TEACHING DIGITAL TECHNOLOGIES IN INDUSTRIAL/PRODUCT DESIGN COURSES IN PORTUGAL

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ABSTRACT
In full 21st century and living in a digital age, technology advancements have led to the development and use of digital media for product design projects' support. It starts with education and training, making students to contact and learn tools and methods of computer aided design (CAD). Believing that the level of digital technologies knowledge to design and representation is one of the basic requirements to get a position, and sometimes it makes the difference in choice requisites, this study presents the results of a critical diagnosis about the presence of 'informatics contents' applied to design in the academic curricula of industrial/product design in Portugal. As part of a PhD research focused on product design curricula's adequacy to business challenges, this study aims to demonstrate how important is to keep up with the fast technological development, increasing the professional perspectives for design students. Editing/treatment of image and sound, printing technologies and multimedia communication are some of the significant contents covered by those courses. Based on the gathering and interpretation of several Portuguese design education curricula for undergraduate and master degree programmes. It appears that the introduction of the principles and practices of digital tools and methods are transmitted early in the education process. Especially on undergraduate courses, contributing to a better preparation of the design students to the market and its demands and challenges.

Keywords: Design education; product design; digital and technological contents

1 INDUSTRIAL DESIGNER'S SKILLS: THE PROFESSIONAL PERSPECTIVES

In a period of significant change, design education and training should anticipate the business demands and provide the development of adequate professional skills. It starts with the understanding of the professional perspectives about the designer's profile.

According to Gomes [1] who studied the designer competencies profile facing the emerging market, one can assess it according to two approaches – the personal training (behavioural characteristics that depends of the tacit knowledge) and the professional qualification. Focusing on the second approach, we can find transversal competencies (such as ethical values, responsibility, dynamism, capacity to take initiative, creativity, entrepreneurial and innovation) and specific competencies that depend of the sub-area of design. Specifically on industrial design expertise (also referred as product design) the competences integrate the domain of specialized software for 2D and 3D visualization, the realization of models, the knowledge about the user/customer, the ability to design spaces and equipment, objects and artefacts appropriated for a defined target group [2] [3].

However, design education needs to be reviewed and updated periodically. With the continuous and rapid transformations of new technology and the product development process, what is teach today will be out-of-date in five years, i.e. the skills that students are learning in schools today will be out-of-date when they get employed [4]. So, this leads to a fundamental question on which we must reflect: how can industrial designers adjust and update their competencies to be competent for the emergent jobs?

2 EDUCATING DESIGNERS FOR DIGITAL TECHNOLOGIES

2.1 Bridging the sketches by hand with CAD and digital design

It is known that a good interface between education and business is a necessity and a prevailing concern. It is also known that the reformulation of academic curricula, based on the work of researchers, is a constant in any design course [5]. Living in a digital age, the level of digital technologies knowledge to design and representation is one of the basic requirements to get a position, and sometimes it makes the difference in choice requisites, because the main focus of concern and requirement for the business sector is currently the performance of the designers in the field of technology combined with new technical skills [3] [4] [5]. So, if the student's familiarity with the computer aided design (CAD) systems increases his/her professional perspectives, the tools and methods of CAD are also the first step to break with conventional drawing on paper. However, this has little effect on the initial phase of the design process [6], being assumed as fundamental at more advanced stages of the conceptual development. It is with sketching that the creative process starts, because innovation is controlled and limited by software [7]. It is through sketching that mental activity is available for the systematization of information, for studying the coherence of form, to generate the best technical solution and, consequently, for creativity [7]. Although drawing may seems having an abstract feature, it is strictly necessary the establishment that designer do with his/her drawings, through different scriber tools [7], because "sketches not only serve as the descriptive tool for designers to record what is within their minds but it is also a tool for designers to reinterpret the sketches previously made and to reorganize their concepts" [8] [9]. Sketching is not only the tool to register the first ideas but the tool to verify various hypothesis, being known as the procedure to express, interpret, criticize, evaluate and clearly define the projective intent. It should remain inseparable of training and professional practice, mainly by incorporating its critical dimension in the conceptual design process [9] [10]. So, the introduction of new technologies as bi and tri-dimensional tools of representation, through specialized software, emerge as auxiliaries and facilitators of the conceptual design process [7]. The new technologies proliferate in contemporary society compared to the traditional paper support [11]. However, and although the systems of representation in the creative process are increasingly computerized, Sketching by hand can never fall into disuse because it is the direct tool for the representation of ideas, which usually emerge random and amorphous during the design of a product [9]. In fact, making use of digital tools facilitate the designer's everyday tasks, it saves time [10] , but also allows to design with rigor and detail which most of the times is hard to be done by hand drawing [12]. The use of drawing software also allows error detection and a quick translation to industrial production systems in the shortest possible time [12] [13]. The freedom in the creative process provided by sketching must be complemented and reinforced by the use of digital tools that make easier to produce detailed and precise drawings.

2.2 From CAD to…

The software for computer aided design (CAD) is framed as graphic tools supported by computer technology whose objective is the development of projects with high level of accuracy that enable control of the development process [15]. Some information related to sizing (thickness, weight, concavities, convexities) are generated, thus enabling rapid presentation of alternatives (colour changes, surfaces, textures, decorative elements) and photorealistic images with renderings (these possibilities depend on the software used and installed computing capacity). So, CAD systems act as auxiliary tools in the creation process, making it possible to display three-dimensional (rotation) and parameterized design (construction with mathematical data) object and as a tool to aid preparation of technical drawings [14].

Resorting to Rapid Prototyping process, which starts in the CAD system (where the product is designed in the virtual three-dimensional form, with output files in STL format - stereolitography) followed by sending the data to a CAM (that selects the best cutting tools for a particular material and specifies the appropriate speed of operation, optimizing the process) [14] today a product does not need to be manufactured to be exposed to the consumer [13]. Everything can be done on specific software and tested by the target audience to see if this product is ready for market or not [13]. With the advancement in the quality of designs, the decrease time and costs and increase of the overall productivity, the development team can have a feedback from user/consumer. So, after knowing their

reaction, the development team will be able to adapt the product to market needs, in the shortest possible time [13].
Marsh e Arthur [16] defend that the CAD and CAM learning process, similarly to other disciplines in the design area, must be done having as a departure point the debate, the exchange of ideas and the group work. This enhances students' critical awareness as well as boosts their knowledge and skills like management and communication, necessary to function productively in large interdisciplinary teams and organizational structures. Thus, the designer's main function is to use the available technology effectively as a facilitator and innovator way to materialize products, increasing the freedom of the creative process [14].
More important than which software is learned, is the designer's ability to do 3D drawing renderings and to make sophisticated models, and because educators cannot predict the possibilities of technology, industrial designers will always need to adjust and update their competencies [4].

3 DIGITAL TECHNOLOGIES IN INDUSTRIAL DESIGN HIGHER EDUCATION – PORTUGAL AS CASE STUDY

In Portugal, currently, industrial design higher education offers 29 undergraduate courses and 22 master courses. Integrating our PhD research, we mapped those courses and made the gathering and interpretation of their official curricula (publicly available in their own webpage) to verify the presence of digital technologies contents.
In order to make the curriculum benchmarking it were created two analysis grids (one for undergraduate and another for the master) about the courses which offer digital technologies curricular units (CU). Those grids were organized into four sections: i) identification of the institution of higher education (based on mapping previously done); ii) identification of the CU; iii) the semester it occurs; and iv) the percentage of ECTS of these CU(s) facing the total academic degree ECTS.
As it can be seen in Figure 1, all of the undergraduate courses offer digital technology contents. Nevertheless, this existence is reduced when we compare the curricular unit ECTS with the whole ECTS of the course (180 ECTS = 100%). Table 1 shows that the prevalence of digital technologies curricular units varies between 3.3% and 30.6%, with an average of 13.3%. These approaches occur all the semesters, in a balanced manner, however, it's more evident during the second year of the undergraduate programs.

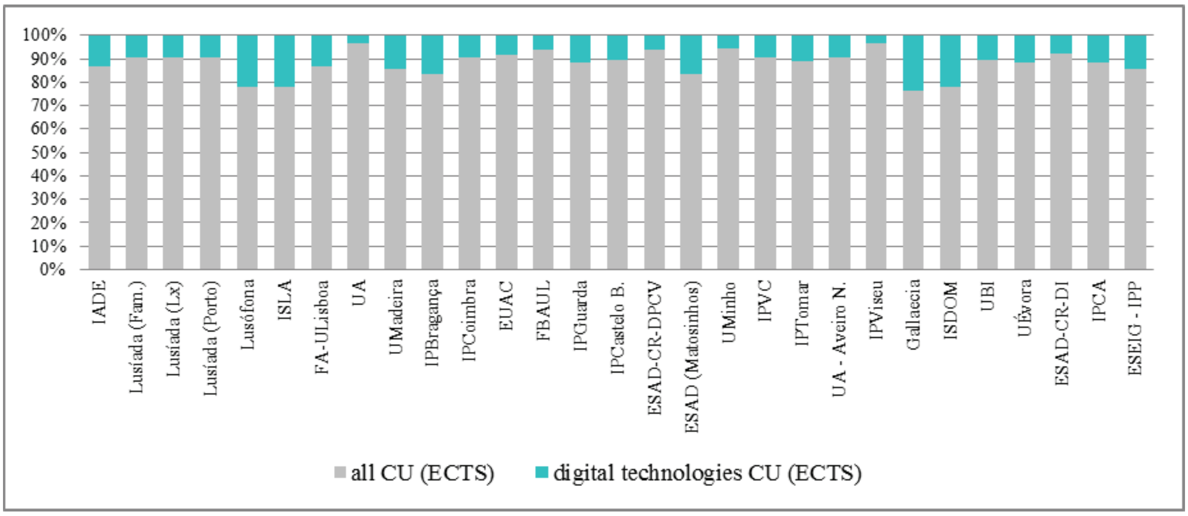

Figure 1. The existence of digital technologies CU in industrial design undergraduate programs

Table 1. The existence of digital technologies CU in industrial design undergraduate programs

IHE | DISTRICT	SEMESTER / ECTS									%
IADE | Lisboa	1st	3rd	3rd	4th	5th	6th				15%
	3	3	3	6	6	6				
Lusíada (Fam.) | Braga	1st	2nd	3rd	4th	5th	5th	6th			13.3%
	3	3	3	3	3	6	3			
Lusíada (Lx) | Lisboa	1st	2nd	3rd	4th	5th	5th	6th			13.3%
	3	3	3	3	3	6	3			
Lusíada (Porto) | Porto	1st	2nd	3rd	4th	5th	5th	6th			13.3%
	3	3	3	3	3	6	3			
Lusófona | Lisboa	1st	1st	2nd	2nd	3rd	4th	5th	5th	6th	27.8%
	6	4	6	4	6	6	6	6	6	
ISLA | Lisboa	1st	2nd	3rd	3rd	3rd	4th	5th	6th	6th	28.3%
	6	6	3	6	6	6	6	6	6	
FA-Ulisboa | Lisboa	2nd	3rd	4th	5th	5th	6th				17.8%
	3,5	7	7	7	3,5	7				
UA | Aveiro	4th	5th								3.3%
	2	4								
Umadeira | Madeira	1st	1st	3rd	4th						16.7%
	7,5	7,5	7,5	7,5						
IPBragança | Bragança	1st | 2nd	3rd | 4th	3rd | 4th	5th | 6th						20%
	10	6	10	10						
IPCoimbra | Coimbra	1st	2nd	3rd	4th						10%
	6	6	3	3						
EUAC | Coimbra	1st	2nd	3rd	4th						8.9%
	4	4	4	4						
FBAUL | Lisboa	3rd	4th								6.7%
	6	6								
IPGuarda | Guarda	1st	2nd	4th	5th	5th					13.3%
	5	5	5	4	5					
IPCastelo B. | Castelo Branco	1st	2nd	3rd	4th	5th					11.7%
	5	4	4	4	4					
ESAD-CR-DPCV | Leiria	3rd	4th								6.7%
	6	6								
ESAD (Matosinhos) | Porto	1st | 2nd	1st | 2nd	3rd | 4th	5th | 6th						20%
	9	9	6	9						
Uminho | Braga	3rd	4th								5.6%
	5	5								
IPVC | Viana do castelo	5th	6th	6th							10%
	6	6	6							
IPTomar | Tomar	2nd	3rd	4th	4th						12.2%
	5	6	6	5						
UA - Aveiro N. | Aveiro	1st	3rd	4th							10%
	6	6	6							
IPViseu | Viseu	1st									3.3%
	6									
Gallaecia | Viana do Castelo	1st	2nd	3rd	3rd	4th	4th	5th	5th	6th	30.6%
	8	8	9	3	8	2	7	3	7	
ISDOM | Leiria	1st	1st	2nd	2nd	3rd	4th	5th	5th	6th	27.8%
	6	4	6	4	6	6	6	6	6	
UBI | Castelo Branco	1st	2nd	3rd	3rd						11.7%
	6	6	6	3						
Uévora | Évora	1st	1st	1st	2nd	2nd	2nd	4th			13.3%
	5	5	2	4	5	2	1			
ESAD-CR-DI | Leiria	3rd	4th	4th							8.3%
	6	6	3							
IPCA | Braga	3rd	4th	5th	5th						13.3%
	6	6	6	6						
ESEIG – IPP | Porto	1st	2nd	4th	5th	6th					16.7%
	6	6	6	6	6					

As it can be seen in Figure 2, fifteen of the master courses offer digital technology contents. Nevertheless, this existence is reduced when we compare the curricular unit ECTS with the whole ECTS of the program (120 ECTS = 100%). Table 2 shows that the presence of these curricular units varies between 4.2% and 19.2%, with an average of 9.4%. These approaches occur mainly on the first year of the master programs.

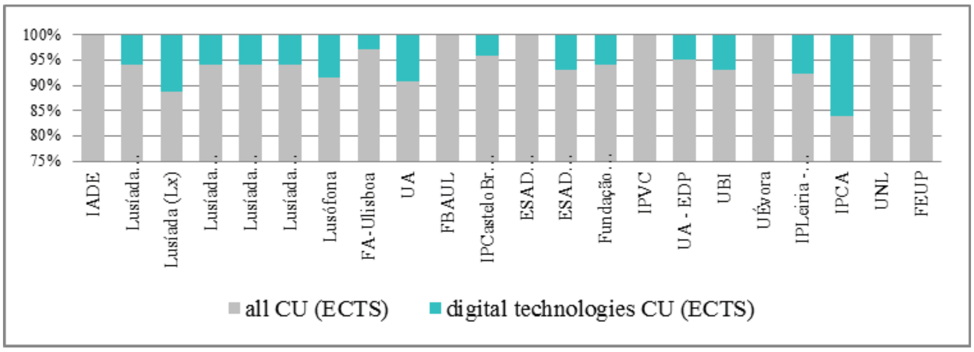

Figure 2. The existence of digital technologies CU in industrial design master programs

Table 2. The existence of digital technologies CU in industrial design master programs

IHE | DISTRICT	SEMESTER ECTS				%
Lusíada (Fam.) | Braga	1st 3,75	2nd 3,75			6.25%
Lusíada (Lx) | Lisboa	1st 7,5	2nd 7,5			12.5
Lusíada (Lx) – DP | Lisboa	1st 3,75	2nd 3,75			6.25%
Lusíada (Porto) – DP | Porto	1st 3,75	2nd 3,75			6.25%
Lusíada (Porto) – DIE | Porto	1st 7,5				6.25%
Lusófona | Lisboa	1st 5	2nd 6			9.2%
FA-Ulisboa | Lisboa	3rd 3,5				2.9%
UA| Aveiro	1st 6				10%
IPCastelo B. | Castelo Branco	2nd 5				4.2%
ESAD (Matosinhos) | Porto	1st | 2nd 9				7.5%
Fundação RES | Lisboa	1st 3	2nd 2	3rd 2,5		6.25%
UA – EDP | Aveiro	1st 6				5%
UBI | Castelo Branco	1st 3	2nd 6			7.5%
IPLeiria – ESTG | Leiria	1st 5	2nd 5			8.3%
IPCA | Braga	1st 5	1st 7	2nd 5	2nd 6	19.2%

About the CU program contents, they are based on three main approaches: i) creation and editing/treatment of images (such as the ability to do bi and tri-dimensional representations, i.e. enabling to do technical and vector drawings, to make sophisticated models and to do 3D drawing renderings), ii) to prepare it for 2D and 3D printing tools (enabling the use of Rapid Prototyping and Computer Aided Manufacturing) and iii) introduction of multimedia tools (audio and video). This allows not only the representation and manipulation of images, but it also facilitates the presentation/communication of the created objects. The first is evident in both education levels but there is an emphasis on the second and the third approach on the master degrees. Concerning the CU program goals, they mainly focus on the understanding of the relationship between analogue and digital design expression, through the proper use of the digital tools and software and comprehension of its possibilities.

4 DISCUSSION AND RESULTS

This study aims to identify the given importance of teaching digital technologies in Design Education system, keeping up with the fast technological development. Based on the gathering and interpretation of industrial/product design undergraduate and master Portuguese curricula, it turns out that the contact and learning of tools and methods of computer aided design (CAD) occurs early in the formation process, especially on undergraduate courses, and with a specialized approach to the production (CAM) and prototyping on master courses. Those courses that address digital technologies issues (tools and methods of computer aided design) must be used as support of Design Education, specially to the processes of collaborative and participatory design, promoting the interdisciplinary nature of the course, establishing the link between pedagogical knowledge and educational practice, exercising the exchange knowledge and build new concepts [17]. Focus on the bi and tri-dimensional representation, manipulation of images and presentation of the objects created, every Portuguese undergraduate courses offer digital technologies learning tools. In turn, this approach with the emphasis on Rapid Prototyping and CAM is more evident on the master levels.

Believing that the knowledge about CAD and CAM emancipates the designer, allowing him to assist the sketching (solving technical problems that sketching cannot detect) and to present their own projects to the client without having to be prototyped, the new systems of representation enable the increasing detail avoiding faults in the production process; thereby reducing waste and contributing to more sustainable product development [14].

In a period of significant change and living in a digital age where new technologies proliferate in contemporary society, design education and training should anticipate the business demands and provide the development of adequate professional skills, instilling in students the knowledge concerning digital media for product design project's support. That domain contributes to a better preparation of the design students to the market and its demands and challenges.

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