2EL2120 – Design Science

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Department: DÉPARTEMENT GÉNIE INDUSTRIEL ET OPÉRATIONS
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Business Sciences
Advanced level : No

Description
This course allows to understand the major concepts of Design Science and Engineering, and to practically experiment the design of products, services and business models on various examples. The design examples are, among others: launch of a brand new hotel chain, design of an apartment bicycle, of a commercial airplane, of a smartphone for more inclusiveness, perceptual and emotional design of a wine glass, service design in the context of a classy restaurant or a hotel reception, design a carpooling service, business model of a travel agency.
The lecture is reduced to 1.5 hour out of 3 per session, in order to leave room for rich and varied contexts of experimentation (case studies during exercises, practice of design platforms, debates, quiz and final poster session). One debate is organized with several invited design practitioners.

Quarter number
SG6

Prerequisites (in terms of CS courses)
no prerequisite

Syllabus
The 10 course sessions cover a variety of design topics.

1. Introduction
This session introduces the activity of designing from a historical perspective, the vocabulary and stakes of design, the design communities and the convictions of a group of academics that design is a scientific discipline. “What is design? What can be designed? Why is it a science?” are the questions addressed by the lecture and debated by the students.

2. Design process

The interest of describing design processes is illustrated. Prescribing a design process is done with the underlying idea that it is likely to have a good design outcome when a quality design process has been conducted. Four types of prescribed design processes are presented. First, some generic and simple models are described such as Design Thinking, double-diamond and Radical Innovation Design. Second, some Engineering Design (ED) models, well adapted to design complex engineering systems, are presented. Third, New Product Development (NPD) models like the Stage-Gate® model of Cooper are presented in the context of large industrial and business projects where market analysis, innovation strategy and project management are important. Finally, it is shown that large companies are generally adopting a fourth approach that of hybridizing the ED and NPD approaches, with the use of Design Thinking in the system innovation part.

3. Capturing and expressing the need - Part I: conventional requirements engineering

Design requirements describe the characteristics that a product must have to meet the needs of the stakeholders. They are made of functional requirements (service functions) and non-functional requirements (quality attributes and constraints).

4. Capturing and expressing the need - Part II: non-conventional requirements engineering

Non-conventional requirements engineering techniques are evoked: Use case, user story, emotional engineering, perceptual design, opinion mining. They constitute a wide range of requirements specification techniques available to designers.

5. Design a product

The concept of product architecture is defined. The process of designing is presented as a top-down multi-level structural design while adopting design principles. It is shown how a function is represented as a flow inside a structure representation and how a value analysis allows to balance the design choices of the structure with the functional requirements.

6. Design a service

Goods and services can be viewed as supporting human activities and a design process can be considered as a transformation of a user activity system. Service blueprinting is presented as the means to represent a service and to improve it. The tools for designing a product and designing a service are finally compared. The conclusion leads to the necessary hybridization of product design and service design methods, and consequently advocates for the design of Product-Service Systems (PSS).

7. Design for, by and with people

It is imperative to know how to design for people (designers learn from the usage expertise of people), design with people (users are active participants in the design process) and design by people (designers help users to become design actors and make their own decisions). In the first part (for and with people), personas and customer journey maps are studied as major tools. In the second part, it is illustrated how human models and human beings may be used in the design process. One speaks of Human-in-The-Loop (HiTL) simulations.

8. Universal design

The observation can be made that, still today, most of the time companies design products and services in the "one size fits all" mode for a perfect "averaged" customer. In consequence, designers do not consider the diversity of people and of activity contexts during the design process so as to ensure that the design outcome effectively delivers its expected value with a satisfactory user experience. Impaired, elderly and young people are example of often ignored (not so small) minorities. Universal design – also "called design" for all or "inclusive design" - is defined as the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. The inclusive design process of EDC Cambridge is presented in details and some extensions are proposed. This inclusive design process is not intended to be used only in extreme situations, but it pretends to be a generic design process to follow as soon as the product or service to design requires a human interaction.

9. Design a business model

The business model is the concept that allows a company to make money, the business plan is the operational plan to achieve it. A business model describes the rationale of how an organization intends to create, capture and deliver value. Several canvases are presented to represent and design it, among them the famous Business Model Canvas (BMC). It is then showed that the BMC may be not enough for guaranteeing success on the market. A BMC-RID variant has been proposed to consolidate its weakest points.

10. Prototype, test and validate

The cycle « Prototyping – Testing/Experimenting – Evaluating – Validating » is situated at the end of a design process. It is shown that the design of a prototype derives from the design of an appropriate experiment with expected evaluations, deriving from a subset of challenging performances (specified in the requirements specifications), deriving from a value proposition, deriving from an activity to improve. Numerous techniques of virtual and physical prototyping are presented, notably videos for illustrating existing usage scenarios and dreamt usage

scenarios. Finally, the importance of documenting during the design process and especially the prototyping stage is evoked.

Class components (lecture, labs, etc.)

Each class session is typically composed of 1h30 presentation of the daily topic, and 1h30 of exercises. During one session, a debate is organized with invited design practitioners.

There are 60 WLH in total, compared to the 33 hours of lectures and exercises and 2h of final poster session. The 25 additional hours are decomposed in 1h30 in average for completing the exercise after each session by groups of 4, and 7 hours to prepare the final poster session.

Grading

The final grade is composed of 15% of the homeworks (in group), 35% indivual quiz and 50% of the final poster (also in group).

The final poster session consists in the documentation of a trend, method, tool, concept or particular project or designer of Design Engineering & Science. Let us call it an object for instance *Jugaad innovation, Minimum Viable Product, Eco-innovation, The practice of Design Thinking in companies...*

The poster must illustrate:

- The principles of your object
- Its stakes
- Its successes and failures so far
- Its economical interests
- Its compatibility and interests in regards with the U.N. Sustainable Development Goals (SDGs)
- Your clear-cut opinion “We should do that or avoid to do that…”

... and it must be illustrated, cool, informative and original!

A very funny, participative and intensive poster presentation is organized. By groups, you present your poster several times: to professors, to classmates and you are yourself in a jury to evaluate the posters of your classmates. Each presentation is 5 min. + 8 min. Q&A. A video (January 2020) of the last poster session event can be seen here: https://web.microsoftstream.com/video/79bf09a7-d0bd-4aca-8ab9-d017bddb34ca

Course support, bibliography

- Yannou, B. & Farel, R. eds. 2011. Déployer l'innovation : Méthodes, outils, pilotage et cas d'étude, Paris: Techniques de l'Ingénieur, ISBN

978-2-85059-129-7. Accès direct à ces fiches pratiques à http://www.techniques-ingenieur.fr/fiche-pratique/genie-industriel-th6/deployerl-innovation-dt30/ de Centrale
- Yannou B., Deshayes P., 2006. Intelligence et innovation en conception de produits et services. collection "L'esprit économique", série "Economie et innovation", Paris: L'Harmattan-Innoval, ISBN 2-296-00644-2.
- Yannou B., Bigand M., Gidel T., Merlo C., Vaudelin J.-P., 2008. La conception industrielle de produits - Volume I : Management des Hommes, des projets et des informations, Paris: Hermès Sciences, Lavoisier, ISBN 2-7462-1921-2.
- Yannou B., Robin V., Micaelli J.-P., Camargo M., Roucoules L., 2008. La conception industrielle de produits - Volume II : Spécifications, déploiement et maîtrise des performances, Paris: Hermès Sciences, Lavoisier, ISBN 2-7462-1922-0.
- Yannou B., Christofol H., Troussier N., Jolly D., 2008. La conception industrielle de produits - Volume III : Ingénierie de l'évaluation et de la décision, Paris: Hermès Sciences, Lavoisier, ISBN 3 978-2-7462-1923-6, ISBN général 978-2-7462-1920-4.
- Pahl G., Beitz W., Engineering Design: A Systematic Approach, Springer, Technology & Industrial Arts, ISBN 3540199179, London, New-York, 1996
- Ulrich K.T., Eppinger S.D., Product Design and Development, McGraw-Hill, New York, 1995
- Otto K.N., Wood K.L., Product Design - Techniques in Reverse Engineering and New Product Development, Prentice Hall, New-Jersey, 2001.
- Yannou B., 1998. Chapitre 3 : Analyse de la Valeur, In Conception de produits mécaniques : méthodes, modèles et outils, Vol. ISBN 2-86601-694-7, Tollenaere M., eds Hermes, pp. 77-104.

Resources

Teacher: Flore Vallet
Size of exercise classroom: 35 students
Online softwares and design platforms

Learning outcomes covered on the course

- Understand the major concepts of design science and engineering
- Experiment practically with product design, service design and business model design
- Understand the stages of a design process and the different methods and theories that may be useful to deal with design issues

- Be able to investigate on a design issue or design trend, to document it and to find appropriate attitudes and methods to solve it
- Understand how end-users and design experts can intervene along a design process

Description of the skills acquired at the end of the course

- C1.1 : Milestone 2: Know how to conduct a questioning process to address the different aspects of the problem and highlight its interactions with the outside world, based on a scientific and economic culture
- C1.4 : Milestone 1: Specify and design a system or part of a system
- C3.6 : Milestone 1: Evaluate the effectiveness, feasibility and robustness of the proposed solutions according to the expectations of the problem to be addressed
- C4.1 : Milestone 1: Identify the client(s) of a situation or project. Identify your main objectives and needs,
- C4.2 : Milestone 2: Propose one or more solutions that optimize value for stakeholders, including the customer, and distinguish value and cost from a solution.