(re)Designing Design Labs. Processes and places for a new generation of Designers=Enterprises

Massimo Bianchini[1], Patrizia Bolzan[2], Stefano Maffei[3]

Department of Design, School of Design, Politecnico di Milano
[1]massimo.bianchini@polimi.it
[2]patrizia.bolzan@polimi.it
[3]stefano.maffei@polimi.it

Abstract
The rise of the new *Designer=Enterprise* model [2] is being driven by the emerging manufacturing renaissance [11] and geared by the integration of digital and analogue production processes and technologies. This emerging productive model generates new categories of *designers micro/self-producers* that act as *independent innovators* [20] in developing original, autonomous and integrated design-manufacturing-distribution processes. The paper argues that current design education processes and practices could be changed and updated in order to provide these new skills. The first part analyses how designers' capabilities are changing due to the development of experimental makerspaces like Fab Labs. The second and third parts combine literature review and desk research to verify how design schools and universities belonging to Cumulus Networks are (re)designing their makerspaces in order to develop new forms of design education (and vice versa). Finally, the basic knowledge identified is used to define what form this design education could take.

Keywords: Designer=Enterprise, Design Education, Digital fabrication, Self-Production

1 The emergence of the 'Designer=Enterprise' model and the change in design educational models

Labs and *workshops* have always played a central role in design education by enabling experiments through a learning process based on *action-research* and *clinical practice* [14]. The main historical examples, which have become archetypes in the twenty-first century, are provided by *Ecoles des Beaux Arts*, *Arts and Crafts Schools* and *Polytechnics*, but the modern concept of *design lab* is based on a genealogy created in the Bauhaus and finally developed at School of Ulm [21].
Until the last century, with the Arts and Crafts [7] movement and its derivations in the 1900s, design and craftsmanship were two partially overlapping worlds. Today, by contrast, a *design educational activity* needs to be adapted to a complex and interconnected society in which the economic system for design professionals is rapidly changing. The issue of change in designer educational models has for long been a matter of debate among numerous design

theorists. In 2001, Findeli [10] launched discussion on rethinking design education in the twenty-first century by surveying the evolution of the teaching models first developed by the Bauhaus and based on the interaction among art, science and technology – an interaction which changes over time but in which designers must be *“interested in the origin and destination of their projects, then the complexification of the process and the product should be completed by the complexification of problem setting and by the complexification of the impact of the project”.* In the same period, Cross, on analysing the evolution of design practice and design education in the Information Age, expressly spoke of the "Information Age Bauhaus" [5]. He anticipated in fact a set of aspects today very apparent in the new profiles of designers: (i) the rapid informatization of design practice, (ii) convergence on a global scale among design technologies, process stages, product technologies, (iii) progressive divergence on the concept of standardization in relation to the industry, (iv) the complexification of ideative and productive products and processes; (v) connectivity and the propensity to adopt participatory design processes; (vi) the optimization of products and processes (dematerialization) through micro use and nanomachines, (vii) the appearance of new forms of social responsibility directly imputable to the designer. Also Friedman, in a study envisioning the future of design education [13], identifies design capabilities which match those specified by Cross. Among them he emphasises in particular the capacity to materialize ideas through the exploration of innovative technologies, the processes of refining and co-refining ideas (perpetual-beta design), verification of the positive outcome of the design process, and its implementation through an activity of socialization.

It is interesting today to frame these analyses in light of a set of social, economic, and technological phenomena that have modified the ‘production ecosystem’ in which designers operate. Many designers work in a context characterized by the co-existence of outsourcing, deindustrialization and insourcing processes combined with an availability of low-cost manufacturing technologies, open source design (and hardware) resources, and Do-It-Yourself platforms [18, 19, 25].

This phenomenon is both a threat and an opportunity for designers. On the one hand, it may be a problem because the number of potential competitors is growing rapidly: subjects like makers and expert amateurs ‘can design without designers’. On the other hand, it is an opportunity because designers can develop their autonomous artefactual products by acting as manufacturers. This has led to the appearance of a new professional figure called *Designer=Enterprise*[1] (D=E) [2], an expression which also denotes similar professional roles like those of *designers-makers* and *designer-craftsmen* [22].

Essentially, D=Es can be defined as *“independent agents who work with various design, production and distribution networks without being constrained by the need, even in the presence of a market success, to automatically make scale changes or stabilize their activities or products thus becoming outright enterprises”* [2].

These actors exhibit three main characteristics. The first is their ability to intervene design-wise not only on the product-service system but also on the production system in terms of (re) designing techniques, tools, technologies and manufacturing processes. The second one is the ability to implement integrated and autonomous processes of research-design-production/promotion-distribution that enable the D=E to develop an idea, produce it and place it directly on the market. The final characteristic is the ability of D=Es to multispecialize themselves with multidisciplinary skills which regard a set of enterprise functions: R&D, design, engineering, communication, production management, marketing.

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In order to respect these characteristics, D=Es develop new capabilities such as continuous self-learning, personal leadership, and a capacity to undertake rapid-prototype business processes [2]. Moreover, for D=Es, adopting a tinkering approach is essential for them to innovate within a constantly changing production environment [24]. Therefore the challenge is to rebuild an idea of creativity that is nourished by multiple types of intelligence and personal education experiences. Hence the design education system is directly involved in helping future designers to operate in this different scenario.

2 How the Designer=Enterprise perspective could influence design education activities?

But how can one find evidence of new educational models in regard to the skills of actors like D=Es in the current system of design education?
The hypothesis is that, in the design field, it is substantially difficult to promote change in the training models intended to develop particular design skills unless there is a parallel change in the places where these new capabilities are developed. A possible method of verification consists in analysis of places like design labs and of the activities and processes that take place in them, the purpose being to determine whether they promote or respond to the change in the figure of the designer.
The paper proposes three levels of analysis. The first identifies a geography of makerspaces where the skills of D=Es are today most enhanced. The second conducts desk research on the facilities of the design schools and universities of the Net Cumulus in order to verify (with all the limitations of this method) the presence and amount of the maker-places that connect design and making. The third level analyses a more limited number of design education schemes relatable to D=E themes, identifying the principal features of these activities and the places where they take place. The aim is to understand how the configuration of these places and activities influences the development of new designer capabilities.

3 The rise of makerspaces and the evolution of design educational activities[2]

The rapid growth of the Maker Movement [8] impacts on how designers can work and learn. Makerspaces, such as Fab Labs, are frequented by designers in order to prototype or produce new artefacts, taking part in collaborative experimental projects and learning the use of technologies. We shall study the main characteristics of this phenomenon through a mapping exercise. A first methodological concern is the types to be included in the selection using the following criteria: the existence of similar makerspaces located in different socio-geographical contexts and the presence of *local makers communities* able to connect with similar ones to create networks combining educational, experimental and production activities. What emerges from a desk research is a first *taxonomy* of physical and virtual makerspaces [Table 1].

Physical Makerspaces	***Links***	***Basic information about spaces and communities***
Hackerspace	*hackerspaces.org*	956 community-operated physical places
Fab Lab	*labs.fabfoundation.org*	294 Fabrication Laboratories
Makerspaces (Make Mag.)	*makerspace.com*	103 places that respond to Makerspaces Playbook's tasks
DIY Bio	*diybio.org*	40 places for a community of DIY biologists
Public Lab	*publiclab.org*	21 labs open to the public
TechShop	*techshops.it*	9 units operating; 11 units are opening in USA
Physical/Virtual Makerspaces	***Links***	***Basic information about spaces and communities***
3D Hubs	*3dhubs.com*	Maker Network of 536 hubs, which are members of an online platform

[2] This analysis is part of a PhD Research titled *'Design for Microproduction. New design processes between advanced fabrication and distributed production'* PhD Candidate: Massimo Bianchini, Tutor: Stefano Maffei, Department of Design, Politecnico di Milano. Information are updated to December 2013.

Maker Map	*themakermap.com*	Maker network of 500 ≈ places on an online platform
100kgarages	*100kgarages.com*	Maker network of 500 ≈ places on an online platform
Virtual Makerspaces	***Links***	***Basic information about spaces and communities***
Ponoko	*ponoko.com*	Web platform with 200.000 products and 15 making hubs in the world.
Instructables	*instructables.com*	Web community of 2 millions members (50 mlns pages visited per month)
Thingiverse	*thingiverse.com*	Web platform with 100.000 objects uploaded (21.1 mlns of download)

Tab. 1 – Makerspaces taxonomy (updated to May 10 2014)

Mapping these makerspaces yields some basic information in terms of education and production offer.
In the former case (educational offer), since the first edition of 'how to make almost everything' course (2002 at MIT) and the growth of Fab Academy[3] [15] and projects like fablab@school[4], today Fab Labs organize various design educational activities focused on electronics, physical computing and fabbing [4, 6, 27]. While makerspaces like Artisans' Asylum[5] work exclusively on basic education and the implementation of artisanal production capabilities, Tech Shop implements new service formulas based on a membership policy and oriented to personal training in the use of machine tools. In the latter case (production offer), the rapid development of technologies, spaces and platforms for digital and personal fabrication is creating a supply chain of 'personal fabrication' services allowing designers to realize any product they desire (or parts of them) without intermediaries or clients. In other cases, inside and around universities (e.g. the School of Design at the Politecnico di Milano), the opening of 'maker-services' and 'maker-shops' enables micro and self-production activities.

Moreover, all these places highlight aspects that influence design education processes in terms of new educational figures and new tools and technologies for learning. Two new types of figure emerge: technical and non-academic trainers specialized in one-to-one relationships (masters, instructors, tutors, mentors and coaches) and professional or expert amateur communities [17] generating a system of one-to-many and many-to-many relations based on information sharing and collaborative learning.
Also new sets of tools and services emerge from micro and self-production practices. These can be based on the interaction between D=Es, between D=Es and technologies, and between D=Es and media (as in the case of open design and video tutorials on how to make) [6]. Finally, the possibility of combining these types of interaction promotes the creation of interfaces that can be used in the processes of design, manufacturing and distribution.

4 The analysis of makerspaces in Cumulus Network design schools and universities[7]

In light of the development of makerspaces and educational experiences, it is interesting to

[3] The Fab Academy (http://www.fabacademy.org/) is a Digital Fabrication Program directed by Neil Gershenfeld of MIT's Center For Bits and Atoms and based on MIT's rapid prototyping course, MAS 863: How to Make (Almost) Anything. The Fab Academy began as an outreach project from the CBA, and has since spread to Fab Labs around the world. The program provides advanced digital fabrication instruction for students through an unique, hands-on curriculum and access to technological tools and resources. An interesting link shows the quality of many project developed by FabAcademy students (http://fabacademy.org/archives/2014/students/index.html)
[4] fablabatschool.org/, http://edutechwiki.unige.ch/en/Fab_labs_in_education
[5] Artisan's Asylum, Inc. (https://artisansasylum.com/) is a non-profit community craft studio located at 10 Tyler Street, in Somerville, Massachusetts. Their mission is to support and promote the teaching, learning and practicing of craft of all varieties. To support that mission, they offer the following: a fully equipped and professionally maintained manufacturing facility, which includes capabilities for precision metal machining, electrical fabrication, welding, woodworking, sewing & fibber arts, robotics, bicycle building and repair, lampworking, jewellery, computer-aided design, and screen printing.
[6] Craft Tuts (http://crafts.tutsplus.com/), Instructables (http://www.instructables.com/), The Projects section of Make Magazine (http://makezine.com/projects/).
[7] This analysis is part of a PhD thesis titled *'Design for Microproduction. New design processes between advanced fabrication and distributed production'* PhD Candidate: Massimo Bianchini; Tutor: Stefano Maffei, Department of Design, Politecnico di Milano. Information is updated to December 2013.

conduct a preliminary survey on the presence and evolution of these space within design schools and universities.
For this reason, the presence of spaces and facilities dedicated to making and self-production was analysed in the 189 design schools and universities of Cumulus Network. Desk research was carried out on its websites in order to verify the presence of makerspaces: a final group of 152 schools and universities have been analysed[8]. Starting to considered all limits of this method, the desk research was carried out in December 2013. A second taxonomy, supported by examples, of physical and virtual makerspaces specific for design was obtained [Table 2].

Type of makerspace *(number of units)*	***Short description***	***Example***
Workshop (115 on 152)	Workshops are used in order to learn specific prototyping techniques or to use specific materials such as wood, metal, ceramics, glass and polymers.	***Royal College of Art London (RCA)[9].*** RCA gives great importance to analytic learning processes including 'discovery phases' based on prototyping and materials testing, which are considered crucial for the realization of any project. RCA puts at the students' disposal a range of maker facilities, which combine both digital and traditional fabrication[10], enabling designers to become professional self-producers. The Royal College of Art has also organized several exhibitions attracting numerous visitors during the Milan Design Week. Finally, some designers are now part of the Craft Council network as designer-craftsmen[11].
Research Lab (36 on 152)	Design) Research labs connect education and research activities experimenting with technological, methodological and instrumental aspects of design and making.	***D.School at Stanford University.*** D.School is an innovation hub devoted to creating transformative learning experiences. The approach is learning by doing: the question is not how to solve a problem, but how to define what the problem is. The Basic Training course is a hands-on session practicing with tools to bring ideas to life. To develop the project, the School has partnerships with corporate, no-profit and government-sector organizations [16].
Hackerspace & Makerlab (15 on 152)	Hackerspaces represent an evolution of electroshops, physical computing and interaction design labs. Makerlabs represent an evolution of hackerspaces	***EPFL+ECAL Lab at ECAL Lausanne***. Its mission is to explore the potential of emerging technologies through design and to offer new areas of creativity to designers. ECAL Lab also works with other renowned partners and designers depending on the specific theme and requirements of each project. The Lab involves

[8] Desk analysis identified other kinds of facilities with possible links to maker-places: design hubs (20 on 152), design agency/studio (6 out of 152), design libraries (97 out of 152, an increasing number of libraries offer the opportunity to digitalize contents with 3D scanners, 3D printers and a link with open hardware platforms and communities), galleries (60 out of 152), incubators (8 out of 152) and material shops (5 out of 152). No information was found about 37 schools and universities (or labs did not exist). In the same research it was also possible to carry out a systematic survey of teaching labs focused on self-production.

[9] Another interesting example is Design Academy Eindhoven (DAE), The design lab tackles every year a different topic usually finalized to re-establish a direct relationship between design practice and the public. Students work individually to design their own production lines creating machines, tools, or products. Furthermore the laboratory promotes a direct interaction with the public that can suggest to designers alternatives solutions to industrialization, production and consumption. DAE puts at disposal its own internal workshops (wood, metal, plastics, screen printing, textile, ceramics, digital technology, a photo studio and a library) while at the same time there are active collaborations with external enterprises and museums in order to promote local manufacturing techniques. Design Academy Eindhoven counts very much on the organization of international events9 where the presented projects ('alpha phase') are 'pushed' to become quickly efficient self-production business models. 10 Personal work space in the studio, traditional

[10] Personal work space in the studio, traditional facilities for woodworking, metalworking, plastics and resins, computer-driven 3D milling equipment, Apple Mac and PC based 2D and 3D modelling programmes, and finally Rapidform RCA, the College's rapid prototyping centre.

[11] http://www.labcraft.org.uk/

	and can be organized as Fab Labs or out-and-out Fab Labs.	industrial partners to ensure that the best results may better benefit society as a whole, be it in terms of services, products or economic development. The Lab also develops continuing education programmes to investigate new practices.
Factory[12] (4 on 152)	(Design) Factories They are structure which include maker-places and combine its with co-working spaces and other functions linked to research, production, promotion and incubation.	***Design Factory at Aalto University***. Design Factory is a 3.000 m^2 working environment which enables creative work, knowledge sharing and experience exchange. All facilities are designed for flexible uses, with free interaction and prototyping made as easy as possible. Spaces can be easily modified and rearranged for various set-ups and different purposes of use and to encourage open communication and spontaneous encounters. In 2012 the community was composed of: more than 700 students, 30 staff members, 30 teachers, 20 researchers, 35 collaborating industry partners and 5 in-house companies [26].
Living Lab[13] (3 on 152)	Living Labs are structures which include makerspaces and combine them with co-working spaces and other functions linked to research, production, promotion and incubation.	***Fabriken at Medea - Malmoe University.*** Fabriken is a Fab Lab in Malmö. The lab (originally a part of a Living Lab) is run at Malmö University. The idea of Fabriken is to foster development in which qualified technology becomes smaller and cheaper and thus more widely available. The main users are citizens, researchers, companies and public institution. In the lab there are tools and new technologies, but the users can also find knowledge and skills in order to experiment with and prototype ideas, products and services. Fabriken is constantly changing its maker focus from digital fabrication to physical computing [23].

Tab. 2 – Kind of makerspaces present in the design schools and universities of the Cumulus Network

The desk research shows that some design schools and universities have different kinds of makerspaces that enable an educational model focused on the development of D=E capabilities.
The educational experiences developed in these spaces testify to the transition from 'stereotyped' educational processes to the simulation and testing of real design, production, distribution and entrepreneurial processes (from idea to market and from idea to business).
The first important finding is that design schools and universities are no longer exclusively dedicated to teaching activities but are also suitable for micro scale production activities.
The mapping activity highlights the predominance of traditional workshops and vertical specialization in *design through making*. In these places a sort of *crafts knowledge* facilitates the product's development, but at the same time the presence of specialized technologies and technical capabilities (often linked to the local context) tend to standardize the design-production process (routine). But many workshops are not connected either to each other or to local or global 'designers and makers communities'.

The other types of makerspaces behave differently from workshops. Cases of makerspaces which integrate research, design, production, promotion and distribution - such as hackerspaces/makerlabs and factories - are rather few. In these spaces a *multidisciplinary*

[12] Design Factory is a 3000 square metre working environment enabling creative work, knowledge sharing and experience exchange.
[13] A living lab is a user-centred, open-innovation ecosystem, often operating in a territorial context (e.g. city, agglomeration, region), integrating concurrent research and innovation processes within a public-private-people partnership.

knowledge set coordinated by design capabilities enables product and production development and encourages new forms of entrepreneurship.
The second important aspect of these spaces concerns the change in design teaching and learning practices. Educational activities developed in makerlabs and factories tend to move from hierarchical teacher-learners relations to the creation of temporary collaborative design communities (extended to external subjects such as companies and professionals) with a shared goal: developing innovation processes. A standardized presence of multipurpose technologies (digital fabrication)[14] is combined with the presence of local makers communities and global networks of other Fab Labs and makers. Thus, the projects developed often result in the designers' (makers') social interactions and by available technologies. In factories, which normally include other makerspaces, multipurpose and specific production technologies can be mixed with external ones (provided by enterprises) enabling personal and unique design-production-distribution processes.
The third aspect concerns 'connectivity'. The development of external relations (citizens, amateurs, enterprises, and professionals) is an important part of the educational process because it influences the development of design activities and critical and collaborative (peer-to-peer) review processes, and it provides opportunities for real on-field experimentation.
The final aspect concerns the 'cultural and technological excitement' that characterizes makerspaces. These places afford direct access to technical equipment and knowledge and promote experimental hands-on activities stimulating designers to develop a critical thinking and making approach to the processes developed [9].

5 Conclusions

The analysis has shown that the principal role of workshops in design schools and universities is still that of flanking the teaching program. In parallel, there exists a smaller number of institutions that have decided to incorporate the makerspace model into their structures. Finally, an even smaller number of institutions have created their own makerspace models within which to develop training activities based on hybridization between design and other disciplines.
It is therefore apparent that, in the design field, there are new practices performed through activities and resources in places that are typologically novel. Places like factories constitute examples that can influence the design educational network in relation to the evolution of the design skills of figures like D=Es.
If the intention is to promote forms of contemporary innovation based on new designer figures (as in the case of Designer=Enterprises), it is necessary to intervene in the places where the new processes of development and materialization of ideas can come about.
Moreover, inspection of the relationship between places and teaching activity seems to identify two main models [Figure 2].
In the first model (A) there exists a single place which concentrates spaces for design, production and promotion. In this place, teaching coexists with research, incubation and free experimentation. In the second model (B) there is instead a principal teaching activity (which may have connections with research and incubation) distributed among a network of places: there is a space where the teaching takes place, a set of spaces in which the productive phase occurs, and other places (physical and virtual) where the activities are promoted. In the first model it is the place that influences the activities, while in the second model it is the teaching activity that influences the choice and configuration of the places.

[14] Wiki Fab Lab and Fab Foundation provide a great deal of technical information about Fab Lab set-ups and technological equipment http://wiki.fablab.is/wiki/Portal:Equiment.

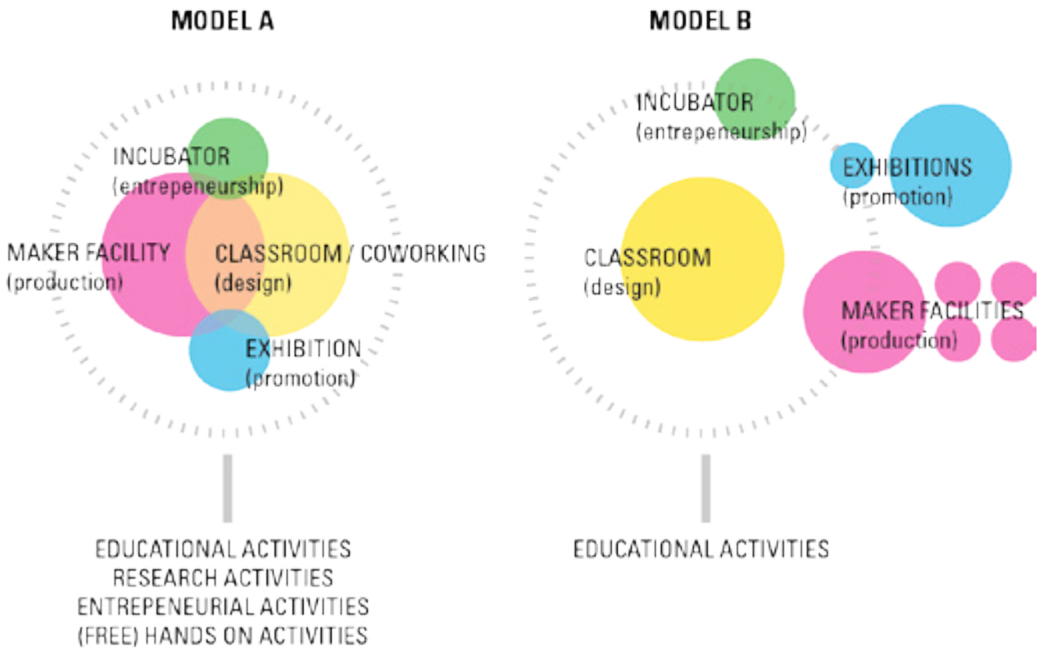

Fig. 2 – Comparison between model A and B

These two models have a feature in common: both can be conceived as *enabling educational environments*, environments that comprise a set of interrelated favorable conditions: regulatory, organizational, economic, info-communicative, cultural, and political. These conditions influence the capacity of the designer to act within society as an organization, and they induce him/her to engage in processes of development of his/her activity that are sustainable and efficacious.

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