HOW DESIGN IS TAUGHT? A SURVEY OF APPROACHES, MODELS & METHODS

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ABSTRACT
How to teach design? This is not the first time that this question is asked and there are probably as many answers as design academic programs in the world. Knowing how to design is not enough to teach someone to do it. There are numerous experiences in this matter profusely published on literature. However, this information is sparse and does not exist in a summarized and comparative way, and knowing how design is taught is crucial to build other design academic programs in the future and enrich the pedagogical practices of the existing ones. Every design program should be based in a conceptual framework in which there are mainly two multidisciplinary fields: design and education. This framework provides a structured and concrete way of improving learning activities in design. In this paper, we will focus on design education identifying, summarizing and comparing its pedagogical practices (PP's) published in this matter. The first objective is accomplished with a survey of approaches, models and methods of teaching design (PW's), made from 204 publications not only in product design but in architecture, arts and other disciplines. A comparative table shows the name of the PP's, its conceptual foundations, the use of technology, role of the teacher and disciplinary origin. The second objective identified the elements in design education context to be able to describe relationships between them in the form of a pedagogical model to build in a future project.

Keywords: Pedagogical practices (PP's), teaching design, pedagogic methods, pedagogic approaches, pedagogic models, contextual elements of how design is taught.

1 INTRODUCTION
Product design academic programs should be founded on clear conceptual frameworks integrating design and education matters. However, this is not always the case due to the complexity of the elements involved in those programs. We believe that such frameworks should state clearly the main conceptual elements of the academic design activity: first, what design methods are and how one or more general design theories explain those methods (i.e. Yoshikawa's Suh's, Axiomatic design or C-K theory); second, models about the technological context, the user and the interaction to be incorporated in the product being designed and third, a pedagogical model of teaching and learning design. This paper presents then the first part of a future project intended to construct such a model. Having as future goal a more structured design program where each student's learning process is clearly justified, the choice and application of the teaching objectives and pedagogical tools are clearly settled, and the evaluative processes are supportive for the learner in his knowledge acquisition process. If such a framework is not clear, it's up to the professor's pedagogical skills to guarantee the success of the educational process. There are teachers who make it, there are others who don't.
This paper consists in a survey of methods, models and approaches published on literature to build these clear guidelines for the future. We understand a design academic program as a means that "enables the transition from the complete novice status of the beginner to the well-initiated status of the graduate designer" [3]. We've chosen this definition because it's not biased by a particular pedagogical stance and Pedagogy is defined by Oxford dictionary as the method and practice of teaching. A pedagogical model (PM) is a reduction and abstraction of the variety and complexity of elements and issues of the teaching process [6] with "a further level of abstraction of the learning activity"[7]. Teaching methodologies (TM) are specific guides to teach with a lower level of abstraction than a PM [8–10]. Lastly pedagogical approaches (PA) are those with a pedagogical stance but without any specific procedures or guidelines to teach design [11] (i.e. problem based learning sets the base of the education on the problem solving without saying specifically how this task has to be

taught). One difficulty tackled in this survey was that educational concepts are named ambiguously on the design literature. This happens often with PM, TM and PA. This impedes the clear-cut analysis of the subjects found. We decided consequently to keep the PP's name given by the author in which it was found. Design knowledge would be "a body of information which provides an understanding of the principles, practices and procedures of design" [5]. In a broad way of understanding design, Gray (2011) defines it as "the activity we humans engage in when we are not satisfied with our reality and we decide to intentionally change it" [4]. When executing and learning such activity, the cognitive theories explain how the mind works in design knowledge acquisition and creativity's phenomena [3]. As Baughman & Mumford (1995) said, creativity is how people work with knowledge in the generation of ideas [2]. The first objective of this survey is to describe the different PP's present in literature, and the second, to identify elements of design education that aren't explicit in the PP's but are relevant to the understanding of its complex nature (i.e. gender, diversity, engagement, the who-how-where and what to teach, etc.). A deeper analysis of this information will describe design education in the form of a pedagogical model to build in a future project.

2 METHODOLOGY

In a first phase, we constructed a database with the literature, which was analyzed in the second phase. Figure 1 explains in detail the methodology followed. We used Qiqqa, a computer assisted qualitative data analysis software (CAQDAS), because it allows an effective classification and analysis of an important amount of qualitative information.

2.1 Construction of the database and its classification system:

204 publications were gathered on product design, industrial design, architecture, engineering and fine arts pedagogy books and design conferences papers (EPDE, ICED, DESIGN, TMCE among others). We looked for publications with a diversity of conceptual foundations and approaches to the ways design is taught. The search continued through the review of the publications referenced in each paper using Qiqqa's Google scholar real time connection and its TPR technology which recommends publications from a citation distance calculus. The search stopped when a saturation point was reached, i.e., when there were new publications but they failed to provide different information about the ways design is taught. Qiqqa counts with 3 AI tools allowing the software to divide texts into discourse units, calculate statistical proportions of keywords and approximate concepts from a large set of documents (Semantic Analysis) [13]. These tools make it possible to search and tag inside all the documents and make a useful, coherent and sufficient database mentioned before. The publications were classified manually using 99 tags (e.g pedagogical models, methods and approaches, cognitive tools, constructivism, cultural aspects, etc.). Those tags were extracted from the titles, keywords and abstracts of the publications and then confronted with the ones generated by Qiqqa automatically to filter ambiguities. Each time a publication was added to the database it could be tagged with already known tags or had new tags assigned to it.
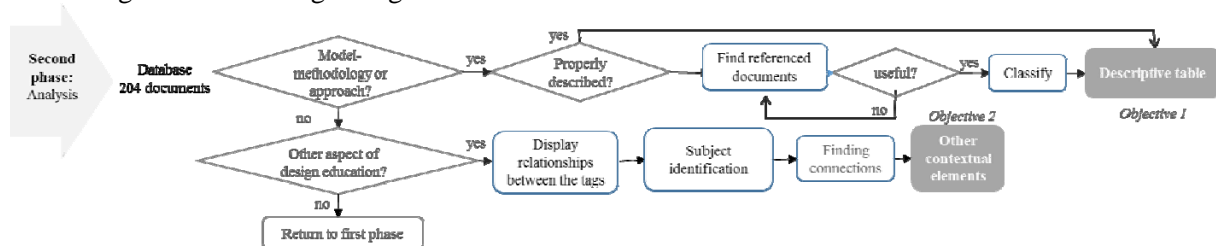

Figure 1. Database's analysis method

2.2 Analysis of the database:

This phase describes the PP's found in the database and identifies other contextual elements of how design is taught by analyzing the publications' tags (2nd paper objective).

2.2.1. Identifying the PP's to teach design

Papers with tags as Models (PM), methodologies (TM) and approaches (PA) were considered directly as PP's to teach design. The documents tagged were read to extract the following characteristics,

Table 1: name of the approach-model-method, conceptual foundation, use of technology when teaching, role of the teacher, design knowledge taught, and disciplinary origin.

2.2.2. Identifying other contextual elements of how design is taught

The tags used to categorize the database are grouped by design subjects (e.g. design methods and design tasks are part of a design group of topics). Then, Qiqqa's brainstorm utility displays the relationships between the documents as a net and clusters groups of papers with similar concepts.

The connections of this visualization (figure 2) are used to verify the group or subgroup assigned in the structure of topics shown in figure 3 (e.g. if the position of "Design for X" is unknown, the visualization shows the documents nearest to other design methodologies, so this topic is located in this group).
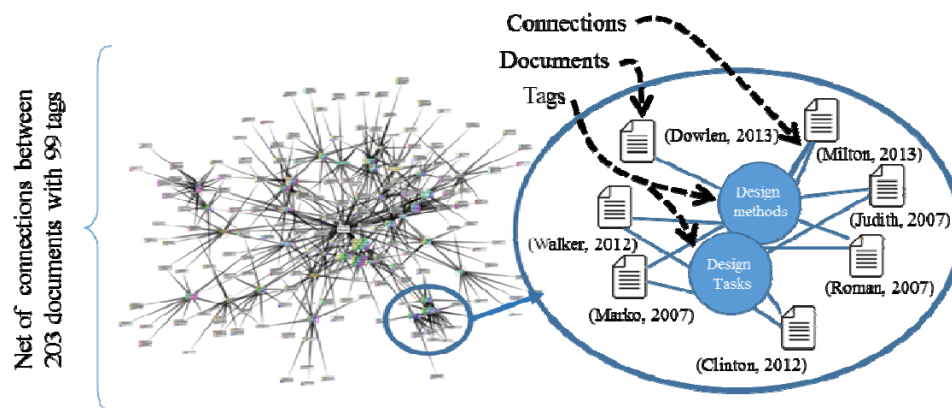

Figure 2. Issues to be taken into account and their relationship's visualization

3 RESULTS

3.1 PP's characteristics:

All PP's are featured through 6 characteristics: *1. Name of PW's*, with a high level of abstraction if it is M, lower if a TM or just an A. *2. Conceptual foundations* which are basic concepts or theories of each. *3. Using technology when teaching* are mentioned by its name, not specified (NS) or not mentioned (NM). *4. Role of the teacher* shows the pedagogical stance of the way design is taught. *5. The design knowledge taught* are design methodology (DM), a technological or contextual knowledge (K), or a particular skill needed to design (S). *6. The disciplinary origin*: a practice, a theory or a trend as source of the PP's. The PP's are on the same table because their limits aren't clear even by having different levels of abstraction.

3.2 PP's to teach design

Each PP's is described below and compared in table 1 with its corresponding characteristics.

3.2.1 Five pedagogical Models (PM):

1. Conceive-Design-Implement-Operate model, CDIO which produces "complex value-added engineering systems in a modern team-based engineering environment"[14]. Used for academic programs in Sweden, the USA and France [15]. 2. *Instructional models* are a set of models based on teaching by instructions, "typically specifying learning objectives and perhaps engage the learner in a project, assuming that he will understand and buy into the value of the problem" [16]. 3. *Kolb's experiential model* is a theoretical model based on the notion of experience as an organizing focus for learning from concrete experiences, reflective observations, abstract conceptualizations, active experimentations [11]. It's composed by two theories: Learning Style inventory (LSI); and the experiential learning theory[12]. 4. The *Studio model* is about design *skills* and behaviour. It's a "location where projects are individually or collaboratively executed, where projects are normally selected based on their applicability and conformance to the actual practice of that design discipline"[4]. 5. *Reflective Learning Model* based on Schön's book E*ducating the reflective practitioner*. In which the conscious practice of design is enhanced: "reflective thinking generally addresses practical problems, allowing for doubt before possible solutions are reached" [17]. The student learns to be a 'reflective practitioner' engaging in his professional activity.

Table 1. Descriptive table of the ways used to teaching design

Name	Conceptual foundations	Technology Used	Teacher's Role	Design knowledge	Disciplinary Origin
CDIO Model	Standards/Rubrics/Auto-evaluation/ humanistic and technical skills	NS	Assessor	SK	Engineering practice.
Instructional Model	Plan-implement and evaluate	NM	Instructor	K	Learning theories.
Kolb's Model	Learning Style inventory (LSI) The experiential learning theory.	NS	Professor	S	Psychological studies
Studio Model	Design thinking, design skills, the environmental factors, social interaction, cognitive development and evaluation.	NS	Indirect instructor	DM/S	Art practices since renaissance.
Reflective Learning Model	Reflective practitioner (engaged professionals)/ book knowledge/ reflection-in-action (present) and reflection-on-action (past).	NM	Professor	DM	Epistemological focus-Rationalism
Situated learning (TM)	Learning environment / learner–environment interactions/ involvement/ choices of learning strategies	NM	Future client	K	Epistemological focus-Empiricism
Systems thinking (TM)	Complex problems and relations between its elements. Nonlinear thinking, team working, decision-making processes.	NM	NM	DM/K/S	Systems theories
Think-Maps (TM)	Design thinking, thinking process, ways of store and encode design knowledge, presence of knowledge (explicit or not), concept mapping.	WebPad	NM	DM	Epistemological focus-Constructivism
Project based learning (TM)	Driving question/ activity of designing/ formatively assessed and revised/ presentation of the project.	NM	Director	DM/K	Educational trends
Whole brain Approach	The brain of each person specializes in 4 brain quadrants: theorists organizers, innovators, humanitarians	NM	Professor Assessor	S/DM	Neurological studies
Learning by doing EA	Trying something/ seeing how well or poorly it works/ reflecting on how to do it differently/ trying it again and seeing if it works better.	NM	Guide	K	Educational trends
Problem based learning PA (PBL)	Presentation of the problem/ learners autonomy, small groups, resources available/instructor assessment/ content knowledge is acquired as needed/ reflection phase.	NM	Assessor, facilitator	S/DM	Educational trends
Strategies of experts EA	Problem perception/problem-solving-behaviour/ meta-cognitive knowledge/skills and cognitive strategies/ implicit knowledge.	N/A	Professor	S	Design practice

3.2.2 Four teaching methodologies (TM)

1. Situated learning TM is based on situated cognition theory. It posits that "learning is unintentional and situated within authentic activity, context, and culture. It has been applied in the context of technology-based learning activities that focus on problem-solving skills" [18]. *2. Systems thinking TM* was born from the need for a better way of testing social systems, in the same way we can test ideas in engineering [19]. It prepares "for interconnected thinking to deal with complex problems in a systemic, integrated and collaborative fashion–working together to deal with issues holistically, not simplistically"[20]. *3. Think-Maps TM* is based on the constructivism so "by constructing a conceptual map that reflects one's thinking in a domain, we make explicit the knowledge learned" [21]. This TM is focused on teaching how to construct knowledge related to designs, instead of constructing designs [21]. *4. Project based learning TM* is an instructional method based on the knowledge needed to solve a real problem while obtaining the skills to apply the solution.[10]. Teaches a particular method using knowledge and skills required in the project but other project, may need different skills.

3.2.3 Four pedagogical approaches (PA)

1. Whole brain PA criticizes education of the rational part of the brain omitting the rest of it. Everyone uses their brain in a specialized way originating "from socialization-parenting, teaching, life experiences, and cultural influences-far more than from genetic inheritance"[12]. 2. *Learning by doing PA* states that the most powerful learning always occurs when engaging in action. Engagement and experience are the most effective teachers. Involves learning by trial and error in safe environments [22]. 3. In *Problem based learning PA* "students direct their learning by working with and understanding the problem statement of the specific project. They are active in the knowledge acquisition and learn how to attack problems" [23]. *4.* The PA of *Strategies of experts in design* as Kesselring, and Pahl, describe how *s*ome design methodologies are developed by designers in their process of learning how to successfully design [24]. Therefore, this approach studied what they have in common and defines the skills that a designer should learn from an expert point of view.

3.3 Other contextual elements of how design is taught

The figure 3 is a proposal of a general view of design education context and its PP's. The elements in the reviewed literature are not explicitly connected with the PP's but, with further studies, could be found as important parts of the mentioned model to build in the future. This structure was constructed with the sematic analysis tool of Qiqqa as seen in figure 1. It presents 2 branches of design educational topics. The first, is composed by PP's (M, MT & A), philosophical affiliations (with constructivism as the most mentioned) and other issues (cultural aspects, students' engagement, etc). The second, shows *who* (agents), *how* (methodologies), *where* (learning places) and *what* (design knowledge: design process, tasks, methods as design for x or UCD methods, design tools, and skills, multidisciplinary aspects and HCI). The third branch shows the *cognitive topics* comprising: creativity topics and psychological topics.

Figure 3. Structure of design educational topics found on literature

4 CONCLUSIONS

The 13 PP's identified and described from literature can be compared in three characteristics: 1. Some PP's in which design is taught are *centred on the learner* (e.g. studio model, Kolb's experiential model, learning by doing, etc.) but there are others *centred in the design knowledge* to be learnt (e.g. Instructional model, CDIO, problem based learning, and expert's strategies). 2. There are ways to teach design based only on the *cognitive activities* involved in learning design (e.g. Systems thinking, whole brain model). Other ways are based on *other learning levels*, (e.g. humanistic and technical skills, the human senses and learning to behave and think as a professional designer). 3. *A professional profile* developed is shown when some models embrace the *diversity of the learners*, teaching them to find the design tasks of their expertise (Kolb's experiential model and whole brain) but somehow, others tend to form an integral designer (expert's strategies). The PP's have different sources: design history, the industry needs, the knowledge of experts in design and the scientific and philosophical theories from which the PP's were born. The PP's conceptual foundations are diverse: some describe their teachers as instructors, teaching by giving instructions to the students; others, as assessors to advice and guide their process; some have objectives as goals (Instructional PM) and others, have standards as guiding principles of the design learning process (CDIO PM). This shows deep differences between the PP's in need for the *construction of evaluative systems* that do not exist today. This evaluation, necessary to the further *construction of the model* sought, will be carried out in a next

step of the future project. Questions are open for further studies along with the study of the relations between the cognitive topics and the design methodologies, and the epistemological structures (i.e. philosophical affiliations) of the PP's. It's important to highlight that this paper is limited to the information existing in literature; further studies will address other sources of information. However, this survey developed a large repertoire of possible choices when building a clear PP's for product design engineering programs. Further explorations will seek to find more about the product design methods and general design theories, creativity and thinking processes models and user-product-interaction-context models, their strengths and limitations.

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