In the international scene, the system of knowledge and skills is increasingly fragmented and evolves rapidly due to technological innovations such as the Internet of Things and the digital society revolution. In this context, it could be useful to question whether Design can still be considered a discipline of "doing" with a strong technical-applicative value or is it giving way to other more specific technological know-how, such as engineering, carving out for itself a new role into the fields of cultural studies and human-studies with a predominantly critical-speculative approach. This trend, that seems to lead towards an assymetrical competitive system, has to be considered a drift, an opportunity, or an inevitable evolution?
The issue 70 of **diid** aims to investigate if and which forms of intersection are taking place between Design and other knowledge and also how Design is redefining its knowledge.

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Focus

Undisciplined knowledge in the digital age

Design disciplines and territories are expanding rapidly, due to the increasing importance of design as one of the means potentially helping to respond to grand global challenges. Designers are currently required to work in dynamic ways, and to be capable of approaching wicked problems creatively in many different areas of knowledge. If on the one hand this scenario is very present in design practice, the knowledge transferred during education doesn't seem as up to the task as it should be. Studio-based learning is still the core pedagogical approach for design where the ethos is put on the relationship between master and apprentice, the physical encounter, and the hands-on spirit of contextual enquiry. We contend that this tradition is now facing a turning point, linked both to teaching methods, and to the increasing importance of diverse types of data and disruptive technologies in the design project. Drawing on the direct experience developed in a 28-months European co-funded research project, where industries, creative professionals, and design educators were consulted to co-develop a framework of competences for the digital creative professional of the future, we discuss the implications of the current changes for the discipline. We propose that, for the future knowledge designers will need, there is value in teaching/practicing the development of ill-defined solutions as well as ill-defined problems, where the system (product, service, interaction) developed is itself a learning actor. Furthermore, we discuss the possibility of adopting a *blurred* design approach, less divided by individual approaches, but based on a dynamic mix of competences coming from different disciplines that would help evolve design knowledge outside of the traditional disciplinary boundaries.

[design education, digital transformation, design pedagogies]

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Learning models in Design: an evolutionary perspective

Universities are the ideal context to observe the way knowledge has been organized and transferred during different eras, as they should responsively follow the changes in industry, government and society. However, the current model still reflects the paradigm of production and consumption needed to support industry after the First Industrial Revolution, developed during the Enlightenment and led by concepts of hierarchy, standardization and quantitatively measurable productivity.

During this shift from the artisanal and farming society to the industrial one, also design developed as a formalized professional practice evolving through different schools, including the Arts and Crafts movement of late 19th Century and the Bauhaus and the Ulm schools (De Fusco, 1985). The first one was a reaction to the standardized products required by industrial constrains and wanted to instil in objects the same qualities that Masters of Arts were previously able to create (Cumming & Kaplan, 1991). This model inspired the development of one type of design school, that flourished all over Europe and still exists today in design education. For example, the workshop-based learning model is one of the archetypical expressions of design pedagogy directly connected to the tradition of apprenticeship in ateliers. The second and third emerged from the need of codifying design practices to adapt them to industrial manufacturing, and still inform current models. The original goal of the Weimar School was the reunification of all disciplines (architecture, painting, photography, …) in a single "art of building", capable of bending industry into a new language embedding the typical expressive qualities of arts and crafts (Forgács, 1995; Bergdoll & Dickerman, 2017). The original aim to reconcile industry and the arts has progressively changed both in the evolution of the Bauhaus and in the experience of the Ulm School of Design. Few premises, like the focus on usability and function further developed into more radical principles like functionalism and rationalism, that inspired the so-called Modern Movement (Bradbury *et al.*, 2018). During Modernism, several schools of design and architecture were established or reformed, with the goal of formalizing practice-based educational approaches into codified theoretical corpuses (Spitz, 2002). This is still true today, when many teachings characterizing design pedagogy come directly from the Bauhaus and Ulm seminal experiences.

Design becomes a bridge between arts & humanities and science & engineering only with Simon's theory of the limited rationality, followed by Schön's concept of the epistemology of praxis (Simon, 1969; Schön, 1983). Simon constructed a model of rationality suitable for the sciences of the artificial (architecture and design); while Schön was one of the first to challenge the positivist doctrine implicit in the theses of *design as science* contrasting Simon's argument with the observation that practitioners can produce generalizable and codified knowledge through their practice.

Following this evolutionary perspective, it is clear that many components of design knowledge today, belong to a specific time frame strictly connected with

the need of harmonizing the tension between practice-based learning and codified theoretical foundations, that has contributed to creating an original model of teaching and learning more recently synthetized as design signature pedagogy (Shulman, 2005).

Drivers of change

As traditional models of university are currently transitioning due to several change factors, also design pedagogy needs to undertake transformation. In particular, two elements of change can be highlighted: the processes of knowledge creation, and the pace of technological advancement.

In the first case, a radical change has happened in the way knowledge is created, shared and transferred, as well as used in innovation processes and accessed by organizations and individuals, impacting not only educational models, but also professional identities and careers. In the economic and social sciences this transition has begun in the mid-sixties, when a reflection on the relevance of different factors on innovation processes was made, finally placing intangible assets (i.e., human resources and knowledge) at the core (Marzano, 2008). These theories marked the emergence of the so-called knowledge economy, where the nature of work shifted into new forms of horizontal teams, organized in parallel functions and focused on project-based work. Here, miniaturized technology made more broadly applicable and the greater number of knowledge-creating organisations redesigned the boundaries of companies and professions, transforming them from closed entities to integrated systems of collaborative networks (Nonaka & Takeuchi 1997).

More recently, the Fourth Industrial Revolution with the advent of new technologies and the integration between physical and virtual realities is posing new challenges. Unlike the previous technological paradigms, its faster pace has imposed the need to rethink the typical mechanisms of professional updating based on generational rotation, consequently requiring the transformation of educational models.

In light of this scenario, also design is looking to understand the best pedagogical approaches to educate the professionals of the future, as well as their relevant competences. Based on several studies, that recently have evaluated the impacts of digital transformation on the nature of work, design is often pinpointed as less subject to obsolescence: indeed, there is general convergence in describing creative jobs as non-replaceable, including art, science and engineering (Frey & Osborne, 2015). At the same time, however, the new shape of organizations, requiring multidisciplinary project-oriented teams, asks design to redefine its perimeter and find a common language with tangential disciplinary fields. This is especially true for the growing complexity of design problems, the networked and distributed nature of the knowledge that drives innovation processes, and the emerging traits of new technological artefacts conceived as evolving learning systems. For these reasons, a reflection on design competences and disciplinary boundaries, accompanied by a clearer understanding of the impacts of digital transformation on design knowledge and practice are required.

The model of signature pedagogies in design

To understand how these evolutions might contribute to reshape design knowledge, it is relevant to adopt the frame proposed by Lee Shulman in the mid-2000s. He claimed that professions rely on characteristic forms of teaching and learning, which he refers to as signature pedagogies (Shulman, 2005, p. 52). Shreeve (2015) has applied this notion to design, describing its signature pedagogies with the following elements: the physical studio environment, the issuing of projects and briefs, materiality, dialogue, the evaluation mechanism of the "crit," and the requirement to undertake contextual research. Tovey and Bull have elaborated further on this, suggesting that signature pedagogies support students in developing a passport to practice (Tovey & Bull, 2010), that is, a portfolio of work to demonstrate their readiness for professional practice.

If in the traditional curriculum proposed to educate designers this is perfectly reasonable, scholars have also highlighted a reconfiguration in current design practice. Meyer and Norman (2020) have described four orders of challenges that have transformed methods, tools, and knowledge for design: performance challenges, related to the know-how of designers; systemic challenges, related to the complexity of designed systems; contextual challenges, related to the relationship with cultures, environments, and policies; global challenges, related to the interconnection of systems. These challenges require models of knowledge capable of going beyond established disciplines towards a responsive reformulation of practices where the boundaries of design disciplines are blurred and reconfigured according to needs. Bremner and Rogers (2013) call this undisciplined design, «an ability to mash together jumbled ideas and methods from a number of different, distinct disciplinary practices that can be brought together to create new unexpected ways of working» (p. 12). Other scholars have also discussed the blurring of the boundaries of design disciplines (Rodgers & Smyth, 2010); in 2008, also the Design Research Society had identified this issue and underlined a discussion about challenging existing design specialisms. Finally, Blackwell (2008) distinguished design from other disciplines because the second are recognised for their rigour in addressing well-formulated problems through agreed methods of inquiry, while design mainly builds on subjective intuitions; he thus acknowledged design as undisciplined, identifying a more radical approach to creating and circulating knowledge that transcends boundaries and can thus deal with ill-defined issues (Buchanan, 1992). According to these scholars, it would seem that strict delineation of sharp professional boundaries is no longer possible, also due to the increasing importance of disruptive technologies (i.e., artificial intelligence) as new design materials that create continuously evolving learning systems as ill-defined outputs of the design process. Accordingly, the future that students in higher education are preparing for is far less certain than at any point in recent history. Building on this, the project "DigiMooD" has explored the development of a new *curriculum* to educate hybrid creative professionals at the crossroad of Design, Business, and Technology.

Research process: "DigiMooD"

The project is a 28-months collaborative effort aimed at tackling the lack of a cross-cutting curriculum linking creativity with technological and business skills: the "DigiMooD" consortium has brought together a small ecosystem of competences, where academics have worked closely with industry and experts of e-skills, thus enabling a virtuous cycle and dynamic balance with different stakeholders to test and validate process and contents developed.

The project has focused on mapping the digital skills gap for creative professions and on its translation into educational modules. To do this consistently, it has adopted a co-design approach, aiming at guaranteeing constant dialogue with external stakeholders (industry) and between different disciplinary fields (design, management, informatics). Dialoguing with industry, the research has aimed at comprehending employers' and entrepreneurs' needs; confronting different disciplinary knowledge, the project has aimed at being multidisciplinary in its nature, experimenting at the crossroads of traditional academic barriers. Several activities have run parallelly: four specific moments have been organised to dialogue with industries, namely a focus group, a survey, in-depth interviews, and a co-creation session involving overall more than 70 companies and delivering both quantitative and qualitative research results. Finally, several meetings have actively involved in the co-design of the educational offer different types of stakeholders, from domain experts, to institutions and practitioners.

The proposal of a framework of competences

The research on competences has led to the description of a framework, that has consequently been translated into six teaching modules. This has been developed and tested through two co-design sessions, involving 17 companies and recognising three main areas: Creative, Business and Technical capabilities.

The creative area includes the competences useful to discover and prototype new opportunities to solve problems in new ways. Among these capabilities, the aptitude for experimentation in all its forms, for which design is considered even more relevant in the current context of uncertainty, has proved to be primary. Here the use of digital tools to empathize with specific communities, experiment emerging technologies and respond to companies' demands for transformation is emphasized. The mindset of creative profiles to which the framework refers is related to looking beyond current practices, building on these and innovating. Amongst creative capabilities, another area of competence (communication) regards the ability to study and communicate the cultural background of people and their values. In particular, in the digital context these skills regard the ability to tell a story using the most appropriate medium to vehicle a specific message. The last creative competence (engagement) is linked to understanding the interaction between people and technology, particularly linked to the interplay between physical and digital touchpoints.

The business area includes the competences aimed at creating value through digital activities. Strategy planning, with particular emphasis on new decision-making models based on the analysis of large data sets (the so-called Big Data) has been considered the most relevant competence. This consideration has raised interesting questions about the nature of the data typically used in the design process, mainly related to a context and specific user needs, and their potential integration with Big Data. In addition, business acumen relies on understanding innovation strategies and the new ways of organizing the company taking advantage of the information available through digital tools. Another area (network management) focuses on the abilities of managing virtual relations, which means being able to work with peers and colleagues remotely, using digital platforms to interact with customers or partners. The last area (logistics management) regards the abilities to organize the infrastructures of a company focusing on the relations with the suppliers in the value chain.

The third area of capabilities covers those competences which require a knowledge of technologies, considering in particular the so-called disruptive technologies (i.e., Internet of Things, Augmented Reality, Artificial Intelligence and cloud computing). Here the importance of data is again highlighted, since the capabilities related to data analysis and management, with particular attention to visualization, have been considered the most relevant. This confirms that creative professions are also undergoing transformations due to the so-called "surveillance capitalism"(Zuboff, 2019), where data are the main engine of the economy and drive social behaviours. Another area (digital manufacturing) concerns creation through the use of digital production tools (e.g. 3D printer). The last area (algorithm design and programming) concerns the knowledge of programming languages in order to be able to interface with design also in new areas where decisions and activities are driven by algorithms.

Discussion: designing for wicked problems and solutions

The project "DigiMooD" has experimented on several different topics concerning the transition of design, both as discipline and professional practice. Firstly, it has explored the blurring and expanding of design knowledge to new areas and domains, like technology and business. Although on the one hand this may seem a subject already very debated, to date design has not yet been able to give its own answer with approaches that hybridize its skills with other disciplinary areas (i.e., Design Thinking, which – emerged from Management – has been able to reconcile business and creativity).

Furthermore, it raised initial reflections about changes in the design process and the new nature of the artefacts that designers are called to device. In the first case, it is above all the nature of the data used to design that emerges as an area of interest, with particular attention to the need to hybridize contextual and punctual data typical of design and the Big Data available to companies. In the second case, one of the insights concerns the need for design "indisciplinarity", mainly linked to the uncertainty and complexity present not only in the problems faced but also in the solutions developed.

In fact, it seems that design practice today is subject to the demand to solve not only uncertain problems, but also to develop uncertain solutions. This does not mean implementing projects halfway but proposing solutions capable to accommodate the characteristics of new systems (digital and intelligent, and therefore able to evolve over time) as actors in continuous evolution. Together with this, designers are also required to have a deep understanding of social challenges, human behaviour and business models in order to face new ethical issues related to globalisation, sustainability, different cultures and their value systems. These elements demonstrate the importance of overcoming individual disciplinary points of view, as no one seems able to cover all aspects of the complexity of modern problems. According to Marshall and Bleecker (2010), already 10 years ago the answer was "indisciplinarity" as an added value to make design a wider knowledge creation process. Working in such a meta-dimension seems to represent what design is called to do today to face complex socio-economic challenges and to manage the hybridization of its knowledge while maintaining its own identity.

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