes it easier to take the decision to go ahead. What I experienced at the d.school is close to what has happened inside the company with our corporate partners.
The scaling-up of the space should be in line with the scaling-up of people and the development of tools. As noted in Hillen and Levy (2013), it is essential to maintain that balance between place, people and process: creating a space is the easiest way to show that something is happening. In these conditions, serious investment decisions can be made more easily. The risk is that people may not feel comfortable in the space, either because of the consequences of this kind of decision-making process or because of the showroom style of the space. A space that is not used enough is doomed to failure. Starting small and low cost, with a high degree of individual personalization, is a safe way to avoid strong resistance and to maintain a balance with efforts in building a community and appropriate tools. Investments should seek to create a balance between tangible and intangible assets: space is a tangible asset, which plays a demonstration role, but should be balanced with investment in recruiting the human resources that will make things happen in that space.

The scaling up of space in the d.school Paris reflects the creation of a growing community in France, which believes in design thinking. The next steps are first to refurbish the studio to reflect the boat metaphor (2016), second to create dedicated experiential prototypes relating to d.school Paris (starting with a showroom for seniors in 2017), and last but not least, in the long term, to create a whole building that offers a unique experience and ecosystem with different stakeholders (companies, research labs, schools) dedicated to the city, as our location (Cite Descartes) has a worldwide reputation for this expertise in research and education. The spatial upscaling should reflect the growing community and the growing number of projects.

The combination of symbolic, functional and emotional elements to structure the studio, which exemplifies a world of exploration based on specific know-how and savoir-être (life skills)

The d.school aims to deliver experiential learning of innovation through a culture of exploration. Space is a key element in helping people to feel this before they understand it. Space helps to create a spirit of exploration. It is one of the elements of the behaviorally complex learning environment (Kolb, 1984) that faculty and their universities are responsible for providing. Space has an influence on the development of attitudes and skills.

The work of Doorley and Witthoft (2012) based on years of prototypes and iterations with d.school students and space clearly demonstrated the importance of space on teams’ dynamics. They offered strategies and settings to influence both mindsets and activities.

The d.school Paris space has been structured around nine tipping points that I identified in my visits to a dozen innovation places in Silicon Valley: a kitchen, 7s shop, a library, materials library, project space, fun space, zen space, brainstorming room, lounge. However modest the space, this layout fosters an altered state of mind compared with conventional workplaces. The aim is to foster a spirit of exploration when people enter the space. The purpose of each type of space is described in Hillen (2014). Each has to be justified. The three dimensions set out below represent a structuring model that explains the rationale.

Whatever the size of the space over the last eight years of practice, it has always been set up to accommodate three dimensions: the symbolic, the functional, and the emotional. Each component of the space needs to be justified in terms of these three dimensions. The purpose is to create a whole environment dedicated to fostering an efficient culture of exploration. The rationale is to maintain a coherent and natural storytelling space. This explains all the efforts and the unusual elements by comparison with the traditional settings of a culture of exploitation.

The evolution of PEOPLE: from multidisciplinary teams to ecosystems

From multidisciplinary teams to trans-discipline teams\footnote{Hillen, V. (2014). 101 Landmarks I’ve discovered to innovate thanks to design thinking. Retrieved from www.veroniquehillen.com}

Whether in Silicon Valley or in France, the lone inventor or designer still exists. However, projects (and problems to be solved) are becoming ever more complex and therefore call on different skills and disciplines, hence the growing emphasis on the need for multidisciplinary teams. As with creativity and prototyping on the process side, there is even a tendency to reduce design thinking on the people side to the single question of multidisciplinarity, as if that were a guarantee of success. From experience, in fact, what should be the dream team quickly becomes the team from hell... At best, people show each other respect by lowering their sights and looking for a soft compromise on a few simple ideas. When the personalities are strong and ambitions high, the team dynamic becomes stormy. In the absence of a shared language, misunderstandings and latent conflicts proliferate, leading to differences in perception, which generally explode in the form of attempts by team members to impose their own ideas. That is the difference between multidisciplinarity and transdisciplinarity.

The multidisciplinary team is an (almost) necessary but not sufficient condition!
Design thinking is like a “glue”\textsuperscript{306} between the members of a multidisciplinary team, i.e. a culture and language common to the different team members. Design thinking is a transdiscipline that helps multidisciplinary teams to innovate. A concept devised by Jean Piaget in 1970, transdisciplinarity is based on the idea of fluctuations in the boundaries between disciplines and on three postulates: interaction between subject and object; the notion of complexity and interlinking; different levels of reality at odds with each other (according to B. Nicolescu, Chairman of CIRET, CNRS researcher). The purpose of teaching the transdiscipline of design thinking is to get the team to steer in the same direction: a collective and shared understanding of the context, of the principles of design, of possible and appropriate solutions, together with a joint commitment to their implementation and dissemination.

“All these disciplines, and many others, have long contributed to the development of new products and services, but these days they coexist within the team in a shared space and employ the same processes.” (Brown, 2009)\textsuperscript{307}

\textbf{From teams to a community and an ecosystem}

From 2007 to 2008, organizing multidisciplinary teams, on both sides, students and faculty, proved such a challenge that I asked myself whether it was worth the effort, given the student outcomes observed (ideas pitched with no tangible artefact, let alone useful things implemented in a real-world context). Multidisciplinary teams are a mantra of design thinking. However, the longitudinal study shows that they do not provide the best learning experience for students in design thinking, given the potential tensions between disciplines and faculty, which leads to discouragement and loss of commitment. It also shows that, even when successful, a multidisciplinary approach is not enough, while design thinking provides a transdisciplinary approach which is effective in creating useful artefacts cheaply and quickly.

To belong to a community of practitioners is fundamental for anyone wanting to innovate, especially through design thinking. In every d.school, the role and importance of the community are fundamental in the conception, development and survival of this milieu. Since 2008, we have been members of the ME310 international academic network, comprising a dozen universities on 4 continents and encompassing some twenty industrial partners, thirty teachers, thirty teaching assistants, some thirty mentors and more than a hundred students. This community brings mutual enrichment through diversity and a shared desire to produce. Each person brings their own perspective, expertise and sensibility. Each possesses the same desire to undertake, to make, to produce. Everyone is committed to a Silicon Valley perspective and design thinking.\textsuperscript{308}

\textsuperscript{306} Design Thinking as providing “a glue that brings teammates together around a common goal: make the lives of the people they’re designing for better.”, http://dschool.stanford.edu


\textsuperscript{308} Hillen, V. (2014). \textit{101 Landmarks I’ve discovered to innovate thanks to design thinking}. CC
“Radical collaboration” (Hillen 2014, p. 41) is one of the mantras of the Stanford d.school, the ambition embodied in its founding myth. Students, business representatives, professors, i.e. people of radically different experiences, horizons and backgrounds, collaborate on joint projects. This type of “radical” collaboration is central to the teaching of the discipline of design thinking. It requires the building of an ecosystem.

Design thinking becomes effective when there is access to target users: once again, this requires the building of an ecosystem with different stakeholders. For instance, the expertise with seniors at d.school Paris is leveraged by the network of retirement homes (including ergotherapists, doctors, nurses, psychomobility specialists, sports coaches, executives), families, government bodies, associations and industrialists (large companies and start-ups). Building such a network takes time. Trust is gained by delivering useful artefacts for real contexts: people can feel the benefits of working with us and the advantages of the methodology, which is quick, cheap and efficient.

Implementation requires the trust of real-world stakeholders: in the ME310 framework, our corporate partners have not only to believe in the outcomes of the project (vision, products/services), but also to be able to get their colleague on board and initiate the necessary operations to pursue the development process inside the company after the project. In consequence, as faculty involved in such ambitious programs, we not only organize teams within universities (with students and teaching teams, sometimes with research labs), but also have to help our partner to build an ecosystem of relevant people inside their company, in order to increase substantially the probability of implementation, i.e. the likelihood of launching a product/service/system based on the work we (both students and teaching teams) have done over the year. Years of practice have helped me to decipher the internal dynamics of companies (including process and people). In 2013/2014, pedagogical action research reflectively dissemination measures I have developed to foster this kind of ecosystem for implementation.
The evolution of PROCESS: from instructions for self-reflection on action

The evolution of briefs: from broad topics or technologies to framed briefs for DT

Initially, student briefs were a simple statement with half a page of description. In 2008, all our briefs were broad topics, with no target users or context.

Design thinking briefs have since refined the nature of the constraints. This brief is given in the “official definition” of design thinking (Brown, 2009). I would like to reformulate it: the objective is to create a new experience that allies user desirability and technical feasibility with existing technologies, as well as economic (and organizational) viability within our partner’s business model.

The practice of teaching design thinking has clearly shown the importance of defining a brief that is feasible for students within the time available: students should be able to carry out all the activity phases, in order to feel a sense of pride in achievement. Otherwise they do not see the difference from other innovation methods. I have created a formula for defining a student brief in design thinking: How to reinvent this “artefact” for “those target users” in that “given context”.

Experience shows that the more specific the object is, the better it is for the learning experience. This is the opposite of the normal way of defining a brief in France, which gives a broad topic with no specific context. A more specific brief prevents students getting lost in diverging. It prevents intellectual wandering with no action. It avoids a long phase of reframing, which can jeopardize the ideation and implementation phase. It allows students to embrace greater ambiguity if necessary and to be able to alternate between divergence and convergence while making sense for the people they want to innovate for.

From Stanford through IDEO+Stanford to d.school Paris’ process

At d.school Paris, we primarily rely on two standard processes (Fig. 28): the Stanford d.school process for our beginner programs/projects, and the third generation of the IDEO process (popularized by Tim Brown) for our expert level projects. We emphasize the cyclical and iterative nature of the process. So that students see the correspondence between the two processes, we have adopted and extended the Stanford d.school process by adding the following activities:

It is essential for any school or company to ensure that the implementation phase is adjusted to match the likely degree of completion and the internal process of the organization, which will launch and implement the project. The key players need to be motivated from the start through communication or “dissemination”.
From assignments to self-reflection in action with a new tool: learning stories

Assignments are important in defining faculty’s expectations of students. The longitudinal study clearly shows the truth of the following statement: the clearer they are, the better the student outcomes. Design thinking is an emerging discipline, which requires great deal of development in terms of the competence framework and pedagogical materials, in order to gain legitimacy and effectiveness for dissemination in national programs.

Teaching design thinking also means a broader learning experience than assignments alone. Experiential learning with real-world projects requires a lot of effort on the part of students to conceptualize what they learn from doing (Kolb, 1984). Learning by doing should transform into learning from doing, in order to generate long-term knowledge.

With his 1983 book “A Reflective Practitioner”, Donald Schön, Professor of Education at MIT, brought a new paradigm to the academic world. What distinguishes a professional is their capacity for self-reflection, i.e. their ability to think about what they need to do to improve the situation and its outcomes in a given context. This leads to the accumulation of a type of knowledge based on practical self-analysis. It contrasts with the dominant technical paradigm derived from positivist epistemology, which considers only the process of problem solving, and ignores the previous stage, definition of the problem. Schön created a new paradigm based on the capacity to generate knowledge through the practitioner’s reflection on her actions in a given context. The practice is not the application of a theory, though it sometimes draws on theory, just as it draws on its own practice by generating experience and knowledge.

“Fail faster, succeed sooner” (D. Kelley, Deep Dive, ABC network, 1999) is a mantra of design thinking. Failure is part of the process of design thinking, especially in the ideation phase.


In France, we talk about failure, in Silicon Valley they call it learning. The word failure is even banned amongst the teaching staff at Stanford! “Failure is simply the opportunity to begin again, this time more intelligently” (H. Ford). Success serves as a model for everyone. Only people who have experienced failure can learn from it, provided that it comes with self-reflection. This means analyzing purely in order to draw lessons from experience and to try again, and again, in order to succeed. It’s not about identifying culprits or finding excuses not to act or to accept failure and stop there. It requires a certain outlook, skills as well as method, particularly in individual and group self-reflection.

In their final presentations, some teams described their journey of exploration (Fig. 29), their discoveries (through needfinding, prototypes, testing, etc.), the directions they had believed in, those they chose and why. This was the most convincing story. From one project to the next, I noticed that the most effective teams were those with a great capacity to reflect on their journey: what discoveries had they made? How? What new pathways then emerged? Why did they decide to abandon certain pathways? When I applied this structure to teams that had lost their way, I found that they rediscovered their sense of direction. In my research, I came across the work of Hummels and al. (2011) who described the way her students were prompted to think about the decisions they had taken in their projects, in terms of their capacity to explore the context, their vision, their achievements and their analyses. These milestones are used to guide our students in their journey of self-reflection. I am convinced that an awareness of the route traveled is the way to discover and rediscover opportunities. This is one of the fundamental capacities of a leader: to see what is meaningful.

**Fig. 29. Learning story, a new tool for an efficient dissemination**

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Societal impact: Make Tomorrow

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
A tool for universities to develop DT pedagogy: a scaling up model

Design thinking courses entail a great deal of work by faculty to create the “right conditions for our students to innovate” (Larry Leifer, Stanford, 2009).312 It is a risky journey both for faculty and a university (high investments, real world projects with companies, paradigm shifts in education in terms of epistemology, learning experience and role of teachers). The historical eras in my practice have paved the way for a scaling up model and indicate the first three steps for faculty and universities to develop design thinking pedagogy in a fruitful and low-risk way. A jointly written chapter that describes a new kind of university (2015)313 capitalizes on a real case experience of university transformation. Experience in countries such as Finland314, France, and the USA315, opens up the promising prospect of influencing national education, from kindergartens to high schools. The scaling up model recommends five steps for a safe journey to develop design thinking pedagogy:

- Step 1 aims at getting started with a course.
- Step 2 aims at developing a dedicated program with a full curriculum.
- Step 3 aims at gaining recognition at institutional level (e.g. national, European, international level) with the development of a d.school, which is an ad hoc structure grounded in a consortium of different schools or universities that have created a partnership, with local operations and transformations.


• Step 4 aims at transforming the university itself, with the transformation of curricula, faculty and campus.

• Step 5 aims at transforming national education, with the transformation of official curricula, from primary schools to higher education.

Table 20 describes an overview of milestones for each step in terms of people involved (faculty, student, partner), space involved with the level of ambition and needed teaching resources.

Table 20. Milestones to develop DT pedagogy

<table>
<thead>
<tr>
<th>Step 1: Start</th>
<th>Step 2: Develop</th>
<th>Step 3: Create</th>
<th>Step 4: Transform</th>
<th>Step 5: Disseminate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A course</td>
<td>A program</td>
<td>A d.school</td>
<td>A university</td>
<td>National education</td>
</tr>
<tr>
<td>1 to 3 professors</td>
<td>5 to 15 professors</td>
<td>Up to 70 so far</td>
<td>Over hundreds</td>
<td>Thousands</td>
</tr>
<tr>
<td>Up to 70 students</td>
<td>Up to 70 students</td>
<td>Up to 650 so far</td>
<td>Over thousands</td>
<td>Hundreds of thousands or more</td>
</tr>
<tr>
<td>None to 5 partners</td>
<td>Up to a dozen financial partners and sponsors</td>
<td>Governmental and private financing with up to a dozen partnerships</td>
<td>Governmental grants or/and private funding</td>
<td>Government grants and private funding</td>
</tr>
</tbody>
</table>

---

For each step, faculty staff should find the right balance in terms of people involved (students, faculty, partners), place (size, materials, dedicated space for design activities) and project process (motivation, possible access to real world issues, partnership). The PPP framework is recommended as a management tool to develop design thinking pedagogy. For each step, ambitions need to be adapted to the available funding and resources, which govern the level of commitment and refinement possible. Tables 21, 22 and 23 indicate the key questions that steer the development of design thinking pedagogy, in terms of 5 levels of ambition, along line the PPP framework and a fourth category, that is to say pedagogy.

**Start with a course**

<table>
<thead>
<tr>
<th>People</th>
<th>Place</th>
<th>Project process</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>What support from my department?</td>
<td>50 m² are permanently available for students with a DT atmosphere</td>
<td>Should I advocate a change in curriculum? Why? What?</td>
<td>What levels of prototyping, given my resources?</td>
</tr>
<tr>
<td>Is there someone from another discipline who might be interested?</td>
<td>What location and furnishings in the school?</td>
<td>For whom do I want to innovate? What problems motivate me as an individual? Why?</td>
<td>Can we share the workload of course development? How?</td>
</tr>
<tr>
<td>How can I create multidisciplinary teams?</td>
<td>Can we have a common space or should we navigate between places?</td>
<td>How is the course promoted to different students?</td>
<td>What assignments and when for the given project?</td>
</tr>
</tbody>
</table>
### Develop a program

*Table 22. Key questions for a program using PPP framework*

<table>
<thead>
<tr>
<th>People</th>
<th>Place</th>
<th>Project process</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the administration convinced?</td>
<td>Minimum of 150 m²</td>
<td>Either argue the benefits or negotiate conditions.</td>
<td>Where does it fit into the overall strategy?</td>
</tr>
<tr>
<td>Which professors? How?</td>
<td>Dedicated space for each one + 7s Shop (light machine shop)</td>
<td>How is the program promoted?</td>
<td>What level of syllabus development?</td>
</tr>
<tr>
<td>How to attract students from different disciplines?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which outside partners?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What support inside or outside the school?  
Create 9 symbolic “corners” (Zen room, material and book library, kitchen, living room, brainstorming, prototyping, project space, fun)  
Do I need partnerships?  
How can I get access to the real context? Which ones?  
What ethnographic research tools for the project situate and users?
Create a d.school

Table 23. Key questions for a d.school using PPP framework

<table>
<thead>
<tr>
<th>People</th>
<th>Place</th>
<th>Project process</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>What decisions-makers are concerned in the administration?</td>
<td>At least 300 m$^2$ of dedicated space in a well situated building</td>
<td>What accreditation is needed to get official recognition within my school? Who is financing?</td>
<td></td>
</tr>
<tr>
<td>Who are the professors that can be involved? How to motivate them? How to train them? How to help them to set up and run such courses?</td>
<td>Is there a dedicated space for them to meet?</td>
<td>A human resource process should be applied to lead this part of the project.</td>
<td></td>
</tr>
<tr>
<td>What types of students for which purposes?</td>
<td>Refurbish with the same 9 spaces but adapted to multiple classes at different times</td>
<td>How to communicate to students? How to make courses attractive and available?</td>
<td></td>
</tr>
<tr>
<td>What stakeholders outside the school?</td>
<td>Define fields and access.</td>
<td>How to create and animate a community? How to create and maintain an ecosystem?</td>
<td>Develop dissemination skills for students.</td>
</tr>
</tbody>
</table>
### Transform the university

**Table 24.** Key questions for a university using PPP framework

<table>
<thead>
<tr>
<th>People</th>
<th>Place</th>
<th>Project process</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>What strategy from the president and the provost?</td>
<td>Which parts of the campus need to be transformed? Where should we demonstrate such a pedagogy? How? Should a new building be constructed?</td>
<td>Fundraising, construction procedure, human resource management, budget allocation.</td>
<td>Industry/university partnerships. Place setting. Global communication.</td>
</tr>
</tbody>
</table>

### Disseminate in national programs

**Table 25.** Key questions for national programs using PPP framework

<table>
<thead>
<tr>
<th>People</th>
<th>Place</th>
<th>Project process</th>
<th>Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry-level</td>
<td>What means to adapt the classrooms?</td>
<td>Strategy, directives and bids.</td>
<td>Curriculum transformation per level</td>
</tr>
<tr>
<td>School directors</td>
<td>How to adapt my school’s place? What dedicated places and resources? What projects?</td>
<td>Budget process, human resource management, project management</td>
<td>What activity book and projects for which students?</td>
</tr>
<tr>
<td>Teachers</td>
<td>How to adapt my classroom for such activities?</td>
<td>Curriculum transformation and pedagogical action research</td>
<td>Activity development, project management, grading.</td>
</tr>
</tbody>
</table>
An activity-framework to disseminate design thinking education

The literature and syllabus review initially helped me to identify seven learning activities for design thinking: needfinding, framing, creativity, prototyping, teamwork, reflection and storytelling. Seven years of practice have helped me to refine these activities and to identify three new ones (inspiration, ideation, culture building):

<table>
<thead>
<tr>
<th>Initial concepts (2008)</th>
<th>Emerged concepts</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needfinding</td>
<td>Ethnographic research</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>Inspiration</td>
<td></td>
</tr>
<tr>
<td>Framing</td>
<td>Continuous reframing</td>
<td>2012</td>
</tr>
<tr>
<td>Creativity</td>
<td>Abduction</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>Ideation</td>
<td></td>
</tr>
<tr>
<td>Prototyping</td>
<td>Experiential prototyping</td>
<td>2012</td>
</tr>
<tr>
<td>Reflection</td>
<td>Self-directed learning</td>
<td>2015</td>
</tr>
<tr>
<td>Storytelling</td>
<td>Dissemination</td>
<td>2014</td>
</tr>
<tr>
<td>Teamwork</td>
<td></td>
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<tr>
<td></td>
<td>Culture building</td>
<td>2014</td>
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</tbody>
</table>

Findings from the longitudinal study on seven years of practice include the development of an activity-framework for design thinking education, with 10 core elements:

1. Ethnographic research  
2. Inspiration  
3. Framing  
4. Abduction  
5. Ideation  
6. Experiential prototyping  
7. Reflexivity  
8. Dissemination  
9. Team work  
10. Culture building
For each activity, five items have been identified over time and are detailed below in Bloom’s terminology as part of the student’s learning experience.

**Ethnographic research**

What: The ability to conduct fieldwork and uncover unmet needs, in order to notice shortcomings in existing solutions or gaps in the existing offerings.

Why: People should be the first source of inspiring to innovate.

Students should be able to conduct:

- Activity 1: Data collection from the field
- Activity 2: Pattern finding through analysis
- Activity 3: Data synthesis and presentation
- Activity 4: Imperatives
- Activity 5: Point of View/vision/direction

**Inspiration**

What: The ability to inspire oneself in order to create something new

Why: Innovation needs creative synthesis from many sources.

Students should be able to leverage on:
Activity 1: Context map
Activity 2: Archeology of the problem
Activity 3: Benchmarks (technologies, products, services, culture, history)
Activity 4: Analogies
Activity 5: Their sensibility and experience

Continuous reframing
What: The ability of students to reframe their problems/opportunities from their reflection and discoveries from the field (context/users), prototypes (making), thinking

Why: Ill-defined and wicked problems needs to be reframed to find a sense-making direction.

Students should be able to:
- Activity 1: Understand the different components of the brief
- Activity 2: Reframe on the basis of teaching team’s and partner’s feedback
- Activity 3: Take different perspectives that shed light on the brief
- Activity 4: Continuously reframe on the basis of their own different discoveries
- Activity 5: Make sense of any discovery

Abduction
What: The ability of students to create a possible new path

Why: Solution generation should be appropriate to a context and users.

Students should be able to:
- Activity 1: Unlock their personal creativity
- Activity 2: Unlock others’ creativity
- Activity 3: Foster their imagination
- Activity 4: Make sense for a specific context and users
- Activity 5: Find a new possible path for the future
Ideation

What: The ability to test prototypes with users in real contexts.
Why: Users can give better feedback with real artefacts in context.

Students should be able to:
- Activity 1: Run a collective brainstorming
- Activity 2: Find the right prototypes for the right purpose
- Activity 3: Build quick and dirty prototypes
- Activity 4: Test prototypes with users in real contexts
- Activity 5: Synthesize and communicating user feedback

Experiential prototypes

What: The ability to create prototypes that generate an experience for users.
Why: Such prototypes increase the chance of success and reduce time-to-market.

Students should be able to:
- Activity 1: Find the prototypes relevant to users’ experience
- Activity 2: Build prototypes with appropriate levels of definition
- Activity 3: Find appropriate user contexts
- Activity 4: Question users with prototypes and feedback collection
- Activity 5: Learn from the field and make sense

Self-directed learning

What: The ability to reflect upon past action in order to better future practice
Why: Only reflective practitioners become professionals.

Students should be able to:
- Activity 1: Identify what they like/wish
- Activity 2: Be conscious of what they learn for the project (“I know I don’t know the skills”)
• Activity 3: Be conscious of how they learn ("I know I am acquiring the skills")
• Activity 4: Be conscious of team dynamics ("I know how we move forward together")
• Activity 5: Learn from practice ("I know what to do next time")

Teamwork

What: The ability to work efficiently in teams for fruitful exploration

Why: Innovation requires fruitful team dynamics.

Students should be able to:
• Activity 1: Have a positive attitude in a team
• Activity 2: Know their place in a team (what and how)
• Activity 3: Commit to make it happen
• Activity 4: Be proactive
• Activity 5: Take leadership when needed

Culture building

What: One has to build one's culture of design thinking over time, based on knowledge, know-how and savoir être (life skills).

Why: Design thinking is a culture of exploration, in which it takes time to become a professional.

Students should be able to:
• Activity 1: Understand milestones of DT culture
• Activity 2: Communicate DT culture
• Activity 3: Demonstrate DT values with appropriate behaviors
• Activity 4: Demonstrate DT activities with practice
• Activity 5: Contribute to DT culture
Dissemination

What: The ability to communicate design thinking and project outcomes.

Why: Implementation requires the creation of an ecosystem with different stakeholders, whose trust and commitment have been gained through communication and successes.

Students should be able to:

- Activity 1: Develop storytelling
- Activity 2: Create confidence with the partner
- Activity 3: Integrate the partner's DNA and business model
- Activity 4: Create events for sharing with the partner
- Activity 5: Create event for decision making from the partner

Limits of this research lie in the fact that such an activity-framework has not yet been implemented to assess students and/or to help students to carry out self assessment. In the course of the academic year 2015/2016, the teaching team carried out a self-assessment: students were asked to self assess themselves according to activities described above with 5 possible stages of development: blank, awareness, depth, expertise and visionary (Hummels & Vinke, 2009). The teaching team was under shock while reading the results: over 80% students over estimated their capacities compare to their real performance in projects. Students assessed the project performance rather their real personal performance. They did not realize the impact of the teaching team's guidance. Such attitudes reflected the extreme arrogance felt at any time by the whole teaching time since the beginning of the program. ME310 Paris pedagogy did not make students realize their level of competence.

As a consequence, future research should be conducted in the direction of how to develop self-assessment not only for autonomous learning (Vinke & Hummels, 2010), but also for students’ awareness of their competences: how useful is this design thinking activity framework to create a personal development plan? How should it be implemented? Answering such questions would require a new piece of research, with further development in terms of the learning environment (with for instance student showcases and periodic assessment reviews with faculty) and further pedagogical action research to evaluate the impact on the learner’s competence development.
Conclusion

Chapter 5 presents two frameworks for the dissemination of design thinking pedagogy: an activity-framework for the teaching of design thinking and a scale-up model for the development of design thinking pedagogy, from a course to university and curriculum transformation. In addition to my personal experience and reflection through a longitudinal study, both frameworks have been enriched with the experience and works of other academics:

- The scale-up model is based on my experience and the experience of other universities, especially the transformation of PhilaU led by Randy Swearer, whose lessons are set out in on chapter of a collective publication (2015). Staircases within this scaling-up model for the development of design thinking pedagogy have been built through seven years of practice and self-reflection.

- The activity framework is based on the works of Hummels and Vinke (2009) on industrial design competence framework in the department of industrial design at Eindhoven University of Technology, the Netherlands.

Both aim to help faculty as individuals and institutions to structure their path to the development of design thinking pedagogy, with the hope of achieving societal impact.


Conclusion

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Is it useful? Is it adaptable? Is it transferable? Here are three questions that my scientific supervisors asked me many a time in the course of my research. I am very grateful to them for asking such fundamental and challenging questions. Of course only the future will tell if this piece of research will have a positive impact, not only on the transformation of higher education in innovation, but also on changing real contexts and the experiences of some users, and to what extent. Nonetheless, current developments in new projects indicate a couple of promising directions for this research to be useful, adaptable and transferable in the near future, subject to further developments:

- **design thinking as a transdiscipline** needs to be combined with **specific expertise** in order to be effective and relevant: it is crucial for project managers to possess a combination of expertise with target users, artefacts (product, service, process, system, place) and cultures. It takes time to develop further relevant tools and processes suited to a specific project and artefacts. It takes time to develop expertise in users (access, community, insights). It takes time to develop the ecosystem of stakeholders to make it happen. At the d.school Paris, we have decided to start by focusing on seniors and their autonomy in the home, as well as design for extreme affordability in Latin American villages.

- **design thinking as a transdiscipline for project pedagogy** needs further development in terms of **specific pedagogical resources** in order to spread more broadly through faculties and departments: Firstly, project briefs and pedagogy need to be adapted to a department’s core subjects, which demands a great deal of time in terms of building partnerships, refurbishing the curriculum, selecting and training legitimate instructors. Secondly, faculty needs ready-to-use pedagogical resources that can be easily implemented in their courses, which will demand the development of large volumes of material.

- **design thinking as a culture of exploration in companies** needs spread through the development of a roadmap based on two tools: strategic staircases (adapted from Baden Fuller) and the PPP framework. The case study of the creation of CarValeoLab is a good example of such developments: the identification of steps based on the PPP framework has maintained the balance between building a place, an ecosystem with people and appropriate process and tools. Its success clearly demonstrates the utility and adaptability of the framework as a way to build capacity in design thinking.
How to disseminate design thinking in different cultures and contexts

On May 6, 2015, we organized an international conference on the future of design thinking (the full video can be viewed on the d.school Paris TV channel). Over 500 people attended. The conference was structured on the assumption that the future of design thinking lies in the capacity to further develop the fundamentals of this transdiscipline in order to adapt them to different cultures, target users and expected artefacts. The panels reflect the possible future directions of d.school Paris: the city, public sector, seniors and universities.
Country adaptations of design thinking landmarks

In July 2014, the d.school hired three Colombian students to pursue a collaboration with Valeo following a ME310 project over the academic year 2013/2014: two of them helped to create a CarLab for a year and one worked over the summer to develop specific documentation. In collaboration with a professor who moved from Cali (Columbia) to the design factory in Melbourne (Australia), they decided to develop an adapted version of my book “101 landmarks I’ve discovered to innovate thanks to design thinking”. They were free to change the concepts, texts and pictures. Minor changes were made to the concepts (in a couple of places) and texts (introduction). Most of the pictures were changed to show their projects, students and places in their context.

This version went online in July 2015 and registered over 1300 downloads after 9 months, which is close to the number of French downloads after 18 months. Its success has been confirmed with the comments of readers and professors.

“The book is a significant contribution for the Spanish-speaking countries. It will be the bedside book of all our students and professors at the Design Factory! Until now the main literature is mostly in English and therefore, it is not so popular in our community”. Andrea Órdenes Godoy, Academic Coordinator, DUOC Design Factory, Chile

Three adapted versions (English, German, Italian) are under development with three co-authors who are well-known professors in design thinking (Larry Leifer at the d.school at Stanford, Franziska Haeger at the School of Design Thinking at HPI/Potsdam, Matteo Vignoli at the innovation for food program at Unimore/Reggio Emilia).
Specific ecosystems and tool development for targeted users, such as seniors

The development of specific tools between 2013 and 2016 (compare with the stability of place and people landmarks) demonstrates the necessity and importance of adapting tools, especially in the phase of inspiration for specific targeted users.

In terms of targeted users, in the last 8 years, d.school Paris has developed expertise with seniors (the over 60s) with a dozen or so projects in different areas (mobility, public space in a retirement home, light systems, cockpits for cars, bathroom furniture, kitchen, refrigerator, music box, sport activities, outdoor furniture…). Seniors are extreme users: what they all need is comfort. Disabilities create constraints and imperatives in terms of expected usability and simplicity. Creativity under such constraints creates solutions and experiences that are more comfortable and simpler for all.
Professionalism in designing for seniors through design thinking is acquired from accumulated experience in implementing ethnographic research for this particular user group, with many challenges such as:

- How to gain access to the ecosystem of different stakeholders, ranging from ergotherapists, doctors and nurses, to families and homes, public bodies and associations, such as the silver economy in France, and specialists in private companies;
- How to interview and observe people who have various levels of awareness and disabilities in conditions that are emotionally intense and difficult;
- How to tackle the variety of artefacts, contexts and types amongst seniors, which requires a great deal of attention in order to capture surprising insights and specific imperatives.

How to innovate for seniors through design thinking is fully explained in a publication\textsuperscript{319} about the bathroom furniture design project conducted in cooperation with Lapeyre, as part of the ME310 Design Innovation program with Aalto University.

Specific development for systems, such as integrated urban systems

The development of design thinking courses for ENPC’s Cities and Transportation Department clearly shows the importance of developing specific tools for these kinds of artefacts (a system rather than products and services) and this specific context (public space and cities rather than artefacts for use in private contexts). Developing specific tools for each phase of the process (inspiration/ideation/implementation), as well as building partnerships with many different stakeholders, are necessary elements of design thinking projects adapted to the context of a city.

Many challenges have been identified for each phase, with possible exploration paths and expected promising results:

- Participatory videos are effective for low-income villages in emerging countries, as demonstrated by cases recorded by insightshare. Adapted to citizens in industrialized cities, they offer a promising path for ethnographic research, as a way of reinventing public consultation between municipalities and citizens. Lancaster university has already carried out promising experiments in this field;

- New tools of analysis need to be developed, especially to make links between objects, services, systems, public spaces and expected impact for a city and a region;

- During the ideation and implementation phases, partnerships with stakeholders, both private and public, facilitate the testing of prototypes in the city. They are a prerequisite for a pilot in the implementation phase. Investments may be high and testing pilots in the city requires authorizations;

- After the project is finished, resources should be dedicated to evaluating the impact on citizens. Most solutions, which are a combination between objects, services and systems and are used by a group of people over time, can only be assessed after a period of at least a couple of months. They usually require additional resources for adjustments. Such resources should be available locally to increase the probability of project success.

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The main risk of design thinking for the city is either to create small objects with little impact or “to think big” with such a level of abstraction and broad concepts than nothing tangible is created. It represents a high level of risk for the teaching of design thinking, which requires a great deal of work before, during and after delivering the course. It demands a high level of collaboration, coordination, expertise in the city and in-depth knowledge of users’ needs.
How to disseminate DT education with d.school Paris

The experience of d.school Paris has helped to identify many challenges in the dissemination of design thinking pedagogy. Promising avenues of inquiry are currently being developed and tested.

First, it is difficult and risky for faculty to develop projects with real-world stakes and partnerships: defining briefs is hard as they have to meet objectives that are both pedagogical and real-world; pedagogy may be sacrificed for the sake of creating value for the partner and the project; interactions with real partners is difficult to manage for both faculty and students; partners may change their level of commitment in the course of the class because of operational pressures and shifting priorities. The satisfaction achieved may measure up to the efforts made by faculty. As a consequence, it is safer to develop a basic course without a partner. The challenge is to provide the pedagogical materials needed to facilitate such a course and to disseminate at a broader scale. Online platforms with digital pedagogical resources and specific materials are currently available and can be adapted to pedagogical formats and objectives.
Secondly, long-term success depends on the quality of the education delivered. When scaling up in terms of students, courses and faculty numbers, there is a risk of loss of consistency in quality. The challenge is to set up a process that helps faculty to reflect in action and to self-assess their design thinking competences, so that they can adjust their level of ambition to their personal skills. Pedagogical action research is an efficient way to improve the practice of teachers. An accreditation system for faculty, with different levels of ambition for a course, is one promising of maintaining continuous learning for faculty wishing to develop their design thinking pedagogy from basic courses to advanced programs.

As a consequence, future research should needs to focus on assessing the impact of the dissemination of ready-to-use pedagogical materials, as well as on the development, testing and assessment of an accreditation system for faculty with different levels of complexity.
How to disseminate DT in companies

Mature businesses need to engage in strategic renewals to avoid decline and bankruptcy (Baden-Fuller & Stopford 1994; Baden-Fuller & Volberda 1997). The literature in corporate entrepreneurship, especially in its subfield of strategic renewals, recognizes the conflict in large companies between exploitation and exploration: “How do large multi-unit firms in a deconstructing world reconcile the conflicting forces of profits for today and flexibility to adapt for tomorrow? Profits for today require order, control, and stability. Adaptation for tomorrow requires flexibility and creativity in the value-added system. Large firms in many industries are confronted with this challenge of exploration and exploitation.”

The quest for a balance between exploiting the present and exploring the future is considered by many researchers as a major competitive advantage (Abernathy, 1978; March, 1991; Benner & Tushman, 2003; Hargadon, 2003; Sutton, 2004; Martin, 2008; O’Conneli, 2008), especially in turbulent environments (Tushman & O’Reilly 1997, 2003; Volberda, Baden-Fuller, van den Bosch, 2001; O’Connor, 2008): “Maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity” (March, 1991, p. 71). The essence of exploration is the refinement and extension of existing competences, technologies and paradigms. Its returns are positive, proximate, and predictable. The essence of exploration is experimentation with new alternatives. Its returns are uncertain, distant, and often negative” (March 1991, p. 85).

The funnel of knowledge from exploration to exploitation

Roger Martin (2009), who advocates for design thinking, invites large companies to engage in combining both exploration and exploitation: the first stage is the exploration of a mystery, which may take an infinite variety of forms, and relate to technologies or people. The next stage is a heuristic, a rule of thumb that helps narrow the field of inquiry and break the mystery down to manageable size. As an organization puts its heuristic into


operation, studies it more, and thinks about it intensively, it can convert from a general rule of thumb to a fixed formula. That formula is an algorithm. The exploitation of knowledge at a given stage – that is, running an existing heuristic, gently honing and refining it, but not seeking to move knowledge to an algorithm or running an existing algorithm and not seeking to explore the next mystery – is the administration of business.

The lack of solutions for complex problems in the modern world, such as environmental issues, cultural clashes, and economic priorities for companies,\textsuperscript{328} indicates that we might have reached the limits of the Western world’s rationally and positively driven practices. The same inputs with the same process can only lead to the same outputs and results. Most companies and society at large, especially in long industrialized regions like Europe, have focused on exploiting discoveries that date back to the end of the 19th century. At the beginning of this new century, there is an obvious need to explore new ways of thinking and acting in the world, in both the economic and societal realms. There is an imperative need for change-makers able to have positive and large-scale impacts sufficient to open up a wide range of new paths towards growth and social justice. In such difficult times, there is a great opportunity to redesign what we are used to, in order to create better futures, for both companies and society. Economic growth without positive social impact is doomed to create clashes of cultures that can lead to disorder and even war. Economic growth without positive ecological impact is doomed to create natural anomalies that can also lead to social disorder and even war.

The high risks of embarking on a strategic expedition are taken in the hope of high returns. The history of human exploration shows us that the main purpose of exploration has always been exploitation for huge profit! In human history, the peak of exploration took place during the Age of Discovery (from the 15th century to the early 17th century), when Europe made contact with the rest of the world.\textsuperscript{329} Explorers, usually on behalf of a government or a large organization, looked for new worlds, taking high risks in the hope of high returns. It was this hope that was the trigger for such ventures. When successful, they discovered new worlds, with people, places and rules different from the world they came from. While a few individuals immersed themselves in those new worlds with empathy, and discovered a new way of living, most exploited those new worlds to the point of total destruction. The first boat was usually friendly, open to discoveries and exchanges. Should it be successful in discovering promising new resources, the purpose of the second visit was to exploit them at any cost. It is also interesting to note that natural or human resources with no value in the new world have been converted in huge profits in the old. In an attempt to take a more positive view, it could be said that explorers who identify and transfer resources in new worlds can exploit and convert them into wealth in the old one. Last but not least, the early explorers made preparations by recruiting a crew with multiple skills, by


carrying some navigation tools, and by having a global but imprecise idea of their destination, with waypoints on their map. They had only a rough idea on where they were going and how to reach their destination.

Disseminating a culture of exploration such as design thinking in a large company is challenge. It is another interesting research question for the future. This piece of research suggests two promising paths.

First, it is essential to provide a structured learning experience in order to bring about cultural transformation in a company through to design thinking. Different levels of competences can be identified and developed. Online training programs can provide access for every employee, whatever the size of the company, in order to raise awareness: “I know it exists”. Short workshops should provide the first level of experiential learning to identify the culture’s different milestones: “I know I don’t know how to do it in real life but I have experienced it in controlled environments”. A series of workshops with projects managed in a semi-controlled environment should provide the basics of a first practice: “I can do it under guidance on simple projects”. Mentoring real life projects with a combination of coaching in the field and project reviews is a way to reach a level of expertise: “I can do it on complex problems in uncontrolled environments that is to say real life”.

Second, the conceptual framework (people, place and process) has proved to be a very efficient way to establish an internal capacity for innovation through design thinking. Success depends on step-by-step upscaling, while maintaining a balance between creating an ecosystem of engaged people, creating an appropriate space for exploration and developing the right tools for each phase of the process, geared to specific users, artefacts and contexts of use.

To my mind, leaders should be the people who are the first to know what to do and how to do it, quickly and efficiently (with limited time and resources). They should be innovation leaders. They should be change-makers, not just thinkers, but also doers. Leaders like this, when setting out on a journey of exploration, need milestones to prepare a crew, a boat and navigation tools. Design thinking provides effective and promising milestones for those setting out on a journey of exploration and to discover new opportunities for the future.

Epilog: my journey of exploration

This text is adapted from Loreena McKennitt’s introduction to the Book of Secrets.

This music has been an endless source of inspiration while writing, both in Stanford and in Paris. I discovered it by magic while staying with Patrick Friedenson, who had swapped his apartment in Paris for a history professor’s house at Stanford. Thank you to the editor of this section who helped me to refine the meaning and the tune, with grace and caring.

Over a number of years I have been ruminating on the distinctive characteristics of design thinking activities in the realm of sense-making and actualizing innovation—making it felt and meaningful in the world—through implementation. I began to wonder if my fascination with the exploratory journey of design thinking arose from an inner need of mine, an involuntary response to innovation processes that were left fallow precisely at the point where they could grow into implemented products, services and experiences that could nourish the world. I have recognized in myself a restlessness, a drive, that has its roots in an insatiable curiosity about what is really possible—and a commitment to make things happen in the world.

I suspect it was my growing awareness of my own wanderlust for real impact that made me aware of the sense of connection I felt with the lineage of design thinking, as part of that New World extension of a people in Silicon Valley. And the more I learned of design thinking culture and its unexpected twists and turns, the more I was drawn to learn about their contemporaries, which in turn set me off on tangents which might have little or no connection to the designers themselves.

As I cast my net as an inspired self-reflective practitioner, I became familiar with the humility that came from seeing the best-laid plans go awry, and the research process evolving towards something other than what I originally expected. So, I set out from Paris to travel through the landscapes and cultures of Silicon Valley and other inspiring places in the world. With an endless attraction to Stanford and an irresistible fascination with SF … My journey was originally oriented directly toward understanding corporate entrepreneurship and the conditions that create breakthrough eco innovation, but I ended up traveling on a train across the fields of design thinking, sense-making, and the dynamics of implementing. I learned that the journey, not the destination, was my source of inspiration.

In the end, I am left thinking that one of the most important moments in my journey might have been when I threw away the map. When I jettisoned the bramble-lined mazes that structured my own preconceptions about what design thinking and research meant, as well as where it would lead me, I was better able to find the real secrets of each experience I lived; to remember that I, we, are all intertwined with a rich, unknowably complex human history. These writings have been assembled like the narrative mosaics of the ancient Roman villas, each carefully designed...
and positioned to convey the stages of my journey and present its overarching meaning. They are for me also the recollections from my inquiries at Stanford and the d.school Paris: shards of personal history brushed clean and carefully examined to reveal meaning. They represent my personal transformative journey.

My hope is that this text fuels your curiosity like the best travel narratives. All journeys, be they imaginative, emotional, geographic, or intellectual, leave us with souvenirs, each a reminder that we are inspired by a fusion of place, experiences, people—and unexpected encounters with characters that can transform our lives... Souvenirs such as these help me recall a simple truth: creating an inspiring life-path involves the same imagination and serendipity as the best designing and artmaking. My journey has far exceeded my quest for meaning, intellectual curiosity, unforgettable human adventures and commitment to make it happen. The world of design thinking makes me grow everyday. My world of design thinking expands with my practice. Some people fall in love with a man or a woman. I have fallen in love with design thinking, forever.
Appendix 1
Data analysis through pedagogical action research

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
Appendix 1 - Data analysis through pedagogical action research

7.0. Recording template defined for DT pedagogical action research

- **Situate**: Problem situation/need assessment/identification of a research focus
- **Plan**: Thinking of ways to tackle it and action planning
- **Act and Observe**: Practicing and observing action
- **Reflect**: Understanding action and learning
- **Improve**: A new action cycle modifying future practice
7.1. First historical era from 2007/2009: How to develop a curriculum

2007/2008: First experiment on teaching multidisciplinary teams

Situate: The oldest French engineering school with an inspiring expedition at Stanford

The academic year 2007/2008 was my second at ENPC as a professor in corporate strategy and innovation and as academic director of the Industrial Engineering Department (GI Dept.). The department was almost “dead” with only one student registered from the main track. My conviction was to reposition it to intrapreneurship, which is the development of new activities based on product innovation and supply chain management. In 2007/2008, I did some research and wrote a 20-page document on why ENPC was the best positioned of France’s top engineering schools to host this intrapreneurship project with a national and international platform of multidisciplinary teams (see extract in the introduction in Section 1).

I was in charge of developing an innovation track. Multidisciplinary teams were considered to be an ideal form of organization to foster innovation. I ran two sessions of multidisciplinary programs (Chaîne de l’Innovation – Innovation Chain) in cooperation with 5 schools (engineering, business and design) for M2 Masters students. My observation was that so-called dream teams were in reality more likely to be teams from hell: conflict and tensions arose from the confrontation of different backgrounds. Students were demotivated and deserted the work. They pitched ideas and hid the reality of no team work and no enthusiasm in order to meet faculty’s expectations and stakeholders’ beliefs in multidisciplinarity.

Quick overview on my first multidisciplinary course in 2006/2007

Following the decision in the second semester 2006 to develop a new range of courses and projects in innovation, a project-based curriculum was chosen, which would be available for third year students as soon as the first semester of the new academic year 2006/2007. This program, with the title “Chaîne de l’innovation” [innovation chain] was set up and managed by Companieros in partnership with the consultancy firm Accenture, and academic partners. In 2006/2007 it was open to students of different backgrounds from leading French Grandes Écoles (Centrale, ENPC, HEC, Strate). Companieros is an educational engineering company that provides large French companies and schools with...
education programs that bring together students from different schools around different societal topics (innovation, handimanagerment, sustainability…). For its part, Accenture’s objectives in the program were to foster a culture of innovation within the company, to attract new talent and to develop new client offerings in innovation. The “chaîne de l’innovation” program combined a student track and an executive track. The involvement of the Grandes Écoles consisted of varying levels of contribution by different teaching teams, on the basis of their availability, interest and expertise.

For academic year 2006/2007, Accenture’s executives identified three areas of concern (mobility, sustainability and clients) based on their perception of the firm’s priorities. The Department Director selected two of these (mobility and sustainability) to be proposed to ENPC’s students, because of the potential for combining technologies and users. The third was discarded as too vague. In academic year 2007/2008, Accenture clients were involved and provided briefs (cosmetics, energy management, multimedia offerings). Only one brief was selected for ENPC students because of the relevance of its scope (energy management for a condominium: the potential of an offering by an electronics distributor such as Darty, which had already launched an internet offering to capitalize on its trustworthy image). The brief combined sustainability, user understanding, technologies and systems thinking with multiple stakeholders.

For academic year 2006/2007, the consultancy firm Companieros identified the project assignments: Kick off meeting, acculturation, creativity workshop, business development. However, in academic year 2007/2008, Companieros was no longer involved, and an Accenture team took over the organization with the same milestones, with the exception of acculturation, which was replaced by the task of problem definition. Students were asked to conduct a weekly project review with an Accenture consultant. Teaching teams were invited to the milestone events: 2 project reviews; the creativity workshop facilitated by an expert in creativity from a company called Creargie; final presentations. Acculturation was defined as a phase in which students will acquire knowledge in all the fields relating to their subject (by identifying sources of expertise and posting summaries on a group website). The creativity workshop was a whole day event facilitated by an expert in creativity (Paul-Hubert de Mesnard from Creargie) on the basis of a well-structured method. ENPC’s administration was reluctant to “outsource” the pedagogical process. Further follow-up was therefore organized with one-to-one and group coaching, as well as rigorous attendance and active participation in all milestone meetings organized by Companieros and Accenture.

Before launching the first session of Innovacteurs, and after running the innovation course and the multidisciplinary program for M2 students, the research director and I visited Stanford and ME310 in February 2008: we were impressed by the place, including the general facilities on the campus and ME310’s loft setting, which gave each team dedicated space and a shared workshop. The ME310 loft looked messy at first sight, but was full of energy and different settings.
I was impressed by the level of enthusiasm, the spirit of making and the commitment by both students and teaching team. I was struck by the feeling of a strong and open community, which believed in what it was doing. Larry Leifer, founder of the program, set three conditions for exploring a possible partnership between ENPC and ME310: a dedicated space for the program; living the experience with the ME310 teaching team at Stanford; common projects/partnerships with companies. Larry made a remark that I myself have endeavored to make happen for the last seven years: “as academics, our job is to create ideal conditions for students to innovate”.

**Plan: French multidisciplinary projects**

For 2007/2008, I decided to take part in a second multi school program for M2 students organized by two consultancy firms (Companieros and Accenture) and to develop French multidisciplinary teams for M1 students with major French design schools, École Nationale de Création Industrielle/ Les Ateliers (ENSCI) and Strate College Designers. The first program (*chaîne de l’innovation*) was in the first semester and the second (Innovacteurs) was a 13-week project in the 2nd semester. The estimated number of personal student hours was between 30 and 100, representing 6 ECTS.

The pedagogical objectives were defined as follows:

- To provide a real experience of product design and experience of projects with at least 4 students from two different backgrounds;
- To confront students with different ways of thinking and acting;
- To challenge industrialized products through the lens of sustainability;
- To reconcile heart, mind and hands;
- To learn by doing;
- To engage students in creativity and development;
- To engage students in self-reflection (in terms of project management, product design, multidisciplinary team, sustainability).

For Innovacteurs, 2 multidisciplinary teams (ENPC/ENSCI and ENPC/Strate) and 1 mono discipline team who represented 12 students in total and 6 ECTS were set up. 2008 briefs were given by teaching teams:

- Reinvent rainwater for houses (mono team: ENPC)
- Reinvent packaging of a luxurious brand for sustainability (multi team: ENPC/Strate)
- Reinvent a luxurious bag for sustainability (multi team: ENPC/ENSCI)
- Reinvent the bottle of water for sustainability (multi team: ENPC/ENSCI)
M1 and M2 students followed the same course on general principles of innovation, which involved adapting a game project that a colleague had run for workshops in creativity and communication. One lecture with a guest speaker on “the what” and “the why” of emotional intelligence was organized. The teaching team included a designer for each design school, myself representing the business aspects and researchers specialized in water. There was no dedicated space for Innovacteurs projects, no teaching of a process or tools, no handbook. There was only an assignment structure: one-page brief and a PowerPoint presentation for kick-off, three collective project reviews (problem definition/creativity session/feasibility assessment and project management) with the teaching team and a final presentations. Students could request more project reviews by appointment. A number of experts whom I identified and contacted before the start of the projects were available to students on request. No report was expected. Student satisfaction polls and interviews were run for ENPC students at the end of the course.

<table>
<thead>
<tr>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
<th>Month 4</th>
<th>Month 5</th>
<th>Month 6</th>
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<tbody>
<tr>
<td>Kick off meeting</td>
<td>X</td>
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<tr>
<td>Problem statement</td>
<td>X</td>
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<tr>
<td>Creativity phase</td>
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<td>X</td>
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<tr>
<td>Concept selection</td>
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<td>Visualization</td>
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<td>Feasibility study</td>
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<td>Communication</td>
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<tr>
<td>Debrief</td>
<td>X</td>
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Based on the IDEO process before 2008 as described in chapter 2.2, students receive the following assignment structure:

- **Immersion (understand market, clients, technologies, constraints)**
  - Observation of societal evolution (trends, behaviours, use scenario)
  - Observation of technological trends (materials, which influencing parameters)
  - definition of requirements and targeted users
• **Brainstorming**
  - One day workshop with an expert
  - Idea presentation
  - Selection

• **Faisability studies**
  - Technical faisability with a quick and dirty prototype
  - Industrial study
  - Market study

After years of practice now, I must admit the instructions did not reflect what should be done with design thinking: quick and dirty prototypes for instance cannot test technical faisability, but a possible new experience for users.

**Act & observe: Dream or hell teams?**

**Course in innovation:** High level of satisfaction from students who were both M1 and M2 students. The prototypes produced and tested in class for the game were interesting in terms of outputs (cardboard, plastic elements), game rules and tests among students. It was surprising to observe that students had really prototyped as much as possible during their Christmas vacations. They had a lot of fun testing in class. The game that was voted number 1 was gross in human terms: people had to perform unethical acts (such as hitting their grandmother) in order to escape from a kind of prison. I was horrified by this vote. One game that was excellent in prototyping and rules was a mix of trading and monopoly. Simple electronics has been added to cards and a board.

**A lecture on emotional intelligence:** The engineering students did not like this and found it weird. Engineering students and ENPC are not open to the value of emotional intelligence, which is considered to be a funny concept that makes no sense. There was not a single student who was convinced by the lecture. The guest lecturer gave a rational demonstration with scientific evidence, with no emotional content. Students were disrespectful to the point that it was embarrassing. My interpretation was that she was a woman and that her career credentials were not impressive enough for these students, despite the fact that she worked with professors at MIT. I realized that introducing this kind of topic into this kind of school and with these kinds of students should be done very carefully. Perhaps it would be better to do it than to talk about it. Lectures are not enough for teams to understand and to adopt an attitude that combines intellectual and emotional intelligence.
In the two sessions of the *Chaîne de l’Innovation* program from 2006 to 2008, it was apparent that multidisciplinary teams generated more conflict and tension than collaboration and efficiency. Only three students of mine participated in this program with 5 other schools in engineering, design and business. I had little control over the curriculum, which was organized by consultants. This was apparent in the student evaluation forms. The so-called “dream team” quickly became a “hell team”: it was an exception when a team worked efficiently in the same direction (though not impossible, as was the case with one Innovateurs project in 2008), with a good atmosphere and interesting outcomes. Instead of building on complementary perspectives and competences, they usually failed to understand each other. They started fighting to defend their ideas (which leads to poor compromises) or they gave up (which leads to no result). No in-depth “situate” work was done. Solution generation was poor or inappropriate. Before assignments, one student would take the lead and others would contribute by splitting tasks and working remotely and individually. None of the students from any of the schools were committed and no teachers attended any sessions, even the final presentations. I was shocked. It was more a publicity exercise than a collaborative project for students. Outputs did not matter. Among the many pitfalls observed, we could mention no deep understanding of context (“situate”), no in-the-field work, no prototyping, “paper” presentations with no real-world impact, poor team dynamics between engineering and design students. The only milestone that was appreciated by students was a one-day brainstorming session organized with a consultant in creativity. I concluded this kind of program with all its logos was simply a publicity action for the consultancy firm and the schools, with no in-depth learning experience and no output that made sense. It was not even a fun experience for students, who hated it and were disappointed compared to what I had promised and what they expected.

**Innovateurs projects:** Only one professor in design came to ENPC for project reviews. The other one was not committed and fully invested (see the impact on the team for luxury packaging), even with his students and at his school. My coaching was influenced by Christophe Gaubert, both a professor at ENSCI and a professional designer, who has his own agency. He was used to project reviews and team coaching at ENSCI. I had never done any before this experience.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main observation</th>
<th>Project outputs</th>
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</thead>
<tbody>
<tr>
<td>Household water</td>
<td>Students were demotivated: because they failed to provide sense making analysis, the TT asked to do it again and thus they lacked time to prototype. Students were only motivated by a real functional prototype.</td>
<td>A final presentation with a PowerPoint presentation. Ideas of possible solutions.</td>
</tr>
</tbody>
</table>
Luxury packaging | Engineering students were demotivated and limited by the desertion and the preconceptions of design students. | A final presentation with a PowerPoint. Brand analysis. Low definition drawings.
---|---|---

In the household water project, the team analysis did not make sense in pragmatic terms and according to the experts at the first project review. Students were asked to reframe and do more analysis. The team was badly demotivated because their shared goal was to prototype something real. The team did a second analysis that made sense from the teaching team’s point of view. They had no time to prototype. They were very disappointed because of their initial expectations for this project. I felt guilty about killing so much enthusiasm and willingness for action. I told myself that too much analysis kills action either through lack of time or through loss of motivation.

The team on luxury packaging should have been headed by a teacher from Strate (who was also a packaging professional). No feedback was given at project reviews and the design students were demotivated. I came back from holidays to organize a common project review at the end of April but it was too late in terms of student commitment and team dynamics. During this project review with the professional designer, I tried to motivate the students, but he criticized any student idea so harshly that I felt they would be brave to pursue the project! The engineering students were therefore disappointed not only by the design students’ lack of commitment, but also by the way they tackled the subject (which was restrictive because it was limited to the idea that luxury packaging should be black) and discarded any of their ideas (the main idea was a luxury hotel where the packaging was not discarded because it was a kind of small ornament): “We could have gone further without designers,” one engineering student said during debriefing. The experience of multidisciplinary teams was not a dream, but quickly became a hell…

Concerning the team on luxury baggage, they worked with a specific department, which was specialized in cloth making. Boys from the engineering school were working with girls from a fashion specialization. They took over the leadership, without being fully competent. Engineering students enjoyed the experience. The outcome was merely a presentation, without unfortunately
any prototype. It was rather a discourse on brands. Openness of students was interested, even if deliverables were not of the greatest quality.

The team working on the bottle for sustainability was very committed and performed beyond expectation. Design students took leadership of the project: they felt they were representing their design school in a pilot project with a top engineering school. This feeling came from the introductory speech by the director of the design school, who opened the kick-off. It was a strong and lasting factor of motivation from the beginning to the end presentation, and even afterwards. The project presented was considered as outstanding by other teams and the TT in many respects: sense making, great storytelling, realistic pictures, very detailed description of the “what” in all aspects (design/technical/communication/business). The students wanted to form a company. The student outcome was a PPT presentation with drawings of very high quality (see data record 2008). It was presented at Stanford during a session at Center Design Research. The project was analyzed with another sustainable project conducted by Stanford students under the supervision of Banny Barnejee, professor at the d.school (ICED 2009). No prototype was made.

With the exception of the bottle team, none of the teams followed all the assignments requested for each of the three steps (see the box on the section plan). Assignments were either too ambitious or vague. Not all intrapreneurship activities are feasible on a course like this.

Deep analysis of the best Innovacteur project 2008: Reinvent the bottle for sustainability. The brief was chosen by the teaching team for several reasons: issues of sustainability raised by plastic and drinking water, a tangible and attractive artefact for students in engineering and design, the importance of market size. Plastic water bottles are commodified, ubiquitous products readily available to consumers, and at the same time have become largely symbolic of environmental damage that any nature lover will experience when hiking in a forest or sailing at sea. Facts and figures confirm this observation: in 2005, over 30 billion plastic bottles were manufactured while only 12% were recycled. Plastic disintegrates in 500 years and plastic incineration generates toxic gas. The production of plastic bottles for US consumption alone requires more than 17 million barrels of crude oil. Secondly, drinking water will become a major issue in the next twenty years, with a drastic shortage around the world. Today, approximately 1.5 billion people have no access to safe drinking water. Around 4 million die very year from waterborne diseases. Thirdly, the water bottle was a tangible and attractive artefact for both kinds of students to work on: materials and mechanical constraints could represent a challenge for engineering students, while the combination of shape and function posed a challenge for design students. Last but not least, the worldwide market for plastic bottles represents around 22 billion dollars with 89 billion liters sold per year.

Students were asked to reinvent the water bottle for sustainability through a design process and from the perspective of creating new business activities. To give students complete freedom,

the faculty decided not to cooperate with a company. In addition to the brief, the students were given milestones: problem statement two weeks after kick-off, concept presentation two weeks later, and a review one month before the final presentations. Other reviews were done at students’ request. Table 3 shows the assignment structure and schedule. Students were asked to use the tools they had acquired during their courses in product design, corporate strategy (such as the tools in Kim and Mauborgne’s Blue Ocean Strategies from)\(^{332}\) and eco-innovation (such as Robert’s Natural Step framework). The faculty members did not specify particular tools in order to test which ones the students used.

Instead of optimizing the bottle of water, students envisioned a water operator. Sustainability was achieved by eliminating the idea of a disposal bottle. Not only did students envision a new “what”, that is, a new concept for a product line, switching it from product to services (new user experience and technical feasibility), but they also developed the project in its “how”, i.e. which business model (brand, communication, marketing segmentation, commercial website, experience as a client, business plan, and the use of some tools from corporate strategy such as value curves). The business model of the water operator combines the one from TV operators (multi waters from your home with a single invoice) from Nespresso (through the sales of flavour caps). The classical business model based on products (production of plastic bottles) has been switched into services. Dematerialization is often quoted as a way of doing eco design in the sense of New Business Development. There was no requirement asked in terms of the business plan (for examples, market analysis, financial forecasts, competition analysis, risk analysis and regulation) and students have done more than expected by envisioning a new business model. The ‘value curve’ (Fig. 33) tool used to compare the new and traditional filtered water alternatives (bottle, tap, Brita).

Students in engineering appreciated working along the principles of design approach and students in design appreciated approaching business developments and technical feasibility, which “was a catalyst to transform our ideas into a reality” (student in design). At each project review, students delivered concrete artefacts such as a brand (Eve), a logo, storytelling, visualization of the experience, graphic design for the website, design of a new lasting bottle, schemes of technical feasibility, experience prototypes and analytical artefacts, such as global analysis and elements of business plan (Fig. 32).

Students from both backgrounds appreciated and enjoyed the experience of working together. Following is a series of quotes from students in the class:

• “At the beginning I did not believe in our project. I was convinced when I realized how important our subject was and when we found out this new concept”

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• “As a Chinese student, my objective by coming to France in Génie Industriel was to understand how we can create new products and minimize risks; with that project and the collaboration with designers, I have found many insights”

• “I study engineering but I also draw and feel like an artist; this project has helped me to find what I want to do and I will work one year in the special commands of Louis Vuitton to make the link between special commands to industrialized products, between creation and industrialization”

Surprisingly, most students have shown a strong interest for entrepreneurship:

• “As students in product design we focus on objects; such a project has made me understand how to create a company by enlarging our skills to many other disciplines”

• “I am ready to create this company now because I strongly believe in it”

• “I know how to develop a new company”

• “I do not want to create my company right after my studies but after a couple of years I will want to and I’ll surely develop the way we did in that course”

• “We are inquiring how to create a real venture from that course and if we can find an incubator to carry on”

• “I come from Shangai and over there everybody wants to create a company; I feel such courses will help people to do so”

The limitations observed in the student projects related to implementation. More could have been done on the implementation phase (e.g. how to set up the system in the kitchen, a real prototype to test technical feasibility, further analysis on water quality and selection of suppliers). We also observed little use of tools presented in the previous course. Students were able to analyze the issue at an abstract and system level, but sustainability paradigms such as The Natural Step were found too theoretical to be useful. Time constraints impacted the outcomes, especially in terms of implementation at the later phases. In addition, students also found it difficult to tackle a major issue, since they were restricted in terms of needfinding because of limited access to the right people, budget and time constraints to prototype and test. More details on the bottle project with lessons drawn to modify pedagogy in sustainability are available in a 2009 ICED paper.
**Best students’ outcomes of a project**

- Sense making analysis.
- Reframing.
- Concept generation in quantity and flexibility.
- Quality of the concept, high level quality and high degree of refinement in terms of how the experience of users is imagined and presented (“realistic” pictures), as well as in terms of assessment for real implementation: technical drawings for technical feasibility, value curves for different alternative offerings, a logo, a brand, definition of communication actions with drawings of the different elements (outlook of a website, street event), business plan for market potential.

**Reflect : A need of a common language**

Multi school programs (*Chaîne de l’Innovation*) organized by consultancy firms were dropped after two years of experiments with 2nd-year Masters-level students for the following reasons: limited control by faculty over briefs and pedagogical activities; low commitment of students from other schools; a process influenced by consultants’ analytical thinking, focus on market studies, business plans and sales pitch; students stuck too closely to the consultants’ positioning; consultants’ lack of knowledge and practice in innovation. The lesson is that multi-school innovation programs can be a terrible learning experience because the main objective is more about advertising than pedagogy. This was the main reason why I endeavoured to develop my own curriculum with multidisciplinary teams.

In the Innovacteurs projects, two teams were dissatisfied and frustrated because of the lack of a prototype on one side, and very low commitment from design students on the other side. **First**, even if the analysis is not scientifically accurate, there is a need to move ahead and prototype. Otherwise the team gets stuck in analysis until the end of the course because of a lack of time and motivation. **Second**, the combination of design, engineering and business with multidisciplinary teams (for both students and academics) is initially a factor of motivation (curiosity), but quickly becomes a factor of complexity and demotivation (different priorities and commitment, too much time and energy, no understanding, no respect). Diversity represents a factor of divergence, tension and conflict. Only when the team establishes trust and efficiency does diversity become a factor of performance. **Third**, it is also difficult for the teaching team to give feedback with such different stances: mutual understanding and respect for different stances are prerequisites for motivating students effectively.

For both, instructions should be more developed, in order to avoid students getting lost in understanding what to do and how to do it; sale pitches with PPT presentations (even with
realistic drawings) should be only one of the expected outcomes, not the sole outcome, in order to educate students to become not only pitchers, but also makers. Teaching with lectures does mean that students will do things the way they are taught. Although organizing multidisciplinary teams from different disciplines and schools in itself represents a lot of work for academics, this kind of logistical organization is not enough to offer an optimal learning experience. After so much effort, the experience for an academic can be depressing. Without a greater probability of better outcomes, I concluded that this kind of organization took too much time and energy for poor and uncertain results.

In conclusion, I drew three lessons:

First, I feel that with such bright students, the focus should be on sense making and creating tangible outcomes, because students can easily and quickly cover up their weaknesses (lack of collaborative work or even simply lack of work) and those of the curriculum and teaching team, by pitching not only ideas they do not even believe in, but also multidisciplinary dynamics that they do not even appreciate and build on.

Second, students produce no tangible outcomes, but only analysis, sometimes with no sense making, and idea pitching because the focus is on generating ideas and students are not fully committed. They focus on producing PowerPoint presentations in a sales pitch mode.

Third, organizing multidisciplinary teams between schools (timetable, traveling distance, getting to know each other, approvals...) is costly in time and energy with poor and uncertain results, in terms of learning experience and outcomes. Instead of waiting for a miracle to happen because of highly committed students, I felt that as academics we should do a better job in terms of staging such multidisciplinary teams, with at least a more refined curriculum and a shared space.

The idea of bringing together multidisciplinary teams as the core factor in fostering innovation is great in theory, but not spontaneous in practice. The dissemination of a common language, in order to create the “glue” within multidisciplinary teams, was the first need I identified.

**Improve: No talk, action is needed!**

The decisions to improve the learning experience were as follows:

- Continue to believe in what I do, with a rational and neutral attitude
- Be resilient and smart
- Explore new ways of teaching innovation, with more practice and more pragmatism to teach emotional intelligence to engineering students than lectures

334 Design Thinking as providing “a glue that brings teammates together around a common goal: make the lives of the people they’re designing for better.”, http://dschool.stanford.edu
• Learn new ways of teaching than lectures
• Find a community outside France
• Find a dedicate space
• Kick-off, project reviews and final presentations to be equally organized on both schools
• Create mono disciplinary student teams
• Keep only one committed design school and one committed professor in design
• Understand better how designers think and work
• Find a committed professor in engineering to create a multidisciplinary teaching team
• Discover the Silicon Valley with direct experience
• Understand the way Stanford teaches innovation especially in the program ME310
• Drop industrial feasibility as an assignment, and perhaps market feasibility
• Find new ways of making innovation and teaching innovation
• Drop teaching if only ppt presentations and sales pitch after a few attempts at new curriculum!

Epilog to my second year in pedagogy at ENPC

By early July in this second pedagogical experiment, I was doubtful about pursuing a career in academia. As a former company CEO, my job was to minimize the risks of failure and to maximize opportunities for success. My responsibilities encompassed the place, the people and the process. This framework was a natural one for me. However, I felt that I did not know what to do in terms of “creating the best conditions for our students to innovate”, as Larry had advised me. Setting up multidisciplinary teams was a hard job, but still an incomplete job. My school director gave no signs of giving his approval for me to become a visiting scholar at CDR at Stanford University (although I fulfilled all the conditions required and I was not asking for any financial support, except the maintenance of my (low) salary), in order to discover the culture of Silicon Valley and learn my job as an academic. I was about to give up when I received approval in mid-July: 5 weeks later, I was flying to Silicon Valley with two suitcases, my son and my cat…

My mission was to identify and understand the “secrets” of Larry, ME310, Stanford and Silicon Valley: which process/tools; what about people; what about place. I needed to improve by joining ME310 at Stanford and learning about design thinking through real experience.
2007/2008 : Learning about a culture of design thinking

PEOPLE

Multidisciplinary teams (39) are not enough. Commitment is key. I have realized the risks of high IQ with no creativity, high skepticism and no action, because of too much analysis and no enthusiasm. There is a need to find ways how to teach EI (33) to engineering students by not lecturing, but by action and commitment in terms of activities. The *ingenium*, which was the core of the engineer’s mindset (50), and especially ENPC alumni, is not any longer a core value of ENPC whose curriculum is almost completely analytical and deductive. I discovered the dominant paradigm of positivism over constructivism (43): Such a difference in epistemologies (42) has a strong influence on curriculum design.

“People” was first my focus of inquiry. When I started, as most (if not all) people (still) do, I believed that multidisciplinary teams were a promising way to foster ideas and innovation: Different stances, approaches and tools should mutually enrich each other, creating great dynamics for the solving of problems. In practice, the opposite happens: Multidisciplinary teams represent a source of tension, conflict and desertion. I’ve started to realize the importance of a balance between people, place and process, as three core factors in teams’ dynamics and project outcomes.

PROCESS

The process was inspired by a 5 step IDEO process found on the internet. Assignments were structured with 3 project reviews (impregnation for problem definition/brainstorming/assessments: technical and industrial feasibility, market potential). Creativity (88) was organized with the facilitation of an expert and represented a major event.

The principal of this process was to combine the tasks of a designer, an engineer and a business person. The design professor saw reframing as the core of design, even more than creativity: looking at the problem from a different perspective, in order to generate new concepts. Thinking about the technical aspects of the solution was the role of the engineers. Thinking about the business aspects was considered a prerequisite for making it happen in real life.

The assumption of the professional designer who was coaching the students was that they should not be given any tools: each project is unique and students should reinvent tools; the process is enough to drive teams (brief, problem statement, creativity, development). The influence of Marc Giget and my interest in the culture of design made me investigate the notion of dialectics.

I could feel a difference between theory and practice: in theory, the culture of design was promising; in practice, it was not clear and structured enough for me to implement as a teacher. There was a huge difference between the ambitious process and assignment structure I planned with a five-step IDEO process,336 which I talked about at the kick-off, and what was stressed in project reviews with the professional designer, who did not believe in process and tools. I was influenced and was caught between the two stances. My interpretation of the IDEO process, which was reflected in the assignment structure, focused on thinking (problem understanding, idea generation, assessment), not making.

The lack of syllabus development, the lack of tools available to students and the subjectivity in feedback to students (which could result in arguments from authority on the part of the teaching team, if they agreed with each other) were sources of discomfort.

The best project shows that students navigate between concrete outcomes and abstract analysis, between reality and imagination, between open and closed decisions: “In the course of the two projects, we have observed students navigate between tangible artefacts and abstract analysis, between reality and imagination. Innovative concepts have emerged. We still need to better their performance and increase their abilities to apprehend higher abstract briefs, to assess systemic consequences, to justify the better performance of their projects (in terms of sustainability and of return on investment) and create broader impact.” (Hillen and Banerjee, 2009).

The recommended process was structured through milestones, such as: problem definition/creativity/feasibility assessment. A multidisciplinary team for a sustainable challenge, which outperformed design activities in quantity and quality, demonstrated excellent skills in reframing, concept generation and complete development in how to implement the project (a brand, graphic design, a website, communication campaign, technical feasibility with precise drawings, positioning of different offerings, value factors, business plan). They produced a lot of visual artefacts, but no prototype. Industrial feasibility was not tested (how to produce, cost, investment): these kinds of studies are beyond the scope of students and requires professionals from the field.

**PLACE**

The team with the best outcome (the bottle for sustainability) told me how valuable the space at ENSCI was for working together and how important it was for their team dynamics and projects. They cited the following factors: the location in Paris, the ambiance of the loft, individual spaces where they could leave their work permanently and return to it later, the possibility of talking to people in an open space.

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My visit to Stanford University (1) in February 2008 with ENPC’s director of research convinced me of the influence of space on team dynamics and innovation: there, I identified a loft (8), a workshop (10), project spaces (11) and the kitchen (13), as important milestones on how to stage it.

I did not know exactly what to do in terms of space at that time. I was only convinced that a dedicated space should be available to project teams.

The key notions I discovered for innovating through design thinking are fully described in the book\textsuperscript{337}. Table 29 describes tipping points discovered in 2007/2008 and numbers for each concept refer to pages in the book.

Table 29. Tipping points in the culture of design thinking discovered in 2007/2008

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>PLACE</th>
<th>PROCESS</th>
</tr>
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<tbody>
<tr>
<td>Multidisciplinary teams (39)</td>
<td>Stanford (1)</td>
<td>Constraints and dialectics (65)</td>
</tr>
<tr>
<td>Emotional intelligence (33)</td>
<td>Loft (8)</td>
<td>Creativity (88)</td>
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<td>Constructivism (43)</td>
<td>Project spaces (11)</td>
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<td>Engineers (50)</td>
<td>A workshop (10)</td>
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<td>Risks with IQ (31)</td>
<td>Kitchen (13)</td>
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<tr>
<td>Epistemologies (42)</td>
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</table>

\textsuperscript{337} Hillen, V. (2014). \textit{101 Landmarks I’ve discovered to innovate thanks to design thinking}. Retrieved from www.veroniquehillen.com
2008/2009: A stay at Stanford with a new track at ENPC

After the field trip to Silicon Valley with industrial engineering students, I stayed at Stanford for the first semester: I discovered ME310, the d.school, design companies in Silicon Valley and reflected a great deal on People/Place/Process, as well as the consequences of sustainability for DT practice. My main discovery during my stay at Stanford was the sense of a common culture driven by a set of values. I did not yet realize that it was a transdiscipline and I thought of it rather as an interdisciplinary process. I identified numerous spatial milestones. I discovered different schools of thought in design at Stanford: engineering design, which focused on creating a series of prototypes, proof of concept and technical feasibility, versus industrial design, which was trying to escape the limitations of its paradigm by tackling large-scale complex problems with the power of reframing and solution generation. I could feel the emergence of another design culture, driven by needfinding, quick-and-dirty prototypes for user tests, and experience design. Even after a stay of 6 months, I could not claim to know how to teach design thinking. The second semester of multidisciplinary teams between ENPC and ENSCI demonstrated a degree of progress by developing better instructions regarding the expectations for assignments, to drive weak teams and increase sense making.

I drew lessons from the experience of developing a course: Is it useful? Transferable? Adaptable? Teaching design thinking is a paradigm shift for traditional higher education in terms of epistemology, the role and skills of teachers, who need to become self-reflective practitioners in order to become professionals, learning experiences for students. Pedagogical action research is an efficient protocol for self-reflection and as a way to improve the quality of design thinking pedagogy. The PPP framework began to emerge as a useful tool for guiding faculty in developing such a pedagogy, with recommendations on how to start a course.

Situate: Discovering the Silicon Valley

Stanford, ME310, the d.school: Design thinking, a glue between disciplines?

My stay at Stanford lasted from August 2008 to February 2009. I stayed at the Design Research Center, headed by Larry Leifer and Mark Cutkosky, both in charge of the ME310 program. I was part of the ME310 teaching team and attended other courses. When I arrived, ME310 was called ME310 Design Entrepreneurship. After Christmas 2008, Larry decided to rename it ME310 Design Innovation, which I found more appropriate, given the fact that students aimed to create products in existing companies, not new products to create new companies. This mission matched my pedagogical objective of educating intrapreneurs.
Through interviews and visits to design spaces at Stanford, I quickly realized that four product design communities were living side-by-side, representing three schools of thought in product design:

- The spirit of engineering design, with faculty from the mechanical engineering school;
- The spirit of industrial design, with faculty from the Arts school;
- The spirit of human-centered design, with d.school faculty drawn from consultancy innovation companies such as IDEO;
- The spirit of entrepreneurship, with faculty coming from the business school.

Those four schools of thought match my identification from the literature review of three strands of research (design engineering, design, innovation management and entrepreneurship). The human-centered approach was not obvious in the literature review on innovation and product design; it only exists in ergonomics and interaction design (human machine interface).

**ME310 is a radical course that has been taught at Stanford University since 1967. The year-long course is a graduate level sequence in which student teams work on complex engineering projects sponsored by industry partners. Student teams complete the design process from defining design requirements to constructing functional prototypes that are ready for consumer testing and technical evaluation** (Carleton and Leifer, 2009). ME310 is described as the combination of a problem-based learning, an immersive experience and a simulation of real life conditions. The course has evolved over years and nine eras have been identified, among which the most lasting one is the transformation into a truly multicultural global network.

ME310 was located in a loft on the 5th floor of the Terman building, which was dedicated to the mechanical school of engineering: Fred Terman was a professor in electrical engineering and has been endowed as the father of Silicon Valley: “**Terman’s best-known role is that of inspirational mentor to HP founders William Hewlett and David Packard: Terman, who kept track of his former students, gave Hewlett and Packard a list of about 25 potential customers for their first product, an audio oscillator. One was J.N.A. ‘bud’ Hawkins, chief sound engineer of Walt Disney Studios, who in 1938 purchased eight oscillators at $71.50 each**” (Dawn Ley, 2004). The place was imbued with the garage spirit. Entrepreneurship was a core value. The emphasis on technical prototypes to create products was at the heart of the process: prototypes should be as real, refined and technical as possible. This building has been pulled down and the mechanical engineering school’s design faculty been asked moving to the same building as the d.school and the Masters degree school.


The ME310 Design Innovation course takes place at Stanford, which is located in the middle of Silicon Valley, where the concentration of design consultancy companies is very high (see FORTA study from the Danish government which locates who they are, where and what they do): Stone Yamashita, One&One, Frog Design, LunarDesign, IDEO, Jump Associates...

During my 6-month stay, I wrote a research journal with thinking, discoveries, practice, and self-reflection, and I took field notes on People/Place/Process. I also videotaped interviews. Place was the first and easiest focus of inquiry. Findings on people were mainly driven by observations of ME310’s lectures and coaching and interviews with students and academics. Findings on processes came from interviews and readings (website, syllabus).

**Which conditions for students to innovate?**

**Findings in terms of place: 9 landmarks for innovation space in the Silicon Valley**

After visiting around a dozen places and interviewing a hundred people, my main findings were about how to stage an innovation place and about numerous “landmarks” (see the following section: “Lessons on place”). Even if messy at first sight, lofts, studios or garage style spaces are structured to encompass a number of symbolic and functional elements, which create emotional comfort and a certain mindset. Most people on a learning expedition find these places “crazy”. They see no differentiation or structure. They respond like tourists on a whistlestop tour. By contrast, I identified 9 landmarks in all the spaces I visited, which structured the spirit and the activities. The more I visited, the more I identified milestones, the better I was able to decipher the logic and the impact.

**Findings in terms of people: A dogma with multidisciplinary teams. T-man.**

The d.school’s manifesto was displayed on a billboard in CDR where my office was.

The description of the anticipated people dynamics as stated on the Stanford d.school website, is shared in practice, in both industry and academia. The d.school has paved the way to a definition of the pedagogical principles of DT:

- “hands-on real world projects”,
- “radical collaboration between faculty, students and industry”,
- “a methodology of innovation that combines creative and analytical approaches”,
- “learning by doing”,
- “bias toward action”,

Data analysis in 2008/2009
“to learn the process together and then personalize it, internalize it and apply it to their own challenges”,

“we don’t just ask our students to solve a problem, but to define what the problem is”.

The T-man is the expected profile for students after a course of design thinking. Interviewed by Adam Bryant on October 24, 2009, Brown340 pointed out that “there’s this idea that McKinsey first articulated many years ago of the T-shaped person, which is somebody who’s got some deep craft — a great writer or a great designer or a great architect, engineer or whatever they might be — and that’s the vertical stroke of their T. But then the horizontal is that they’ve got clear empathy and interest in engaging with other disciplines and doing other pieces of the process or playing other roles”.

The dogma of multidisciplinary teams was as powerful in practice as in the literature.

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Findings in terms of processes: The glue? Different schools of thought...

I interviewed around a hundred students, coaches and academics, to understand their stance, motivation and practice, including process and tools. In terms of process, four courses structured my findings: ME310 Design Innovation, d.school elective courses including “Design for Extreme Affordability” and Stanford design program.

The ME310 process can be described as follows: “Teams observe and interview users to better understand their needs, benchmark existing technologies and products to identify the design opportunities, extensively brainstorm to discover the obvious, crazy, and novel ideas, and iteratively prototype to quickly test their ideas and get a better understanding of their designs. The end result is a refined design concept backed with key insights” (website). The emphasis is on 5 main kinds of prototype (CFP/CEP, darkhorse, funky, funktional, final prototype). Most of the 40 students are from the mechanical engineering school. The course is a major, involving an average of 3 days a week over three quarters.

For the d.school, the process is described as follows: “Students start in the field, where they develop empathy for people they design for, uncovering real human needs they want to address. They then iterate to develop an unexpected range of possible solutions, and create rough prototypes to take back out into the field and test with real people. Our bias is toward action, followed by reflection on personal discoveries about process. Experience is measured by iteration: Students run through as many cycles as they possibly can on any project. Each cycle brings stronger insights and more unexpected solutions.” (Kembel, 2013)341. The emphasis is on needfinding, reframing and concept generation. Students come from the 7 Stanford schools and these courses are elective, with or without credits. They are considered as minors and are offered to hundreds of students.

I also discovered the course “Design for Extreme Affordability” developed by Jim Patell, a professor at Stanford business school: “Need finding, user empathy, rapid prototyping and iteration” (…) “Teams gain empathy with all stakeholders in order to develop solutions that fit into the culture, aspirations, and constraints of their target customers. Teams will iterate on their designs and business models through a rapid sequence of prototypes, user tests, and design reviews”. The emphasis is on implementation in real conditions, including the creation of new business models and start-ups. The 40 students comprise: 25% business students, 25% engineering students and 50% from other programs across campus. The course lasts over 2 quarters and is considered an intensive and substantial commitment.

For the Stanford design program (with a master degree), the process can be described as follows: « We work simultaneously in the creative framing of the problem domain and generating a wide array of innovative solutions. We dive deep into the human condition, using ethnographic research methodologies and behavioral sciences to discover latent needs.

Our methodology combine intentionality, design expression and an questioning of the larger implications, allowing us to arrive at innovative solutions to appropriately framed problems. Students are selected on design portfolio, regardless of their background discipline, for around 12 slots each year. Students study for this Masters on a full-time basis.

Since then I have identified a dozen of processes in design thinking, both in academics and in the industry. Some of them represent adaptations, others’ re-interpretations miss the point.

Which hope for sustainability? How to combine it with design thinking?

Over 6 months, I conducted research to understand whether pioneering designers in Silicon Valley had changed their practice to incorporate sustainability, with the hope of creating a curriculum in eco-innovation that would be a combination of best practices.

Table 30. Data collection for research in design and sustainability

<table>
<thead>
<tr>
<th>Survey focus</th>
<th>Data collection techniques</th>
<th>Aims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large French companies</td>
<td>An online questionnaire based survey with around 40 pre-defined questions in 2007 and 2008.</td>
<td>• To gain knowledge on practices in large French companies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To identify relevant case studies.</td>
</tr>
<tr>
<td>Leading eco designers</td>
<td>7 one-to-one face-to-face semi-structured interviews with designers located in France between Feb and Dec 2008.</td>
<td>• To gain knowledge about motivation and experience of designers.</td>
</tr>
<tr>
<td></td>
<td>3 one-to-one face-to-face semi-structured interviews with designers located in other European countries in 2009.</td>
<td>• To obtain an understanding on changes in their practices when tackling sustainability.</td>
</tr>
<tr>
<td></td>
<td>15 one-to-one face-to-face and 1 one-to-one phone semi-structured interviews with designers located in the Silicon Valley between February 2008 and February 2009.</td>
<td>• To understand the potentialities of a ‘designerly’ way when eco innovation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To identify whether cultural differences.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To identify case studies relevant to our research area.</td>
</tr>
</tbody>
</table>
This was supposed to be pilot research for primary research on staging multidisciplinary teams for sustainability in an academic environment. Brand (2003) contrasted the underlying beliefs of a technology-orientated approach (based on equipment and manufacturing) with those of a behavior-orientated approach: “Technological advances will save us” versus “Behavioral change will save us”. Building on this simple dichotomy and research in the literature, Table 31 summarizes the main different characteristics.

<table>
<thead>
<tr>
<th>Underlying belief</th>
<th>Technology approach</th>
<th>Behavior approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
<td>Engineering background</td>
<td>Sociological background</td>
</tr>
<tr>
<td>Objective</td>
<td>Analysis of bottlenecks of a product in various stages of its life cycle / optimization with quantitative criteria</td>
<td>Create new sustainable patterns of production and consumption by generating totally new function / experience fulfillment</td>
</tr>
<tr>
<td></td>
<td>Exploitation of current product lines. Exploration based on functions</td>
<td>Exploration of systems innovation and entanglement between actors</td>
</tr>
<tr>
<td>Nature of problem</td>
<td>Defined problems</td>
<td>Wicked problems</td>
</tr>
<tr>
<td>Reference tool</td>
<td>Life Cycle Assessment</td>
<td>“Out-of-the-Box” thinking before NPD in order to question assumptions</td>
</tr>
<tr>
<td>Metrics</td>
<td>Quantitative data from the past</td>
<td>Qualitative scenarii for the future</td>
</tr>
<tr>
<td>Key words</td>
<td>Product modification and pragmatism</td>
<td>Innovation and idealism</td>
</tr>
<tr>
<td>Associated terms</td>
<td>Design for Environment (DFE), ecodesign, life cycle design, green design, environmental product development, energy efficiency, waste reduction, recycling</td>
<td>Sustainable product development (SPD), eco innovation</td>
</tr>
<tr>
<td>Reference authors or organizations</td>
<td>van Hemel and Brezet, 1997 (Delft University)</td>
<td>Papanek, 1985, 1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stahel and Giarini, 1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bakker, 1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>McDonough and Braungart, 2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bahmra, Lofthouse 2001</td>
</tr>
</tbody>
</table>
The purpose was to develop an understanding of the subject area surrounding the initial research questions: can sustainability be a major driver of innovation, especially for multidisciplinary teams in the early phases of radical innovation? Is there a ‘designerly’ way to innovate for sustainability?

After an unfruitful survey in 2007 to identify relevant case studies in large French companies, another field of inquiry was selected for its suitability and expected richness: designers identified between 2007 and 2009 as pioneers in sustainability, either in Silicon Valley or in France. Two main categories of inquiry were defined to structure our explorative research: people and process. Surveys were carried out, with face-to-face interviews on a selected sample. The objective was to provide the ‘deep’ and ‘broad’ perspective required to answer questions on the ‘what’, ‘why’ and ‘how’. Research questions included: Why are some designers committed to sustainability? What is their contribution to tackling such issues? Have they adapted their practice, methods and tools for sustainability? If so, how? What difficulties do they encounter? Is there any exemplary case study? Concerning multidisciplinary teams with different backgrounds in either engineering or design, research questions included: Is sustainability a driver? What is the influence of a ‘designerly’ approach on the dynamics of multidisciplinary teams, and especially for sustainability? What are the difficulties encountered? Why?

Findings were as follows:

- Sustainability does not represent a driver to innovate: even if included in the brief, sustainability is often ‘sacrificed’ during the project for many different reasons (cost or desirability reasons in the case of incremental innovation, lack of motivation from team members, lack of imagination in the case of radical innovation, lack of understanding of what sustainability means...);

- Despite difficult conditions, there is a strong personal commitment from genuinely convinced designers to develop specific knowledge, practice, methods and personal projects “to make it happen”: these convinced designers are the drivers of eco-innovation;

- Three types of designers in sustainability: nature lovers; opportunists; pragmatists;

- Pioneering designers with practice in sustainability are true lovers of nature: they advocate that everything changes when sustainability is included and there is a huge need for serious expertise (materials, process, sourcing) with a combination of technology- and behaviour-orientated approaches

- Space is used by pioneer designers to act and disseminate eco-culture;

- Design thinking emerged as a possible driver for multidisciplinary teams and eco-innovation (a switch from technologies to behaviour), but it is unclear how it could be integrated into a curriculum and no case was found.
Designers’ spirit, values, thinking and methods help multidisciplinary teams to navigate in the unknown and envision new possible futures for sustainability, even if refinements in terms of staging are needed.

My research both in the literature and in the field showed that incorporating this new dimension would be too risky with corporate partners, especially those driven by other paradigms (LCA, technology...). The most skilled designers in Silicon Valley combined a high level of design thinking to tackle behavioral changes and a high level of technical expertise in sustainability. I had no expertise in either of these two fields. The challenge appeared to great. I have written over 50 pages on this research, which has not yet been published. Only lessons from best projects at ENPC with the previous year’s project (water bottle for sustainability) and at Stanford’s d.school class on scale up change for sustainability were published in a paper for ICED 2009: “Modifying design pedagogy for sustainability.”

The ICED paper written at the end of 2008 was the first opportunity to conduct pedagogical action research, which has considerably increased the quality of my pedagogy and resilience, with an impact on team dynamics and projects.

Executive Learning Expedition from Thales executives: a start for ME310 Paris

Executives from Thales decided to make a learning expedition and I organized 6 visits to design places (three in design consultancy companies and three in academia) with 5 key learning topics: T-man profiles; IQ/EQ; “I do/I am” versus “I think/I am”; learning from failure; ecosystem.

Discussions, videos and PowerPoint presentations, which are available in the data record, reflected the level of energy and enthusiasm generated. Thales is a technology-driven company with the administrative processes of a large company. The human-centered design approach with quick implementation was an inspiring paradigm shift.

When I returned in Paris, a workshop was organized in June with facilitators from IDEO and Creargie, in order to redesign a vision for Thales, with design thinking principles, tools and space setting. 70 proposals emerged, which were divided into 6 topics. 6 teams of executives conducted these projects for the next 6 months, including 2 projects on design thinking: one on how to disseminate design thinking within the company and the other on the application of design thinking in one area of business.

Given the enthusiasm and promising prospects, the codirectors of strategy, human resources and information systems, who organized the learning expedition, decided to support the launch of ME310 Paris with 5 projects over the next three years, two of them to start the following academic year. The decision was supported by a 25 page document describing the challenge of educating trapreneurs and the benefits of ME310 in achieving that goal.\footnote{Available on data record 2009/2010.}
Back to ENPC

The innovation curriculum for M1 engineering students consisted of a field trip in Silicon Valley in September, a course in the first semester, a one week workshop in February before the second semester, and projects in the second semester in cooperation with ENSCI only. The course of the first semester was run in a business school (ESCP Europe) and focused on entrepreneurship.

ENPC’s dean of studies was prepared to create a common space with a workshop and different project spaces: half a floor was dedicated to those projects with a prototyping room and 50 m² for industrial engineering. The space was well positioned in the main building, with easy access. It was empty apart from some old traditional furniture.

Plan: First edition of Innovacteurs

The plan was to start projects (called Innovacteurs) with a one-week workshop, where students could customize the space and run mini projects of their choice. I returned and ran Innovacteurs projects in the second semester with a design faculty from ENSCI. A 5-day workshop was held with lectures, including one on foresight given by Bill Cockayne from Stanford. The students undertook mini projects before embarking on main projects.

Following the one-week workshop and discussions between teaching team and students, 5 multidisciplinary teams (including design and engineering) and 3 mono teams with only engineering students, were set up. Students could create their teams without any outside recommendations: the view was that students should feel comfortable with the classmates with whom they were embarking on the great adventure of innovation. The students were all invited to learn more about themselves by completing a personality questionnaire (Myers-Briggs), the results of which were processed automatically. Where students asked for it, I gave them personal face-to-face feedback to interpret the results, so that they could take action to develop different aspects of their personality. A dozen requested this and were interested. At Stanford, students are asked to complete this questionnaire and teams are composed in such a way that the four types of personalities are evenly distributed. At ENPC, there were no constraints imposed on team composition for two reasons: first, to lower the risk of students working with people they didn’t get on with, and second, so as not to provide an excuse for poor team performance.

The briefs were redefined by the students on the basis of a 5-page document setting out principles of project definition (a better world, a project you believe in, a project that aims to reinvent products/space/services for sustainability/an industrial entrepreneurship project/a project that applied design thinking principles). They were given a list of projects to be carried out in cooperation with outside designers specializing in sustainability or with consultants (eco-building with a room in the house; space design for decision makers; luxury packaging for sustainability; sneakers for sport; sustainable booths). In this document, similar to a syllabus, students were
also given a list of lectures together with a calendar of milestones for their projects, steps and expectations.

The students chose the following briefs:

- Reinvent the train with airplane standards (multi)
- Reinvent the shower experience in an international student residence (mono but international)
- Reinvent city light for sustainability (multi)
- Reinvent luxury grocery for sustainability (multi)
- Reinvent the kitchen for sustainability (multi)
- Reinvent a space for decision making for a consulting company (mono)
- Stress and commuting (mono)
- Valorization of the pork industry (mono).

The teaching team comprised three members: a design teacher from ENSCI, a researcher in mechanical engineering from ENPC, and myself representing business. The students were given 4 milestones (problem definition, concept generation, business model, communication), with two project reviews and a final presentation. They were able ask the teaching team for additional coaching if required. It was also suggested that in the course of their project, more experts could be contacted, at the initiative of the students or the teaching team. DT principles and values were taught through lectures, with the expectation that students would apply them in practice with projects.

In the 5-page syllabus, students were expected to follow the following process:

- First, they were asked to apply the steps of design thinking, described as follows:
  - Understand the issue or the problem to be solved (product environment, principles of sustainability)
  - Observe users
  - Frame or reframe
  - Brainstorming and concept visualization
  - Prototyping
  - Test and iterate with users

- Second, they should think about a business model: how to buy, produce, distribute, and transport, in order to practice industrial entrepreneurship for sustainability.
• Third, students were asked to do as much communication as possible, preferably through
digital means such as a website and a wiki.

Two dedicated project rooms were available at ENPC, as well as individual spaces and
machine shops at ENSCI.

Expected deliverable: final presentations and a report. Students were graded 50% on the
report, which was graded by the teaching team alone, and 50% on the final presentation, with
the following criteria: “I love it” (‘coup de coeur’), problem statement, creativity, user friendly,
technical feasibility, economic viability, presentation quality. Each team could grade the other
teams’ presentations on this set of criteria. The final grade for the presentation was weighted half
and half between the grade given by students and by the teaching team. The report was expected
to present the results and reflections on the project.

Act & Observe: Concept generation, with (almost) no tangible outcome

The engineering students did not like the business school course which focused on the reading of
case studies and presentations: They complained about the lack of lectures and content.

Brief definition. For the workshop and Innovacteurs, two different attitudes were observed among
industrial engineering students: either interested and committed, or skeptical and reluctant. None
of the design students was able to attend the whole week of the workshop. Only a few showed
up for the introduction. The objectives of the week were to define a project for the rest of the
semester and “to practice DT”. Students could define their own projects or choose one from five
options (defined either by professional designers or the teaching team). Three projects were defined
by students, two with successful outcomes, another one with no outcome. None of the five set
project options was chosen, though they had been defined with professional designers and were
based on real sustainability issues, which was surprising. For us, the explanation was that students
were not interested in sustainability issues. They were no more attracted to working on briefs
defined by professional designers outside the school than by the teaching team. This led us to 2
conclusions regarding student choice: first, sustainability is not attractive; second, defining projects
with students is time consuming. Most students were unable to frame a project. The teaching team
thought that students would be motivated to work on projects they had defined themselves. The
reality was different: first, some students did not work harder and did not feel more empowered;
second, it was hard and time consuming for them to define a brief; third, students did not have
a “gut feeling” for the projects, and only jumped on the bandwagon to define their own brief.
Asking students to choose their projects is risky: it takes them a lot of time and sometimes the
direction of reframing lacks promise. It is not a guarantee that students will be more motivated
to complete their projects.
The teaching team should be responsible for framing briefs, in order to save time and to meet pedagogical objectives. Students do not feel more empowered when they define their own projects. The better framed a project is, the better the output.

### Table 32. Classification of Innovateurs’ projects 2008/2009

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main observation</th>
<th>Project outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shower experience (inter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City light (multi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luxury and sustainability (multi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen (multi)</td>
<td>Students did not work hard. They pitched a lot very simple ideas. They had so willingness to reframe. One did not know whether they are authentic.</td>
<td>Concepts were poor and made people laugh to the point it was embarrassing. No partner came to presentations.</td>
</tr>
<tr>
<td>Space redesign (mono)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress and commuting (mono)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pork industry (mono)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Briefs on public and private space (urban space, transportation and even a room in a house) are the most complicated for design thinking: it is hard to do needfinding. It is impossible to do real tangible prototyping, let alone to test in real contexts. Prototypes can take the forms of drawings with a storyboard of how people experienced the project. Static drawings with no experience should be avoided in teaching design thinking. At best, a video with a Wizardoz can simulate the ideal experience in the space. It is thus hard to test it with users.

**Team commitment.** Team dynamics between engineers and designers were very different during projects, ranging from desertion to strong commitment and great cooperation. At the beginning of the projects, the multidisciplinary teams were highly motivated to work with different backgrounds. As time went on, some designers deserted through lack of motivation. Engineering students felt greater ownership of the project. Three factors may explain this: first, there were more engineering students than design students and they represented a whole cohort from the same department, which created a sense of competition. Second, this kind of project has a strong impact on curriculum and grading. Third, the projects were under the authority of the Department’s academic director, which raised the stakes and the pressure. The previous year, the design students working
on the water bottle had also felt empowered following an introduction by the design school’s director at the kick-off event.

Team commitment has a strong impact on the quality of thinking and outcomes. Students are more committed when they feel real issues from real people, especially when pressurised by a local figure of authority. Broad abstract issues, even if highlighted at the beginning of a project, do not drive and empower teams as much as local leaders.

**Team performance.** Teams produced very different outputs, in terms of sense making, quality of presentations and reports, and the level of intellectual refinement. Three mono French teams (6, 7, 8) were demotivated and provided poor results in terms of sense making and deliverables. One mono international team (2) was committed and delivered interesting results. One multi team (4) achieved interesting results (despite the desertion of designers), one multi team (3) achieved average results (with average commitment on both sides) and another (1) outstanding dynamics and results (with high commitment). No team reached the making stage (except one with high definition packaging and another with a very low definition soap dispenser), beyond PowerPoint presentations. The grading by the teaching team and students was very similar. There was no argument between members of the teaching team about which projects were good and which were poor. Some projects did not make sense in the “what” and the “why” to the point it was embarrassing at final presentations (pork, space, commuting, eco kitchen). The quality of final presentations and reports are two further criteria, in addition to sense making. Last but not least, students were encouraged to create prototypes, with the highest possible level of definition. Team performance is measured on the 4 criteria: sense making; final presentation; report; prototypes.

Sense making (versus none) emerged as the first criterion of performance. Multi and mono teams can perform equally, in terms of sense making and quality of deliverables.

The multi team working on **train travel** spoke in unison at the final presentation, with an outstanding concept (augmented reality in train windows to get information about the landscape and regions), a very high level of outputs in terms of slides and report, and a lot of positive feedbacks about the learning experience between design and engineering students. The latter enjoyed the space, the ambience and the mindset at the design school. The design students appreciated the quality of thinking and commitment of the engineering students. The team worked exclusively at ENSCI with very regular meeting points and shared work. One student stepped into the shoes of a train passenger and lived the experience as if were real. At least one student did extensive needfinding on trains. Given the concept, the prototype was a video with a wizarddoz of good quality. These were impressive outcomes. Students tried to contact train operators to test their concept, but failed to do so. Tests with users were limited to the class during final presentations, which gave very positive feedback. Technical feasibility and economic viability were explored, without extensive studies.

The international team working on the showering experience in the international student residence in Paris did outstanding needfinding with a lot of pictures, interviews and an experience
curve, which brought a lot of insight. A solution was generated so quickly that the team became stuck with only one idea. The designer in the teaching team helped them to unlock their imagination and find many new ideas by working on images and analogies: students were asked to select images that inspired them and then to discuss why they were inspiring and to apply those findings to their project. Students found a more comprehensive solution for the shower and more small ideas to improve the whole experience. They tested ideas with other students who were interested in adopting them. They felt very frustrated at not knowing how to implement their ideas: who could produce the appliance for the shower? Who could operate it? They suggested that this kind of project could interest companies like L’Oreal, but with no strong personal conviction. They did not make any contact with companies and real stakeholders, such as the facilities manager for the student residence. The report and presentation were of good quality. A quick-and-dirty prototype was made.

The city light team found it hard to narrow such a broad topic down. They set up a blog (experiencingthestree.worldpress.com) to share their thoughts and experiences in the street. They removed 5 topics and voted for one: how to improve urban lighting for sustainability? They conducted an analysis of perceptions of the street in the day versus at night. They clearly identified the issues and conducted a survey on the expectations of people around them: the conclusion was that people perceive the city as having too much light and do not know which color they prefer. They conducted a benchmark of existing technologies and the benefits in terms of sustainability and the range of possible colors. They contacted two real-world stakeholders for reality checks, including a company in the sector. They presented a product with the user cases, technical feasibility assessment, cost/price/market estimates, and elements of communication for marketing.

The team working on luxury and sustainability had trouble in finding a sense making direction because of the breadth of the topic: luxury packaging and sustainability. By interviewing experts (Edouard Malbois from a specialized food design company and a seller of luxury brands), they came up with the idea of luxury packaging for tea breaks. The designer quickly deserted the team, which was exclusively made up of female engineers. At the first project review, the team did not dare to express their sensibility and gave extremely analytical presentations and views. I asked them why (because it looked to me as though they had other talents) and they answered that they were afraid to be “too artistic” in an engineering school with their classmates, especially after the designer had left the team. I encouraged them to draw on their sensibility and artistic style, in order not only to find ideas, but also to give them form. The outcomes were beautiful, in terms of presentation (both for the report and final presentation), packaging, graphic design, forms and color of chocolate cakes, and in quality of expression. The team contacted a number of possible outside partners: a baker made the chocolate cakes; a luxury food retailer (Hediard) was interested in selling them in their stores, should they produce them; a design expert gave them legitimacy and approval.

The four other teams (kitchen, pork, stress and commuting, space redesign) were embarrassing in terms of sense making and deliverables: no one, not even the teams themselves, believed in what was suggested and delivered.
In the ecokitchen team, the three engineering students (from the most prestigious track in the school because these students came from the France’s leading engineering school) were males and the three design students were females: two of them failed to grasp design thinking during the field trip in Silicon Valley. They “imagined” concepts in a design way, with drawings and breakthrough thinking, without a reality check from users and experts in the field. They did a better job in pitching their ideas and making drawings. It was obvious that none of them had done any needfinding in the field: they frequently argued that “they knew all about kitchens as they are such simple objects”.

For the other teams, it was a catastrophe. The pork team just wanted to turn it into a joke and presented a communication bus in the form of a pig. The space redesign team argued that they could not interview decision makers in order to find out their needs (and did not even contact the consultants who provided the brief); they presented a quick-and-dirty small prototype; the consultants asked them to produce a buying list and to find interior design suppliers; having a real partner with real needs and objectives was not a plus factor of motivation for these students: it was more a way to avoid the teaching team’s recommendations and instructions, by arguing that it the consultants had not asked for it. The team working on stress and commuting thought that the day-to-day experience of commuting was enough to know the subject and did not bother to take pictures or conduct interviews; they presented XXX. No reframing of the problem was done for any of these projects. The teams believed that the value of the project was to generate concepts original enough to be felt as “weird”: it was a way for them to pitch the disruptive aspect of their project. None of these teams generated any interest in the jury or real people outside or potential stakeholders or users. There was a flagrant lack of sense making and appropriateness.

Sense making is the first criterion of team performance. The ability to conduct needfinding in the field (by observing and interviewing both users and relevant experts) has a strong impact on sense making.

None of the teams used digital communication methods or looked into the business model aspects, as recommended in the syllabus. When there was an attempt at needfinding, there was no presentation of data collection and insights: it was used only to fuel ideas. Only two teams (luxury breaks, shower) did a prototype and tested it with users and/or experts before the final presentations.
<table>
<thead>
<tr>
<th>Project name</th>
<th>Outputs</th>
<th>Reflection to teach design thinking</th>
<th>Identified problems</th>
<th>Reflection on the culture of design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train experience (multi team): augmented reality on windows.</td>
<td>Sense making breakthrough concept and presentation. A Wizardoz prototype with a video was efficient.</td>
<td>Needfinding had an influence to frame the problem and generate a sense making direction.</td>
<td>The brief was broad and risky to teach DT. The concept was so breakthrough that technical feasibility and economic viability were difficult to find out.</td>
<td>Students allowed themselves to imagine and visualize a great ideal experience.</td>
</tr>
<tr>
<td>Shower experience (mono, but international team): a hotel of beauty.</td>
<td>Students explored their subject by observing problems in their daily life. They did the most extensive needfinding, a few prototypes and could test them with other students.</td>
<td>Access to the field allows needfinding and user tests. The nature of artefacts allows real prototyping. It is fruitful to teach design thinking.</td>
<td>No transformation of the real situate could be carried out without authorization of stakeholders.</td>
<td>Unlock creativity with exercises in imagination was an added value of the culture of design.</td>
</tr>
<tr>
<td>City light (multi team): a new light system.</td>
<td>Students did observations in the street and imagined a new way of lighting. No prototype tested.</td>
<td>The nature of the project does not allow real prototype. A wizardoz with simulation should have been recommended.</td>
<td>Urban space is difficult for needfinding, prototyping and testing.</td>
<td>The extended culture of the coach in design was helpful to reframe.</td>
</tr>
</tbody>
</table>
Luxury breaks
(multi team):
packaging
and cakes.

Students interviewed
experts, users, did
many prototypes,
including two final
ones with outside
experts. Reframing
from a broad topic
was great for DT.

The nature of
artefacts allows
real prototyping. It
is fruitful to teach
design thinking.

Neefinding was
difficult because
it entails entering
private homes
with specific
users. Prototype
appliances and
partnership with
a company were
needed to go
further.

Graphic design
could have
helped to
enhance outputs.

Eco kitchen
(multi team):
a place on a
boat.

Students did not
do any needfinding
and produced a ppt
with drawings. No
prototype tested.

The concept was
too familiar, broad
and ambitious.
Detailed drawings
and a simulation
are the best
prototypes and
outcomes that can
be expected.

A space with
ambitious elements
is too complicated
to prototype.

Students were
inspired by
original concepts
from the design
coach.

Three kinds of prototypes emerged, which can be produced on this kind of intermediate
course and reflect the nature of different artefacts: quick-and-dirty or more refined prototypes
for small objects; wizardoz prototypes with a video for experience and objects, which are too
complicated technically to prototype within the framework of the course.

**Influence of place.** As a teaching team, we noticed how the place where we held the kick-off
and project reviews could influence team dynamics: students of the school where we were felt
more responsible for taking the lead during the presentation and Q&A; the students listened more
to the types of arguments emanating from the discipline of the school where the meetings were
held; students develop more in the project and were better at tolerating stress; students told us that
one discipline would take the lead depending on the place where the project reviews were most
frequently held. We were surprised by this outcome, since we shared feedback time in project
reviews equally between the two of us. In brief, we noticed the influence of the place where
meetings were held: the more meetings we had with students in one school, the more students in
that discipline took the lead. In addition to this observation, some teams decided to work together
at ENSCI because of the atmosphere and facilities. Meetings with the teaching team were held in
the ENPC space, but students were not attracted to work there. The space furnished with ordinary furniture, with no factor of attractiveness. In conclusion, two main observations were made:

- First the influence of the location of meetings with the teaching team: it has an impact on who (designers versus engineers) takes leadership of the project;
- Second, the importance of the staging of the place for whether or not students were attracted to go there: no attractive staging = no student in the place, even if it is available.

The place where meetings are held has an influence on team dynamics, in terms of which team gains ascendancy over the other. Staging governs whether a place is attractive or not.

**Multidisciplinarity.** The four multidisciplinary teams had very different dynamics: in the luxury break, the designer deserted “because it was not design”; in the ecokitchen team, the fact that the designers did not think about going in the field for needfinding was a relief to the engineers who did not want to do it, “because the kitchen is so obvious” (as they answered when I asked them why they did no observation and no interviewing for needfinding). The train team combined both processes (of design thinking and the culture of design) with respect and mutual enrichment, which was rare and outstanding. However, they paid no attention to technical feasibility and economic viability: exploring a brand-new concept was the priority for the whole team. The engineering students wanted to adopt a design mindset. The city lighting team generates an interesting dynamics of complementary skills and mindsets, in terms of thinking (analysis, brainstorming, assessment of solutions), which could be felt in the report.

The teaching team learned how to work and coach together. In this second year, a new member joined the two-person team from a mechanical engineering background with no training in design or DT. It was a challenge to be effective with the teams: feedbacks from different perspectives with a common direction is key to effective team management, but hard to do. My two colleagues were harsh in their feedback and I tried to maintain motivation by emphasizing strengths and interesting avenues of exploration. My colleague in mechanical engineering was more critical than supportive, although open to a new way of driving students from different disciplines. She found it hard to find her place: technical feasibility was not the first priority and she understood neither the culture of design nor the culture of design thinking. My colleague in design provided inspiring input because of his broad educational background. Students were sometimes unable to understand his way of reframing or his sources of inspiration: I had to make links with the project for students to understand why it could be interesting to explore or consider his inputs. I realized that if I had maintained my focus on business models, it would have been an unreal exercise for students and would have not brough added value for how to implement the project. It was already very difficult to make students do needfinding and prototypes, as well as reframing. I realized that following the outcomes of those activities was more my responsibility than inviting students to think about business models on projects that did not make any sense.
I could feel that the culture of design as advocated by my colleague in design, was different from the culture of design thinking, for example in the following respects:

- An appetite for comparing viewpoints rather than a shared search for what makes sense
- No interest in needfinding was the most obvious difference: inspiration comes from everywhere and particularly from the designer rather than from the outside and users
- A quest for a different look on things (“regard décalé”) versus a quest for reframing to match a given situation
- A stress on using the imagination to find breakthrough and original concepts and making them visual with drawings versus a stress on finding appropriate solutions that can be implemented in a given context
- Pitching big ideas rather than implementing small ones
- No process or tools given to students: each project is unique and designers have to create specific processes and tools for each project

There was a conflict of references, both among the students and the members of the teaching team: the culture of design is different from design thinking. The engineering students did not understand design thinking sufficiently to explain it to design students, who did not believe in the key concepts (the value of getting into the field and testing prototypes with users). The course was not promoted to design students as a course in design thinking: it was promoted as a course that brings together students from different backgrounds with different points of view and processes. “The confrontation of points of view and methods” was supposed to lead to fruitful collaboration. The syllabus given to engineering students was not transmitted to design students, who thought they knew more about product design. No common language was created or even encouraged between designers and engineers. The lack of an agreed process or tool was an additional source of looseness, debate and tension, because no one have a clear idea of what had to be done.

My role was not to represent business in a multidisciplinary teaching team and stress how to implement in terms of business model thinking, but to enhance the student experience in design thinking. At that time, I identified three key elements of the process: needfinding, prototypes for user testing, storytelling.

**Sustainability.** At that time, I did not completely give up the idea of introducing the issue of sustainability: I not only looked for briefs with sustainability at their heart, but also suggested that this dimension should be incorporated into the projects. The students showed no interest in these briefs, which was disappointing. For the three interested teams, it was an added factor of complexity, as the students did not know how to interpret it: the luxury packaging team decided
that the packaging should not be thrown away; the ecokitchen team decided to introduce the idea of a kind of circular economy; the city lighting team assessed the impact of the technologies and solutions chosen in terms of energy consumption. It was the only team that came up with a solution that combined the user experience and reduced electricity use.

Best outcomes from three different projects (1: train traveling 2: shower 3: city light 4: luxury snack)

- Sense making analysis, with stakes and analysis of context (1, 2, 3, 4).
- Needfinding: observation with real pictures and verbatim (2, 3); a personal experience for 1).
- Promising reframing (1, 2, 3, 4).
- Concept generation in quantity, craziness and flexibility with definitions of facts / objectives / scope / constraints / criteria of selection (1, 2, 3, 4, 5).
- Two reality checks with contacts with two different real stakeholders (3, 4).
- A final prototype of a good quality: wizardoz for the experience of a transportation service (1), a packaging (4), a snack made by a professional baker (4).
- Benchmark of existing technologies and technical drawings for technical feasibility (3).
- Assessment of the ecological impact of the solution (3).
- Communication: a brand and a logo (3, 4), a one-page brochure (3), tagline with user benefices (3, 4).
- A short realistic business plan with evaluation of number of buyers, rough production cost, rough estimate price given existing reference points of an existing company (3, 4).
- Quality of the presentation and the report: esthetics, clarity, quantity, bibliography (1, 3, 4).
Reflect: Emerging pedagogical issues for the teaching of design thinking

Pedagogical priorities for teaching multidisciplinary teams and design thinking started to emerge from this first year of experience:

- Brief definition: Who defines it? How? The teaching team should be responsible. Broad topics are time consuming and jeopardize the other activities in the process. The nature of the brief influences the way students think and the outcomes;
- Influence of place on team dynamics: what impact?
- Definition of criteria for team performance: sense making, final presentation, reports, prototypes. What other criteria could be identified?
- Access to the field is key for needfinding and testing with users: should it be a pre-requisite for a project? How to prepare access to the field?
- The impact of needfinding on sense making: how to make students do needfinding?
- The impact of stakeholders’ reactions. It gives legitimacy to a project, belief and pride to students: should real-world partnerships be a condition for projects?
- The nature of prototypes depending on the nature of artefacts: objects versus service versus space: should this be specified at the beginning of projects? Should it be the same for all students? What prototypes can students be asked to produce?
- If implementation depends on outside stakeholders and there is no possible influence, it is a limiting factor on project development; only positive feedback can be expected to give a project legitimacy and credibility: how can we help student go further in terms of thinking about how to implement?
- Design and design thinking are different, in terms of values, process and performance criteria. Teaching both is difficult: Is it possible? Is it advisable?
- Organizing and running multidisciplinary teams with a multi TT is time-consuming and difficult for both teaching teams and students: is it worthwhile for teaching design thinking?
- More instructions on assignments prevents students arguing about what to do;
- Too many projects with too many directions represent a high risk for the quality of coaching (reviews too long, no expertise, no insightful feedback): what expertise beyond design thinking should the teaching team have in order to steer teams effectively?
- I feel differences in the culture of design in Silicon Valley and in France, including a stress on the value of making versus abstract concept generation: call for action is not enough to push teams into making. How can they be convinced? Is it better lecturing?
- Lecturing on a process does not mean that students will follow it, especially when the teaching team does not remind them all the time and does not share the same vision.
**Improve: Explore real challenges with companies and Stanford**

The decisions to improve the learning experience were as follows:

- Stage dedicate space with 9 milestones discovered in the Silicon Valley
- Find sponsorships from companies to be part of ME310 network
- Create a coherent curriculum with a field trip / a course / capstone projects
- Drop thinking of business models and concentrate on exploring design thinking activities
- Develop new lectures to explain DT better: Convince first, then action
- Work on briefs
- Explore ambitious capstone projects with real partners and stakes with or without sponsorship
  - Explore the ME310 Design Innovation syllabus based on a field trip, paper bike competition, a series of prototypes and three phases: make it up / make it real / make it happen
- Explore multicultural partnerships
- Do it with people who want to do it, instead of pitching to people who do not believe in what we do
2008/2009: Learning about a culture of design thinking

**PEOPLE**

At university level, I used the T-man shape so popular at Stanford to explain what we were doing (34). I used Cross’ analysis of the design culture to create the manifesto of our values (23) which I promoted through PPT lectures. I used the notion of epistemologies (42) to explain the differences between the cultures of engineering and design, especially by explaining the differences between positivism, constructivism (43) and pragmatism (44). I was influenced as much by the culture of design and designers (51) as by the culture of DT. During my stay at Stanford, I was greatly inspired by people: Larry Leifer (48), Banny Banerjee (49), David Kelley (47). I realized the value of community (46) in gaining faith in what I was doing. The work of Andrew Hargaden, who studied IDEO process and teams with Bob Sutton from the business school at Stanford, had a strong impact on my thinking by stressing the capacity of innovators to bridge small words and build new ones: he called them technology brokers (56), though the notion of technology is broader than technical issues.

Great students know what to do and perform well, even with loose instructions. High commitment and hard work are key factors of success. Students with low commitment pitch and defend their ideas, in order to hide a lack of sense making, field work and effort. Mono discipline teams can be more efficient in terms of teams’ dynamics, reframing, sense making and thinking of how to implement.

**PROCESS**

I discovered the necessity of embracing ambiguity (59), the difference between well defined and wicked problems (61), the importance of brief definition (63), DT brief (64), user center design (66), foresight (74), function/affordance (77), the art of observation (79), visual thinking (73), brainstorming rules (89), the use of post-it (90), how to learn from failures (100).

Process is still believed to be about mixing different disciplines. The second process experienced was structured with three steps provided: design thinking activities, thinking of business models and communication. The introduction of specific design thinking activities (neediting, prototyping and user tests) in the process has qualified results: the design students did not always accept it and the engineering students did not always do it. Students did not think about business models or explore them in depth: this is not the focus of either design thinking or the culture of design; it represents too much work for small courses.
The lack of a common culture between designers and engineers seemed to be the main problem for teams’ dynamics: It creates misunderstanding, conflict and low commitment, which may end up with low levels of performance (lack of inquiry and solution search).

PLACEx

I discovered the spirit and energy generated by a properly staged space from Stanford (1) and the d.school (3), as well as studio/garage/loft (8). I understood the link between space and mindset (7). I identified 9 milestones (9) in how to stage innovation space through the visits of a dozen places in the Silicon Valley: 7s shop (10), project space (11), fun space (12), kitchen (13), Zen space (14), brainstorming room (15), library (16), material library (17), living room (18), red sofa (19).

Dedicated space should be staged to be attractive and contribute to create a specific mindset and activities related to design thinking.

Table 34 describes tipping points I discovered in 2008/2009 to learn about a culture of design thinking. Numbers refer to the pages in the book343, which provide a full description for each concept.

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>PLACE</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manifesto of our values (23)</td>
<td>d.school (3)</td>
<td>Ambiguity (59)</td>
</tr>
<tr>
<td>T-man (34)</td>
<td>Space and mindset (7)</td>
<td>Wicked problems (61)</td>
</tr>
<tr>
<td>Designers (51)</td>
<td>9 spaces (9)</td>
<td>Brief definition (63)</td>
</tr>
<tr>
<td>David Kelley (47)</td>
<td>7s shop (10)</td>
<td>DT briefs (64)</td>
</tr>
<tr>
<td>Larry Leifer (48)</td>
<td>Fun space (12)</td>
<td>User center design (64)</td>
</tr>
<tr>
<td>Banny Banerjee (49)</td>
<td>Zen space (14)</td>
<td>Foresight (74)</td>
</tr>
<tr>
<td>Epistemologies (42)</td>
<td>Brainstorming room (15)</td>
<td>Affordance (77)</td>
</tr>
<tr>
<td>Constructivism (43)</td>
<td>Library (16)</td>
<td>Art of observation (79)</td>
</tr>
<tr>
<td>Pragmatism (44)</td>
<td>Material library (17)</td>
<td>Visual thinking (73)</td>
</tr>
<tr>
<td>Community (46)</td>
<td>Living room (18)</td>
<td>Brainstorming (89)</td>
</tr>
<tr>
<td>Technology brokers (56)</td>
<td>Red sofa (19)</td>
<td>The use of post-it (90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to learn from failures (100)</td>
</tr>
</tbody>
</table>

Conclusion: Is it useful? Is it adaptable? Is it transferable?

Design thinking is useful in changing the outcomes of a course, and in changing values and student activities. As presented in Hillen and Levy (2013), student outcomes have been transformed from concepts arising from abstract analysis and presented through PPT presentations into tangible prototypes based on needfinding and testing with users, together with potential implementations that create value in real-world contexts. Educating multidisciplinary teams with design thinking creates a common language, the “glue”, in which the focus is on making sense for the people one wants to innovate for and the bias is towards action by quickly and cheaply delivering something that is useful to them. A DT course represents a shift from problem solving and function analysis to the concept of affordance and relational design theory (Maier and Fadel, 2009).

A DT course represents a shift from knowledge dissemination with right and wrong answers to situated inquiry for adequate solutions with a positive impact, from positivism to constructivism (intent driven with a positive impact), phenomenology (situated inquiry in interaction with people in a given context) and pragmatism (action-biased with quick delivery). It has the potential to bring about an epistemological paradigm shift in higher education. It also shifts the role of faculty from authoritative experts to learning facilitators (Hummels and Vinke, 2009).

The main lesson I have learned (Hillen and Levy 2013) is that developing DT pedagogy involves becoming a self-reflective practitioner in order to become a professional (Schön, 1983). Two additional lessons are that design thinking should be approached as a transdiscipline (and not as a compilation of multidisciplinary approaches) and be taught with cultural adaptations.

The conditions of success for the transfer of a design thinking course to cultural contexts other than Silicon Valley should nonetheless be taken into consideration:

- The pedagogy of design thinking as taught at Stanford and practiced in Silicon Valley needs to be adapted, not so much in terms of content (e.g. values, process or tools), but more importantly in terms of how it is taught. In France, people need to understand the what, the why and the how before moving to action;
- One needs to protect oneself from emotional reactions by skeptics people by developing professionalism and self-reflection through a structured protocol;
- The conditions (people, place, process) need to be carefully set up in order to reduce the


risk of student failure, and to make the pedagogy demonstrative and attractive, as well as to ensure medium and long term development;

• It needs to be labeled “design thinking” in order to avoid confusion with multidisciplinary approaches that do not convey the spirit, method and tools of design thinking. Design thinking should be recognized and taught as a shared transdiscipline, not a multidisciplinary approach.

Last but not least, People Place Process is a useful and transferable conceptual framework on which to base the development of a course in design thinking: it obliges faculty to consider the conditions needed and to stage an adequate learning experience for innovation teams. As described in Hillen and Levy 2013, it is useful for faculty to begin by setting up a course in order to acquire the necessary skills as staging directors, curriculum designers and course instructors. The recommendations for a course are as follows: 50 m² of dedicated and staged space with 9 points of reference/ideally a maximum of 5 teams of 5 students with 2 instructors/no partner or a local partner with direct access to the field and no real-world stakes/brief on defined objects, context and users/use of existing tools and teaching materials, such as the design thinking toolkit for educators, bootleg bootcamp, Innovating for people, Design works, etc.. There is no need to run multidisciplinary teams, as they are time-consuming to set up, team dynamics and cooperation with faculty from other disciplines are always a challenge, as well as a source of misunderstanding and tension.
7.2. Second historical era from 2009 to 2012: How to Develop a Global Program

2009/2010: A first year of international collaboration

Situate: A garage style

A new president, CEO of a supply chain consultancy company, is appointed to head ENPC’s Industrial Engineering Department. I set up ME310 Paris, thanks to a partnership with Thales on two projects (in addition to one project provided by Stanford with Pioneer) and the recruitment of a ME310 alumnus with an engineering background. In addition to ME310 and my position as an academic director, I am in charge of three courses at ENPC: ecobootcamp, Innovacteurs and corporate strategy.

A double degree agreement is signed between ENPC and ENSCI.

The industrial engineering innovation curriculum is structured over two years, as are all curricula at ENPC when students enter a department: in the first year, all M1 students from the industrial engineering department (called “GI” – “génie industriel”) have to follow the track in innovation, which consists of one course in the first semester (called “ecobootcamp”) and capstone projects in the second semester. During that year, they combine this track with a range of other courses, either compulsory or elective. In their second year in the department, they can choose from different tracks, either at the school or abroad. These numerous possibilities include the option of ME310 Paris. This new track in innovation is elective and open to all students at ENPC, not only GI students. It is in competition with many other options. Most students interrupt their studies between this first and second year in order to work in a company.

I run ecobootcamp with ME310 alumni from Stanford and Innovacteurs with the same coach at ENSC as the previous year. I run a corporate strategy course on my own.

GI students from the 2009/2010 academic year did not do a field trip to Silicon Valley but to Barcelona, with visits combining innovation and supply chain. The course in innovation is named “ecobootcamp”, the label used at Stanford for introductory courses in design thinking. Ecobootcamp includes mini assignments and a case study on eco innovation. The students are given additional assignments before the project: description on how they do their Christmas presents with 5 main questions; pick a picture of a shoe and describe it; pick a picture of a place that can rejuvenate your body/mind and spirit and describe it. The purpose of the first assignment was to gauge their level of empathy; the purpose of the second was to understand the multiplicity of different perspectives on an object (engineering, commercial, artistic, daily life, empathic …);

Analysis in 2009/2010

the purpose of the third was to help them understand the importance of place for self-reflection
and state of mind.

Table 35. General metrics for grading in ecobootcamp

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Incomplete</td>
</tr>
<tr>
<td>1</td>
<td>Mostly irrelevant and missed the point entirely</td>
</tr>
<tr>
<td>2</td>
<td>Completed with minimal effort</td>
</tr>
<tr>
<td>3</td>
<td>Adequate but lack of surprise and proactivity</td>
</tr>
<tr>
<td>4</td>
<td>Beyond expectations of the teaching team</td>
</tr>
<tr>
<td>5</td>
<td>Superb! Well beyond expectations and strong impact on the audience: you did it!</td>
</tr>
</tbody>
</table>

ME310 2009/2010 was set up with a generous donation by Thales, which sponsored two
projects, and Stanford’s expression of trust in bringing a partnership with Pioneer. The two projects
with Thales were carried out with the Design Factory in Finland and the Pioneer project with
Stanford. A dozen students were recruited from 3 engineering schools (Polytechnique, ENPC,
Centrale Paris), one business school (ESSEC) and one design school (Strate College Designers)
without recruitment procedures, upon recommendations by teachers in those schools.

Plan: Develop a new track for intrapreneurs

ME310: An expert multi cultural program with Stanford network and companies

Three projects are set up for the academic year 2009/2010:

- Redesign a helicopter cockpit with Thales Avionics
- Redesign a social networking device with Pioneer
- Define a new use for a flock of small drones with Thales Underwater Systems

A 25 page document was produced on the why, the what and the how of such a program,
the aim of which was to educate intrapreneurs in order to rejuvenate large companies with a
new offering of products and services. My view was that sustainability should be leveraged
for strategic renewals.
Extract: Description of planned ME310 curriculum to educate intrapreneurs

Start with a clearly stated problem. Define and redefine the problem, then find solutions, test them concretely and retain the ones that are most effective in terms of benefits created for users, and finally develop an operational prototype by incorporating and developing the technological bricks needed to achieve the desired performances. The process breaks down into the following activities:

- understanding what the problem is, through empathy, analysis and observation
- redefining the problem
- generating alternative concepts (ideation)
- creating prototypes
- testing them in real world conditions

The process is at all times iterative – and never linear. It therefore includes analysis, definition and constant redefinition of the problem, creativity, concept visualisation, and immediate in situ implementation. The process alternates between phases of divergence and convergence from a fixed point constituted by the clearly stated problem.

Learning how to state a problem by empathy, observation, and analysis

This skill the students will develop will be to be able to state a problem through the development of a savoir-être (life skills) based on empathy, know-how based on observation of the uses of a product or a service in order to define a radically new offering, knowledge based on the analysis of historical trends as a forecasting tool (relating both to technical changes and sociological trends).

The goal is to find the “right” specifications at the interface between user value, technical feasibility and economic viability:

- What benefits does the solution offer users? (So-called “users/usability” dimension)
- What is the technical feasibility of the solution in terms of technological integration? (So-called “technologies/feasibility” dimension)
- What are the economic conditions needed to make this product in a way that gives consumers satisfactory value for money? (So-called “business/viability” dimension).

At the heart of the questioning process is empathy with users: quantitative market analysis is contrasted with qualitative needs analysis and physical in situ implementation of the product in its environment of use. This is a so-called “user-centric” approach, i.e. one that focuses on the users of a product or service. In order to capture uses and users, the main quality that must be developed in the students is empathy.
Empathy is the faculty whereby an individual can, in a neutral fashion, understand the deepest emotions and feelings of another person, through a capacity for projection into their lived experience. Dev Patnaik, who teaches the famous “needfinding” course on the Stanford Masters program in design, and Peter Mortensen, from the Jumps Associates agency, have just published a book called “Wired to Care” which demonstrates how empathy is the most important faculty needed for our organizations to prosper, both in grasping outside trends (major changes which may affect the organization, its customers or users), and in creating an internal culture that maximizes employee motivation. This faculty of empathy is considered to be a major characteristic of the most charismatic leaders.

The observation of users as a primary source of value

In order to start from a well stated problem, the process of innovation is anchored in a deep understanding of the context in which the products or services are used, through a field analysis based on observation. The aim is to understand how the product or service is used, in what situations, the nature of the perceived constraints, the problems generated, the dissatisfactions as well as the expectations and benefits experienced by users at all possible levels: physical, functional, emotional, symbolic, even philosophical (in particular if use of the product is linked with the identity of the person who, through the project expresses a desire, a dream or a personality trait).

In markets that have reached saturation point, in order to avoid the trivialization of product ranges, and the ferocious price and cost competition that ensues, companies need to differentiate their products and services with so-called emotional brands, which affect individuals in their sense of identity. With these products, the perceived value is such that consumers are ready to pay a bit more. Marc Giget calls this the quest for “very high added values”. Through observations, students must be able to understand the what and the why of the use of a product or service better than the user herself, and go as far as possible into these VHAV. To do this, the situation in which the product or services used must be understood precisely.

The analysis of the context at different levels, including the immediate physical and situational context, people, activities, objects, actions, time, objectives, feelings, is a way to understand the meanings and significance associated with attitudes and behaviours. That is why these methods of observation are called ethnographic. They draw their inspiration from the ethnographic skill of observing living populations in their original context without influencing the course of action, in order to understand mechanisms, behaviours, language, culture... There are more than fifty of these methods, the choice of which depends on the situation and the object observed. The methods of observation vary and are classified into several categories (participant observation through presence...
in the real-world situation; nonparticipant observation via film, photographs, sketches; ethnographic interviews in the field; passive observation; “nethnography” using the Internet to collect data), as are the results (discovery reports, storyboard). The master of these methods is the world’s greatest design studio IDEO, based in Palo Alto, whose founder David Kelley set up the famous d.school at Stanford University in collaboration with the founder of SAP, Hasso Plattner. Students must learn to handle these methods in order to define problems precisely in relation to a given context.

Empathy is an antidote to a world of abstraction.

Faced with a deluge of information, people like to boil things down. This puts them in danger of making poor decisions based on incomplete or distorted information.

Dev Patnaik & Peter Mortensen

p.19: Wired to Care, 2008

Analysis of so-called big trends

Armed with the data generated by observation, students must then navigate from this concrete level to a level of abstraction:

- in order to synthesize and identify the strong ideas that emerge from the observations
- in order to incorporate environmental dimension into the problem data
- to challenge either the starting or the external hypotheses
- to reposition the data in a wider context (historical, sociological, cultural…)

Students are exposed to a large volume of data of different kinds, which they must handle and convert to a concise and logical form, both in terms of their observations and in terms of the analysis of the trends underlying their investigative field, as the problem needs to be repositioned in a broader context, with two primary objectives: to feed inspiration, and to grasp changes.

In the tradition of the French futures school, as defined by Bertrand De Jouvenel and Gaston Berger, a set of tools has been established by professors Tamara Carleton and Bill Cockayne of Stanford University to analyse technical, sociological and human trends, and to think about possible futures, by devising the most probable scenarios: demographic trends, urban trends, sociological trends, technological trends, historical trends, notably in relation to the history of begin venture’s and breakthrough products which have been highly successful on the market. Analyzing these trends enables students to put their observations in perspective, to make logical deductions about future scenarios, and to base their quest for new concepts on major changes with
promising prospects.

Including the environmental dimension means taking into account a number of elements possessing a high degree of abstraction: the evolution of a sector, of technologies, of modes of production and consumption, life-cycle analysis tracking the life of our industrial products through the whole process from the extraction of the raw materials, transportation and production, up to recycling, criteria for measuring environmental impact, balance and analysis, optimisation tools... Incorporating an environmental variable into the complete reinvention of systems requires one to understand and define what this notion means in the given sphere. The objective is to tackle real problems as they are and in their totality through multiple variables that will be reference points for generating revolutionary alternative concepts.

Students must develop their capacity to quickly acquire the most up-to-date knowledge on what sustainable development means in that given domain, to organise it logically, to grasp its major priorities and trends, to deduce the most probable scenarios for a number of variables, to examine and re-examine the hypotheses that they have formulated or identified in key areas, and to draw on the analysis of connected fields to find sources of inspiration and generate alternative concepts.

**Between imagination and creativity**

Creativity makes it possible to find original solutions to an identified problem, imagination to project oneself into a universe that does not exist but is desired by an individual who finds in it compensation for the perceived constraints of existing reality. In order to imagine, one must be creative, but one can be creative without imagining new worlds, because it is a long journey to be able to create and project a parallel world. Creating a new, breakthrough product requires one to possess these two faculties.

“Imagination is not fantasy, nor is it sensibility, difficult though it would be to conceive of an imaginative man who was not sensitive.

Imagination is a virtually divine faculty that apprehends immediately, by means lying outside philosophical methods, the intimate and secret relations of things, correspondences and analogies.”


The methods of creativity are numerous. The objective is to generate ideas in quantity and variety. By contrast, to say that there exist “methods of imagination” sounds like an oxymoron. However, we can draw inspiration from style exercises in literature and from some used by designers (such as responses to the meaning of images/
photos selected by students on a given theme, a method proposed by C. Gaubert/ENSCI and tested in InnovActeurs on a team thoroughly made up of student engineers, which gave very good results).

Students will be encouraged to practice creative brainstorming as often as possible throughout the year, with different aims at different stages. They will be taught by Paul Hubert de Mesnards, an engineer pianist who will head a few sessions in order to acquire the mindset and tools (methods of analogy, inversions…). The principles developed by the world’s top design studio IDEO and taken up by the Stanford d.school will be systematically applied.

Students will be encouraged to develop their imagination throughout the year by means of a series of exercise, the most instructive and appropriate of which are the art of telling a story based on historical facts or foreseeing a futuristic world on the basis of the potential of new technologies. These style exercises promote projection by empathy, construction from real elements, creativity applied to the creation of a coherent world.

Experimenting with prototypes to conceive innovative new products

The prototype occupies a central position in design when knowledge of the project can neither be formalised nor stabilised. Making the prototype raises the possibility of testing. The making of the prototype is also sometimes the activity during which the idea emerges. Design is not a linear and sequential process. There are innumerable detours on the way from goal to realisation. They reflect the exploratory nature of the quest for solutions, the ups and downs of the industrial context, and changes in specifications based on newly discovered solutions. Trials are fundamental moments in the design process: checking and validating of solutions, production of knowledge on phenomena and products, grasp of the manufacturing process. The knowledge generated around prototypes arises from the bodily engagement of people with objects.[2]

Students will produce 4 types of prototype out of the five observed in practice: “mock-up”, “dark horse”, “critical functional prototype”, “refined prototype”, “pre-series prototype”. Each type of prototype corresponds to a different role.

The “mock-up” is a prototype made with DIY tools and makeshift materials such as paper, cardboard, sticky tape… It’s role is to move very quickly from idea to realisation, in order to activate the right brain relative to the left brain, from the conceptual and analytical to the concrete and intuitive. The “mock-up” is a way to get different people to interact around an idea, particularly users targeted as future customers, in a way that is concrete but open to discussion, since the object in its external appearance is still in an embryonic state.

The “dark horse prototype” is a so-called extreme prototype, in other words a way of testing a wild idea for possible solutions, because even if it is known to be
unfeasible (for example because of the unit cost of production), it is nevertheless firstly a way to acquire a mindset for maximum exploration and creativity, by developing the faculty of imagining new worlds, and secondly of learning lessons that can be applied through successive recombination so adaptations (“keep the soul of a poet while acquiring wisdom”).

The role of the “critical functional prototype” is to test one or two critical functions of the product, generally in its physical aspects (weight-bearing strength of the planned material, pivot point of a structure, crash testing of the material at different speeds and weights…).

And finally, the “refined prototype” shows the outside appearance of the object as it would be used in reality. For big objects, reduced-scale models can obviously be envisaged, but the objective is to approach as closely as possible to reality and ideally to have a scale 1 prototype. This prototype takes one month to build at Stanford. It generally requires the development of technological bricks and the acquisition of high-level technical expertise (programming, electronics, micromechanics…).

The competences developed in students through the production of prototypes of different kinds are the demands and the agility that characterize design based on experiment as the primary way of exploring and seeking innovative solutions.

The capacity to demonstrate and to communicate

At the end of each cycle (December, March, June), students are asked to present their results to a mixed audience, including the partners of the program and the School, both in writing and orally, in the style of a competition presentation in accordance with our School’s ancestral tradition.

Beyond the communication tools acquired in the School’s communication seminars, which they will be expected to have fully mastered, specific new tools – called “design storytelling” – will be introduced, which enable an audience to project itself into the situation observed and the solution proposed in its real-world context. There are a dozen different techniques for this, ranging from the storyboard, simulation (which can vary considerably in form depending on the nature of the object, e.g. between a product and a service), prototypes, films, computer-generated images, drawings…

Students will be expected to show an ability to persuade, both in speaking and writing, both with the general public and with experts, employing all the tools of communication and the specific tools of “design storytelling”. It is entirely conceivable that teams will be able to publicize their achievements and the artefacts produced in the School’s general communication in order to contribute to its reputation and attractiveness.
ME310 teams had full-time access to a dedicated space, sharing a redecorated space with the Innovacteurs teams. Outside coaches for ME310 were selected by the TA from ME310 alumni, as happens at Stanford. In September 2009, Sushi Suzuki, a 2008 ME310 alumnus and development director for ME310 at Stanford in 2008/2009, joined the adventure of starting ME310 in Paris. He mainly contributed to the development and delivery of lectures, to the coordination of guest speakers, assignments, grading and feedback, the identification of competences, project reviews, coaching, communication (including brochures and conferences), student recruitment and closing interviews of students for research purposes.

### Innovacteurs: An experiment with design fiction

**Brief definition and students’ choice.** A 10-page document was written for the students, presenting four types of briefs: - Design for the Neglected - Sustainable building in emerging countries - Imagine a sustainable world with new technologies using design fiction - Design a product from a brief given by a company. It was difficult and time consuming to identify briefs with coaches/partners and to explain them thoroughly in a document of that length. In total, 10 projects were suggested: one part of a competition for a humanitarian mission (Fondation casques rouges), one from a company for a product design (KENZO), one technical topic from an entrepreneur alumnus, one broad topic on design fiction from ENSCI, 6 projects including technical work from researchers and a consortium of French engineering schools and one from a ME310 team. None of the technology-orientated projects provided by researchers was taken. Students who were attracted by the idea of combining technology and design picked up the subject from the entrepreneur alumnus: for technophiles, entrepreneurship was more inspiring than research. Most GI students were attracted by the possibility of working with ENSCI design students. That is why three teams were formed. The students’ choices cast doubt on the value of endeavoring to identify projects and experts in advance.

Technology-oriented briefs were not as attractive as expected for engineering students. They were more attracted by the possibility of working with multidisciplinary teams, regardless of the nature of the project. It was a waste of time identifying briefs with outside experts and real world issues, as students did not choose them. The assumption is that students are more committed if they work on a project they have chosen, while taking into account that very often do not know how to to define a project of their own.

9 Innovacteur projects are set up for second semester:

- One student in cooperation with the helicopter team from ME310,
- One multi team for a poor village in Marocco (including a field trip),
- Three multi teams on abstract concepts defined by ENSCI’s coach: *Transparency* *What if lights did not exist* *What if the fridge did not exist,*
• Two projects suggested by students: * Create a new offering for a student consultancy firm and * How to tackle stress at work,
• One mono team provided by an alumni, who created his start up: * Which solar systems in high turbulent zones,
• One mono team in a hospital * to redesign the waiting experience.

Design fiction was introduced as a new method for three multidisciplinary teams on abstract concepts defined by ENSCI. The other teams followed instructions given by the coaches, except the hospital team which followed the process propagated by the d.school at Stanford at that time (Understand/Observe/Point of View/Ideate/Prototype/Test), on which there had been lectures in the previous class.

Customized spaces in two different locations (ENPC and ENSCI) were provided as available.

I discovered the paper by Beckman and Barry (2007) while at Stanford and it remained an endless source of inspiration. In 2008, there were very few publications on how multidisciplinary teams could leverage design thinking. Beckman is a professor at Berkeley and Barry a founder of a consultancy firm and a lecturer at Stanford. They clearly explained an innovation process based on a learning model (derived from Kolb and Owenthe ) and design thinking (see further details in conclusion to this section).

**Act and observe: A promising start with challenges**

**ME310 Paris: How to make it happen**

The two projects with Thales were provided by executives who had been on the learning trip to Silicon Valley and wanted to explore the possibilities of these new methods. Both of them were CEOs of business units at Thales: Thales Avionics and Thales Underwater Systems. Both had to deliver a project, 6 months after the learning trip, which they believed in and was the result of their learning experience in Silicon Valley. Each was part of a team of around 6 people. In total 6 teams were created from a workshop in June 2009 on visions for the future of the company. 70 ideas emerged and were sorted into 7 main orientations. The two ME310 projects were among the 7 orientations to be explored in the next 6 months and presented to the executive committee (January 2010).
The helicopter team was lost until February when I stepped in and deciphered ethnographic research with both teams and recommended directions. Fortunately, I held all the meetings at Thales and had the chance to interview helicopter pilots as students. I noticed that the students were tired from the trip back from Stanford and did not pay enough attention to what was said. The ME310 alumni even fell asleep during meetings. Apart from one student, they were not active in asking questions and did not take enough notes. It looks as if the team was relying on him. I was angry with them but did not dare saying anything. I decided to carry out my needfinding by asking a lot of questions, in the hope that they would understand and do the same. Unfortunately they did not. As I knew that it might be the only time when there would be so many people from the company and real pilots, I decided to do the needfinding myself, in case we had no access in the future. I took personal notes and asked the consultant pilot a lot of questions on different occasions over the day: at formal meetings, during breaks, lunch and dinner. The answers given were not always the same, so I dug into the differences. I took dozens of pages of notes, which I gave to the students and explained when we returned. They paid no attention until they were completely lost, and I shouted at them and threatened that I would come back to project reviews only when they would be ready to think and produce better. The ME310 alumnus was shocked by my reaction: I explained that the students were stuck in a syndrome of failure and I needed to set up a “before and after” in order to create an effective psychological shock. He said I was acting like a CEO and not a professor. I replied that I was not sure he was right; I thought it was what was needed to get them back on track. The following week, they had recovered their belief that they could make it happen. I urged them to explore all their findings again. The Finnish team visited the following week and I decided to show my field notes and shared my findings: the eureka flash came from a German girl in the Finnish team. She listened to my insights, was mad that the French team had never transmitted my field notes from needfinding and found a sense making direction with a new seat for pilots. At that time, I did not dare to be too directive in my approach. So it was time consuming to explain without giving clear insights and directions.

The insights were in fact as follows: pilots were afraid to tell the Thales engineers that in the most critical period of their missions, which lasted between half an hour and two and a half hours, they sometimes switched off the dashboard and, instead of using the multiple screens, preferred to fly their helicopters “by ass and sight”, which gave them two main indicators (sight and thrust) that they could respond to very quickly, as decisions had to be taken in less than a second. The engineers’ pride in the thousands of possible combinations of graphics display on the screens was useless at times of intense action. Even worse: there was no one screen that showed the two most important pieces of information that a pilot needed. Pilots needed “to feel their machine and to pilot with their bodies”. They talked about their helicopters like riders about a horse. On the basis of this insight, the team decided to create a new seat for pilots that would provide information on sight and thrust. After benchmarking, they realized that there had been no innovation done on this area and that the seats were really uncomfortable: pilots would never complain about the uncomfortable seats, as they wanted to appear tough.
The French team consisted of three engineering students (two from ENPC and one from Polytechnique) and one design student (Strate). The design student was not as committed as the engineers. At times, she felt lost and overwhelmed. She was not sufficiently committed to put her points across, despite the fact that she had some good ideas, especially an ideas book with drawings to explain each new idea to the partner, which she never finished, and despite having a strong family interest in aeronautics. Drawing was clearly the main skill she brought to the team when needed.

When the French students flew to the design factory to build the final prototype, they were disappointed to learn that the Finnish students were busy with other course requirements and were not committed to making it happen. The French identified suppliers in Finland and claimed to have built 90% of the final prototype. When the pilot in Paris sat in the fake cockpit in our school, the smile on his face said more than a long speech: it was comfortable and he found the idea of feeling sight and thrust promising.

Unfortunately, although many people at the company, including the CEO, were convinced that the direction was promising, there was no push for implementation. We do not know why: perhaps because it needs to stay confidential until it is submitted in a contract bid or perhaps the idea has been dropped because of a lack of proactivity at operational levels. The company’s innovation group set up a partnership with a rival engineering school and felt in competition on methods. I have no idea about what happened to the project, which was disappointing.

In January, the drone team chose a direction with no sense making (both in reality and for Thales), influenced by one team member from a business school who pitched to the French and the Finns: the idea was to design a drone to survey beaches and rescue potential drowning victims. He was not motivated by what made sense for Thales and the project, but by what was fun and trendy. Two French students (one in design, one in engineering) voted against and the rest of the team, especially the Finns, were seduced by a lot of movie clips of rescues on Miami Beach. The best alternative was to assess the possibility of designing a swarm of mini drones to detect mines on the edges of Asian beaches. Another was to use a swarm of drones to detect oil leaks on offshore platforms. The two French students were the only ones committed to the project and worked on it nearly every day: I asked them if this direction would not kill their motivation. They replied very pragmatically that for the oil platforms they had been unable to make contact with an oil company and for the mines the other students were against the project because of the association with military issues. If they wanted to carry on, they had to follow the rest of the group and at least there was a hope of prototyping and testing the project, which was far from being obvious for others. My view was that the idea of a swarm of drones to detect mines on the edges of beaches made more sense and would bring much more value for the company. I called them. Although my contacts agreed with my point of view, they were open to the other option, in the sense that it was more attractive to students. There was no business for Thales with municipalities (no centralized decisions for a fleet of drones; the budgets were 10 to 100 times lower than average). The corporate liaison said he knew how to make the project work for business purposes. The weakness was
that no needfinding was done with real stakeholders, except with the corporate liaison and experts at Thales. Without needfinding, the alternative was to follow the corporate liaison’s most promising business path or to follow an attractive direction that the students would enjoy.

With regard to the team dynamics in Paris, four students who had been recruited on the basis of recommendations by professors felt that they were representing their disciplines and schools: three were in the drone team (2 in engineering and 1 in business) and thought that the program was lucky to have them and that this was enough. They had other commitments in their original school, had to travel an hour to get to our school and were not greatly motivated by the project. They “learned enough with a couple of lectures” and “had no time to prototype and test”. Fortunately, the engineering student I recruited from the Polytechnique via the Industrial Engineering Department and the design student recommended by one of my professors, who was also director of a design school (Strate), created a proactive and closely knit team. They liked each other and worked hard. This team looks like having two hard workers and two hard pitchers, with a visitor coming to assist one of the pitchers.

The final prototype was sufficiently operational for testing in a swimming pool. The students made the hardware and software themselves, so the level of definition was average. The ergonomics for rescuing people were very limited factor in the design. Functionality was the first priority, in order to provide proof of concept for a small drone for Thales. When the students visited a small R&D unit at Thales dedicated to drones, they were told that making such a small drone work with no expertise and in such a short timeframe was impossible. The corporate liaison, who believed strongly in the transition from big drones to swarms of small drones for new applications and new businesses, was able to show in-house with the functional drone that if a bunch of students with no expertise can do it in less than a year, internal experts no longer have an excuse for not making it happen. He hired a student from the M1 track for 6 months, in order to create a simulation of a swarm of drones to detect mines on the outskirts of Asian beaches. This simulation was part of a successful bid for an Asian government contract, but no functional aspect of our prototype was included in the bid. The corporate liaisons leveraged the ME310 project dynamics to generate the internal attention and tension needed, both at executive and operational levels, and to disseminate his vision of potential new business.

The Paris device team experienced internal tension and conflict throughout the whole academic year. An ENPC engineering student (from the mathematics and simulation department) took leadership of the team, with lots of ideas about possible development and lots of software development. He was extreme in his ideas and his practices. The design student felt left out of the process. The business student and the other engineering student from the same department were not fully committed to the project. So the team leader, who was bilingual, felt more connected to the Stanford than the Paris team. The three males clearly expressed their view that the female designer understood nothing about design thinking, despite being convinced that she knew more than them: she had no sense of users, needfinding, prototyping and testing. They saw her as lost in abstract thinking, unaware of the reality of real contexts.
and users. The cooperation was not fruitful and the design student felt so frustrated that she almost gave up the project.

The team started to do needfinding with young people, as the brief was to create a home device that uses social networks. The finding from interviews was that young people were satisfied with their phones and computers and did not want any additional devices. I told the team that they should not assume that, because people say that they are happy with what they’ve got, that they won’t adopt something new when it becomes available. I gave the examples of mobile phones and computers. Nonetheless, the team felt lost and demoralised. On the Stanford side, the insights and directions were no better. I suggested that they should take a radically different approach, and think about non-users of social networks: creating a non-product for non-users of social networks. Initially, the team found the principle weird and unrealistic. I gave them a week to think about it. The following week, I asked them again who were the extreme social network non-users: they all replied seniors. I suggested that they should look into this group and gave them a brief introduction to Blue Ocean Strategies: when the market is saturated with competitive products for existing clients, look for non-users, redefine a non-product with radically different criteria of value and create a brand-new market. I was about to become the first professor to test their new simulation.

It was early January 2009. The first prototype they made was a cube with a screen on each face. Each screen provided specific information (weather forecast, news, pictures from family…). Experts and seniors surveyed by the students themselves gave them the feedback that this kind of cube was difficult for seniors to handle, with the risk of dropping and breaking. Personally I liked it a lot but did not say so, so as to respect the process of reframing with feedback from users on prototypes. I asked them how they would reframe on the basis of that discovery: what were the main potential directions of social networking for seniors? What content was exchanged and between whom? They replied that the content was pictures exchanged between seniors and their families. I stressed that they had started with young people. They could draw on this knowledge of users and combine the two: what about a device to exchange pictures between grandparents and their grandchildren? They quickly came up with a tablet with buttons; early February, the Stanford students presented the idea to Pioneer executives, who were very interested and expressed an interest in producing it. This feedback created a very high level of motivation among students.

Both the hardware and software were developed for a tablet for seniors (the family flip). The seniors received pictures sent by their grandchildren on phones or computers. At the event, the seniors used their tablet to store pictures in an album and to send handwritten comments to their grandchildren. The tests with users were very positive and motivating. In April, Apple launched the ipad. At the final presentation and demonstration, people compared the two and asked what the added value was. In response, the team showed that touching a screen to control a device did not come naturally or easily to seniors, even former NASA engineers. Seniors preferred buttons. They also showed that a specific picture exchange and storage application was of interest to this demographic. Instead of recognizing the potential of what
had been discovered and developed (in terms of specific applications and uses), the company dropped the idea at the end of June. A few years later, a ME310 project was sponsored by Microsoft and the final prototype was an album for seniors based around the exchange of pictures between family members. The students also demonstrated how interested seniors were in this experience. The use of the device and technical feasibility were different.

Strong commitment from students is key for sense making. Needfinding and tests with users are key for sense making. Depending on the subject, access should be provided by the company.

**Best outcomes from the three projects (1: helicopter 2: drone 3: tablet)**

- Sense making analysis, with stakes and analysis of a situate (1, 3).
- Benchmark of existing technologies (1, 2, 3).
- Needfinding: observation and interviews (3).
- Promising reframing (1, 3).
- Concept generation in quantity, craziness and flexibility with definitions of facts / objectives / scope / constraints / criteria of selection (1, 2, 3).
- Reality checks with contacts with users (3).
- A final and functional prototype of good quality (1, 2, 3).
- Technical assessment for implementation (3).
- Communication: a brand and a logo (3, 4), brochure (1, 2, 3), a booth (1, 2, 3).
- A short realistic business plan with evaluation of number of buyers, rough production cost, rough estimate price given existing reference points of an existing company (3, 4).
- Quality of the presentation and the report: esthetics, clarity, quantity, bibliography (1, 3, 4).
**Innovacteurs 2: Briefs are key to teach or not to teach design thinking**

All team dynamics were of good quality, with mutual respect, enough commitment and proactivity.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main observation</th>
<th>Project outputs</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Outstanding presentation. Reports? Prototypes tested and implemented. Great interest from the hospital.</td>
</tr>
<tr>
<td>1. Transparency (multi)</td>
<td>Students struggled to frame a project, were lost in abstract thinking, did not do any needfinding or prototype.</td>
<td>Concept generation with drawings. Historical benchmarks. One team with ideas of products (names, logo, sales argument).</td>
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<tr>
<td>2. What if electrical light does not exist (multi)</td>
<td></td>
<td></td>
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<tr>
<td>3. What if the fridge does not exist (multi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. One student with ME310 helicopter team</td>
<td>Either the brief (5, 6, 8) did not allow to carry out activities of design thinking or students were lost to do any (6 and 7).</td>
<td>No needfinding. No prototype; No test. No value created for a partner, except technical assessment for the start up.</td>
</tr>
<tr>
<td>2. Create a new offering for student’s consultancy</td>
<td></td>
<td></td>
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<tr>
<td>3. Stress at work</td>
<td></td>
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</tr>
<tr>
<td>4. Which solar systems in high turbulent zones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Zilf in Marocco (multi)</td>
<td>Students were lost in empathy: when they returned from the field trip, they could not find out any solution but explained why things were like they were.</td>
<td>Students were transformed and learned empathy. Data collection was huge without any ability to get insights, framing, solution generation or implementation.</td>
</tr>
</tbody>
</table>

After a global overview of team performance, details will only be given on the hospital project, the multidisciplinary teams on design fiction (2, 3, 4), and social entrepreneurship (9).
Design fiction is not design thinking

Upon suggestion of my colleague from ENSCI, an experiment of design fiction was carried out with three multidisciplinary teams on three topics.

The brief for students was written by the coach in design and read as follows: “While innovation is usually orientated towards the future, it is obvious that it is anchored in the present and rooted in the past. The history of technologies is a complex genealogy, whose major discoveries have been synonymous with social progress and economic growth. As product inventions, these objects and services have profoundly influenced our habits, moulded our environment and fed our imaginations. Saturated with all these products, today’s world is looking for alternatives to the choices it previously made without awareness of the future. So it is perhaps time to think differently and to devise new ways of innovating, ways that are ethical and responsible. However, desirable changes can nevertheless come into conflict with the inertia of unchanging roots and past decisions that nevertheless affect our future. So what if some of these decisions, these inventions had never happened? What would today’s world be like? How would we imagine the world of tomorrow? On the basis of the idea that an influential, world-changing technology had never happened, the task is to retrace a fictional history in the absence of that technology, and to deduce the alternative that would have emerged. Imaginary alternatives that are nevertheless imaginable as potential innovations, that constitute a break with what exists and an idea about what might exist. For example, what if electricity had never been invented? What if the refrigerator had never been invented. What if transparency did not exist?”

The main learning objectives were as follows:

• To learn a method of innovation from the culture of design
• To experience the dynamics of multidisciplinary teams with different backgrounds
• To unlock the imagination of students
• To imagine a better world by challenging existing technologies
• To foster a new generation of concepts that could become a reality.

The concept was almost science-fiction, except that the imagined world needed to be realistic in terms of current reality.

Wikipedia, Jan 11, 2010 – Science fiction is a genre of fiction. It differs from fantasy in that, within the context of the story, its imaginary elements are largely possible within scientifically established or scientifically postulated laws of nature (though some elements in a story might still be pure imaginative speculation). Exploring the consequences of such differences is the traditional purpose of science fiction, making it a “literature of ideas”. Science fiction is largely based on writing rationally about alternative possibilities. The settings for science fiction are often contrary to known reality.
The process was structured on project reviews where students were asked to 1/ reframe and pitch their hypothesis 2/ develop their hypothesis and present a possible genesis 3/ present an “Avant projet sommaire” (preproject abstract) that would identify alternative innovations within the fictitious genesis as an outline of an object and/or service 4/ Definitive preproject: “based on the outlines, a full implementation demonstrating the viability of the idea in the real world, design of all the elements of the system including the graphic identity”.

All of the students were at a loss to understand how to get started on design fiction. One team almost came to believe in what they had imagined.

The team working on transparency was completely lost, from beginning to end: the idea of non-transparency was so abstract that it “raises so many questions for the creation of a new product and service that could be adapted for the real world” (extract from student introduction). They explored the idea of buildings without windows (igloo, cottage, yurt, bathroom, movie theater). In the creativity session they put together a story about living in such a building, with 5 concepts (diaphragm, sundial, darkroom, sun shower, dream catcher). They decided to explore the idea of non-transparency as a luxury. They imagined a luxury cocoon for hotels and then a “democratic version” with a bathroom sink. The team did not check their ideas with outside people. The team was led by designers. The engineers were lost and thought it did not make sense.

For the no refrigerator team, students produced interesting historical analyses and storylines, but when they tested one fictional hypothesis with butchers they quickly discovered it was regulated and the service they imagined would not be allowed; consequently, they pitched the second hypothesis (an internet based order system with shared neighborhood fridge spaces) without testing the idea. Nobody dared to test it: they preferred to believe that it could work, so the project was delivered.

Unlike the two previous teams, the no electric light team clearly identified the process of design fiction in the introduction to their report: “The innovation methodology of design fiction relies on the following steps: hypothesis formulation “what if…”; creation of a fiction: a world that is imagined in the framework of that hypothesis; analysis of that fiction: how that world would work, behaviors and needs; creation of products and services in the framework of that fiction; adaptation of those created products and services to the real world” (extract from student report). They also clearly identified its benefits and difficulties. In their new world, they identified three ways different types of people could adapt their behavior in the absence of electrical light, and a series of fictitious everyday objects. Back in reality, they created a new brand, called “Varia”, for an existing company (Velux), with the idea that their project would be more realistic with a better chance of implementation if it fit in with the values of an existing company: Velux is a company that specializes in roof lights (usually for rooms where ordinary windows cannot be fitted). This realistic context helped them to develop a “realistic” fiction for a new brand with four products (lamps and floor carpet). They did not succeed (or want) in contacting the company. This project was the most successful of the three projects: they understood the process and followed it; they were not lost all the time and came out with concepts that were sufficiently developed in terms of
drawings, pictures of realistic products, graphic design and sales materials. They did not produce a prototype, or do any user testing or reality checking. This kind of a shift from roof lights to light systems would represent a dramatic change of business model for a company like Velux, and the students were unaware of this. The teaching team was relieved that the team was able to make sense in terms of values and had provided a realistic context for product design.

The design coach was interested in the way they navigated between concepts, imagination and real products. He thought that the students did not work hard enough, that the engineers were lost with this kind of method, while the designers had another big project running in parallel. The engineering coach did not understand but was supportive. I was disappointed by the outcomes: the students were lost and did know what they were doing; the gap between imagination and the return to reality was so long, fragile and awkward that I doubted whether it was worthwhile putting so much thought and imagination into creating new products. Both sets of students were lost. The design students took the lead because they felt that it was their responsibility and was closer to their world. I thought it was an interesting exercise for unlocking imagination and conceptual thinking, but not an efficient way to teach how to design real products and services. These kinds of methods are time consuming and risky, because students become lost in the conceptual struggle both to understand the method and to navigate intellectually. In addition, none of the students truly believed in their suggestions. Sense making was lacking, as well as reality checks with users, experts and stakeholders. Without any objective feedback from outside experts or users, the project was judged by the teaching team: to me, it became a pitching contest and intellectual competition.

Design fiction is too time consuming and risky for multidisciplinary to learn how to create new products or services. It can be an interesting exercise to unlock imagination and generate breakthrough concepts, but not to design market ready products or services.

**In emerging countries, extreme innovation may have a big impact**

The extreme innovation team grew out of the strong motivation of a Moroccan engineering student, who recruited another engineering student and three design students. The report was written in English dissemination outside the course alone. The village of Izilf was identified by a humanitarian organization with which a humanitarian student association at ENPC was working. It was a very remote village in the Atlas Mountains. The students undertook a three stage process that began with a field trip on which some students observed and interviewed people in the village, followed by collective brainstorming and finally the development of the selected ideas. When students presented their needfinding, they were unable to find any direction or insights. They were lost in empathy for the people of the village: they identified so many important issues and associated constraints, and were so keen not to judge by western standards, that they were afraid to select one rather than another. This is reflected in the report: 17 pages explaining the issues, 2 pages on “a system to collect and recycle the plastics that are disposed without regard to its consequences”, which was what shocked students the most. Those two pages were only a
pitch: arguments were made to convince, with no sense making or reality check.

Starting a social entrepreneurship process with just a field trip for needfinding implies many flaws: lack of trust by the villagers who are “observed” with no idea of what was going to happen and whether they would see those western guys again; no sense making by students with perhaps no value for the village because there was no commitment to do anything real after the course.

**Design thinking in a hospital is promising**

The students suggested a partner with which to pursue their project: a Rothschild hospital. They found the brief after a conversation with the partner: re-inventing the waiting experience in a hospital eye clinic. They were a mono disciplinary team wanting to do design thinking. The projects suggested were either too technical (subjects submitted by ENPC researchers) or abstract (design fiction) for them. The students did the needfinding without any assistance and presented insights and solutions that were interesting. They quickly prototyped and tested their solutions in situ. It interested the hospital staff enough for three of them to come to the final presentation, including an executive from the foundation that was looking to finance a big idea. After so many high-impact incremental improvements at the Rothschild hospital, I anticipated that there would be expectations for a big idea after so many small quick fixes. One of the three members was disappointed not to hear a “big idea” at the final presentation: “I was coming for a big idea I could finance; after so many successes in the department that could be implemented with existing means, I told myself that a bigger idea might need further funding”. In any case, the value brought by the students was recognized by the doctor and nurses. The students identified a margin for improvement, which took account of existing constraints and planning problems. They did not attempt to revolutionize the waiting list upfront: they worked on reinventing the waiting experience, by introducing activities and fun to reduce patient stress and make time pass quickly; the staff could see how most of the ideas tested could be implemented and appreciated them.

Students gain in sense making and create trust in the ecosystem when they make small incremental innovations that are useful and quickly implemented. Stakeholders can see value being created and are open to a subsequent higher level of innovation.

**Best outcomes from the hospital project**

- *Sense making analysis, with clear stakes and in-depth inquiry in the given situate.*
- *Benchmark of existing technologies and products.*
- *Needfinding: observation and interviews.*
- *Promising reframing.*
- *Concept generation in quantity and flexibility despite a lack of craziness.*
• Reality checks with contacts with users and stakeholders.
• A final and functional prototype of good quality.
• Technical assessment for implementation.
• Communication with stakeholders: trust and interest were raised.
• A short realistic assessment of cost for implementation.
• Quality of the presentation.

Reflect: The ambition of design thinking is to make it happen

ME310: Involvement of all stakeholders is key

Prototyping without sense making results in the students losing their way and does not contribute to creating sense and reframing. I felt that it was time consuming while bringing the partner no added value and showing no path to explore. If the students failed to find a sense making direction, the question was whether the TT should provide one. The Stanford alumnus did not think enough about what made sense for projects and concentrated on checking deliverables. There was a lack of expertise in the TT (in Paris and abroad) about the different subjects: sense making has no impact if students get it quickly or if it is provided by the partner; it has a huge impact if the team fails to find a promising direction for the project, and as a consequence, the TT needs to get involved in reframing if students fail.

Multidisciplinary teams formed solely on the criterion of multidisciplinarity can generate tension and conflict. There is no spontaneous benefit to multidisciplinarity. Committed students who are proactive, pragmatic and want to make sense for the partner should be favored, even to the detriment of discipline.

Two of the design students were lost with DT and real partners, while one contributed hugely to the project. A business student always pitched ideas to cover an obvious lack of work. It was hard to work with the Finns on both sides but no problem with the German or Stanford students. Students with different agendas and other strong commitments at another school quickly deserted: they were only pitchers. If there was commitment, team dynamics between designers and engineers were easier than with business profiles, who only valued communication, especially sales pitching, to the detriment of sense making and making.

Acquiring projects with sponsorship requires a lot of time.

The pedagogical innovations tried in 2009/2010 included:

• Being close to partners with the possibility of direct conversations without students: this helps in understanding the company’s internal priorities and the partner as an individual;
• Delivering speeches inside the company to explain the why, the what and the how of the program: students are not comfortable explaining what they do, especially at the beginning, because of their own lack of understanding

• Splitting project reviews into 50% thinking and 50% doing with little emphasis on logistics: first, it gives the right balance for students in terms of what is valued; second, it requires the teaching team to think with students (instead of performing only a task checking role)

• Going into the field with students is an efficient way to evaluate how they behave in terms of observation and dynamic conversations. Doing ethnographic research as a teaching team also speeds up knowledge acquisition or prevents mistakes

• Getting students to redesign their space has an impact on team dynamics: the more students are involved, the more they feel at home, which creates emotional comfort

The teaching team should be involved in understanding the issues and users, especially in close relationships with corporate partners and needfinding.

_Innovacteurs: Teaching design thinking should be a focus for all disciplines_

One discipline takes the lead role over the other simply because kick-off and project reviews are all conducted in one school or another.

Design thinking and design fiction are different in terms of outcomes, process, learning objectives: design fiction generates breakthrough abstract concepts; it unlocks creativity and imagination; it is hard for students who easily lose their way: it appeals to the mind, not to the heart or the hand. Teaching design thinking needs to focus on generating pragmatic, user-centric solutions.

The case of Rothschild hospital clearly shows:

• The context (“situate”) of a place where people go about their usual business and where students can observe and test is an interesting setting for a design thinking project and teaching;

• A mono disciplinary team made up only of engineers can experience all the activities of design thinking, with interesting outcomes in terms of learning and value creation;

• Two important factors that create trust among stakeholders in a given ecosystem: the importance of ethnographic research and tested prototypes in the field to generate appropriate solutions, as well as how incremental solutions foster openness to breakthrough innovation.
Abstract concepts as briefs require a lot of time from students to reframe when possible, unlock imagination, breakthrough concepts with no sign of implementation. Design fiction and design thinking are different and cannot be taught together.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Outputs</th>
<th>Reflection to teach design thinking</th>
<th>Identified problems</th>
<th>Reflection on the culture of design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three projects with design fiction (mult)</td>
<td>Abstract thinking on a broad topic. Concept generation. Ideas of products. A brand and a logo.</td>
<td>Teaching design thinking is different from teaching design fiction.</td>
<td>Briefs were broad and risky for students to be able to reframe it with sense making. At best, the threshold from fiction to reality.</td>
<td>Abstract thinking is highly valued: It can generate either new perspectives that make sense, or abstract concepts with no connection with reality.</td>
</tr>
<tr>
<td>The hospital</td>
<td>Incremental innovations that can be implemented in a real situate.</td>
<td>Implementing pragmatic solutions for real people should drive design thinking’s approach.</td>
<td>The brief is key: The situate of a place where students can easily do needfinding and prototyping allow the learning experience.</td>
<td>The skills of designers (graphic, interaction, industrial design) enhance the deliverables in implementation.</td>
</tr>
</tbody>
</table>

Lecturing, even on how to perform the different activities, is not enough to engage students in a dynamic of making. The focus of lectures is still knowledge dissemination. Design thinking is a culture, which requires knowledge acquisition, but also experience through practice. In order to live that culture, students should be aware of the different elements (self-awareness) and live them as a learning experience. Navigating between theory and practice requires the development of specific curriculum. It is a challenge for faculty, because they are used either to the knowledge dissemination model, or to the feedback model. We can simplify these two models by contrasting learning in a studio based on a project and feedback from gurus and learning in an engineering school based on theory acquisition and right/wrong answers to pre-defined exercises. Design thinking needs an alternative learning model, which combines knowledge acquisition with practice, self-awareness and reflection on theory and practice.
Sense making and implementation should be the two key factors of success for DT student projects: the value created for people in a given situation is an objective indicator of performance.

**Improve: Sense making and implementation, the core of design thinking**

The decisions to improve the learning experience were as follows:

**INNOVACTEURS:**
- Drop design fiction for Innovacteurs, if the focus is on teaching DT
- Share knowledge on DT between engineering and design students

**ME310:**
- Ask students to focus on generating and implementing incremental solutions in the ecosystem because they contribute greatly to generating relevance and trust, and only then to pursue breakthrough innovation: no breakthrough before incremental innovation
- No prototyping without context (situate): making should be done in the real situation, in order to increase sense making and implementation
- Students should be asked to personalize their project space, in order to test their skills and to increase emotional commitment (space contest game)
- Organize specific actions involving the TT in order to create momentum inside the company, including kick-off and projects reviews
- Prohibit students from setting off in directions that do not make sense from the perspective of either the company (business model) or the possible customer
- Develop the ME310 syllabus further with more lectures
- Find experts for outside coaching instead of alumni
- Avoid recruiting students who cannot work on a full-time basis and/or in situ with long distances between schools
- Recruit students with the same level of potential commitment
- Identify DT skills.
2009/2010: Learning about a culture of design thinking

A balance between People/Place/Process is perceived as an effective framework through which to develop design thinking pedagogy. People were focused on multidisciplinary teams with real stakes. Experiments were made with tipping points in Place. The focus of Process was on the delivery of prototypes for ME310 and a series of design stages for Innovateurs: problem statement/ideation (which was defined as brainstorming at that time)/Implementation (which was defined as sense making, use of prototypes, storytelling and visualization capacity).

**PEOPLE**

I was starting to identify core values in DT – empathy (25), kindness (26), optimism (27), making – and to advocate them as pre-requisites for students with the notion of territory set by the space. I discovered the value of doing versus thinking; I do, therefore I am (24). I experienced radical collaboration (41).

An ecosystem should be created that includes students, teachers, experts, corporate liaisons and more people inside the company, in order to accelerate sense making and increase the probability of implementation.

**PROCESS**

Sushi explained needfinding, the Stanford method of ethnographic research (75) with a stress on frameworks (85) and on how to present findings from the field. Benchmarking (82) is a key tool for understanding problems at ME310. I started to reflect on the art of prototyping (92) and the use of different prototypes for different purposes (93). ME310 students had two processes in mind: the process provided by the ME310 syllabus and the table of contents required for the report (need and problem statement/design requirements with functional and physical requirements/design development with needfinding and benchmarking/prototypes including design specifications) and the process provided at that time by the Stanford d.school (Understand/Obsere/Point of View/Ideate/Prototype/Test).

The ME310 students were more influenced by the culture of engineering than the culture of human-centric design and empathic innovation. It was hard for students to carry out needfinding, as well as to prototype and test with users: access to the field is key.
PLACE

I visited half a dozen living labs in Europe (2) and started to understand the differences and similarities. I visited the Design Factory (5). I understood the value of the students customizing their space (21): “make it yours!” I experienced and reflected on space and mindset, as well as the 9 milestones: even if symbolic, they have an influence on student mindsets. The first style I experienced was the garage style!

Staging Place with the 9 milestones, even if symbolic, with a garage style, is enough to generate team dynamics and attractiveness.

Table 37 shows tipping points that I identified in 2009/2010 for learning about the culture of design thinking. The numbers refer to pages in the book350, which provide a full description:

Table 37. Discovery of tipping points in design thinking in 2009/2010

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>PLACE</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empathy (25)</td>
<td>Living labs (2)</td>
<td>Ethnographic research (75)</td>
</tr>
<tr>
<td>Kindness (26)</td>
<td>Design Factory (5)</td>
<td>Frameworks (85)</td>
</tr>
<tr>
<td>Optimism (27)</td>
<td>Customization of space (21)</td>
<td>Benchmark (82)</td>
</tr>
<tr>
<td>I do, therefore I am (24)</td>
<td></td>
<td>The art of prototyping (92)</td>
</tr>
<tr>
<td>Radical collaboration (41)</td>
<td>Different prototypes for different purposes (93)</td>
<td></td>
</tr>
</tbody>
</table>
2010/2011: Briefs matter to do design thinking or not!

_Situate: Same conditions_

In addition to ME310 and my position as an academic director, I was in charge of three courses at ENPC: ecobootcamp, Innovacteurs and corporate strategy.

The GI innovation curriculum was the same as in the previous year. For the 2010/2011 session, the industrial engineering students made another field trip to Barcelona, with visits combining innovation and the supply chain. Ecobootcamp was run by my teaching assistant. I gave only one lecture (on the subject “Making or buying an innovation, the difference between in-house company processes versus collaboration with external design consultancy companies) and I took part in the final presentations. My assistant decided to eliminate the previous mini assignments (Christmas presents, shoes, place) and the case study on eco innovation. He set three design projects: Incremental innovation at ENPC; Empathy and understanding people; The EDF sustainable design challenge organized by a design manager, Gilles Rougon at EDF who gave a lecture on “Changing energy together for better living”. The students could carry on their projects in the second semester and run for the international competition. The project evaluation criteria were identified and given to students. They were given to all the members of a mini internal jury (with ME310 students, alumni and professors) to assess final presentations. As in the previous years, two guest lecturers were invited: an expert in creativity (Paul-Hubert Desmenards, Creargie) and the design director of an advertising agency (Stéphane Gauthier, Babel). Students were required to give a final presentation, with informal intermediate project reviews. The course was in English. A syllabus was prepared, based on the previous syllabus. The skills developed through the course are were once again specified: empathy and understanding of people; rough, rapid, right prototyping; ability to reflect on one’s process; understanding the current situation in the world; ability to work in a team; brainstorming skills. The focus on innovating for sustainability was maintained, with the objective of raising student interest and awareness, not to develop specific skills. The projects varied in quality: the brief was too broad for such a course and some teams found it difficult to reframe and find a sense making direction. Only one team wanted to carry on and run an Innovacteurs project on that topic.

The academic year followed the same objectives in terms of course development (ecobootcamp, Innovacteurs with ENSCI, ME310 with the Stanford network) and the same resources, in terms of teaching team and space. Students were recruited from a broad range of schools (ENPC, Polytechnique, EFREI, Mines de Nancy, Science Po, Dauphine, Strate, TokyoTech), disciplines (engineering, design, business, finance, politics) and from 7 nationalities. Students were recruited through personal connections outside the school, the industrial engineering curriculum, cooptation from alumni, recommendations from professors, presentations in different universities.

351 lectures and outcomes in data record 2010/2011.
and publicity measures (with a brochure at exhibitions). Recruiting students was time consuming. The ME310 budget came from the ENPC Foundation. Four ME310 projects were acquired from four French companies: Thales Optronics, EADS, Suez Environment, Amplitudes Technologies. Two projects were run in cooperation with the Design Factory, one with Stanford and one with HPI. One project was acquired thanks to an Innovateurs student from the previous year.

Innovateurs students were recruited from the industrial engineering department and ENSCI (a design school).

**Plan: The 2nd edition of ME310 and mono teams for Innovateurs**

The data records for 2010/2011 include reports, syllabus, lectures, assignments and field notes for:

1. Three ME310 projects: EADS, Amplitudes, Suez, Thales Optronics
2. 5 Innovateurs projects

ME310 projects for M2 students include the initial following briefs:

- Invent a civil application for a military technology (Local Situation Awareness) with Thales Optronics
- Airport of the future with EADS
- New waste and water services with Suez Environment
- A new protontherapy model with Amplitudes Technologies and INRS

The syllabus of ME310 Stanford is implemented. Weekly lectures on different topics of innovation, strategy and design thinking, are added. ME310 alumni, who helped me to set up ME310 Paris, was not open to pedagogical innovations from ME310 syllabus. I could not plan any new assignments from the initial syllabus. I developed new lectures and feedbacks are focused on creating value for partners.

After discussions with the design professor from at ENSCI, no multidisciplinary teams were formed this year, because of students’ commitment to a big project. Nonetheless, he was still part of the Innovateurs teaching team, together with the professor of mechanical engineering and my teaching assistant for ME310. After discussions with a corporate partner from ME310, two projects were defined and proposed to engineering students. One group of student wanted to pursue the EDF project, while another suggested the opposite brief: people producing energy, instead of reducing consumption.
5 Innovacteur projects had only mono teams:

- Improve life in a Marrocan village
- Reuse human movements for energy production (based on EDF project)
- Electricity and behaviors: linky offering for EDF
- Improve waste recycling in buildings for SITA (two projects)
- Create a platform for ENPC projects

That year, I was involved at the two project reviews and the final presentations as in previous years. We decided to strongly advise students to make individual appointments with the members of the teaching team: the mechanical engineering and design teachers and my assistant. Apart from the two teams with the corporate partner, none of the teams came for advice between project reviews: they met my assistant and the professor in design. With the other teams, the teaching team including my assistant did not put enough emphasis on the user’s experience as the driver for thinking and acting. This was apparent in the project reviews and reports: it was not at the heart of their dynamics, and in some cases there was no clue who they were innovating for. Unless constantly reminded, the students forgot to think about users, although it was a common topic of the lectures.

The teaching team should make students focus on user experience as a driver for thinking and action at each point throughout the process.

From Lofthouse, 2001\textsuperscript{352}, general metrics defined for the previous year\textsuperscript{353} were replaced with a set of competences developed by the course as described in Table 38.


\textsuperscript{353} plan and data record from 2009/2010
Table 38. Evaluation criteria for design thinking projects 2009/2010

<table>
<thead>
<tr>
<th>Design stage</th>
<th>Analysis criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem statement</td>
<td>Evidence of context understanding including user understanding</td>
</tr>
<tr>
<td></td>
<td>Process of scoping the research task</td>
</tr>
<tr>
<td></td>
<td>Evidence of reframing the original brief</td>
</tr>
<tr>
<td></td>
<td>Evidence of identifying relevant issues/problems/constraints/expectations</td>
</tr>
<tr>
<td></td>
<td>Research methods used (quantity, quality) including use of needfinding and analysis tools</td>
</tr>
<tr>
<td></td>
<td>Depth, quality and method of analysis</td>
</tr>
<tr>
<td></td>
<td>Use of both quantitative and qualitative analysis</td>
</tr>
<tr>
<td>Ideation</td>
<td>Quantity and quality</td>
</tr>
<tr>
<td></td>
<td>Innovativeness</td>
</tr>
<tr>
<td></td>
<td>Appropriateness Quantity and quality</td>
</tr>
<tr>
<td></td>
<td>Innovativeness</td>
</tr>
<tr>
<td></td>
<td>Appropriateness</td>
</tr>
<tr>
<td>Implementation</td>
<td>Relative success in overcoming issues identified</td>
</tr>
<tr>
<td></td>
<td>Realism and coherence: sense making</td>
</tr>
<tr>
<td></td>
<td>Use of prototypes</td>
</tr>
<tr>
<td></td>
<td>Storytelling and visualisation capacity</td>
</tr>
<tr>
<td></td>
<td>Evidence of evaluation and reflection on outcome(s) generated</td>
</tr>
<tr>
<td>Design process</td>
<td>Design process spirit (e.g. reflective, iterative and/or solution-focused)</td>
</tr>
<tr>
<td></td>
<td>If and how findings of user centred research has been applied in designing process</td>
</tr>
<tr>
<td></td>
<td>If, how often and how creativity techniques have been used</td>
</tr>
<tr>
<td></td>
<td>If and how storytelling has been used</td>
</tr>
<tr>
<td>Others</td>
<td>Aesthetics (of the presentation and the report)</td>
</tr>
<tr>
<td></td>
<td>Team dynamics (proactiveness, effort, enthusiasm, conviction)</td>
</tr>
</tbody>
</table>
**Act and observe: How can implementation happen**

**Innovacteurs 3: Brief and access to the field matter**

Most GI students in this cohort were not interested in innovation (as expressed in their future career preferences between innovation/entrepreneurship and supply chain management) and some were very difficult in the sense that they were not team players, acted like teenagers on the field trip and argued a great deal over any instructions. It was a difficult cohort. Under these circumstances, setting up only mono disciplinary teams was a good decision. Table 39 gives an overview of team performances.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main observation</th>
<th>Project outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDF challenge</td>
<td>Analytical students</td>
<td>Technical and cost assessment. BP. SWOT. Porter. Value curves</td>
</tr>
<tr>
<td>Decomplex center</td>
<td>Analytical students who were lost in finding users and reframed with instructions.</td>
<td>User finding. Ideas. 3D modeling. Energy production and consumption calculation.</td>
</tr>
<tr>
<td>ENPC projects</td>
<td>Students were not hard working.</td>
<td>Needfinding with interviews. A poor idea portfolio.</td>
</tr>
<tr>
<td>Extreme innovation</td>
<td>Two French students were biased in pre conceptions with a teenager’s attitude.</td>
<td>No respect in analysis and idea generation. No assessment, no implementation.</td>
</tr>
<tr>
<td>Waste A</td>
<td>Students were committed and team players.</td>
<td>See box “best outcomes”, except implementation, 3D modeling, system solution.</td>
</tr>
<tr>
<td>Waster B</td>
<td>Students were committed, with a leader.</td>
<td>See box “best outcomes”.</td>
</tr>
</tbody>
</table>

The EDF mono disciplinary team did only analysis (except three idea tests with users, which were described in one page in the annex, in order to pitch the idea that users were interested in energy reduction and saving): product and offering benchmark, regulation, energy consumption and suppliers, energy issues, a Pestel analysis, the structure of the market with Porter and a SWOT, a value curve derived from concepts in blue ocean strategies. They described in words the customer experience with the new offering. Despite the fact that students were analytical thinkers and did not want to do design thinking, the nature of the project based on a subscription package for energy saving was too abstract. They had no experience or feedback from experts, in order to gain in sense making and pragmatism, whether from the
perspective of users or the company. They framed by logical reasoning using data they could find on the internet. They claimed to have practiced design thinking (because of a session in creativity and speaking about users), but did nothing active (no needfinding in the field, no reframing, no prototyping, no testing, no storytelling…). They were not aware of their ignorance, did not understand the process and did not follow it.

Some students think they understand and do design thinking, but even after a course, some of them still don’t know they don’t know. In these circumstances, self-awareness is hard to teach.

A mono team decided to explore the idea of creating energy from people’s movements, instead of reducing energy consumption as suggested by the EDF challenge. After briefly investigating three sources of energy production (dynamo, floor slab, battery), they relied on their creativity session to find ideas. They dropped the idea of producing energy with floor slabs after a couple of interviews with parents and kids and after the project review with the professor in design, who did not believe in it. They decided to devise a center (decomplex center) where overweight people would practice sport to produce energy, with eco principles in the architecture of the building and personal track control devices and applications. They developed the concept with technical assessment and calculation of the energy produced versus consumption. They reflected on their process over a couple of pages in their report: they diverged from their initial idea of e-velib – how can a bicycle produce energy? They spent a lot of time defining who could produce energy (prison, kid square, schools, amusement parks, metro…) with floor slabs. They were heavily demoralised after a project review with the design professor because they felt judged and that all their ideas were rejected. They focused only on brainstorming as a source of inspiration. Ideas were selected only on the criterion of novelty. They reframed following another project review with my assistant. Students developed the outcomes they considered important to justify their project: calculation with technology benchmark, 3D modeling, business plan and market analysis; then after a collective project review and my feedback, they wanted to take into account the experience of users in the building. They were destabilized by this new perspective: I did not realize it before reading their reflections. I took it for granted, given the fact that they had spoken to my teaching assistant and the design teachers. None of them gave feedback on user experience. It became clear that the students had never done needfinding directly from users: they used blogs and forums.

Reflection clearly shows that the students reframed on the basis of feedback from instructors. They were hugely influenced by what the designer would think of their ideas. Imagining a whole building was too complicated and ambitious, and took away from needfinding and making. In cases like this, prototypes can be mock-ups or 3D models. Novel concepts were submitted to the judgment of others in terms of desirability, feasibility and viability, because such an imagined system is not “adopted” by existing users or stakeholders. It is a risk for students. Value creation for a specific group of users who can tell their stories should drive thinking and making for students who are learning design thinking.
Student reflection helps us to understand how they think, how they interpret instructions and why they develop particular elements. Reflection should be included in assignments and reports. Students who reframe only on the basis of feedback from instructors want to please faculty: they are interested in getting a good grade, not delivering real value for real people. Excessively ambitious projects should be avoided, because of the risk of no sense making, no prototyping, no testing, no implementation. At best, such projects can generate breakthrough concepts, if the students and the teaching team are very smart and experts in the field.

The mono disciplinary team on the ENPC projects conducted a lot of interviews to define needs, talking to students, departments and the administration about how to implement student projects: an entrepreneurial track, a better workshop and a digital platform were “the ideas”. The most promising idea of a digital platform was not developed. The other two were beyond their reach in terms of implementation. The whole report and presentation focused on the results from needfinding and idea generation. There was no prototyping or implementation: all that was produced and presented was a form for an ideas box! The three coaches did not ask the students to focus on making it happen. The students were not hard working and were satisfied with a list of ideas.

Transcripts of interviews with users are not needfinding. Needfinding without action is not design thinking: it is a means of making something relevant to people. Making is key.

The extreme innovation project students (mono team) produced a final presentation was so embarrassing that I had to stop it and declare it unacceptable, in order to make the point in front of the jury, because some members were just discovering our school and our programs and these students were conveying an unacceptable image of the school: two French students spoke of Moroccan culture being inferior to ours; the analysis and solutions generated were showed a lack of respect for the people, treating them as second-class citizens lacking in intelligence; one student was furious and argued in front of the whole class; I urged him to stop. Two international students (including one Moroccan) came to my office after the final presentations to explain what they had experienced and how uncomfortable and powerless they felt. The grade given was the lowest ever (4/20): the team was broken up, with two additional assignments, one relating to design thinking, the other a technical assignment in mechanical engineering. The second report by the two international students was sense making because it was limited to an assessment of technical feasibility for a toilet/shower system with recycled water, after identification of an obvious need for water in the village.

Social innovation in emerging countries requires students to be open-minded and respectful of different cultures and people in developing countries. It is a pre-requisite and a condition for carrying out projects. Lack of respect must be sanctioned to the highest degree. Expressions of a sense of superiority are a no-no.
<table>
<thead>
<tr>
<th>Project name</th>
<th>Outputs</th>
<th>Reflection to teach design thinking</th>
<th>Identified problems</th>
<th>Reflection on the culture of design</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDF challenge</td>
<td>A possible vision for EDF based on linky. A ppt presentation and a report.</td>
<td>Such a broad topic does not allow needfinding with real people, prototyping and user test.</td>
<td>The topic is so broad that students spent all their time to find a sense making direction.</td>
<td>Capacities of reframing, imagining and visualising are important.</td>
</tr>
<tr>
<td>ENPC projects</td>
<td>Needfinding. A report.</td>
<td>Topics on services are hard to prototype and test in such a time.</td>
<td>The project was beyond the scope of students because of too many stakeholders.</td>
<td>No designer involved.</td>
</tr>
<tr>
<td>Waste A</td>
<td>See best outcomes.</td>
<td>The partner’s commitment and access to the field were crucial.</td>
<td>A system is complex for students. The possible refocus on a tangible artifact makes it safer.</td>
<td>No designer involved. No needed skill from designers.</td>
</tr>
<tr>
<td>Waster B</td>
<td>Idem</td>
<td>Idem + The combination of a physical artifact and a simulation for the system was ideal.</td>
<td>Implementation of the system was beyond academic scope.</td>
<td>No designer involved. Vizualisation capacity could have enhanced the level of final definition.</td>
</tr>
</tbody>
</table>
Two mono teams carried out a project for a ME310 partner (Suez Environnement): how to improve the process of waste tracking in a building? The two teams performed very well. Both teams were international. One of the two solutions was submitted in a bid for a new building and the corporate liaison won the contract, because of the originality and effectiveness of the idea. Inside the partner company, two stakeholders were involved: two people from the innovation division and one sales manager from a business unit, who was involved in an ongoing bid. They provided access to the field for needfinding, prototyping and user testing. One member of the innovation division was available each week for phone discussions. The partner was committed, open and pragmatic. She worked with me on ME310 and learned a lot about design thinking. User experience was at the core of all our discussions, with or without students. The sales manager needed the results and believed in the pragmatic method, students and discoveries.

Both teams carried out all the activities of design thinking:

- They put into place an organization and planning for their project
- They were regularly seen in the project space
- They did a lot of needfinding in a building similar to the new building in the bid
- They clearly identified all the stakeholders
- They benchmarked existing products, systems and technologies, and assessed them
- They produced a few quick-and-dirty prototypes and tested their ideas with cleaners, facility managers and the corporate liaison
- They developed technical assessment
- They prototyped a final and functional prototype

Team A concentrated on the waste trolley. They reflected individually on the learning experience and summarized the method as “thinking users, instead of technologies”. Their individual self-reflection was thoughtful and interesting, and they had a good team experience. The Key elements mentioned included: the discovery of a new sector, the importance of listening to people when needfinding, how prototyping can be a way to find a solution “with nothing”, the ability to express one’s creativity, project management.

Team B further developed the whole system with a 3D simulation from the user’s point of view. This proposal was closer to the type of services the company was positioned on. They did not write a report but gave another final presentation at the final exhibition of ME310 Paris.
Easy access to the field for needfinding, prototyping and user testing is fundamental for students to conduct all the activities of design thinking. An appropriate brief with this kind of access, commitment and operational stakes from the partner, create the best conditions for students to make sense and implement. Such value creation generates a great sense of pride in students and justifies the what, the why and the how of design thinking.

**Best outcomes of waste management system include:**

- Context understanding with needfinding, sector analysis and technology benchmarking.
- Evidence of reframing from the initial brief.
- Evidence of identifying relevant issues / problems / constraints / expectations.
- Evidence of stakeholder mapping and needfinding for each of them.
- Quantity and flexibility in brainstorming.
- Sense making of exploration paths.
- Technical assessment.
- Visualization of concepts.
- System solution generation.
- Tests with users in real situates of quick-and-dirty prototypes.
- 3D modeling of the experience.
- 1 scale prototypes in low definition.
- Cost assessment.
- Ready-to-use elements for immediate value for the partner in one’s operations.
- Real implementation of suggested solutions.

The best outcomes exceed expectations set out in the evaluation criteria for projects.

Apart from the two teams that worked with a corporate partner, the students were too free to define their subjects, which were not appropriate for design thinking. The students did not pay attention to the evaluation criteria for their projects. They only followed instructions given at project reviews: if the teaching team did not remind them, activities were not carried out.
ME310: excessively ambitious briefs without access to the field?

Local Situation Awareness: Find a civil market for military technology

The LSA team took at least 3 months to find potential civil users for the military technology. I lectured on a tool that did not work very well: which markets/which technologies/which users. It had worked with previous strategic consultancy missions because I facilitated workshops with experts and executives. With students, such a tool does not work. With no user target, the process starts with user finding, which takes a long time and reduces the ideation and implementation phases. As no user was already defined in their brief and as the process was time consuming and difficult, a team created a concept to define the previous step of needfinding: “User finding”. The Paris team had the idea of identifying potholes in roads so that ambulance drivers could avoid them when carrying injured drivers from car accidents.

With no target user given in the brief, students start with a new step: user finding. It is time consuming and drastically reduces the implementation phase.

When they found this direction, they felt much more comfortable. The Stanford team was supportive and both teams developed a functional prototype, which was tested at Stanford with ambulance drivers and fire fighters. The feedback was positive and promising. The storytelling at the final presentation was fantastic: the students described their journey of exploration before speaking about the system they had imagined, prototyped and tested. That year, tested functional prototypes were on show at EXPE Stanford.

Once the users were identified, only one team member immersed himself. He was the leader of the group: proactive, full of ideas, a team player, very supportive of all his classmates and especially a Japanese student who understood neither English nor French. The whole team was involved in testing. The team dynamics was great on both sides (Stanford and Paris). There were no incidents or accidents. The students never completely lost their way. They explored different paths at different paces.

The student storytelling was convincing: they focused on their journey of exploration and did not pitch ideas in an entrepreneurial style. There was no business plan, no marketing strategy, no market studies. They described the turnarounds, the paths explored and the decisions, demonstrated with evidence that the path chosen was the most promising and sense making one. The students spent a lot of time framing and reframing, needfinding and prototyping. All this work should not be sacrificed for the sake of a salespitch: did not work on producing the deliverables needed for that kind of communication exercise.

The final presentation should present the journey of exploration of students and should not be a sales pitch in the traditional style of venture capitalist roadshows.

The corporate partner was satisfied with the project outcomes: a new sense making direction in the civilian market. So were we. Unfortunately, no project manager was identified and assigned to develop this new application and launch it on the market. There is a long
internal process of validation, which includes market studies, further technical assessments, fully operational demonstrator and sales pitches. Two corporate liaisons from the company were involved to a reasonable degree in discussions with students. I did not have personal contacts, as it looked as though the students were managing things very well. In reality, as many discussions as it seemed they did not have so many exchanges as perceived.

Without implementation inside the company, there is a sense of “much ado about nothing”: Implementation is key to justifying the whole journey of exploration.

**Protontherapy: redesign the system for a better experience with social impact**

The protontherapy team was often too abstract in its analysis and thinking, partly because of the personality of one student who was keen to do a lot of thinking and talking, and partly because the subject was too broad and needed reframing. My assistant always stressed the fact that they thought too much without acting. This was true, but abstract analysis was also generated by the complexity of the subject and the sector. The team acquired quickly a lot of technical knowledge. Three members of the team became experts in the technology and the medical situation. The more they understood, the more constraints they discovered, and the more difficult it was to find solutions. They concentrated on how to facilitate the shift from radio to laser therapy by taking account of economic constraints (cost), technical problems (space, radioprotection) and user experience. They had a perfect understanding of what was at stake for the partner and the sector.

The Paris team worked closely with the CEO of the small French company, Amplitudes Technologies. They were not in close contact with hospitals and end users: the CEO gave a couple of introductions to experts, but no partnership was negotiated or trust created by the students’ actions in order to get access to the field. This limitation also reflects the nature of the users concerned: patients in treatment for cancer. Such fields are emotionally difficult for students: they may be sidetracked by too much empathy; they may get emotionally overwhelmed and shut themselves off.

Environments where the user experience is very difficult should be avoided in capstone projects with students who are not prepared and have no vocation (e.g. are not medical students).

The Paris team and I were disappointed at a project review with the corporate partner in January: the quick-and-dirty prototype presented was a cardboard laser machine, designed to test patient anxiety levels when in the tunnel and shape memory for the mattress. The insight was that it takes up to 30 minutes for nurses to find the right position and a couple of second for treatment: if more people could benefit from the machine, more people would be treated, and the social and economic impact would be significant. This would improve both the user experience and the economic outcome, which was the brief. We were quite proud of the
insight and solutions. For the students, it was ideal to this path of exploration, since it made sense and could be fully prototyped. The corporate partner was harsh in his feedback, saying that it was interesting but not his business model. The students were completely demotivated. I still believed that though improving the mattress was not directly part of his business model, it could be a factor of differentiation and a sales argument for the whole experience of laser treatment in competition with alternatives. The partner did not accept that argument. It would have been a risk to go further down this path without any support and interest from the partner.

The scope of the brief and possible outcomes should be discussed between the teaching team and the corporate partner before the course starts, especially for ambitious and broad briefs. Expected outcomes should be brainstormed and anticipated.

After a couple of weeks, the students reframed and found other promising directions, relating to how to set up a machine without demolishing the whole hospital or constructing a new building (assembly of compact modules for a perfect logistical and business model for hospitals). The Paris students were unsuccessful in communicating their findings on how to set up this kind of proton therapy unit, either with their Finnish colleagues, who were developing an application that would allow different stakeholders to share this modular solution with augmented reality, nor at the final presentation at EXPE Stanford, where they had to negotiate hard with the Finnish students. Project fairs at Stanford focus on real prototypes that can be demonstrated and experienced. Business model transformations are not understood and valued in the ME310 community. The Paris students completely changed their presentation for EXPE Paris, which was clear and recognized by the partner as sense making, valuable and operational. The two solutions were experienced by the students as two competing projects, although they were presented in the report as complementary, which could have been the case if the 3D simulation had presented not only the machine, but also the different processes of building a proton therapy unit with and without assembly of compact modules. A simulation of the construction process should have been developed. The application developed did not meet the aim of showing three different scenarios of relevant radiation therapy. The prototyping costs (including augmented reality) were too high for the project budget.

Generating new business models is too complicated for the ME310 students and community, which is used to functional prototypes that can be exhibited at project fairs. A lack of understanding and recognition from one’s peers is difficult for students to experience.

The partner found the findings interesting (potentially a threefold cut in costs). The start-up used part of the findings and outcomes for its fundraising with new investors. The company provided another project for the following semester on the advantages and drawbacks of two different locations for the company: the report was also used in negotiations with politicians. The partner leveraged the brands that ME310 represents (ENPC and Stanford) in both situations.

Corporate partners can leverage the school’s brands, in addition to students’ outcomes, in order to gain trust, legitimacy and power in operational negotiations on their business priorities.
**EADS: Invent the airport of the future**

The EADS team was under pressure from the partner, which behaved more like a client; they got lost in the quest to find an interesting direction and had to follow the partner’s idea; they had no access to the field and the topic was more fiction design (the airport of the future) than DT: they developed a science fiction scenario with no real prototype, part of which was displayed at an exhibition by the partner. Needfinding at the airport was barely done, because no permanent access was negotiated with an airport. Students only did needfinding when flying to Stanford for the kick-off or from personal experience. They did not adopt a professional approach. They took no pictures and conducted no interviews. They relied on emotional memories, as well as on others from the group, the teaching team and the corporate partner. Needfinding was not performed. In addition, the partner put a lot of pressure on the team because in January he let us know that he wanted to use the project outcomes at an exhibition (Le Bourget) and needed to comply with the in-house communication process. The team lacked a strong vision. Because of pressure from their corporate liaison, they felt frustration, anxiety and fear of failure. As a consequence, the students followed corporate partner’s idea: commuting within the airport via a personal shuttle. The user-centric approach was mainly used to justify the concept and to write the storytelling for the presentation. A video was made with a storyboard and outsources to external designers: no real film could be made, so the video was based on cartoon characters.

It is important that the corporate partner should behave like a partner, not a client: otherwise, it can seriously damage the learning experience. It deprives the students of autonomy. Lack of access to the field makes design thinking activities impossible and reinforces the power of the partner over the students, since he remains the sole expert and judge.

**Suez: Reinvent the water and waste offering**

The sustainability team got lost because of a brief that was too broad and tension with the Finnish team. The first quarter was dedicated to exploring both the water and waste offering: the scope was too wide and we decided to refocus on only one. Both teams agreed to reframe on water services and team dynamics improved when they developed the same concept and the French team visited the Finns at the Design Factory. The French team had two outstanding application developers and was thus influenced by interaction design. They were great makers from the beginning. The other team members were less committed, one because of his difficulties with English and French, and the other because of his commitments in another university and his low appetite for exploration. The French team showed a great deal of diplomacy and patience until the very end, which did much to prevent the two teams exploding and for the success of the final outcomes. The two teams developed a series of prototypes, from quick-and-dirty ones to a final functional prototype with wizardoz. The evolution of the different prototypes perfectly represents the ideation phase: the more prototypes they built,
the more testing they did with users, the more insights they got, the more refined the solution reached. The final prototype and business model were sense making and well executed: the students built a functional water fountain with three possible types of water, a screen, personalized bottles and a business model with direct billing and donation opportunities, in order to reinforce the brand around key sustainability.

The evolution of prototypes fostered needfinding, sense making and team cohesion.

The project failed to be implemented in the company because it was initiated and run by the innovation division, which has no operational means to go to market. The advantages for the company and how the solution provided those advantages were not sufficiently stressed (if understood) by the students: this company supplies water with no brand recognition; a communal water fountain that can be installed in companies with a personal bottle, billing and donation system, was an efficient communication tool to enhance the company’s brand. The innovation division contacted a business unit that was trying to launch drinking fountains in public spaces in a French city. The experiment failed so the business units were not interested in the project, which was stopped. A project like this should have been promoted to the director of communications and the CEO, given the brand importance and the change in business models. The outcomes on this project were better than those of the Innovacteurs project in the same year, with more refined prototypes and development (brand, system, application, marketing strategy). Nonetheless, no implementation took place, whereas the Innovacteurs solution was used by a sales manager to win a bid for a new building. The difference was that the operational manager with power to implement was aware of and involved in the project from the very beginning, right back at the stage of brief definition. If the innovation division of a large company cannot carry out a market launch on a project, business units should be associated from the very beginning.

Operational managers who can implement the project and launch the new offering should be involved right back at the brief definition stage, before the course starts: otherwise the project has to be sold internally, which is much harder – if even possible – in terms of negotiation.

The briefs were systems thinking orientated with different stakeholders and no clear identification of users at the beginning. As design thinking starts with needfinding on identified users, it is clear that students need to be taught other methodologies, especially in terms of systems thinking. Such methodologies are: the socio-ecological framework (Flood, 2001, 2011354 p. 120), especially action research methodologies, such as participatory design workshops (Emery, 1989)355 and search conferences (Emery and Purse 1996, Greenwood and Levin 1998)356 which establish


355 Emery, F E. (1959). The emergence of a new paradigm of work. (pp. 38-86), Canberra, Australia: Centre for Continuing Education, Australian National University.

system and environment boundaries, a simple ‘actor archetype’, lawful relations between actors and the system, value propositions.

The two teams that were working in partnership with Finnish students suffered a lot from discussions, to the point that the learning experience was damaged: these kinds of conflicts and tensions should be avoided and the teaching team needs to take full responsibility for avoiding such a situation.

**Reflect: Self-reflection increases the learning experience**

Lecturing on concepts in class and giving assignments for practice in the field does not work: students do not apply what has been taught on the course. Practice needs to be included in the course itself and projects should not follow lectures, proceed step-by-step with deliverables in each class.

Students forget most of the knowledge acquired in class when the action begins. A combination of theory and immediate practice reinforces the learning experience.

Innovateurs: Only the two project teams tackling waste tracking for a corporate partner performed DT activities. Whether or not the brief carried real stakes/included a partner/concerned a broad topic or target users, had a strong impact on outcomes. The learning experience in design thinking can only happen if students have access to the field for needfinding/prototyping/testing and a brief that focuses on delivering value to specific users in a specific situation (and is not a broad topic that needs a lot of reframing to find a sense making path to explore). The more the brief is real and precise with a targeted use, the better the student outcomes are. With a broad topic, students get lost in framing with poor final outcomes, no needfinding, and no prototypes tested with users. With a broad topic, students spend too long struggling to frame their subject and only have time to visualize possible solutions. Usually they get stuck in idea generation. Appropriate briefs need to be defined, on precise objects with access to the field, organized in advance by the TT or the partner.

The teaching team should define appropriate briefs for design thinking. Working with a committed partner motivates students to create value and to develop further.

**ME310: The commitment of partners is not enough if they supply to end users, who are the ones we should be innovating for, and if students do not have direct access to them. If a brief starts with a new technology and no definition of target users, the process does not start with needfinding, but with “user finding”, which requires a lot of time and is not easy for students. It is highly risky to start with these kinds of briefs delivered by a company’s R&D people. Projects that are too broad or too futuristic are also too complicated and do not allow the development of DT skills (no needfinding, no user testing, no pilot). Students should work directly with end users in the field. Lack of access to the field prevents any needfinding and prototyping. In some cases, students have no access to the field: TT or the partner should make sure that it is possible from the beginning.**
Whenever I felt that students were completely lost, I wanted to help them. The three steps in which I felt they needed support were reframing, needfinding and testing. My assistant was against helping students and argue that it was their entire responsibility and it was the normal fuzzy process, where nobody knows what to do but everyone hopes for a miracle at the end. I felt very uncomfortable with these assumptions: I felt that the teaching team has a greater responsibility. I felt that students should not be allowed to get so lost that they become demoralised or carry out activities without sense making. I felt we had a common responsibility to make it happen and to create value for the partners who had trusted us.

The teaching team should take full responsibility for defining (or if necessary negotiating) with the corporate partner a brief that provides a learning experience in design thinking and facilitates access to the field. The teaching team should support students in all activities if they lose their way.

The table of contents given as an instruction at the beginning of each quarter frustrated all the ME310 Paris students: the students working with Stanford did not dare to change it; the students in SUGAR teams tried to negotiate, with or without success. The structure did not provide a thorough description of needfinding and testing with users. The vocabulary used in the instructions (design requirements with functional and physical requirements, design development, design description, project management) suggested a bias towards engineering culture.

Compared with the ME310 curriculum, the following pedagogical innovations were tested in 2010/2011:

- International ambience at ME310 Paris with the recruitment of students from outside the school and from abroad
- Multidisciplinarity for all teams
- A stress on Critical Experience Prototype, instead of critical prototype
- A stress on sense making for corporate partners instead of prototyping at all costs, especially until January
- Value creation for corporate partners as a final objective
- Additional lectures on company dynamics and priorities: innovation, strategic renewals, the duality between marketing and R&D for product innovation
- Additional lectures on buying versus making innovation: consultancy design companies versus internal processes to launch new products
- Additional lectures on blue ocean strategies and value curves
- Additional lectures on needfinding and meaningful experiences for people
- A workshop on the same assignment, based on needfinding for eco-behaviors by employees in a building, in order to assess students’ needfinding competences
• The possibility of not doing assignments on prototypes during the first quarter and in January if replaced by needfinding

• The possibility of changing the table of contents for the report,
  ° in order to allow needfinding and to adapt the types of requirements to the nature of projects, especially in the first quarter: it is hard for students to define physical and functional requirements without knowing what they should do
  ° in order to envision business models and implementation, especially in the last quarter: the development of some projects goes further than design description

• Personal self-reflection in class or assignments

• Assignment for a learning story in June to help corporate partners to disseminate the results of a project inside their company, in addition to the report and the ppt presentation

Assignment given mid-June via an e-mail for the final learning story:

• As a team you have to trace back your learning story in a user-centric friendly way

• The purpose is to spread out your work within your corporate liaison’s company, who will have your ppt presentation of EXPE, your report, and a video to show

• The advised format is a video combining pictures, video, slides, comments: 7mn max

• Here is the video I mentioned (ME310 Journey): https://www.youtube.com/watch?v=_7XktrGRjnQ

• Another good example is the presentation of Paris Thales team at Stanford

For both courses:

A committed partner has a huge impact on student motivation and commitment.

A 150 m² space, staged with the 9 symbolic items, including a light prototyping room, can accommodate 12 students on a full-time basis and another 40 students from two classes.

Individual self-reflection is the best means for faculty to evaluate the degree of self-awareness (whether students know they know and know what they don’t know), the learning experience (in terms of concepts and practice), authenticity and commitment.
**Improve: A need for syllabus development**

The decisions to improve the learning experience were as follows:

**Ecobootcamp**
- Review the curriculum
- Find local challenges
- Increase the level of knowledge in DT from students with an exam

**Innovacteurs**
- Define briefs with objects, users and situates, real stakes and eventually partners
- Find partners as far as possible
- Always prepare access to the field
- Focus on delivering insights from the field and real artefacts

**ME310**
- Find committed partners to make it happen
- Define potential users and customers from the beginning
- Never take futuristic subjects: Reframing requires months at the detriment of ethnographic research and tested prototyped
- Find briefs that combine objects, users and possible operations in the company
- Never take a subject with no access to the field
- Prepare access to the field
- Recruit committed students
- Communicate as much as possible with international teaching teams to create trust and drive students in the same direction
- Find partners, not clients
- Find operational units that have means to launch on the market
- Develop the ME310 syllabus further, especially on sense making linked with business models and operations, dissemination and ethnographic research.

**All courses**
- Individual self-reflection improves learning ability and the understanding of the teaching teams
2010/2011 : Learning about a culture of design thinking

The idea of 101 emerged with the discovery at SF airport of “101 things I learnt in architecture school” and “101 things I learnt in design school” at Tate museum in London. On the flight back from Stanford in June, I identified of 101 milestones in design thinking, within three categories: people / place / process. I am fully convinced of the efficacy of this conceptual framework as a way to foster innovation in multidisciplinary teams.

**PEOPLE**

I discovered Verganti and cultural interpreters (56): Creating new meanings for the society is key to fostering breakthrough innovation. I used his graph to teach breakthrough innovation: sense making with/without technology.

The common goal of creating new meaningful experiences for people should drive teams.

**PROCESS**

I discovered the book of Roger Martin: I used his distinction between mysteries/heuristics/algorithms (60) to teach engineering students the difference between exploitation and exploration to pitch DT to companies (introduction VI). I discovered the power of structuring reflexivity (99) for students to be self aware of their journey and the power of telling their learning story (101) to convince their audience at their final presentations.

Self-reflection enhances awareness and control on the journey of exploration. It should be part of the process. It defines why some back or forward loops can be made between different activities. It dramatically increases team performance and the learning experience.
PLACE

I visited the School of Design Thinking in Potsdam (4). We welcomed a certain number of people in the small space we have. Space is the first thing that people see and feel from the culture of design thinking. It is a demonstrator. Space staging can define a new territory, where values and rules can be different. Space defines the country and people can expect to live another culture, if the staging is different, coherent and demonstrative. Customization increases the level of emotional commitment.

The 9 milestones create a demonstrator for visitors, as well as emotional and functional comfort for teams. It is of essential that every aspect of space staging should be justified at all levels (symbolic, emotional, functional). Space defines the limits of a territory and a country, where one can live the culture of design thinking.

Table 41. Tipping points in design thinking discovered in 2010/2011

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>PLACE</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural interpreters (56)</td>
<td>School of Design Thinking (4)</td>
<td>Mysteries/heuristics/ algorithms (60)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflexivity (99)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learning story (101)</td>
</tr>
</tbody>
</table>

2011/2012: How to make implementation happen

Situate: The opportunity to win a government bid to create d.school Paris

The objectives in terms of course development (ecobootcamp, Innovacteurs, ME310) and available resources (space, two faculty members) were the same as in the previous academic year. In addition to my responsibilities as an academic director of ENPC’s industrial engineering department, I had to enter a bid for a government project and I submitted the project of a d.school in Paris.

Three ME310 sponsored projects were acquired with Thales Angenieux, GDF SUEZ and Panasonic, in cooperation with Stanford, Aalto and HPI. 12 students are recruited from different disciplines, universities and schools (Polytechnique, ENPC, Strate College Designers, TokyoTech, Juavana in Cali…). The teaching assistant from Stanford left and a new assistant, an alumnus of ME310 Paris in design was recruited. He mainly contributed to the development of assignments and coaching.

I had experimented with half a dozen pedagogical innovations in ME310 2010/2011 and now wished to implement them officially in the new edition of ME310 Paris. I also wanted to experiment with new innovations to improve sense making and dissemination in companies.

In the first semester, I wanted to refurbish Ecobootcamp’s curriculum, which was still dedicated to improving sustainability in a student residence (edition 1). Each class was structured with half the time in lectures and half the time in guided exercises applied to a local project of interest to students. An examination was introduced with the objective of improving knowledge acquisition and the ability of students to speak about DT when going for interviews in companies. Assignments for the mini project included a final presentation and a report in the form of an exploration journal. The brief for the mini projects was as follows: create a positive impact for the planet while reinventing the user experience in your accommodation. The objective was to combine a lecture and practical exercises applied to a mini project in a step-by-step way, class after class. I developed a number of new lectures and supports. The same creativity expert was recruited as in previous years and ran one session with the same format as before.

In the first semester, I tried to prepare the Innovacteurs briefs as carefully as possible: as ENSCI did not want to introduce partners for multidisciplinary teams (because of the sponsorships required), we defined one topic on seniors and photography and one topic on social innovation in emerging countries. For projects other than those with ENSCI, partners were acquired without sponsorship on the basis of the nature of the briefs and potential access to the field: Suez, Panasonic, Air Liquide, Stupeflix.

A French government call for projects was issued in October, and the project for a d.school was submitted in December with the support of other d.schools and companies. The bid was submitted to an international jury in March. The project was one of the bids accepted for financial
support, with a grant of 4M€ over 8 years. A team was to be set up for the summer of 2012.

The data records for 2011/2012 include syllabus, assignments, lectures and reports for:

- The 3rd edition of ME310: Angenieux, GDF SUEZ, Panasonic
- The 4th edition of Innovacteurs: 5 projects with multi versus mono teams

Plan: 9 Innovacteurs and 3 ME310

Innovacteurs included 9 projects and over 40 students:

Three multi teams were set up with ENSCI:

- Photography and seniors
- Retired French in Marocco
- Ambassadors of Marrocan culture in Paris.

Six mono teams were set up:

- 1 without partner (at request of students): * Reinvent the waiting experience in commuting
- 5 with partners:
  - Reinvent the fridge for young people with Panasonic (two teams)
  - Which open data services with Suez
  - Reinvent a fabric recycling box with Suez
  - Reinvent picture services for a start up with Stupeflix
  - Reinvent O2 bottles in hospitals with Air Liquide.

All the students took ecobootcamp. The new curriculum provided a better learning experience and was highly appreciated. Students were restricted in terms of implementation by the housing staff, who threw away all the carbo prototypes. This lowered morale. The operational staff had no direction and approval from the facilities management. Interesting brochures (such as how to reduce food waste) were published and distributed. Self-awareness for sustainability was acquired through some actions. As the exams demonstrated, most students got confused between the DT process (inspiration/ideation/implementation) and the process proposed by the creativity expert (impregnation/illumination/crystallisation). Using an examination to test knowledge acquisition was an interesting measure: it clearly showed what students understood and remembered.
ME310 projects included:

- Reinvent energy services with GDF SUEZ
- Reinvent zooms for high quality images in motion with Angenieux
- Reinvent the TV experience for Europeans with Panasonic

Planned pedagogical innovations for ME310 2011/2012 included:

- Learning trips with visits to companies or other locations with students
- Organization of kick-offs and common project reviews with corporate partners
- Organization of visits to corporate partners when possible
- Regular contact between the teaching team and corporate partners without students, in order to discuss internal priorities, if necessary the understanding of design thinking, and student outcomes
- Writing of briefs in cooperation with partners before the start of the course
- Team space redesign challenge in October
- One-week workshop dedicated to ethnographic research (instead of robot prototyping) in early January on a common brief unconnected with their projects
- Writing of assignments in addition to the initial curriculum: spatial context, individual self-reflection for each quarter or after a workshop, individual conversations in order to assess how the experience is lived and to discuss personal skills and commitment
- A two-day workshop on creativity with an outside expert
- Development of additional lectures on: reflexivity - ethnographic research - cross-cultural management - interaction design and phenomenology
- Coaching in cultural management with an outside expert: pre-project survey, analysis and debriefing of profiles, individual follow-ups in teams
**Act and observe: The more incremental steps, the better breakthroughs**

**Innovacteurs: Excellent deliverables, with no implementation**

Most GI students were interested, committed and smart.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main observation</th>
<th>Project outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photography and seniors</td>
<td>The dynamics between engineers and designers was fruitful.</td>
<td>See best outcomes, which were impressive.</td>
</tr>
<tr>
<td>Retired French in Marrocco</td>
<td>Engineers were influenced by the reframing and vision development of designers to the point they got lost. Sense making only emerges when real needfinding was carried out.</td>
<td>Students produced a series of documents, in order to create an association. The final presentation was carried out under an original format that nobody understood.</td>
</tr>
<tr>
<td>Ambassadors of Marrocan culture in Paris</td>
<td>Idem.</td>
<td>Students produced an application that should identify marocan places in Paris. It was not obvious how it could work and spread out.</td>
</tr>
<tr>
<td>Reinvent the waiting experience in commuting</td>
<td>Refocusing on a local place makes the project interesting and feasible.</td>
<td>Students did needfinding and user tests. They combined the redesign of a tangible place and the imagination of an ideal experience of the system. They made a video including interviews from needfinding, the ideal experience and feedbacks on prototyping.</td>
</tr>
<tr>
<td>Reinvent the fridge for young people (Team 1)</td>
<td>The partner did not drive the teams with activities of DT. It was hard for TT. Designing for themselves was not easier for needfinding. Students understood and performed well.</td>
<td>Students prototyped and combined an artifact of average definition with a simulation, a logo, and an idea on how to manufacture and distribute.</td>
</tr>
<tr>
<td>Reinvent the fridge for young people (Team 2)</td>
<td>Idem + poor performance of student because of a lack of work and reframing.</td>
<td>Students prototyped with a low definition artifact.</td>
</tr>
</tbody>
</table>

Table 42. Quick analysis of Innovacteurs 2011/2012
Open data services  Students got lost in such a broad and new topic. They did not find any sense making direction. They did not follow advice.  Students produced no value for the partner and were beside the point.

Reinvent a recycling cloth box  Students did not observe recycling boxes enough. They listened to TT. They were not inspired enough.  Students prototyped a box they did not test with users and stakeholders. The partner was not enough operational.

Reinvent picture services for a start up  Students were committed and supported by an alumnus.  Students developed applications, with iterative loops of testing to improve it. It was efficient.

Reinvent O2 bottles in hospitals  Students got access to a hospital for needfinding.  Students prototyped a bottle but did not do any user tests. They could also have developed a new system of logistics.

**MULTI TEAMS:**

The best project from the multi teams was the project on photography: outstanding reframing on a concrete object linked with photography from a broad topic (seniors and love), great team dynamics, a wizardoz prototype in a great video that showed the ideal experience, very high level of quality for the report and all presentations.

The team working on retired French people in Morocco gave the feeling that they had understood the people, but no one understood the final outputs and presentation: a bunch of documents for the creation of an association with strange storytelling with sounds and delivery of documents nobody in the jury understood.

The Moroccan Ambassador team struggled to find sense making on how to do it: the final app was not clear and the presentation was average.

These two extreme innovation multi teams were too abstract with no sense of relevant insights (no field trip), no prototype and no action in the field.
MONO TEAMS:

The open data project for Suez was a disaster, as the students understood nothing about the subject, despite warnings by the TT and corporate liaisons. Again the topic was too broad.

The cloth recycling box was of average quality because students did not work with operations people but with the innovation division and with no access to the field. They prototyped a cardboard box, with no user testing.

The O2 bottle project was promising but limited in implementation because the partner was a supplier to the hospital and had little power to make it happen. Students concentrated on a prototype with additional features in cardboard on a real bottle. Ergonomic factors were not detailed enough. The industrial engineering students should have concentrated on improving the supply chain management for bottles in the hospital, which would have produced better results and had an impact on the ecosystem.

The station team did a great job despite getting no help from their partner: interesting ethnographic research, a lot of different prototypes and tests in the station near the school, a final solution prototyped and tested, a video that shows the actual experience and the imagined ideal experience.

The video start-up team performed well with a product almost on the market: in addition to brilliant people, quick decisions with the partner (a ME310 alumnus) made it happen. The team carried out two prototyping/testing loops, which is rare for Innovacteurs projects.

The two teams working on the fridge performed differently: one was committed, the other not. They were influenced by the former TA from ME310 Paris, who identified company track records in innovation (such as market studies and BP), which are not references in DT and beyond the scope of the course. TT should refocus on design thinking deliverables first.

There was no real implementation, despite high-quality deliverables at each step for most students. Almost all teams prototyped in many different ways: from quick-and-dirty to wizardoz prototypes and videos showing the ideal experience from the perspective of users. The TT needs to be obsessed with making it happen. Otherwise there is no chance it will happen, even with very smart students. The learning experience was impressive anyway: should implementation be necessary? It depends on what the learning objectives are.
<table>
<thead>
<tr>
<th>Project name</th>
<th>Outputs</th>
<th>Reflection design thinking education</th>
<th>Identified problems</th>
<th>Reflection on the culture of design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photography and seniors</td>
<td>See best outcomes</td>
<td>A broad topic such as seniors and love was a challenge for students to reframe. When a direction was found, it was much easier and obvious for DT.</td>
<td>No real partner to give legitimacy for implementation</td>
<td>Great value for reframing and giving forms, including industrial and graphic design.</td>
</tr>
<tr>
<td>Retired French in Marocco</td>
<td>Reframing. Concept generation.</td>
<td>The topic was not framed in such a way DT could have been taught.</td>
<td>All students did not access to users and the field.</td>
<td>Reframing was too abstract and get students lost.</td>
</tr>
<tr>
<td>Reinvent the waiting experience in commuting</td>
<td>Needfinding. User tests with a prototyping space. A video showing the ideal experience.</td>
<td>The topic of transportation is difficult for DT: the combination of physical and digital experience is the best direction.</td>
<td>Prototyping and testing in transportation are very difficult for students.</td>
<td>The value of interior and graphic design, as well as movie making, would have enhanced the quality of outputs.</td>
</tr>
<tr>
<td>Reinvent the fridge for young people (Team 1)</td>
<td>Needfinding. Quick and dirty prototypes</td>
<td>The brief is appropriate: observation and prototypes are easy.</td>
<td>Lack of commitment and work.</td>
<td>ID would have enhanced the level of prototype definition.</td>
</tr>
<tr>
<td>Reinvent the fridge for young people (Team 2)</td>
<td>Needfinding. One prototype implemented in a real kitchen</td>
<td>Idem</td>
<td>Time is tight for students to implement.</td>
<td>Idem.</td>
</tr>
<tr>
<td>Open data services</td>
<td>No sense making direction</td>
<td>Design thinking is not appropriate to define the what of a too broad topic.</td>
<td>Students were lost in understanding their subject.</td>
<td>Some subjects are not appropriate for design thinking</td>
</tr>
<tr>
<td>Reinvent a recycling cloth box</td>
<td>Poor needfinding. Prototype.</td>
<td>Needfinding was too difficult.</td>
<td>No test. Lack of operational people.</td>
<td>The box is a piece of the system.</td>
</tr>
<tr>
<td>--------------------------------</td>
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<td>-------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Reinvent picture services for a start up</td>
<td>Great outputs</td>
<td>The brief is appropriate.</td>
<td>Students should know how to develop interfaces.</td>
<td>Digital services are easy for students.</td>
</tr>
<tr>
<td>Reinvent O2 bottles in hospitals</td>
<td>Interesting outputs, even if more should be done.</td>
<td>Idem.</td>
<td>On object in a system is challenge.</td>
<td>A system is hard to test in real context.</td>
</tr>
</tbody>
</table>

**Best outcomes from photography project include:**

- Situated understanding with needfinding: Obvious evidence of observation and interviews with users in real situates, obvious collection of pictures through time and situates in order to deduce insights and design principles, discovery of insights and lively presentations.
- Evidence of empathy, caring and sensitivity.
- In-depth analysis of key concepts in the initial brief related to users’ feelings and experiences.
- Tests with users in real situates of quick-and-dirty prototypes.
- Evidence of reframing on photography from the initial brief (love, dependence and seniors).
- Imperatives (coined by students as a “charte”) in terms of users’ benefits.
- A lot of users’ scenarios in different situates.
- Beautiful and insightful ppt presentations for project reviews.
- Evidence of identifying relevant issues / problems / constraints / expectations.
- Quantity and flexibility in brainstorming with concept visualisations.
- A high quality video that shows before the solution / after the solution in an ideal experience, with a Wizardoz prototype.
- The creation of a logo and a brand.
- A quick technology feasibility assessment.
- High quality reports with a graphic design, a lot of pictures, beautiful texts and self-reflections.
**ME310 2011/2012: Learning story is part of the process**

All ME310 students were proud of what had been achieved. The new TT loved spending time with the students and talking. The dynamics of project reviews were constructive, with no tension.

**Angenieux: Re-invent the capture of high definition moving images for filmmakers**

The Angenieux team was incredibly efficient, in getting access to the field (with no support from the TT and very little from the corporate partner), in prototyping and testing in real situations, as well as in finding incremental innovations that made sense and created trust in the ecosystem. The development of incremental innovations that made sense through prototypes and tests clearly paved the way to finding a sense making breakthrough concept. A functional prototype was developed with downgraded materials compared with real zooms and software. The method of prototyping they found was clever and ingenious. 4D capture with multiple kinnects, finding a way to simulate three high-quality zooms with regular cameras and to develop software to provide depth.

The team was led by a bilingual Irish French engineering student. The dynamics were interesting despite the difficulty of a Japanese student, the lack of a commitment from a French engineering student and the touchiness of a designer. The Stanford students did not fully trust and respect the French team: the French leader found the interesting path and was articulate and charismatic enough to lead both sides.

The partner was committed from the very beginning and had regular exchanges with the team. The project’s outcome created trust and recognition amongst industry filmmakers: “What you have found can change our industry”. Despite recognition from the industry and the company, there was no implementation after the program, because of a lack of project managers who supported it and the feeling that it was outside the business model. Two students from Stanford founded a start-up.

The more immediate value is created with incremental innovations, the greater the trust in the ecosystem and the greater the relevance and sense making achieved by by students.

**Panasonic: Re-invent the TV experience for European markets**

The Panasonic team did poor ethnographic research, despite my efforts to create new assignments and to teach them tools. We were worried but decided to move ahead with ideation: brainstorming, prototyping and testing with users. The team enjoyed that phase and the feedback from users helped them to gain confidence. After a couple of prototypes (mood TV, mom’s TV, one-channel TV) tested with all the employees of ENPC’s research department, who were located on the same floor as their project space, they made interesting findings.
in the ideation phase by prototyping and testing: a double screen with family games played between real people.

There was no leader in the Paris team and the team dynamics were very difficult. The dynamics were affected by an absent-minded designer, with some strange behavior traits and reactions, and a Swiss IT engineer who was lost in the ambiguity of exploration, obsessed by project management and distracted by personal consultancy missions. Fortunately, a duo of French engineers (one who was also a great manga artist) worked until the very end and the dynamics with the German team were smooth and productive. The team was asked to do a lot of self-reflection in January, in order to improve their mutual understanding and the team dynamics, which was difficult given the personality types. Unfortunately, the potential leader, who was an engineer on a special track at ENPC, was too shy to take leadership of the team, despite his capacity. After a couple of face-to-face conservations, he gained confidence, but never dared to give directions to the team.

The former TA, who became the corporate partner in this project, was obsessed by internal criteria of approval for product development (business model and market studies): these criteria should not be taken into account in the exploratory phase of inspiration and ideation, only in the implementation phase if time allows it, because it is not the focus of DT.

The final prototype exhibited at Stanford attracted a lot of attention and interest. The partner was the former TA who had joined a small German unit representing a huge Japanese company. The project got “lost” in the communication between the two.

A team can be lost in inspiration (including ethnographic research) and find its path in ideation, with a new loop of inspiration.

**GDF - SUEZ: Re-invent energy services in buildings**

The GDF SUEZ team in Paris failed to find a sense making direction from interviews with the partner. The Stanford team did no serious needfinding and build prototypes to make people guilty in order to influence their behavior. By January, no sense direction had been found. I decided to step in and to carry out a series of interviews inside the company, in order to understand the priorities. I discovered by doing it with students that I always asked questions in the same order: first I wanted to understand the path people were on, in order to understand their priorities and experience linked with our topic: second I asked always about the same four levels of ethnographic research: constraints/problems with existing systems/expectations of new ones/dreams for the future.

Ethnographic research should consider four levels of needfinding: constraints/problems/expectations/dreams. This process creates confidence in interviews.

The initial brief was too broad and there was no easy access to the field: the partner had to find it in January and negotiate it. A new tool was used to make the team self-reflect:
the learning story, which made them reflect on their journey of exploration. Promising new dynamic was generated.

The more a team self-reflects in the format of a learning story (with such categories as context, findings, prototypes, decisions), the more it becomes self-aware of the journey and incontrol.

At the request of the corporate liaison, an open door event was organized over two days in January with the two teams, from Paris and Stanford. It was located in the company’s main building. Over 60 people from the company attended. The first stream came to explore, and as they were surprised and convinced, they created momentum and a second bigger flow came the following day. This kind of dissemination was a very efficient way to understand what ideas could and could not be implemented. The operational managers reacted to what they could use. The targeted manager who would be responsible for implementing the different possible prototypes found all of them interesting in terms of framing and needfinding, but admitted he was lost in terms of how to implement them (production and set-up). This had great impact on both teams: they realized how important it is to combine conception and execution. The risk is that one can come up with great ideas and no possibility of implementation. After this reality check from the operational managers, the students and corporate liaison worked more closely with them, in order to understand how to create storytelling and a pilot in the implementation phase.

An open door event was a more efficient way to generate momentum and conduct a reality check than traditional project reviews and final presentation.

For the final presentation at Stanford, students could not find a story to tell about their project, essentially because the solution was a system. I had to step in and did it with them: the challenge was to reunify all the different prototypes and elements into a simple and coherent system visualization. The students were easily convinced and did an outstanding job, in terms of slide show and speeches. The presentation was a success, both at Stanford and in Paris, with over 12 people from the company attending. The project was acclaimed one of the best projects of the year in the company.

TT should be ready to carry out parts of the process if students are lost and do not know what and how to do things, in order to enhance the learning experience.

FOR ALL TEAMS. That year, I was able to work more frequently and more precisely on team dynamics. At project reviews, I explained team dynamics, for example in terms of cognitive reasoning, and a number of tools that I thought that could be useful for the specific needs of that team at that time. As a consequence, further pedagogical innovations were developed in action during the academic year:

Additional pedagogical innovations were introduced in January:
• Requirements for sociological trends with historical benchmarks for Panasonic: students failed to carry out any that made sense;

• Collective brainstorming for Panasonic, which was experiencing difficult tensions (360° assessment for each member and personal SWOT inspired by Carlos from Cali ME310 who had explained it at the collective debriefings the previous year: it was a success in terms of mutual understanding and conflict relief, although two members did not change;

• Analysis of team dynamics in terms of convergence/divergence for each phase (inspiration/ideation/implementation/comfort zones for each member/correlation between frequency, amplitude and team performance): the students felt relieved, interested and supported.

• Reflection on lectures, in order to assess what students understood and took away from them.

My teaching assistant wrote assignments in the form of emails to students after a lecture. Each assignment had a deadline. The teaching team gave feedback at the next lecture. These assignments enhanced the learning experience by means of reflection in action and the resulting curriculum adjustment to take account of team performances and reactions.

Example of assignments in action:

“Dark horse wranglers”

As Véronique announced yesterday after Pierre Levy’s lecture, she would like you to take 20 minutes to reflect on a simple assignment by answering these three questions:

1. What are the messages you understood from the lecture?
2. What struck you and inspired you? Why?
3. Select one point or topic and describe how you might apply it to your project.”

Example of a Japanese student’s reply:

1. There is a large difference between ‘sense’ and ‘stimuli.’ While you could design ‘sense’ with your products, you can’t design ‘stimuli’ such as light and tremble of air etc.

Since the experiences of users are exactly what happens, while a user uses the product, your prototype needs to reflect the critical factors of the product. The lecturer also mentioned that the actual experience is different from the memory of the user. So you need to observe the user’s behavior instead of interviewing them.
2. We design products just to help users experience but at the same time, that has quite large effect on users experience. And I was inspired by the show window, which expands when users approach it. It was a visualization of interaction between users and the product. It shows feedback to user’s behavior. The reason why I was inspired by this product is that I think giving feedback is important also in the field of energy efficiency, particularly, to make users aware of their energy usage.

3. As I mentioned in the second question, I would like to try get feedback from users or to visualize interaction between user and product. It might be a product/system that gives users the temperature difference between average room temperature in the building and temp in their room. It can tell a user whether he/she is using the air conditioner compared to other users. If the temperature difference is too large, the user will feel guilty and turns it to reasonable temperature.

It is of paramount importance to combine an official formalized syllabus and additional assignments, which are either available from past experience or developed in action, in order to improve the learning experience and adjust to the specific nature of a project.

In March, additional assignments were required from students, which combined visual thinking and reflection on their actions:

- Learning stories for each team
- Assumptions for the future in terms of users’ scenario
- Exploration maps
- Teams’ Likes/Dislikes, Motivate/demotivate for each member, and an action plan (which was missing and had never been done by Panasonic)

The curriculum for capstone projects in innovation with corporate partners cannot be boiled just to feedback from faculty at project reviews (as could be the case in studios) with either no planned curriculum or a checklist of assignments (with or without feedback from faculty members). Faculty should provide not only specific thinking on the project and help when needed, but also specific assignments to enhance project outcomes and team dynamics.
Reflect: Continuous reframing is a teaching challenge

Ecobootcamp: For the first time, I feel that all the students are doing DT! The course is considered intense and represents a lot of work in terms of deliverables. Negotiations are needed with the manager of the residents through ENPC, in order to get approval at least for tests with low definition prototypes and maybe for implementation. Because of the exam, students are able to speak about DT: knowledge acquisition and expertise are needed to gain recognition in a French context. It is a great help for students at job interviews, in fact mentioned by many of them as the first source of interest from employers. It also makes practice easier: students know what to do. Project reviews are easier: there is no need to lecture or to explain the basics again. The level of performance in activities is obviously higher.

Innovacteurs: A field trip is a prerequisite for innovating for people in another country: otherwise insights and outcomes are abstract, with a lack of sense making and implementation. A brief with a precise object and target user is effective for teaching DT if access to the field is easy: otherwise, there is no time or students may get lost in framing and reframing. Broad conceptual topics lead students astray. Lack of access to the field limits them in terms of implementation, not needfinding.

Wizardoz are a very effective way to present an ideal experience, especially in the sphere of services.

I could not teach DT when working with a design school, because I realized that the course is not promoted to design students as a DT course and the design professor does not want to do so: his objective is to offer multidisciplinary teams, with a belief that “confronting” points of view is valuable, when in fact it leads to misunderstanding and conflict. The focus is on reframing in an unexpected way and imagining breakthrough concepts, not on making incremental innovations. DT is different from the culture of design in France.

ME310: Episodic versus continuous reframing. Teams with the best results have the capacity of continuous reframing versus episodic reframing: they can reframe without the help of outside people and directions in such a way it makes sense for the project. One team did it from the very beginning and the two others failed almost until the end and needed instructions from the TT. This capacity is an essential skill for innovation. Multidisciplinary teams follow the characteristics described by Weick and Quinn (1999) concerning episodic and continuous change, depending on their levels of maturity. Weick and Quinn’s unit of analysis is at organization level. Our unit of analysis is the team level. We have observed similarities in terms of responses to change. The following table is an adaptation of the model given by Weick and Quinn (1999) to highlight differences between episodic and continuous change for team dynamics. The observation of multidisciplinary teams shows they all start with Lewinian change. Then, depending on their level of maturity (defined by their ability in sense making to redirect the course of their project), some teams will follow a Confucian change type.
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**Table 44.** Teams’ dynamics adapted from Weick and Quinn (1999)\(^{358}\)

<table>
<thead>
<tr>
<th>Metaphor of team</th>
<th>Episodic change</th>
<th>Continuous change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metaphor of team</strong></td>
<td>Teams are inertial and change is infrequent, discontinuous, and intentional.</td>
<td>Teams are self-organizing and change is constant, evolving, cumulative.</td>
</tr>
<tr>
<td><strong>Analytic Framework</strong></td>
<td>Project change tends to be dramatic and it is driven externally (corporate liaison, academic partner, team). It is seen as divergence of points of view and ideas. Waiting for project change decisions creates inertia, low performance (no further inquiry, creativity or development) and frustration. Emphasis: short-run compromise between divergent points of view among team members. Key concepts: authority, power negotiation, inertia, focus on divergence of individuals’ points of view, conflict, compromise.</td>
<td>Change is a pattern of endless modifications in work processes and progresses. The understanding of constraints and stakeholders’ needs drive the decisions taken by the team. Numerous small accommodations cumulate and amplify. Inquiry, creativity and development are continuous and shared. Emphasis: long-term perspective of the project and sense making for its stakeholders. Key concepts: recurrent interaction, emergent patterns, translation, learning, vision sharing and storytelling.</td>
</tr>
<tr>
<td><strong>Intervention theory</strong></td>
<td>Lewinian change.</td>
<td>Confucian change.</td>
</tr>
<tr>
<td><strong>Role of change agent</strong></td>
<td>Role: Prime mover who defends personal or group ideas. Process: focuses on divergence of points of view, resulting conflicts and inertia; seeks points of decision. Communicates alternative schéma, builds coordination and commitment, explains different points of view and interpretation.</td>
<td>Role: Sense maker who redirects change according to the last state of knowledge. Process: recognizes, makes salient, and reframes current patterns. Demonstrates sense making directions with ethnographic research evidence, build prototypes that can be implemented.</td>
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The explanation about the sequences of convergence/divergence phases in the course of a project helped all team members to better manage their personal comfort and discomfort zones.

The partner’s commitment increases in student motivation. Corporate partners should be trained before giving feedback to students, or the teaching team should attend project reviews between students and corporate partners, in order to avoid divergence of instructions. There is a need to maintain control and legitimacy over the partner. The use of the term “ethnographic research” instead of “needfinding” make the purpose and the methods clearer for R&D people in a French tech company.

It is very hard for Japanese students: they are lost in terms of language, capacity to interview and observe, creativity. They require a lot of support from French students.

External coaches with expertise on the given subject help students better than alumni.

All the pedagogical innovations improved the learning experience, except the one-week workshop in ethnographic research in a horse-riding school: it was very instructive for faculty to understand how students behave in the field, how they synthesize field data and how they present them. However, students felt that the field was too remote from their projects. Some did not transfer that learning to a new way of doing ethnographic research for their projects. Some complained that it was a waste of time.

**Pedagogical lessons for learning story are as follows:**

- **It is the best way to communicate about the learning journey and to convince about the path of exploration that has been chosen and developed.**

- **A video with historical milestones is the best way to communicate this journey of reflection.**

- **A graph can show the navigation between thinking, making, discovery and vision (RTDP model, Hummels and Frens). This kind of model can be too complicated to teach: students do not know what to do afterwards, but it is a reference model for faculty to check their reflection process and guide them in their journey of exploration, as a balance between the 4 activities should be reached, in order to improve the learning experience in exploration. In this case, students can visualize their navigation between situating, needfinding, prototypes and decisions.**

Doing ethnographic research with students in the field improves the learning experience and the faculty’s assessment of student capacity. The TT should step in when students fail, not only for the quality of projects, but also for the quality of the learning experience.
**Improve: Dissemination inside the partner’s organization**

The decisions to improve the learning experience were as follows:

**Ecobootcamp**
- Keep the same curriculum, which is robust
- Negotiate the possibility of implementation with student housing facility manager
- Simplify the brief

**Innovacteurs**
- Find partners for all projects without ENSCI
- Prepare access to the field for projects with partners
- Focus briefs with ENSCI on one user target (the elderly) and different specific and common objects that can be easily observed and tested
- Assign coach for each team for weekly follow-ups
- Teach DT at last!

**ME310**
- Create training and dissemination events inside the company: a global kick-off with as many stakeholders as necessary for implementation and lectures on DT, an open door event to discuss findings in terms of feasibility and viability, events in the company in the development and marketing teams, a big project fair/exhibition show
- Avoid directions with no operational means
- Support the corporate partner in analyzing their environment and creating momentum
- Find partners in the company who can make it happen
- Avoid broad subjects: the subject needs to be reframed to the point that the TT knows what to do and how to do it from the start
- Make a clear distinction between the prototype-based Stanford syllabus and the ethnography and dissemination based Paris syllabus
- Create an ecosystem that is committed to making it happen
- Train the corporate partners and their ecosystem
- Develop further lectures and pedagogical resources for students
- Be clearer on instructions
2011/2012 : Learning about a culture of design thinking

The identification of the 101 ways is carried out and tested in courses as interesting points of reference to give to students. The format is one concept / one text / one picture.

**PEOPLE**

DT is a way of training both intuitive and analytical skills (29). Intuition should come from exposure in the field (well inspired) (30). I lectured on multiple intelligences (32), the difference between creativity, imagination and abduction (36 and 37). I used the Ten Faces of Innovation (52) to teach DT, with a stress on anthropologists (53). Cross-pollinators (55) demonstrate the efficiency of hacking. Experimenters (57) stress the value of making to learn. I pointed out the difference between speakers, pitchers and storytellers (58). I conducted new assignments on deduction and induction (35). I conceptualized and taught a new tool to help students navigate between divergence and convergence (38). I enjoyed a real human adventure with students and corporate partners (45).

Continuous reframing for sense making determines the level of student autonomy and performance in inspiration. Students can perform in ideation only and not in inspiration first.

**PROCESS**

I stressed to companies the different kinds of risks between exploration and exploitation (62). I introduced the notion of ethnographic research instead of needfinding (75) and showed the differences between traditional marketing (76) and ethnography. Dynamic conversations (80) are conducted with students. The ability of teams to carry out continuous reframing (72) is identified as a core DT skill. The notion of extreme users (78) is used as a tool for all teams. I went into the field with each team for the art of observation (79) and took over when it was badly done. The notion of experiental prototypes (94) is introduced to show the difference from technical prototypes. The value of incremental innovation with quick wins (95) in making relevant breakthroughs and creating trust in the ecosystem is emphasized. How to teach reflexivity (99). The power of telling one’s learning story (101) at final presentation to convince the audience is demonstrated.

Learning stories are an efficient way to make students self-reflect, as well as to gain confidence and control in the exploration phase.

Moving from inspiration to ideation, even if the inspiration results are inadequate, should be maintained in order to help the team move ahead and discover sense making, insights and reframing by making, instead of observing and interviewing.
I experienced the value of stressing the importance of getting into the field with students (22).

The more students and the teaching team are in the field together, the better the learning experience: it helps with sense making and teaching by demonstrating practice.

Table 45 describes tipping points I discovered in 2011/2012 to learn about a culture of design thinking. Numbers refer to pages in the book359, which provide a full description of each concept.

<table>
<thead>
<tr>
<th>PEOPLE</th>
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<tbody>
<tr>
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<td></td>
<td>Reframing (72)</td>
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<td>10 faces of innovation (52)</td>
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<td>Experimenters (57)</td>
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<td>Quick wins (95)</td>
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<td>Storytellers (58)</td>
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<td>Dynamic conversations (80)</td>
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<td>Divergence and convergence (38)</td>
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<td>Human adventure (45)</td>
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<td>Deduction and induction (35)</td>
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Conclusion: Is it useful? Is it adaptable? Is it transferable?

Developing a full-time international program in cooperation with Stanford University was useful as a way of gaining experience and legitimacy in design thinking, and of making an impact on projects that include real stakes and global companies. Is it worth the effort? Larry asked me this very wise question several times at EXPE in June. The level of effort, commitment and ambiguity is so high that this responsibility has an impact on one’s personal life. Beyond the first reason is given, such a program represents a personal challenge, which leads to personal development. The dream is to contribute to the launch of breakthrough innovations on the market with global companies. I think I share this dream with all the corporate partners, students and faculty. The dynamics with students when successful are also very rewarding, especially when students undergo a personal transformation which will have a big impact on the rest of their lives: for example, Pierre Valade, an alumnus from the first cohort, founded his own company, which was sold in April 2015 to Microsoft for $1 million, and was kind enough to recognize that ME310 was a turning point in his life. Amine Bellakrid, an alumnus from the same cohort, told me many a time that ME310 had opened up to him a new range of opportunities that he would have never imagined when he was in Morocco and later an ENPC student. He now works in New York.

I adapted the ME310 curriculum, which was based primarily on a series of prototypes, with two main objectives: first to increase the level of sense making, and second to increase the likelihood of implementation within the company. I developed and tested numerous pedagogical innovations in order to combine user desirability and company viability, including the following:

- In order to increase sense making, the focus in the first quarter (which is called “make it up”) is on ethnographic research: faculty prepares access to the field (with or without the corporate partner) by identifying places and negotiating access for students. Faculty go into the field with students until they have built their own understanding and judge that the students are professional and good enough. I developed lectures and assignments in ethnographic research: how to prepare the field, how to collect, analyze and present data. The second quarter (which is called “make it real”) focuses on testing all the prototypes with real users in a given context.

- In order to increase implementation, the turning point between the first and the second quarter (which is called “make it real”) is exchanges with teams inside the corporate partner’s company. In the first quarter, dissemination actions begin in order to share insights from the field; in the second quarter, there are demonstrations of how users react with prototyped solutions; finally, before beginning the last quarter and developing a proof of concept through a pre-industrialized prototype, we organize open doors within the company in order to understand the conviction that emerges from the company on what to do and how to do it.
ME310 is highly demanding: it is very difficult to set up (company and student recruitment) and to run (skills in design thinking, leadership, project management, dissemination in companies, creation and running of a worldwide ecosystem, expertise in corporate strategy and how to make it happen in a company, ability to decipher a company’s priorities and operations, as well as to trigger internal dynamics). It is transferable provided that resources are available (Hillen and Levy, 2013, see chapter 6). Great attention also needs to given to maintaining the same level of quality, whatever the academic partner. Sharing additional pedagogical resources and developing faculty competences through pedagogical action research represent promising paths of inquiry in tackling such challenges.
7.3. Third historical era from 2012 to 2014: Creating a d.school

2012/2013: A start towards “design thinking for” with social entrepreneurship

Situate: A team without access to operational budget

The 2012/2013 academic year saw the official opening of the d.school Paris. The team consisted of 5 people. I recruited two additional ME310 alumni (one engineer and one designer) and the coach with whom I ran Innovacteurs, a professional designer as well as a professor at ENSCI. The d.school team consisted of three designers (two juniors and one senior), one junior engineer and myself for the business side. The TT thus represented three disciplines. It was located on different floors (half a floor for the mini studio, one office for the staff and my office, all on different floors) in a garage style.

As far as the context of ENPC is concerned, I reported to ENPC’s director of studies in both roles (d.school and the department of industrial engineering) and to the same CEO of a logistics consultancy firm. The director of studies at ENPC did not believe in the values and teaching of DT, or in our mission, which included the development of pedagogical resources. He did not accept that people should be dedicated full-time to the design and development of the curriculum, given the context of ENPC, which differs from any university or school in that it has no full-time professors, only lecturers who are paid on the basis of attendance, at a gross hourly rate of €70 for each class taught. Guest lecturers are expected to develop their courses using their own resources. ENPC also has full-time researchers with no teaching obligations, who receive extra remuneration for running courses. As the ENPC budget was frozen for the first quarter of 2013 and as ENPC’s dean of studies did not support the d.school project, we had no access to any operational ANR (national research agency) funding with the exception of human resources.

ME310 Paris was on hold and I began looking for partners again in the spring of 2013.

I was still in charge of the department, in addition to the creation of the d.school. I was in charge of ecobootcamp, with the support of 3 TAs (who were ME310 alumni) and Innovacteurs, with the support of the 4 members.

Ecobootcamp 2012/2013 included the same mini projects to improve sustainability in student residences (edition 2). The curriculum was the same as before. Before the course, we held discussions with the residence facilities manager for students to be allowed to produce and test prototypes. The results were to be presented for possible implementation. Innovacteurs was run in cooperation with ENSCI and mono and multidisciplinary teams were formed. A new format was tried for M1 students, with two teams, one in Paris and one at the Stockholm School of
Entrepreneurship. The course represented 9 ECTS, with students working half-time for a semester. Ronald Jones, dean of the Konstfack design school, visited us and was in charge of the course.

A training program for teachers from four academic partners (out of five) was launched on the basis of an initial model: Immersion/co-development and co-teaching/transfer. A first cohort of 4 teachers was recruited for the immersion phase.

In September, I delivered a paper at the d.confestival in Berlin on the impact of people/place/process: “It is not only about people!” I was strongly convinced of the impact of the combination of people, place and process.

**Plan: A new international format and an initial model of dissemination**

My co-director and I organized and attended the field trip with GI students.

There were 7 Innovacteurs projects:

4 multi teams with
- Reinvent the showerhead for seniors (ENSCI)
- Reinvent the telephone for seniors (ENSCI)
- Reinvent the fridge for seniors (ENSCI)
- Create a 110 m² house for SolarDecathlon multi-school challenge at students’ request.

3 mono teams:
- Improve the life of inhabitants for the village association (HCD in Togo)
- Reinvent the experience of tourists in a RER (regional light railway) station with RATP (transportation company)
- Reinvent the shopping experience with a start up from a ME310 alumnus, Prixing.

Each team had 4 to 5 members. No prototyping budget was available. Each member of the d.school was assigned 1 to 3 projects for weekly reviews, in addition to 2 global project reviews. Expected deliverables included: 2 intermediate presentations on inspiration and ideation/1 final presentation/prototypes/a report.

Innovacteurs++: an international multi team (4 students in Paris and 3 students in Sweden) was set up in cooperation with SSES (Stockholm School of Entrepreneurship) and its design school, Konstfack, run by Ronald Jones: * Improve the user experience in the new ENPC ecoefficient building.
The training program for faculty included a series of workshops (lectures on the why, the what and the how of design thinking with an open debate) and a workshop with a project (redesigning the inside/outside of the ENPC library in cooperation with the staff). Teachers could travel to Stanford for the ME310 program’s kick-off workshop.

*Act and observe: Extreme innovation provides an incredible learning experience*

The GI students are pleasant and proactive. They believe in DT from the beginning and are eager to learn and do.

**Ecobootcamp**

The dynamics are good and students can prototype more and have more impact (races, blog and websites, practical kit for heat preservation, waste party, redesign for more practical kitchens...). Step-by-step guided exercises applied to real projects are an efficient way to teach DT: the ratio of 4 TT members for 40 students and 8 teams seems ideal for giving valuable feedback on the practice observed during the course. 6 Ws and situate maps are used effectively to frame the subject. Numerous pictures and interviews provide interesting insights. They have the courage to try very bold kinds of storytelling (role play, video, one-man show...) to the point that the presentation style might prove distracting, as students are not performers. The reports are long (30 pages) with very interesting reflexivity. By far the best ecobootcamp ever!

Developing a robust and appropriate design thinking curriculum may take years. Serependity and self-reflection by faculty are needed to find the right balance to engage all students.

**Innovacteurs**

The three multi teams did not perform as expected: all complained about the fact that the design students were not interested in understanding and doing DT. The engineering students mastered the process and were able to explain it much better than in previous years.

- The fridge team was stuck and the use of a storyboard to imagine the ideal experience was helped the team to come up with a sense making system based on existing elements, elements arising from brainstorming and testing, as well as fictional elements that made sense.
- The telephone team produced interesting needfinding and prototypes but a poor report, and complained about the desertion of designers.
- The bath team performed well with very interesting insights, prototypes and reports, and good team dynamics.
Design thinking and design are different. If learning objectives are not focused on design thinking pedagogy and students master the two fields, students are in conflict on what to do: they are no longer driven by designers because of doubts. If conflict arises in the team, the students, who feel they are not in control, desert the project.

The Solardecahon team failed to introduce DT into the project, but succeeded in driving the 8 person multidisciplinary team with project management.

If the whole group of people in the ecosystem of a project (including students and teachers) is not convinced about user-centric approaches, a small team with no authority cannot manage the dynamics, even if exploration paths are recognized as promising.

The station team did not do any needfinding for the first project review: they did it in combination with ideation; it was fruitful; they were limited in implementation by the partner’s understanding of DT (the partner complained about outcomes not being of professional graphic design level!) and the resistance to change. Their reflexivity was excellent.

With self-reflection on problems of implementation, students learn a lot about the internal processes of a large company. No implementation is still a source of frustration and disappointment.

The shopping team brought limited value to the start-up, because the solutions developed were beyond its capabilities.

In order to increase the probability of implementation, the partner organization’s viability principles should be taken into account.

The TOGO team skyrocketed: led by a convinced and enthusiastic student, they were strongly committed. At the first project review, their stance resembled a colonist’s perspective. It changed before they went into the field following my advice. In the field they quickly reframed and prototyped half a dozen incremental innovations. They came back with a big idea: they did fundraising to finance the implementation of a mill that they helped to build in the summer. The final presentation was awesome, with emotions, results, force, poise. This was the first team to go as far as real implementation with significant impact on people’s lives.

Sense making with real impact creates a sense of pride and satisfaction, which transforms the learning experience into a memorable life experience. It justifies all the efforts and hurdles.
Best outcomes from TOGO project include:

- Situate understanding with needfinding in the field: clear evidence of observation and interviews with users in real situations, collection of real pictures and videos
- Discovery of strong insights and design principles
- Evidence of empathy, caring and proactivity
- Faith in one’s capacity to change the world
- Evidence of identifying relevant issues/problems/constraints/expectations
- Quick-and-dirty prototypes with real-time testing with users and reframing from initial brief
- Imperatives in terms of user benefits and ethics
- Capacity to define actions with a big impact in both the short and long term
- Attractive and insightful ppt presentations for project reviews and final presentation
- Evidence of a strong willingness to go as far as possible in terms of implementation
- Commitment to make it happen
- Development of useful artefacts for crowdfunding
- Ability to communicate in a storytelling format in many different forms
- A capacity for hard work
- Ability of making

Reflect: Extreme innovation transforms students

My role as an academic director and the support of my chairman, who stressed the strategic importance of companies transforming their culture, strongly helped to defend the values of DT and made the industrial engineering students the strength to respond to criticism by classmates in other departments. The GI department is strong in defending the industry’s values of pragmatism, people-centrism and making: it attracts the students who are already ready to accept this mindset.

Ecobootcamp: The combination of the new curriculum, easy access to the field, a bigger TT, as well as proactive and convinced students, created a very fruitful learning and teaching experience.

Innovateurs: Partnerships with design schools are time consuming on both sides, a source of demotivation for students and risky for the teaching of DT, partly because of a confusion between design and DT and French design students’ lack of interest in DT. Briefs that are clear with regard to object/user/place are the easiest for teaching DT: students can carry out all the DT activities – inspiration and ideation + storytelling of implementation.
HCD (human capacity development) is an amazing way to teach DT activities: needfinding, reframing, ideation and implementation. Students are highly motivated and transformed as people through the pride of creating real societal impact with their outputs. There was a great combination between the field expert who drew very thoughtful lessons and myself (see the box below).

Ideal experience is an interesting tool for combining different sources of outcomes for systems (benchmark, ideation, imagination).

App developments are an interesting area for DT and engineering students: they require engineering skills; pilots can be produced and it is easy to go to market. 

**For both:** Dropbox, Facebook page, project websites and blogs were organized and created momentum and emulation among students. They helped to create an online community. The combination of a coherent curriculum (field trip, course, projects), more developed lectures and assignements, a trained and experienced TT, and more time for weekly coaching with individual coaches in addition to project reviews, had a positive influence on students’ learning, experience and outcomes.

Key pedagogical lessons for the development of extreme innovation projects, included:

- The choice of the village needs to be based on the criteria of potential implementation and stakeholder dynamics
- Risks of health problems and security issues should be checked prior to the mission
- Discussions with village stakeholders should be carried out by the teaching team
- Expectations of people in the village should be reframed in comparison with traditional humanitarian missions
- Students should stay in ordinary village houses, not the house of the village headman
- When the students arrive, discussions should be held with people who were against the group’s coming, to understand the reasons and break the ice
- The teaching team should go into the field with students, from the very first day of the stay, in order to avoid lack of understanding, misinterpretation and the village’s influence on student thinking and actions
- As many people as possible in the village should be aware of and involved in the project in order to increase the probability of implementation and follow-ups
- Needfinding should be carried out in the field, especially by living the life of the village, and not as outside observers who take pictures
- Specific materials should be brought for pedagogical purposes and meetings

360 data record 2012/2013.
• Debriefings to understand student observations and insights should be held very early, regularly and frequently, especially at the beginning of the field trip.

• The teaching team should facilitate very early need identification and solution brainstorming sessions, with iterative needfinding loops in the village.

• Each insight from prototypes should be formalized after realization.

• Videos should be used, in addition to pictures and interviews, for data collection and presentation.

• Quick wins should be favored to create trust: quick changes with immediate impact should be identified and carried out, in order to create trust and differentiate from humanitarian missions.
2012/2013: Learning about a culture of design thinking

I started writing 101 Landmarks with the help of a graphic designer. I defined the structure based on a concept/a picture/a text on each page. I wrote a conference paper (2013 ICED paper: People, Place, Process: Lessons learnt on the path to a d.school), in order to explain how to develop design thinking pedagogy in accordance with one’s ambition and resources.

PEOPLE

Transdiscipline teams (40) are discussed with Ronald Jones at Konfakt and SESS, now dean of the design school at Yale.

Multidisciplinary teams are different from transdisciplinary teams, which are formed from different backgrounds, but with common values, processes and tools. This kind of common culture should be nurtured and acquired. It takes time. The more different disciplines with a common culture there are, the better the outcomes.

PROCESS

Experience design (67) in the sense of the customer journey (Fraser, 2012)\textsuperscript{361} is an objective from the beginning. Imagine the ideal experience (97) has proved to be an interesting way to combine existing, tested and imagined elements.

Confusion between different processes is often observed amongst both teachers and students. The IDEO process and the process at the Stanford d.school need to be clarified and merged.

I did not make any new discoveries, experiments or improvements on the space, which was operational and suited to our needs. We organized the move to the new building with existing furniture in a garage style, even in the new studio.

Table 46 describes tipping points I discovered in 2012/2013 to learn about a culture of design thinking. Numbers refer to the pages in the book\textsuperscript{362}, which provide a full description of each concept.

Table 46. Tipping points in design thinking discovered in 2012/2013

<table>
<thead>
<tr>
<th>PEOPLE</th>
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</table>

\textsuperscript{362} Hillen, V. (2014). 101 Landmarks I’ve discovered to innovate thanks to design thinking. Retrieved from www.veroniquehillen.com
2013/2014: 100% implementation

*Sitate: A new studio in a new building with the first multi school course*

The d.school moves into a new positive energy building at ENPC (including a studio, open space and access to prototyping hall and classrooms). We share it with two labs. The studio is quickly and efficiently set up with previous furniture, ready for operations.

I am no longer the academic director of GI Dept. The person who replaced me joined the first teaching cohort and is interested in DT. The three designers on the d.school team have left the d.school. A new team is recruited (one administrator suffered from depression in the year, an ethnographer who stayed for a short time and a communication coordinator): the instructor structure is dropped in favor of functional experts.

I was in charge of ecobootcamp and Innovacteurs with the engineering instructor, who stayed at the d.school and was promoted to co-director. We organized the field trip for industrial engineering students in France, but did not attend it ourselves.

ME310 Paris is set up with three projects, three French companies (Lapeyre, Thales, Valeo) and three academic partners (Stanford, HPI, Aalto). 12 students are recruited from 7 universities worldwide (Cali, Cachan, X, ENPC, UTC, TokyoTech, Aalto) and 4 nationalities.

Our aim is to co-develop and co-run a new d.seniors course with 4 teachers from 4 local schools (phase 2 of the initial model): I and my co-director set up a partnership with a retirement home (Fondation Favier) based on proximity and the commitment of the staff. A course “field trip” is launched by a an English teacher who applies design thinking to the building’s eco-garden.

Given all the challenges I have been through, I feel that my strongest motivation for disseminating DT is to make impactful projects happen (launch of real products on the market, tangible local wellbeing, a better life for disadvantaged populations), which is the heart of DT, not teaching and convincing others to do it.

**Plan: ME310, Innovacteurs and d.seniors**

My obsession with all the courses was to make it happen: implementation with sense making projects and real impact for targeted users.

Ecobootcamp was led by me and my newly promoted co-director, who was a ME310 alumnus, engineer and a full-time member of the d.school. The mini project for Ecobootcamp was to improve the user experience in the new eco-efficient building.

As there was no partnership with ENSCI, Innovacteurs had no multi team, only mono teams. Given the strong motivation shown by students with the success of the previous year, HCD projects were further developed up to a total number of 6:
• 2 teams in Togo
• 2 in Ecuador (suggested and supervised by a ME310 student)
• 1 in Tunisia (at the request of a Tunisian student)
• 1 on a worldwide exchange platform (at the request of a student entrepreneur).

2 projects were set up with partners:
• 1 with a retirement home
• 1 with a big global coffee company
• 1 project for an app for students (at the request of students)

In addition to the d.school’s two teaching members, we hired three outside experts as coaches (Jean-Pascal Mathieu from NURUN specialized in app development and design thinking; Stéphane Gauthier specialized in products and design thinking and Roukaya Elhouda, a ME310 alumnus, specialized in extreme innovation in Africa). The creativity expert organized a workshop. Online tools were set up to provide pedagogical resources for students (syllabus, assignments, examples of reports, presentations, articles, delivery of assignments). A prototyping budget was available for each team for all courses. In addition, previous deliverables, students should present their projects at a project fair with ME310 projects.

ME310 projects included:
• Redesign the bathroom experience for seniors
• Redesign the car cockpit for traffic jam with autonomous mode
• Redesign the camera for firefighters given SWIR technology

I designed a new curriculum with a clear distinction between assignments from Stanford (based on prototypes) and Paris (based on ethnographic research and dissemination inside the company), as well as a series of new lectures.

d.seniors was launched in cooperation with a retirement home: teachers from 4 schools would attend and co-manage, especially at project reviews. I lectured. My teaching assistant and I were responsible for the relationship with the partner. The same curriculum as ecoboostcamp was applied.
**Act and observe: Students delivered projects with real impact**

*Ecobootamp. Most GI students are strong in critical analysis and scepticism, with no empathy and proactivity. They are reluctant and harshly critical. Only two of the ecobootcamp projects were implemented (stickers to indicate how to switch lights on and off in the building and redecoration of stairs to encourage students to use them instead of the lift), the other 5 failed to implement anything, despite interesting ideas, because of a lack of determination.*

*Innovacteurs: Extreme innovation is great to teach DT*

The project which performed beyond expectation in terms of sense making and implementation was the development of physical exercises for a retirement home: despite no access to the field for needfinding, they managed to benchmark with an expert in another location; they tested their ideas with a small scale mock-up and were committed to make it in just three weekends.

All HCD projects went into implementation, but with differing impacts: a partnership with a start-up was formed to provide ‘solidrain’ for Equator; tools were created for Togo; a number of different actions were implemented for the Tuni6he coach in Ecuador did not apply the same process as in Togo: only needfinding was done on the first trip, so the local community did not trust them. The coach returned to implement and followed up: the community had forgotten where the experiment to prevent dryness had been done. The students were not motivated enough to return for a second field trip for implementation, except in Tunisia. The social entrepreneur went on a world tour to identify fields, but even the platform was not convincing from a business model perspective.

The coffee team used personas (recommended by the external coach) and got lost in fiction making: they were frustrated by my feedback because of the positive feedback from their weekly coach and the company. They came up with two interesting ideas: a mobile coffee machine cup and a coffee fountain. The final prototypes low definition but had an impact on executives for reframing the coffee experience.

The app team had the field and the skills to develop it.

**ME310: Valeo and Lapeyre highly involved**

The Valeo team was often abstract in terms of analyses and concepts. Three out of the four students had no experience in driving. Project sense making and value for the partner had to be strongly emphasized. They found interesting exploration paths and produced prototypes. Extreme users were a great source of inspiration. The final prototypes needed external experts. Both teams performed well.

The camera team struggled with reframing, with cooperation with the Finnish who were arrogant, access to the field and communication with their partner. I stepped in for needfinding
and team management. Interesting insights were made and prototypes produced. However, they did not understand the value of a system instead of an object.

The Lapeyre team was outstanding, with a panel of users, thoughtful insights, incredible tested prototypes and constructive dynamics with the company. The incredible cooperation led to the launch of the product on the market, after intense exchanges with the internal factory and marketing teams. The project was developed into a case study published in 2016\textsuperscript{363}.

\textit{A new multi school course: d.seniors}

It was difficult to recruit students from four different schools, even with the help of local faculty and the support of the management (10 from a telecommunications school, a few from the architecture school, the urbanism school and ENPC). Students received different credits. They were committed and highly satisfied. The partner was satisfied with the outcomes. The reports were of good quality, as were the presentations.

The disappointment came not from student outcomes or behaviors, but from the involvement of faculty in the course: only one teacher attended regularly; others had other duties. When we debriefed, the teachers were not satisfied: some complained that they could not find a role and function in the course, others about trivial logistical details. I was disappointed by their attitude but understood it as a way to avoid recognizing the fact they should have attended and were using it as an excuse in order to escape having to explain themselves. They behaved like spoiled children. None of them was ready to take over the course the following year. One teacher was ready to do so. My teaching assistant was highly frustrated and demoralised at having done so much work with no recognition from them.

In parallel with this course, a teacher in English asked us for materials, garden tools and pedagogical resources. With only a couple of hours and a very small supply budget, she refurbished an advanced class in English with a real project in the local organic garden she looked after. Students efficiently carried out all the design thinking activities (needfinding, ideation, implementation). The teacher and students were fully satisfied.

\textit{Reflect: Dissemination is key to make it happen}

\textit{Situate:} I have lost authority and prestige with GI students now that I am no longer running the Department. It is more difficult to influence the dominant system of values, as I do not pitch any longer to recruit and push them. The GI mindset once again reflects the global spirit of the whole cohort at ENPC, with variation from one year to another: sometimes sceptical and difficult, sometimes proactive and pleasant. My colleagues at ENPC and I do not understand why such differences can exist from one year to the next. I have observed in the department

that the number of negative versus positive students has a strong influence on the group's dynamics, as well as the ability and mindset of charismatic individuals.

**Ecobootcamp**: The GI students were embarrassed by negative criticism from classmates in other departments who did not understand the value of quick-and-dirty prototypes. They were not strong enough to explain and defend their own system of values: this was because I was no longer an Academic Director and was no longer strongly defending our values.

Each class included a lecture with guided exercises on specific tools, which are applied to real projects. Each class represents a step in the process of design thinking and the real project. This combination between theory and immediate practice is the most efficient way to teach design thinking: students remember what they do better than what they hear. A two-person TT is not enough to run a course for around 40 students.

**Innovacteurs**: For the first field trip in emerging countries, the whole process should be applied, to create trust and understanding from communities. Otherwise they expect money and goods. Quick wins should be the focus, in order to make the community feel the value of students. It is too hard and not the priority for such communities to follow up solutions with long-term investment and impact. The prototyping budget helps to focus on making things and provides the necessary means to create small quick-and-dirty artefacts.

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**ME310 2013/2014: A range of dissemination actions inside corporate partners**

Value generation for the partner, sense making and implementation should drive TT and students, more than delivering assignments: focus on skill development by delivering assignments is easier for the TT than focusing on sense making to create value for the partner. All stakeholders need to demonstrate the value of DT, which is only proved by delivering real products. This is a tension that needed to be carefully managed.

Delivering both a learning experience and real value represents a tension for students and TT.

The combination of additional assignments in needfinding, real-world testing and dissemination is key to generating operations in companies. Dissemination within the corporate partner’s company right from the kick-off and throughout the project is key to implementation. The table below tracks all the dissemination measures so far organized between ME310 Paris
TT and its corporate partners. In this respect, the initial ME310 syllabus includes quarterly presentations, reports and brochures, as well as a project fair at the end of the academic year. Such actions help corporate liaisons to communicate results. The risk with communicating results is to generate resistance and judgment within the company, without creating momentum and implementation.

ME310 Paris 2013/2014 clearly showed the importance of intense exchanges on what students discover (including needfinding and user’s tests on prototypes) with a large audience from different functions inside the partner company, in order to convince operational managers (Table 47).
### Table 47. Analysis of dissemination actions within corporate partners from 2009 to 2016

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* Measured by the intensity of exchanges: 0: none 1: low means quarterly 2: medium means weekly 3: high means weekly and often more than an hour
Operations (R&D, marketing, production, communication) should be generated in the course of the project, in order to launch new products on the market. Generating business models is not enough and wrong if done only by students without support from the company. Actions of dissemination have a strong influence on embarking people in the company.

**d.seniors: The initial model of training for faculty (immerge/codevelop and transfer) does not work**

Multi school courses are very difficult to set up and to run. Finding the same time slot for four schools took a year of coordination. Teachers who were supposed to co-run the courses are not fully committed if they do not feel fully in charge. The initial training program for faculty should be changed to scale up: the model of immersion/co-development/transfer is too slow and does not allow faculty to feel in charge of course development.

As a consequence, I decided to change the training model for faculty: after two years of operations, the initial model had only produced one multi school course with 20 students and no faculty ready to take over. The initial model may produce one course in two years with one potential teacher who would have been ready to take over that course. In comparison, small-scale support to a proactive teacher who gained no personal benefit from it leads to the refurbishment of a course. Faculty who are ready to redesign their curriculum need ready-to-use-materials, a small prototyping budget, a studio and some advice. There is no need for a series of workshops, a field trip and co-development of a course. This model is inefficient.

**Improve: Test another model of dissemination for faculty**

The decisions to improve the learning experience were as follows:

**Innovateurs:**
- For HCD projects, create trust in communities first
- Stabilize and maintain the same curriculum
- Toolkits should be developed
- Projects should stay in the TT’s area of user expertise
- Each project team works for a real partner with a real need and the capacity to implement
- Briefs should include objects/users/context/means for operations.

**ME310:**
- Follow up all ME310 projects after the end of the course
- Develop further resources for partners to communicate internally
• Develop ways to communicate the results of ethnographic research inside the company
• Develop further ME310 syllabus that can be open to the ME310 network

d.seniors:
• Change the training model for faculty
• Create mono school courses open to others to scale up
• Simplify partnership if any for other new courses
• Simplify cooperation between teachers if any
• Create courses with real projects without partner
• Create an accreditation system with 3 levels: basics with exercises/intermediate with real project with or without partner/advance with partners

Training of faculty:
• Develop resources of the studio
• Develop ready-to-use pedagogical supports
• Support teachers in redesigning their curriculum
• Organize a series of discovery workshops
• Avoid enrolling different schools as a prerequisite to set up a new course

For all:
• Define a skills framework for DT
2013/2014: Learning about a culture of design thinking

Writing of “101 Landmarks I’ve discovered to Innovate thanks to Design Thinking” ends in summer 2014 with the help of a communications director, who develops the metaphor of exploration in an appropriate graphic style, supports the author and coordinates tasks.

**PEOPLE**

I discovered creative confidence (28) in the newly released book by David and Tom Kelley: Gaining confidence in the ability to gain relevant ideas from the field and the ability to make them happen. I realized the importance of user experts in the TT: the greater the expertise on users, the better the framing and implementation.

> All the actors in the ecosystem (students, faculty, partners) should be obsessed with making artefacts that create value for people: the sooner they are obsessed, the more it will happen.

**PROCESS**

I modified the process given to students by combining the IDEO and Stanford d.school processes (68) from the beginning and by modifying the last activity: from business model generation to operation generation. I introduced the notion of experience design (67) as a target. I detailed the three phases: inspiration (69), ideation (70) and implementation (71). Personas are excluded and replaced by the notion of authentic characters (81). Insights (83) and patterns (84) are encouraged to the detriment of frameworks (85), which can be too abstract. PoV (87) is dropped in favor of imperatives (86), which are easier to do for students and efficient in driving solution generation. Storyboards (96) are taught and used.

> The more precise the process and the tools, the better the learning experience.

**PLACE**

d.school Paris moved to a new building (6). I experienced the importance of dissemination in companies: a new place in the company can trigger change in the culture with DT tipping points (20).

> Place should be extended outside the studio to other places: the field, where users live and act, and the partner, where the new artefact (product, service, system, place) should be produced and distributed and/or delivered.
Table 48 describes tipping points I discovered in 2013/2014 to learn about a culture of design thinking. Numbers refer to the pages in the book\textsuperscript{364}, which provide a full description of each concept.

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\textsuperscript{364} Hillen, V. (2014). 101 Landmarks I’ve discovered to innovate thanks to design thinking. Retrieved from www.veroniquehillen.com
2014/2015: Local dissemination

Situate: A new d.school team

My co-director abruptly left the d.school: she was demotivated by the lack of recognition from students and teachers, as well as by the inertia of the administration. We did not work closely that year, because of my involvement in writing the book. She was seriously demotivated by the desertion of our administrative coordinator and felt that her competences were not respected because she had to take over a lot of administrative procedures.

I was convinced that the future of DT is in the combination of user expertise and DT, in order to tackle complex problems not only by reframing them, but also by making them happen. A new team of 5 permanent people was recruited, with an addition of 4 experts planned for the following year (eco building, internet of things, public sector, seniors).

The studio was refurbished with Steelcase furniture and the administrative procedure for heavy work brought no interesting results in terms of new studio design, in line with the metaphor of a journey of exploration described in the book. The two projects submitted were based on the ambience either of a library or a luxury shoe shop. They did not fit the expectations of the design of an exploration ship.

Ecobootcamp was transferred to the Department’s new academic director. I run only Innovacteurs for M1 GI students on the second semester.

I launched a new course (d.structure) for M1 students between ENPC and ENSAVT with the help of a researcher in civil engineering and an expert in seniors. I set up a three-day workshop for MBA students. A professor at UPEM started changing her course, which focused on service design.

In cooperation with an expert in sustainable cities, I developed DT projects on integrated urban systems for a newly created executive Masters by ENPC and EIVP in cooperation with two French companies. A partnership with Bouygues Energie is created to work on lighting.

We did not set up a new edition of ME310, in order to test the impact of following up the previous ME310 (2013/2014), with the objective of making them happen in companies.

A former student from Lapeyre’s team is hired to develop senior expertise and to help the corporate partner to disseminate. She was highly motivated. She created a start up to develop products and services for seniors. She was in charge of d.senior. She is willing to carry out pedagogical action research in the same structure as the one developed for this piece of research. That is the reason why the course “d.seniors” will not be developed in the following sections but in a separate paragraph ("dissemination of PAR") at the end of this section.

My focus is on developing the d.school, with a dissemination, locally and nationally. The training model for professors is changed for a broader dissemination: a program of 6 sessions is set up and run; 3 teaching formats are defined. Focus on global communication actions, including...
the organization of an international conference on the future of design thinking (with a dozen of
guest worldwide speakers on our 4 areas of expertise) and the digital launch of 101.

A Spanish version of 101 was developed and launched.

I submitted a bid to the French government to create an online Masters degree in DT, which
was not accepted (ranked 18 out of 50 with only the first 15 accepted).

**Plan: Three new formats (executives, faculty, civil engineers/architects)**

Ecobootcamp was based on urban ecology in a town, which was located an hour’s drive away
from ENPC. Instead of running a workshop between ecobootcamp and Innovacteurs, students
were given a complete toolkit and assignments with a report as the deliverable.

ME310 follow-ups included: press conferences, exhibitions and award submissions for the
furniture. The creation of a DT Lab inside a former partner company using a PPP framework, with
a space, workshops and projects; help to create a start-up to industrialize the camera.

Innovacteurs consisted of 7 projects with 7 partners:

- Redesign farming tools in Ecuador
- Improve life for people in a poor village in Madagascar
- Redesign the spectator’s experience with a theater in Paris (Les déchargeurs)
- Redesign a grease shuttle for a small company SRI
- Redesign communication outside the fire for a start-up (Ektos)
- Redesign commuting services for the disabled for a big transportation company (RATP)
- Design services with real-time local air quality sensors with a laboratory (Sense City)

Partnerships were formed for all projects. No sponsorship was applied for from NGOs, local
partners and start-ups, only low-level sponsorship from companies. The d.school’s TT team
followed 1 to 3 projects each, in addition to one external coach for a field trip in Madagascar
(the same expert M310 alumnus as in Togo). Field trips with coaches were organized in each
country in the spring. Others for implementation were organized in June/July. 2 projects reviews:
ethnographic research and ideation. A 60-page toolkit was developed based on 3 toolkits under
common creative licences (toolkit for educators, toolkit for libraries, HCD toolkit). Students created
blogs for social entrepreneurship projects. Final presentations for Innovacteurs were run at the
project fair, where all courses had their own exhibition stands.

I ran the main project for a newly created executive Master’s program in Urban Integrated
Systems between ENPC and EIVP in cooperation with Bouygues and Alstom: 2 to 3 days a month
from January to July. The Masters program coordinator would be trained at the same time as
delivering the program.
I set up a new course, d.structure, between two schools, an engineering school specializing in civil engineering (ENPC) and a school of architecture (ENSAVT) with a brief based on the observation of needs on campus: how to create a structure for a pleasant outdoor coffee break?

I set up a series of workshops in the format of specific training programs for faculty. Workshops are open to any faculty and employee of the consortium. 6 basic workshops were defined to cover 6 basic topics of design thinking: 1/ The what, the how and the why of design thinking 2/ Zoom on inspiration by user research 3/ Zoom on ideation with brainstorming, prototyping and testing 3/ Zoom on implementation with storytelling 4/ Scientific references in design thinking 5/ Visual thinking or the art of thinking by drawing 6/ The art of experience prototyping. Such workshop could welcome up to 20 people upon registration. Each workshop was structured according to a lecture, an exercice and an informal exchange around a lunch.

I delegated d.senior to a former ME310 student from Lapeyre’s team. I took the role of an assistant. We defined new areas of concern in the same retirement home as the previous year.

Act and observe : A new promising start to engage faculty

The ecofootcamp project was not appropriate for GI students, who rejected it: projects need to be adapted as far as possible to the background of students, so that they can understand their value to their future professional practice and accept them.

Innovacteurs

The ethnographic research reviews showed very different levels of quality: one project missed the point in terms of style and content; three matched the format for presenting such findings pretty well; one did not present any analysis of the first interviews held with experts in the culture and the context of the village they were going to visit, because the students postponed this activity after the field trip; one presentation was too broad and expressed preconceptions about the local culture (poor people can be happy without many possessions). All ideation reviews were of good quality.

The most difficult team was the theater’s one: despite an initial strong motivation, students were lost. They struggled between abstract consideration, analytical thinking and practical details. They were not able to make links. The unexpected difficult access to the field demotivated them.

The teaching team defined areas of concern for the project in Ecuador, which were too broad: I asked for a refocus by contacting the ONG. Applying the whole process as soon as the first trip created trust and interest from local inhabitants.

For the Madagascar team, the solution of an expense tracking system required training programs, follow-ups and a growing community of users to be successful: it is difficult to demonstrate value and impact in the period of the course, and creating any impact is risky. Both teams were committed and performed well. Presentations were of excellent quality.
The shuttle team struggled to find relevant users: in the end, they were successful and found a field with users where they tested and refined a prototype. Lack of interactivity with the start-up was unexpected.

The stand-alone student did a pretty good job thanks to personal contacts with firefighters and pragmatism: the insights were clever, prototypes well tested and the final prototype well managed. A lack of interactivity with the start-up was unexpected.

The team for disabled services performed beyond expectations, with great ethnographic research, insights, a lot of ideas for a system and great storytelling capacity. They created artefacts of value for the company, which was no easy thing in such a context. I had to run the kick-off with too many stakeholders.

The air quality team performed beyond expectations, but more tangible outcomes could have been prototyped.

d.structure

Students did a very poor needfinding. They were inspired by usual sources in architecture: materials, forms and structures from famous architects. They came up with too ambitious and ugly structures. All mock-ups and 2D simulation concentrated on the form, with no reflection on users’ experience. I had to step in: I suggested another form, clarified requirements with no compromise, and I was firm on the requirement of making to pass the exam. Quick-and-dirty prototypes changed their perspective and helped them to integrate users’ feeling. They were reluctant to build the structure in the given time. I challenged them and stressed on project management. Hopefully, a cabinet-maker was among the team. He was highly motivated by the structure I suggested. He found a way to build it and structured the making process very efficiently. The team was then driven by the pride of making something big, real and useful. The structure on campus attracted a lot of attention: after many years, it is highly used on a daily basis. Research departments were highly satisfied to observe the materialization of a theoretical mathematical principle.

Faculty training

Workshops were a huge success: instead of welcoming a few people at the occasion of open doors which were organized in previous years, the attendance for each workshop was around 20 people. The series of workshops reaches all the 5 schools, with a proportion per school in accordance with the total number of faculty per school. Workshops also attract consultants, which was unexpected. It broadened the possibility of faculty who might be interested in transforming their courses. Faculty is also invited to transform only part of one’s course with ready-to-use materials. The dissemination is broader and more efficient.
The international conference in May 2015 was also a huge success: over 500 people attended it. 60% were from companies and 40% from academics. The combination of guest speakers, project presentation and exhibition was a perfect demonstration. The message of the international conference was to stress the importance to combine design thinking expertise with user expertise, in order to carry out efficiently any ambitious projects of redesigning a new offering of products and services.

Integrated Urban System Master

Students struggled to navigate between concepts such as sustainable cities and precise objects such as a connected bow on urban lighting systems. The negotiation with the students was difficult and fragile, which was very tiring and stressful at the beginning. I had to develop new tools such as a “space diagram” to help them to understand the links between different geographical focus: an object in the city then a building then a block then a system then interconnected systems then a city then a region…. Such a tool worked very well to make links between concrete objects and abstract concepts.

The second struggle was to carry out user research in the city: even if my colleague (who was a beginner in the field of design thinking) prepared the field by previous inquiries, students were lost in the field or has a hard time to find users at the time of their research. Needfinding outcomes were very different from one team to another. Their presentation in front of the corporate partner was good enough to make a positive impact. The novelty of the format was also a key parameter to create a surprising impact. Suggested solutions were also very different from one team to another: some of them were relevant and could bring value to citizens; others were beside the point. Levels of definition for prototypes and tests were different, even if good enough to be presented in front of innovation directors from both partner companies. Student results were appreciated to such a point that communication was organized in conferences and exhibitions.

To achieve satisfactory pedagogical engineering and satisfactory results, my colleague and I had to make a colossal effort, which will not be repeated. We were lucky to be successful. The involvement of C. Gratarola was key to the success of the project: he motivated the students. The students were satisfactory, but their commitment was limited to a few days a month and few of them made an effort between sessions: the pedagogical approach needs to take into account professional constraints, the average time available between each session and collective shared time.
Reflect: The valley of death for projects

The valley of death for projects: Follow-ups were key in helping corporate partners to implement in their operational context. The most proactive students were interested in entrepreneurship: projects with partners do not develop entrepreneurial skills and specific DT resources need to be developed for them. In the period after a course and before a contract is signed, a latency period is observed and specific support should be developed.

An obsession with sense making and implementation in real situations is key for the success of projects. The feeling of pride in making it happen contributes strongly to the level of satisfaction among students, TT and partners. It is key to the teaching of DT.

With real partners and innovation projects, there is a tension between educating and creating real value. A subtle balance between knowledge dissemination, guided practical exercises and real practice is key to teaching DT efficiently and maintaining its values. Such courses require a minimum of two TT members to manage 20 students and 4 projects. Developing toolkits for students has a positive impact; they are more autonomous and take it more seriously. However, it is hard to follow all the steps in every project. Students forget in the course of project if they are not reminded through a lecture or other intervention. A more structured curriculum with regular skills assessment could be a source of improvement in the learning experience.

Innovacteurs: For HCD projects, pragmatic solutions with immediate impact that can be scaled up by inhabitants, create real perceived value; otherwise there is no interest, no trust and no perceived benefit: local people see no difference from traditional humanitarian missions. For other projects, access to the field and precise briefs with objects/user/place are prerequisites for project success. TT needs to manage relationships with partners.

The whole cycle of design thinking, from needfinding to implementation, should be carried out in poor villages in emerging countries as soon as the first visit in the field, in order to create trust.

d.structure: The use of traditional architectural tools (inspiration through images, 2D models, drawings, mock-ups) leads them to think like architects: no thinking about the user experience, but only about possible forms and materials. Only quick-and-dirty prototypes, which are tested with users, should be allowed with these kinds of profiles, in order to differentiate them from traditional references and to focus on user experiences. These students need to be supported in doing needfinding. For most of them, the user experience is only an abstract, trendy and commercial argument. Making does not come easily to them, even though it was the initial factor that motivated them to join such a course.

A change of references is needed for architects, in order to understand how to integrate user experiences in their solutions.
Faculty training: An open format of internal training for faculty was efficient: first, it broadens the scope of faculty initially enrolled to such a point that dissemination reaches a large audience; second, it helps faculty to meet, exchange and make collaboration; third, it helps to identify the most motivated and skilled faculty. Faculty should have ready-to-use pedagogical resources, in order to transform their courses. They are too busy to develop their own resources.

Dissemination is of paramount importance to embark the most motivated and skilled faculty. Ready-to-use pedagogical materials make the transformation of basic courses easy for faculty: the more basic elements are taught, the more design thinking is known, the more students are attracted in more advanced courses.

Integrated Urban Systems: Such broad topics on such open fields as a city, with no negotiated access to deployed infrastructures, existing users and services, are highly risky with students; it is impossible to get any implementation with untrained and part time students. The object is hard for students to reframe. The context is difficult to carry out user research. It is almost impossible to create a pilot in the period of the course. Such projects are highly risky for a faculty.

Designing a new urban system requires specific developments before the course starts. It requires a high level of investment. Otherwise such a course should not be offered to students. A basic course without real stakes can be offered.

The link between broad topics, such as sustainable cities, and precise objects, such a citybox for urban lightening, is very hard to demonstrate to students. The latters had the feeling to work on an object with no impact on sustainable cities. 2 days a month over 6 months is unrealistic to experience all the stages of design thinking on such an object, with results that make sense.

Large-scale upstream preparation and large-scale support with more resources are needed for a successful design thinking project on this type of object.

Improve: Develop specific user expertises

The decisions to improve the learning experience were as follows:

Innovacteurs:

- Carry on with the same robust curriculum (partnerships, coaches, supports)
- Ask coaches to consider steps and tools given in the toolkit and to explain if need be
- Maintain the two-day workshop between ecobootamp and Innovacteurs
- Develop online resources for students
- Same partners for social entrepreneurship to create trust and long term effects
ME310:
• Develop a track for entrepreneurs

IUS:
• Develop specific DT pedagogy for systems
• Develop specific knowledge on citydwellers
• Explore participatory videos as a tool for co-design with citizens
• Gain access real infrastructures for tests and pilot

d.structure:
• Transfer the course
• Keep the same challenging brief
• Change the curriculum to avoid standard architectural references and tools

Faculty training:
• Disseminate PAR as a tool for TT debriefings, student assessment and decision sharing
• Develop ready-to-use materials for basic levels

For all courses:
• Do more communication with students to facilitate recruitment and course development
• Test and evaluate the DT skills framework, with self-assessment from students
• Explore solutions to help projects cross the valley of death and get implemented (launch product, scale-up, building...) with two scenarios: either inside a company with support for corporate partners (through the setting up of an internal studio, training programs, workshops, communication actions, projects and coaching); or a start-up with support for entrepreneurs (contract searches, place, communication and coaching)
• Develop user expertise
Dissemination of DT PAR: d.seniors

My colleague who run d.seniors in 2014/2015 used the DT PAR protocol to self reflect on her practice. Table 49 describes each of the 5 steps of the protocol she wrote for d.seniors 2014/2015.

This was the second edition of the d.senior class but the first one I was in charge of and more generally the first time I was in charge of a course. Two other teachers, for who it was the second time, were part of the teaching team from time to time. The course took place in the Fondation Favier, a retirement house on which we choose two subjects: reinvent the lightening in collective spaces and reinvent the experience of the garden. The students were from four different schools. The course had different values in terms of credits from one school to the other one.

The course was organized between classes and projects. Four teams were each composed by 5 or 6 students. The course started with 5 classes and then there was two classes dedicated to research on the field. Then there was a class and direct application on the project until the end.

The final results of the course were not amazing and no as good as expected. The two projects about the garden were interesting in terms of sense making but nothing has been implemented and the projects stayed at the level of a quick prototype. The two others projects about lightening did work and solutions were implemented but the solutions were not astonishing. It was more decoration than innovation. However the students learned the methodology, got empathy and were very happy with the course (91% said they were satisfied or very satisfied by it). Going to the implementation phase was very difficult.
The results of the projects which were not as high as expected are linked to several issues:

- briefs were very large and complex for the time they had. I haven’t chosen the brief and it was complex to guide the students on a brief on which I didn’t perfectly know where to go.

- Several times I was the only one to follow students in ethnographic research and prototyping. One person in charge of four groups makes it difficult to go deeply in the subject and coach them well. When you are not able to drive the groups at the beginning because you see the subject from an outside point of view and you trust them, it’s afterwards really difficult to make them change. The fact that the two ethnographic researches were one after the other one didn’t help in that direction. They didn’t have time to reflect on what they saw.

- For organization purpose we asked the teams to tell us what they wanted to buy for prototyping, directly at the end of ethnographic research. That emphasis on implementation had two bad consequences. First of all, the innovating part was poor. This is why the groups on lightening end up on a decoration style. Secondly, teams thought that budget to prototype was sure (they could spend 400 euros no matter what they were doing). For example, the teams on garden organized themselves to buy the product but didn’t think on how they will do it. They had in mind they could just pay someone to do it and never reframe to make something feasible.

That experience gave me several conclusions on how to improve the class:

- chose a brief on which the teaching team has already ideas of solutions
- follow very well the students during ethnographic research to be able to help them find real insights and sense making directions
- be precise on what we want at the end : an implemented solution in that retirement house which is innovative and could be scaled up in other places
- avoid asking them to make a list of materials they need too early
- reduce the number of people in each team (maximum 5)
I asked her whether the protocol was useful and why. She replied as follows: “It was the first time for me I was analyzing my practice with a research protocol. I must admit that I’m a young member of the teaching team and do not have a lot of experience in teaching. Being able to analyze my practice is very important to be sure that the level of the class is good and is getting better. Thus, following the PAR guideline was very helpful because it was an easy structure to follow to analyse the practice. Many times, when a class ends we are sure we know and we remember what was good, what was less efficient, but in practice, if we don’t write with an appropriate structure we don’t learn for the next session of the class. Analyzing the class thought the PAR the first year helped me a lot for the second year. The simplicity of the structure is really appropriated because it answers to the time and needs you have when teaching. However I think that to be even more efficient we should do it at different periods of time during the course: PAR after one class, PAR after the inspiration phase (5 classes) and finally on the whole course (after 12 classes). Indeed, each one could give different results. I did it on the whole semester, which helped me to understand if the global agenda, the team and the subjects were appropriated. If I would have done it on each class, it would have helped me to understand which precise exercice was interesting, impactful or not and I could have reused that analysis in another course. As a conclusion, using that protocol is key to better my practice. Using it at different times during the course (and not only at the end of the course) would be even more appropriate to have a better analysis and management of my course”.

Data analysis in 2014/2015
2014/2015: Making the culture of design thinking evolve

A free digital version of 101 is available for download. A Spanish version has been developed in cooperation with a Colombian professor in design thinking and is also available in digital format. Publication of a chapter in a German book dedicated to design thinking about my personal experience with the d.school and of two chapters in a book on “How to create innovation leaders”. Work in progress for a new book with a co-author who is a ME310 alumnus – “A journey with seniors” – in order to explain the process through a case study.

**PEOPLE**

I realize the importance of post-course project coordinators who can make projects happen. I need to write on user experts and project developers.

> The more d.ambassadors create a community inside an organization, the better design thinking spreads.

**PROCESS**

More landmarks than those in the book are discovered and tried: the potential role of participatory videos (Insightshare) for ethnographic research and storytelling; the potential of visual thinking to reconcile the left and the right brains; personal diary for TT and students; quick-and-dirty prototypes for architects to gain insight from experience instead of mock-ups and 2D/3D modeling; place diagram to link objects and places with different dimensions (street, block, city, region, nation) in line with a broad concept such as sustainability; sorting pictures from the field by cluster/topic with insights drawn; what if; leveraging points for a system; live my life. I want to write about the tools that were taught and proved effective (but not included in the book): context map (from Cockayne); 6 Ws (from Roam).

> Specific context and target users require the development of additional tools and prior ethnographic research, in order to frame adequate briefs and to compensate for the weaknesses of courses (students proactivity, limited time, limited access to the field...).
**PLACE**

How a culture change can be triggered with the creation of a place staged with DT inside the company (Valeo CarLab). Extreme innovation projects should be located in safe places, even in emerging countries, and be based on a strong partnership with communities. Places should be known in advance by faculty.

Extended d.school spaces in companies is a strong factor of dissemination.

Table 49 describes new tipping points I discovered in 2014/2015 to learn about a culture of design thinking. None of them is recorded in my book and some of them are recorded in no book (Our Jacqueline, space diagrams, leveraging points, d.ambassadors for instance). Their identification depends on the quality of self-reflection. They have emerged as outcomes of the suggested pedagogical action research in this piece of research. The practice of design thinking contributes to the widening of not only one’s personal culture, but also to the field.

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>PLACE</th>
<th>PROCESS</th>
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<tbody>
<tr>
<td>d.ambassadors</td>
<td>Company Lab</td>
<td>Participatory videos</td>
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<tr>
<td>User experts</td>
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<td>Personal diary</td>
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<tr>
<td>Project developers</td>
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<td>Space diagram: from an object to a region</td>
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<td></td>
<td>Picture clusters</td>
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<td>Share stories</td>
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<td>Leveraging points</td>
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<td>Blue print sheet</td>
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<td>6 W</td>
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<tr>
<td></td>
<td></td>
<td>Context map</td>
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<tr>
<td></td>
<td></td>
<td>Design fiction</td>
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<td></td>
<td></td>
<td>Activity diary</td>
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<td></td>
<td></td>
<td>Our Jacqueline</td>
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</table>
Conclusion: Is it useful? Is it adaptable? Is it transferable?

A d.school is a high-impact demonstrator for a university: it attracts a lot of attention from stakeholders, including academic partners, companies, staff, faculty, the press and students. The first impact is therefore communication: the d.school represents pedagogical innovations that fulfill today’s needs for solutions to wicked problems in uncertain, fast-moving and ambiguous environments. The d.school offers an innovative learning environment with a studio, a space that visitors find bewildering and was chosen by the director of communication as a destination for a local visit by two ministers. It represents a factor of differentiation and a competitive advantage for attracting students, companies and partners.

A course at the d.school offers a different learning experience for students and a potential personal transformation. From ideas to making something tangible, students achieve outcomes that are also useful for the people they innovate for. In the long run, the hope is to educate a new generation of empathic change-makers who will have an impact on the society.

A d.school should be adapted to its context and culture, in terms of curriculum design and artefacts. It provides a behaviorally complex learning environment (Kolb, 1984), where skills, attitudes and knowledge can be developed through experiential learning: learning by doing and from doing need to be adapted not only to the initial characteristics of the target learners within their cultural context, but also to the target learning outcomes and profiles. The balance between knowledge, practice and reflection within a course needs to be appropriately managed. The balance between the different learning modes (behavioral, perceptual, affective, symbolic, as described by Kolb, 1984) should be adjusted to the local culture.

A d.school should be adapted to the profile of its faculty members, so that they are sufficiently engaged to disseminate design thinking through a variety of courses. Getting faculty on board for the development of design thinking pedagogy is a huge challenge anywhere. People resist paradigm change. In addition, not everyone is able to develop this kind of pedagogy, based as it is on the creation of behaviorally complex learning environments. However, faculty who are willing to embark on such a journey can deploy faster with ready-to-use pedagogical materials, project definition and development (including partnership and negotiation for access to the field), material resources, teaching assistants and time allocation. Appropriate training sessions and pedagogical resources should be developed and made available. Pedagogical action research should be organized in such a way that faculty can better their own practice class after class and publish their own experience. Faculty should be recognized for the efforts and the skills that this kind of pedagogy requires, with appropriate compensation (financial benefits, time allocation, revised research objectives).

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A d.school is transferable to any university or country, provided that a certain number of resources are available. A balance needs to be maintained between space, people and process through a scaling up model, as described in chapter 6. Success depends on the skills of the project leader, which include their ability to adapt design thinking to the local culture, to build a competent team and to leverage the initial resources. The more support the project manager receives from management (resources, priority, commitment), the easier, the faster and the more impactful the d.school will be. However, although it is transferable, creating a d.school is a big challenge with numerous risks, hurdles and pitfalls. “Is it worth the effort?”, Larry would ask… I guess it depends on one’s ambition and motivation. For me, it is worth the effort! ... It opens up a new range of opportunities on how to transform a company’s culture… It feeds into my thinking, experiments and practice relating to strategic renewals…
Appendix 2
Miscellaneous

People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research
8.1 Bibliography


Adler, N., & Shani, R. (n.d.). In search of an alternative framework for the creation of actionable knowledge: Table-tennis research at Ericsson. In *Research in Organizational Change and Development* (pp. 43–79). doi:10.1016/s0897-3016(01)13002-8


University Press.


**Bibliography from 2006 to 2008: Influence of the culture of design on my thinking and practice**


**French books on design in general**


Reading on the culture of engineering with the choice of not being influenced for the practice


The book that has influenced me the most is Designerly Ways of Knowing from Cross (2007) with the following elements:

- The description of each culture (humanities, science and design) in terms of phenomenon of study (human experience versus the natural world versus the artificial world), appropriate methods (analogy/metaphor/evaluation versus controlled experiment/classification/analysis versus modeling/pattern-formation/ synthesis)
and values (subjectivity/imagination/commitment and a concern of ‘justice’ versus objectivity/rationality/neutrality/ and a concern of ‘truth’ versus practicality/ingenuity/ empathy/ and a concern of ‘appropriateness’);

- The core features of design ability: * resolve ill-defined problems * adopt solution-focusing strategies * employ abductive/productive/appositional thinking * use non-verbal, graphic/spatial modeling media.

I used them to explain through lectures differences of stances between designers and engineers, as well as to justify briefs (instead of well defined problems) and expected ways of behaving.

The thesis that has influenced me the most is: - Describing Design: A Comparison of Paradigms from Dorst, 1997, with the demonstration of two different visions of design between engineers and designers. In addition, a lot of papers, books and essays on the culture of design, were read, in order to find answers to my main questions: How can design be defined, what are the benefits of design for innovation and companies, what is the process / what are the tools.

After the readings of authors on the culture of design, and a first year of practice, I was convinced that multidisciplinary teams should combine references from the three cultures (Cross, 2007), in order to find solutions under constraints (Lawson, 2005).

I felt frustrated, even if I was not either convinced by the stage gate process of product development from engineers. None of the two processes (either the black box or glass process, as highlighted by Dorst 1997) convinced me: one was too fuzzy and could end into one point of view against another, the other one too simplistic and could not generate any interesting outcomes to solve ill-defined problems. I felt lost on what to do in terms of process with such literature. I kept in mind the 5-step process of IDEO for companies.
8.2. List of personal publications


### 8.3. Definitions of design and designing thinking

<table>
<thead>
<tr>
<th>Authors</th>
<th>Definitions of Design</th>
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<tbody>
<tr>
<td>Heskett (^1)</td>
<td>Industrial design is a process of creation, invention and definition separated from the means of production, involving an eventual synthesis of contributor and often conflicting factors into a concept of three-dimensional form, and its material reality, capable of multiple reproduction by mechanical means.</td>
</tr>
<tr>
<td>Moldano (translated by Margolin) (^2)</td>
<td>Industrial design is the planning of objects fabricated industrially, that is, by a machine, and in series.</td>
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<tr>
<td>Simon (1969) (^3), Schön (1983) (^4)</td>
<td>To design is to change existing situations into preferred ones. Design is a reflective conversation with a situation.</td>
</tr>
<tr>
<td>Buchanan (1992) (^5)</td>
<td>Design is a Liberal Art and an Integrative Discipline.</td>
</tr>
<tr>
<td>Buchanan (2001)</td>
<td>Design is the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes.</td>
</tr>
<tr>
<td>Papanek (1971(^6), 1983(^7), 1995(^8))</td>
<td>All men are designers. All that we do, almost all the time, is design, for design is basic to all human activity. The planning and patterning of any act toward a desired, foreseeable end constitutes the design process. Any attempt to separate design, to make it a thing-by-itself, works counter to the fact that design is the primary underlying matrix of life (p. 3) Design is the conscious and intuitive effort to impose meaningful order (p. 4). It is only in recent years that to add the phrase “and intuitive” seemed crucial to my definition of design. Consciousness implies intellectualization, cerebration, research, and analysis. The sensing/feeling part of the creative process was missing from my original definition. Unfortunately intuition itself is difficult to define as a process or ability. Nonetheless, it affects design in a profound way. For through intuitive insight we bring into play impressions, ideas, and thoughts we have unknowingly collected on a subconscious, unconscious, or preconscious level.</td>
</tr>
<tr>
<td>ICSID (2009) (^9)</td>
<td>Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole lifecycles. Therefore, design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange.</td>
</tr>
<tr>
<td>Authors</td>
<td>Definitions of design thinking</td>
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<tr>
<td>Brown, 2009</td>
<td>Design Thinking is a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.</td>
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<tr>
<td>Burnette, 2005</td>
<td>A process of creative and critical thinking that allows information and ideas to be organized, decisions to be made, situations to be improved, and knowledge to be gained.</td>
</tr>
<tr>
<td>Liedtka, 2014</td>
<td>Design thinking is synthetic. Out of the often-disparate demands presented by sub-units' requirements, a coherent overall design must emerge. Design thinking is abductive in nature. It is primarily concerned with the process of visualizing what might be, some desired future state and creating a blueprint for realizing that intention. Design thinking is opportunistic: the designer seeks new and emergent possibilities. Design thinking is dialectical. The designer lives at the intersection of often-conflicting demands—recognizing the constraints of today’s materials and the uncertainties that cannot be defined away, while envisioning tomorrow's possibilities.</td>
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<tr>
<td>Lombardi (2013)</td>
<td>Design Thinking is collaborative, abductive, experimental, personal, integrative, and interpretive.</td>
</tr>
<tr>
<td>Bhan (2013)</td>
<td>Design thinking is one of enlightened trial and error wherein one observes the world, identifies the patterns of behavior, generates ideas, gets feedback, repeats the process, and keeps on refining.</td>
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<tr>
<td>Saffer (2010)</td>
<td>If there is such a thing as design thinking it is probably shorthand for: a Focus on Customers/Users, Finding Alternatives, Ideation and Prototyping, Wicked Problems, A Wide Range of Influences, and Emotion.</td>
</tr>
<tr>
<td>Owen (2006)</td>
<td>Conditioned inventiveness; human-centered focus; environment-centered concern; ability to visualize; tempered optimism; bias for adaptivity; predisposition toward multifunctionality; systemic vision: view of the generalist; ability to use language as a tool; affinity for teamwork; facility for avoiding the necessity of choice; self-governing practicality; ability to work systematically with qualitative information</td>
</tr>
<tr>
<td>Sanders (1992)</td>
<td>He is widely credited in the literature with having coined the term “useful, usable and desirable” products.</td>
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</table>
8.4. Major happenings of the journey

2006

- **Jan.** Appointment at the Dept. Industrial Management (Mgl) of École des Ponts / ParisTech: ‘strategic renewal’ with a new positioning on corporate entrepreneurship and sustainability in large companies (a new curriculum at the master-level with the development of a new course offering in product innovation, the renewal in courses from manufacturing to supply chain, the integration of sustainability in major courses).

- **March.** In charge of courses ‘eco innovation’ and ‘corporate strategy’.

- Discussion with M. Larivière, Professor in design at the Dept. Mgl, École des Ponts and Dean of Strate College Designers.

- **Sept.** 1st edition of “Chaîne de l’innovation” with Accenture/Companieros (product innovation with multidisciplinary teams from engineering, business and design French schools: HEC, ESCP EAP, Ponts, Centrale Paris, Strate). Executive program in parallel. 2 areas explored: professional mobility and eco citizenship. 11 students in their 4th year from Mgl (7 from Polytechnique; 4 from École des Ponts).

- Research in corporate entrepreneurship through innovation: How to raise the bar in sustainability? How to create breakthrough innovation sustainability? How to envision new sustainable products and business models in large companies?

- **June.** Jury for diploma projects of students at Strate College Designers.

- **Aug.** 1st edition of “Observatoire du Management de l’Innovation” with the publication of a white paper and the organization of an Award ceremony: 100 French large companies, 3 partners (BearingPoint, l’Expansion, École des ponts), 180 executives in attendance, 4 laureates (Essilor, Ipsens, SNCF, L’Oreal). Coming of L. Leiifer, A. M., P. Skogtadt from Stanford thanks to B. Borja de Mozotta.

- The article on sustainability and the role of designers for breakthrough innovation by Franck Aggeri (2002) was a “eureka flash”.

- **Sept.** Discussion with Franck Aggeri following a conference given by REMI/École des Mines de Paris/T. Weil; proposition for a dissertation on eco innovation.


- **Dec.** Appointment of F. Aggeri as CGR Director, Mines de Paris.

- Change in the name of the Department into “Génie Industriel”
2007

- Aug. Encounter of Larry Leifer at Award Ceremony of Innovation.

2008

- Feb. Visit Larry Leifer, Director of Center Design at Stanford, Professor of ME310 Design Entrepreneurship.
- Interviews of 7 French designers in the Silicon Valley and 3 academics in design, including B. Banerjee, newly appointed Design Master Director of the Joint Program of Stanford.
- March. 1st edition of Innovactor: 4 multidisciplinary teams for 2nd year students in product innovation for sustainability, in cooperation with students in design from the two top French design schools, ENSCI and Strate College Designers. Areas: industrialization of a luxurious suitcase (ENSCI); reinvent the bottle of water for sustainability (ENSCI); reinvent the packaging of a brand in luxury for sustainability (Strate); reuse of rain water in the house.
- June. Interviews of F. Peltier, Founder and President of P'Reférences.
- July. Finished transcription of the first round of interviews with designers.
- Visiting scholar at the Centre of Design Research, Stanford University.
- Setting up of a cooperation on product innovation for sustainability through design entrepreneurship.
- Interviews of around 100 people including faculty and students from Stanford and other universities, designers from leading design companies, entrepreneurs.
- Sept. 3rd edition of “Chaîne de l’innovation” with Accenture: 3 students in their 4th year from École des Ponts.
- Field trip of the promotion of the Department Industrial Engineering in the Silicon Valley (20 visits from San Francisco to San Jose in 10 days).
- Stay as a visiting scholar at CDR, Stanford.
- Oct. First contact with J-F. Pernotte (Strategy Department) and P. Viviani (Human Resource Dept.) at Thales on the interest for a field trip in the Silicon Valley. 5 key points given: T-man profiles; IQ/EQ; “I do/I am” versus “I think/I am”; learning from failures; dynamics of an eco system.
• **Dec.** Presentation of the “Raflesia project” at Design X (research group in design at Center of Design Research / Stanford): What is the vision? Why and how to introduce design thinking at École des Ponts ParisTech? What already exists and what has to be achieved?

• Developed a new round of questions for open in-depth interviews with designers involved in sustainability.

**2009**

• **Jan.** Data collection with interviews of designers and academics in the Silicon Valley, including meetings with Banerjee and his vision.

• Name change from ME310 Design Entrepreneur to ME310 Design Innovation.

• One-day exchange with EMP steering committee from Thales (P. Anglard – Scientific Director, J-F. Pernotte, Strategy Dept., D. Butler – Campus Thales, P. Viviani – Human Resource) to prepare the field trip of top executives (Execute Management Program) from Thales in the Silicon Valley.

• **Feb.** Return to Ponts ParisTech from Stanford.

• Launch of the 2nd edition of Innovactors: A full week seminar with the participation of B. Cockayne, expert in forecast methodologies + part-time projects on one semester in cooperation with designers from ENSCI: 8 teams. Topics: Reinvent the experience of long travelling with trains; reinvent luxurious snacking for executives; eco kitchen; reinvent the experience of commute transportation; reinvent the ham packaging; reinvent city lights for sustainability; reinvent training places for innovation; reinvent the experience of a shower in student houses.

• **March.** Field trip of 40 top executives from Thales (EMP) in the Silicon Valley. Visits included the three leading design companies (IDEO, Frog design, Jump Associates) and 3 leading academics in design at Stanford (B. Banerjee, Director of the master design; L. Leifer, Director of ME310; G. Kembel, Director of the d.school).

• **May.** Debriefing with the EMP steering committee of the field trip.

• **June.** Workshop at Thales Campus for EMP participants in cooperation with IDEO and Creargie: designing a vision for Thales in 2040. Videos of the field trip with key values. Experience of a specific setting, rough prototypes, storytelling and creativity techniques. 75 ideas of projects.

• **July.** Selection of 6 topics for 6 teams by the steering committee. Team creation by the steering committee.

• **Aug-Dec.** Group follow-up by the steering committee and coordination by a former student from ENPC/Dept. Industrial Engineering.
• **Aug.** 3rd edition of “Observatoire de Management de l’Innovation”. Award Ceremony. Theme: “Innovation to get out the crisis”.

• First research paper co written with B. Banerjee: “Modifying design pedagogy to develop new approaches to sustainability” at International Conference for Engineering Design 2009 in Stanford.

• **Sept.** ME310 Design Innovation launch at ENPC with Sushi Suzuki in cooperation with Stanford and Helsinki; 3 teams (13 students) in Paris: 2 with Thales/Helsinki, 1 with Pioneer/Stanford. Global network with 9 academic partners, 30 professors and teaching assistants, around 80 students, 15 company partners, 30 coaches.

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**2010**

• **Jan.** Final presentations of 6 Thales EMP groups in front of the CTO, Director of Strategy and Director of Transformation (members of the Board).

• **March.** Launch of 3rd edition of Innovactors with 47 students in engineering, 14 in design. 8 teams. Three teams experiment the use of Science Fiction Design to generate imaginary worlds based on new technologies for sustainability: two multidisciplinary teams on “What if the artificial light would not have been invented?”; one team with only engineers on “What if the fridge would not have been invented?”; additional topics were: Design for a Marroco village; redesign solar energy equipments in turbulent zone; explore a new offering provided by Ponts students in services on sustainability for companies; redesign the experience of patients in a hospital; reinvent the nap in large companies.

• **May.** EXPE Finland at the Design Factory with final presentations in front of 45 experts of Thales on their way for a field trip in Finland, including immersion in design thinking approaches.

• **June.** EXPE Stanford with all the projects of the global network.

• EXPE Paris with Innovacteurs and ME310: launch of d.thinking Ponts parisitech.

• **June.** Starting a book: “101 Things I’ve learnt to Innovate thanks to Design Thinking”; 80 activitys identified.

• **Aug.** Visit of Thales Vienna with observation of results in using design thinking for product development.


• **Sept.** Workshop with 45 managers of Thales at d.thinking Ponts ParisTech to experience design thinking approaches.
**Oct.** 2nd edition: ME310 Paris with 4 projects / 4 partners (Suez, Thales, EDF, Amplitudes/INRS) and 16 students (from 7 universities Kyoto University, Science Po, Polytechnique, Ponts, Strate College Designers, INSA Lyon, Dauphine, EFREEI): Local Situation Awareness; waste and water management for communities; airport of the future; protontherapy.

**2011**

- **Oct-Feb.** Bootcamp d.thinking for sustainability run by Sushi Suzuki. Research journal after each class. Assignments: 3 design projects. 7 teams of students in engineering enrolled for EDF challenge.

- **March.** 4th edition of Innovacteurs. No student in design but C. Gaubert, independent designer and professor at ENSCI, still in the teaching team. 7 projects: only one team still enrolled in the EDF challenge; 2 teams on waste management for Suez/Sita Environment; 1 team DeveloPonts (design for extreme affordability); 1 team on implementation of students’ projects; 1 team on self energy generating machines.

- **May.** Suez Challenge: one day with all ME310 teams in Suez offices on employees’ behaviors towards new waste management. The whole process was applied: inspiration/ideation/implementation.

- **June/July.** Workshop for Thales’ executives (in total ca. 100): What and why design thinking.

- **July.** Starting the Handbook of 101 Teaching Tools in Design Thinking: Over 25 exercises formalized as a result of personal self-reflection on practice.

- **Aug.** Recruitment of Julien Mauroy, designer, as a co instructor of ME310 Paris and Innovacteurs.

- **Starting the writing of ME310 syllabus.**

- **Sept.** 3rd edition of ME310 Paris: Thales / Angenieux (reinvent image capturing for cinema); GDF / Provalis (reinvent eco efficiency for buildings); Panasonic (reinvent the TV experience for European markets).

- **Oct.** Encounter with Pierre Levy (Eindhoven University of Technology): discussion of Gibson’s paradigm, 10 competence model in design and RTDP model from C. Hummels

- **Nov. Dec.** Government grant bid “IDEFI”. See the “40-page proposal” for the creation of a d.school.
2012

- **Feb.** Oral defense of the bid.
- **March.** Government approval for 4,1M€ grant.
- 5th edition of InnovActeurs: Air Liquide (reinvent the intelligent bottle for hospital); Suez (Open Data; Textile recycle box); Panasonic (reinvent the fridge); Flexip (reinvent personal event invitation through video creations); ENSCI (reinvent the senior experience: eco tourism in Marroco).
- **July.** Recruitment of a team for d.school Paris: 3 designers, 1 engineer.
- **Sept.** Combination of two positions: Academic director of Ind. Eng. Dept. and dean of the d.school Paris.
- First promotion of professors.

2013

- Innovateurs 5: companies, start up, social innovation.
- Move in a new building.
- The 3 designers left the d.school Paris. Recruitment of a new team.

2014

- Innovacteurs 6: start up and social innovation, one company.
- Enlargement of the team for d.school Paris.

2015

- International Conference on the future of Design Thinking: 450 participants, 15 speakers.
- Innovacteurs 7: only start up and social innovation in Latin America.
8.5. ENPC, an old engineering school founded on experimenters and makers

In France, the building of roads, bridges and canals was for a long time the sole prerogative of aristocrats, merchant associations or monastic orders. With Colbert, more effective policies emerged, but technicians were recruited on an ad hoc basis. It was not until 1716 that a properly appointed corps of engineers was created by royal order: the Corps des Ingénieurs des Ponts et Chaussées. Its mission was to ensure the distribution of riches around the country by maintaining flows of people and goods. Created in 1747, École des Ponts is France’s oldest engineering school.

From 1747 until 1794, the School was marked by the personality of its director, Jean-Rodolphe Perronet. His accomplishments as an engineer, architect and scholar are as remarkable and innovative as his work as director of École des Ponts: he designed some twenty bridges that combined innovation and technical expertise, he was an architect (appointed first architect and member of the Academy of Architecture) and engineer (with research on hydrodynamics), a talented administrator with organizational and leadership qualities, a teacher, adviser on multiple projects, including the design of ports and harbors, a scholarly contributor to the writing of Alembert’s and Diderot’s Encyclopedia, leaving his mark on the Enlightenment through his ideas on the organization of labor... For his students, he was a “spiritual father”, and he implemented an original method of teaching which seems highly contemporary today: project-based learning.

“Before thinking about the mathematization of physical phenomena and even – why not – of social behaviors, an analysis in the most general sense of the term would seem necessary. This is the kind of analysis that Ponts et Chaussées students and engineers undertake through their practice of the project. Despite the weakness of their scientific foundations, the roads, bridges, ports, structures and maps designed within the framework of the education provided by École des Ponts, are experimental in character. This experimental character contributes powerfully to the influence of the institution headed by Perronet” p. 207, A. Picon: *The invention of the modern engineer*.

With a vision rooted in the legacy of its founding father, École des Ponts always founded its teaching on the construction of big projects by its students, which contributed greatly to its international reputation. Under Perronet’s direction, the School’s education was centered on very strong practical training, in particular through annual work on provincial sites, collaborations with scholars and seigneurs, together with an assessment system founded on some fifteen competitions in which students acquired “degrees” based on the prizes they won for their proposals. The school had some 50 students and not a single teacher! So-called theoretical education came through self-learning and mutual instruction, without any lectures.
Perronet resolutely defended the values and skills that set the School’s engineers apart. His successors shared the same convictions regarding the virtues of practice in the design and construction of ambitious technical and architectural projects: “More than anything else, one should avoid undertaking a significant project on simple faith in a formula.” (Prony, 1779)

“Speculative knowledge, even knowledge founded on observations made in solitude, can lead to many errors when it is not linked with experience drawn from the operations of nature itself.” Aubry, 1790

Throughout the 19th century, structures were established to continue to provide experimental workshops on technical problems and design workshops (originally called “draughtsmen’s studios”), which sought to disseminate models for given types of construction via a portfolio of concepts visualized through drawings.367

The approach adopted by Louis-Joseph Vicat in the early 19th century is exemplary in showing how the School’s engineers were able to use their experimental capacities and a much more scientifically inspired systematic approach, not only to bring about considerable progress in knowledge and to make major discoveries (knowledge of hydraulic binders beyond the use of lime and mortar for bridge construction) but also to tackle large-scale industrial development (calculation of supply from 900 argillaceous limestone quarries in France, calculation of the cost price per cubic metre of hydraulic lime for an average factory).

Vicat’s approach as an experimental researcher (Experimental Research in 1818, Summary of current positive knowledge on the reciprocal quality, choices and knowledge of materials suitable for the production of lime mortars and cements in 1828) combined with his activities as an engineer entrepreneur (establishment of a first factory in Nemours in 1818, admittedly of brief duration, then of a second one in 1821). The spread of his ideas outside the corps of Ponts et Chaussées engineers grew with the accelerated development of public works and the proliferation of plants producing iconic lies and the massive use of hydraulic binders and concretes made for the construction of large-scale structures (the Algiers Harbor jetty from 1833 to 1840 and the Joliette harbor wall in Marseille, scheduled by the Act of 5 August 1844).

After the Second World War, the School educated engineers for both the public and private sectors. Societal, economic and technological changes transformed its curriculum and organization. The minutes of the meeting of the School’s Teaching and Research Counsel chaired by the School’s director Mr. Hirsch and curriculum director Mr. Dupuy in 1983 record the results of a multidisciplinary project on the subject of a metal offshore platform designed by the Industrial Engineering College. They also record the speech made by Mr. Hirsch when taking up his position in January of the same year, where he noted: “It should be remembered that Louis Armand began his career improving locomotive boilers, which did not prevent him becoming a great boss of the SNCF.”

Teaching innovation based on design thinking requires teachers to make dramatic changes in pedagogy, a transition from knowledge acquisition and dissemination to the “ability to create the right conditions for students to innovate” (Leifer, 2009), from teacher-centered instruction to student-centered learning through personal transformation based on learning a new culture.

My global research question is how to help academics to develop Design Thinking pedagogy, with one more specific question for teachers interested in such an adventure: How to become a professional practitioner in teaching Design Thinking? This piece of research demonstrates that pedagogical action research is an efficient way to become a professional practitioner in design thinking pedagogy. In the long run, the underlying aspiration of this research is to renew the way we educate future leaders, on the basis of the culture of Design Thinking as practiced with multidisciplinary teams in Silicon Valley, which aims to achieve substantial real-world impact.

This piece of research makes three types of contributions to scholarship:

- Contribution to theory, with two pedagogical action research tools for design thinking pedagogy
- Contribution to practice, with a self-reflection on three historical eras of practice and research
- Societal impact, with two dissemination frameworks.

After an introduction (Chapter 1) which describes how the research question emerged from practice, a literature review (Chapter 2) is carried out first on pedagogical action research, which results in the adaptation of a research protocol for Design Thinking pedagogy, and secondly on the expansive scope of design thinking, which results in the identification of the main different strands in product design (design to engineers with a focus on functions and technologies, design to artists with a focus...
on style and form, design to multidisciplinary teams with a focus on business and experience). The global movement of design thinking is placed in a historical perspective, especially in the academic world, and some tipping points are explained in terms of people, place and process.

The first contribution is theoretical, with the development of two research tools appropriate to design thinking projects, in order to allow faculty to self-reflect on their practice of teaching design thinking:

- A tailored pedagogical action research protocol, structured into 5 steps: situate/plan/act & observe/reflect/improve (Fig. 1a); this tool is derived from the literature review on pedagogical action research as described in section 2.1.
- The development of a conceptual framework based on three core categories: people/place/process (Fig. 1b); this tool emerged from reflection on my practice through pedagogical action research, as described briefly in chapter 3 and in detail in Annex 7.

After this literature review, the longitudinal study of eight years of practice and over 90 projects is presented in three parts: Chapter 3 gives an overview of the data collection, which is broken down into three historical eras of practice: designing a curriculum, developing an international program, and creating a d.school. Chapter 7 (annex) describes each historical era in detail, in terms of the adapted pedagogical action research protocol: situate/plan/act&observe/reflect/improve. This protocol has been used for the year-by-year construction of a culture of design thinking. Each historical era, which represents a higher level of ambition in terms of Design Thinking pedagogy, will be assessed against three main questions: Is it useful? Is it adaptable? Is it transferable?

The second contribution is practical, with a longitudinal study of eight years of practice, 74 projects and over 500 students at Masters level. The reflection on practice shows how this practitioner evolved from teaching a course to the position of a dean of a d.school tasked with dissemination, to the role of creating an international ecosystem. The three historical eras identified in the longitudinal study define three levels in the development of Design Thinking pedagogy:

- Designing a curriculum with multidisciplinary teams of engineers and designers;
- Developing an international program with a global network of over 15 universities and partnerships with global companies;
- Creating a d.school to disseminate practice through the training of teachers.

The adapted pedagogical action research protocol, with narrative case studies, has been tracked so that each academic year can be analyzed and measures taken to improve the development of Design Thinking pedagogy (Table 1). The “People Place Process” (Fig. 1b) conceptual framework, which emerged in the first years of reflection as a tool to guide the development of Design Thinking pedagogy, has guided my practice and reflection over the years through the different historical eras. In this way, I have experienced and identified “tipping points” in the culture of design thinking for each academic year (Table 1). They are classified in relation to the three categories of the conceptual framework. The full analysis is provided in chapter 7 / Annex 1.
The identification and experience of tipping points, and reflection on them, show how a culture of design thinking has been built up over eight years of practice (Fig. 2). This qualitative analysis demonstrates how a reflective practitioner (Schön, 1983) becomes a professional in action through an appropriate pedagogical action research protocol and a guiding conceptual framework, the PPP framework. These two tools are recommended to any design thinking teacher wishing to learn about this new culture, and second to become a professional. It is professional development through research, as well as a transformative personal journey.

The quantitative analysis of how tipping points evolve over time in each category reflects a further two years of intensive academic exploration (from a stay at Stanford then personal empowerment) and different trends in each category: At the beginning, the most intensive focus is on people and place, then the emphasis shifts to process, with the development of new tools appropriate to different artefacts and contexts (Fig. 2). A full analysis is given in Chapter 7 (annex). The journey described in the longitudinal study is recommended for any faculty and university as a sure path to Schön, D. (1982). The Reflective Practitioner: how professionals think in action. New York: Basic Books developing Design Thinking pedagogy: first, design a curriculum to gain experience; second, develop an international program to demonstrate; last, create a d.school to disseminate (Fig.3). Key recommendations are drawn for each category (people, place and process) according to the level of ambition.

Chapter 4 draws the conclusions of this longitudinal study: the construction of a conceptual framework around three categories (People/Place/Process) as a way of guiding the analysis of Design Thinking pedagogy through pedagogical action research, as well as changes in outputs, place and process over the eight years of practice.

Since its lessons are drawn from practice, this research is expected to have an impact on society, with two tools of dissemination as described in Chapter 5:

1) An activity-framework for design thinking, to structure the development of Design Thinking pedagogy. The 10 activity-framework identifies 10 competences for design thinking, with 5 activities per competence (Fig.4). It is a promising tool for evaluating student skills or making students reflect on their own skills development, as well as for structuring curriculum development.

2) A scaling-up model to develop Design Thinking pedagogy, from a course to national educational programs, through an international program and a d.school. The scale-up model is a tool that can guide faculty in identifying the right path in terms of levels of ambition for Design Thinking pedagogy.

The conclusion (Chapter 6) reflects on the ability of dissemination in other contexts: Is it adaptable? Is it transferable? Specific developments are always needed to disseminate design thinking, in order to adapt to different cultures, objectives, artefacts and organizations.
Fig. 35. An adapted Pedagogical Action Research Protocol for faculty to reflect on design thinking projects
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43 years, born on April 27, 1973 (France)

Personal Track

2012 to date
- Founder and dean of Paris d.school labelled by the French Ministry of Education.
- Founder and director of Paris ME310 Design Innovation in collaboration with worldwide d.schools (Stanford, Aalto, Hasso Platner Institute) and leading companies: organic growth by design thinking.
- Visiting scholar at Stanford University.
- Guest speaker in conferences and adviser for innovation directors.

2006/2012
- Professor in corporate strategy at Ecole des Ponts ParisTech (ENPC).
- Academic Director, Dept. « Industrial Engineering », ENPC.

2005/2006
- Research assistant, Chair of Innovation, Conservatoire des Arts et Métiers, Paris.
- Expert at the European Institute of Corporate Strategies (training and consulting in innovation and corporate strategy).

Euroconsult
1997-2004
- Consulting company specialized in the evaluation of markets and corporate strategies in the satellite industry. 500 clients in 48 countries. 30 employees. 3M€ turnover with 3 lines of activities (due diligence, business reports, World Summits).
- Chief Executive Officer and shareholder.
- Launch of 3 to 5 new products per year (incl. World Summits on Financing for Satellite Operators or TV platforms with 700 top level executives from 40 countries).
- Consulting missions in innovation and corporate strategies.

1993-1997
- Management of international high tech projects between governments and private companies: Aérospatiale, international affairs / Paris, Banc of America, specialised services / London, Daimler-Benz, project finance / Stuttgart, MTU, sales / Friedrichsafen.
Studies


1997 • Master in innovation and technologies at Ecole Centrale de Paris, a top French engineering school (with honors).

1996 • EAP (European School of Management) - Paris, Oxford, Berlin. Double masters in France (« Grandes Ecoles de Commerce ») and Germany (« Kaufman »).

1991 • BAC C (scientific bachelor) with honors.

Others

• Shareholder and Vice President of Ipricot, a start-up in high tech (1998/2010).
• Horse riding (jumping and dressage competition), ski, jogging.

Publications

• Editor of a dozen of business reports on the analysis of space industry and TV satellite industry.
• Modifying design pedagogy to develop new approaches to sustainability, ICED 2009.
• People, Place, Process: lessons from on a path to a d.school, ICED 2013.
• 101 Landmarks I’ve discovered to innovate thanks to design thinking, CC, (French/Spanish) 2015.
• Le design thinking par la pratique, 2016, Eyrolles.
People Place Process
A self-reflection tool to become a professional in design thinking, based on Pedagogical Action Research