EVOLVING PERSPECTIVES IN PRODUCT DESIGN

From Mass Production to Social Awareness

Lucia Rampino

D.I. FrancoAngeli
DESIGN INTERNATIONAL

The Design International series is born in 2017 as a cultural place for the sharing of ideas and experiences coming from the different fields of design research, becoming a place in which to discovering the wealth and variety of design, where different hypotheses and different answers have been presented, drawing up a fresh map of research in international design, with a specific focus on Italian design.
Different areas have been investigated through the books edited in these years, and other will be explored in the new proposals.
The Scientific Board, composed by experts in fashion, interior, graphic, communication, product and industrial, service and social innovation design, interaction and emotional design, guarantee the high level of the accepted books. After the first selection by the Scientific Board, the proposals are submitted to a double review by other international experts.

OPEN ACCESS
la soluzione FrancoAngeli

Il presente volume è pubblicato in open access, ossia il file dell'intero lavoro è liberamente scaricabile dalla piattaforma **FrancoAngeli Open Access** (http://bit.ly/francoangeli-oa).

FrancoAngeli Open Access è la piattaforma per pubblicare articoli e monografie, rispettando gli standard etici e qualitativi e la messa a disposizione dei contenuti ad accesso aperto. Oltre a garantire il deposito nei maggiori archivi e repository internazionali OA, la sua integrazione con tutto il ricco catalogo di riviste e collane FrancoAngeli massimizza la visibilità, favorisce facilità di ricerca per l'utente e possibilità di impatto per l'autore.

Per saperne di più:
http://www.francoangeli.it/come_pubblicare/pubblicare_19.asp

EVOLVING PERSPECTIVES IN PRODUCT DESIGN

From Mass Production to Social Awareness

Lucia Rampino

D.I. FrancoAngeli
DESIGN INTERNATIONAL

Cover image by Giulia Pex

ISBN e-book Open Access: 9788835143703

Contents

The Digital Perspective

The Social Perspective

Consolidated and Emerging Issues in Product Design

by Lucia Rampino

Four Economies in Western Societies

Since the advent of design around one hundred years ago, Western societies have undergone systemic change caused by the combined effects of socio-cultural, economic and technological transformations (Brand and Rocchi, 2011).

In economic studies these changes have been named according to their respective dominant employment domain (e.g. agriculture or industry) or the dominant nature of output (e.g. goods or experiences) (Pine and Gilmore, 2013).

In relation to the dominant employment domain, three main economic eras can be distinguished: the agricultural, industrial and knowledge economies. As the focus of this book is product design, we will start with the rise of the industrial economy.

The industrial economy is driven by designing, developing and mass producing new goods by manufacturing companies. However, Pine and Gilmore (2013) have argued that it is very difficult today to invent a truly new product with most product differentiation involving improvements or modifications within existing product categories. The creation of wholly new product categories is a sporadic phenomenon.

The knowledge economy has rewritten these rules. It is an interconnected, globalized, post-industrial society whose most valuable resources are no longer land, machinery or labor, but an intangible asset: knowledge.

For Pine and Gilmore (2013), rather than focusing on the dominant employment domain, economies are best defined by their predominant product: what people obtain from a seller in exchange for money. From this point of view, they distinguish between commodities, goods, services and experiences.

In agricultural economies, the predominant product was agricultural commodities and handcrafted objects. From the Industrial Revolution onwards, factories began producing several categories of goods much more cheaply. Services (i.e. intangible activities performed on behalf of other people, such as cooking meals, cutting hair, repairing tools, cleaning and ironing clothes) already existed in the industrial and agrarian economies, but comprised a relatively small part of them. Subsequently, in order to combat product commoditization, manufacturing companies increasingly moved into services themselves with repair programs, contract warranties and other value-added activities. The Internet is now commoditizing various services (e.g. hotels, airlines, banks, insurance and so on). Consequently, people increasingly buy several services on price and are willing to spend money (and time) on higher value offerings: experiences.

Experiences are defined by Pine and Gilmore (2013, p. 26) as «*memorable events that engage each individual in an inherently personal way»* (e.g. going to a concert, visiting a museum, playing a game or sport, having a birthday party). As was the case with services, experiences are also not new. However, since the end of the last millennium, they have gained significant importance in the offerings of leading brands.

> This economic history can be recapitulated in the four-stage evolution of the birthday cake. As a vestige of the agrarian economy, mothers made birthday cakes from scratch, mixing farm commodities (flour, sugar, butter and eggs) that together cost mere dimes. As the goods-based industrial economy advanced, moms paid a dollar or two for brands such as Betty Crocker for premixed ingredients from which they baked. Later, when the service economy took hold, busy parents ordered already-baked cakes from the bakery or grocery store, which, at US $10 or $20, cost ten times as much as the packaged ingredients. In today's experience economy, parents less and less make the birthday cake – or even throw the birthday party. Instead, they pay an admission fee of $100 or more to "outsource" the entire event to a Chuck E Cheese's, McDonald's, museum, farm or some other business that stages a memorable event for the kids – and often throws in the cake for free (Pine and Gilmore, 2013, p. 31).

The last, most recent stage in economic evolution is transformation, i.e. people's growing willingness to purchase a personal and durable transformation not simply an ephemeral experience. Therefore, the history of the birthday cake above can be completed as follows: today mothers enroll in a cooking course to learn how to bake a birthday cake for their children, partly in order to be able to carefully choose all its ingredients, possibly using zero-mile eggs and milk and a limited amount of sugar and fat. Figure 1 shows the various economies, together with their main outputs, in a historical sequence. The area of product design interest is highlighted in yellow.

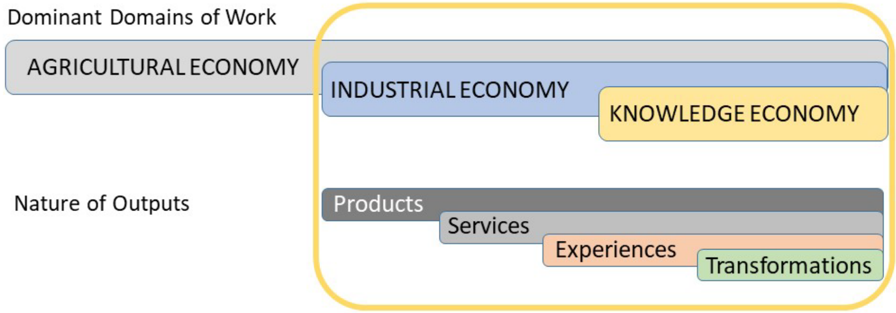


Figure 1: The succession of economies in Western society

What is important to stress is that newer economies do not completely replace earlier ones: they can best be described as adding a new layer to previous one(s), a layer that achieves dominance for a given period until a further layer is added.

In general terms, all the discussions in this book are based on a classification first developed by Brand and Rocchi (2011) and then adopted by Gardien *et al*. (2014). This classification is based on four different economies from a Western perspective: the industrial, experience, knowledge and transformation economies. It mixes up the two previously described economic era classifications (i.e. that based on dominant work domains and that discussed by Pine and Gilmore, based on the nature of economic products) in order to propose a framework suitable to the design discipline. Each economy is thus intended as the result of the combined effect of changing realities which are not just economic, but also socio-cultural, technological and environmental.

The industrial economy is founded on mass production and standardization, its guiding concepts being rationality, efficiency and labor division. In it, value is created by manufacturing companies capable of delivering the goods that fuel mass consumption.

In the experience economy, a Western market saturated with identical mass produced goods starts questioning standardization and asking for something different: targeted products responding to personal requirements and desires. People buy objects not just for their function but also for their ability to say something about their owner's identity. This is particularly evident in the fashion sector. We are therefore witnessing the rise of brands and market segmentations.

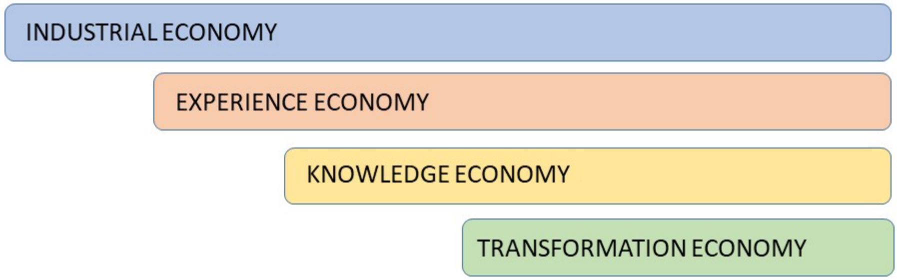


Figure 2: The Four Economies (based on Gardien et al., 2014)

In the knowledge economy, the rise of interactive web 2.0 has ushered in a level of end-user empowerment never previously experienced. In general, all new technologies have inherent attributes which affect the skills and behaviors of the people using them. Digital technologies have transformed every sector of Western economy and society, how we spend our working and leisure time and how we connect with each other:

> Over the past few decades, we have seen the economic and social impact - both positive and negative - of our ability to duplicate, modify, and share music, videos, blogs, news, email, text messages, and other digital material at virtually no additional marginal cost (Gershenfeld *et al*., 2017, p. 6).

In this economy, leading businesses provide platforms which empower people to create and share ideas.

In the transformation economy, the Western world has finally become aware of the downsides of earlier economies: much of today’s environmental decline and social inequality, indeed, can be attributed to the last two hundred years of industrialization, urbanization and consumerism. Therefore, leading companies are now showing an increasing interest in addressing shared global issues such as pollution, malnutrition, environmental decline and aging societies (Brand and Rocchi, 2011).

Four Perspectives in Product Design

In each of the four economies, product design exhibits a specific focus, i.e. a dominant perspective within which designers consider the tasks they are called on to perform and the objects to design.

> The history of design is not merely a history of objects. It is a history of the changing views of subject matter held by designers and the concrete objects conceived, planned, and produced as expressions of those views (Buchanan, 1992, p. 19).

Consequently, each economy has seen the rise of certain design discourses and the development of specific design skills, design methods and design processes.

In the industrial economy, product designers' main concern is product standardization and simplification in order to satisfy the demands of mass production. Moreover, a great deal of attention is devoted to the internal functioning of products and how products' visual forms express such functioning (Buchanan, 1992).

In the experience economy, product aesthetics become central. Designers address the communicative aspects of material objects, eliciting consideration of products' semantic and rhetorical aspects (Buchanan, 1992). Moreover, the design focus shifts from the product itself to the user.

In the knowledge economy, product designers explore material objects as parts of larger, interconnected systems, opening up a wide range of new questions and practical concerns (Buchanan, 1992). Issues include smart and dynamic products and the impact of digital fabrication technologies.

Finally, in the transformation economy, designers are concerned with the overall effect of the products they conceive, not only from an environmental point of view, but also in social and ethical terms.

For each economy, a perspective that dominates the design discourse can be identified. Indeed, design is used by societies to express their values. Consequently, design's norms are shaped by economic and social conditions (Forty and Cameron, 1995). The four dominant perspectives adopted here are as follows: technical (in the industrial economy), human (in the experience economy), digital (in the knowledge economy) and social (in the transformation economy).

Like all perspectives, each clarifies some aspects and stresses some features of the design discipline, at the same time making other aspects less clear and other features less relevant.

The Technical Perspective

The adjective 'technical' is used in the following sense here: «*involving or concerned with applied and industrial sciences*» (on-line Oxford Dictionary). From a technical perspective, therefore, the pervasive influence of the positivist paradigm of modern science is recognizable[1]. Traditionally, from this perspective, engineers and designers are trained in manufacturing and assembly design. Moreover, complexity is driven out of design and cost consciousness is increased.

The first definition of the industrial design profession, given by the International Council of Societies of Industrial Design (ICSID) in 1957, well describes this perspective:

> An industrial designer is one who is qualified by training, technical knowledge, experience and visual sensibility to determine the materials, mechanisms, shape, colour, surface finishes and decoration of objects which are reproduced in quantity by industrial processes. The industrial designer may, at different times, be concerned with all or only some of these aspects of an industrially produced object (ICSID, 1957).

The focus is clearly on the product and its technical aspects. The presence of a human individual required to interact with the product is not yet taken into consideration.

The Human Perspective

By the 1980s, the strong product-centered focus of the technical perspective had given way to a concern for users and their experiences. In the words of Overbeeke *et al.* (2002, p. 9), «*we believe that respect for man as a whole should be the starting-point for design*». The importance of the user to the design process is reflected by a strong user-centered design movement.

This change in focus is the result of a paradigmatic philosophical shift in design culture: from Simon's positivism to Schön's pragmatism. Introducing the idea of the reflective practitioner, Schön questions the rationality and objectivity of science as applied to the intellectual professions in general, and to design in particular, shifting the main focus of attention to the designer per se, and to the study of design thinking (Oxman, 2008). Schön's view also fits well into ethnographic user studies, and, more generally, into all the qualitative user analysis methods typical of the human perspective.

[1] This paradigm, together with the modern fine art paradigm, will be described in Chapter 2.

The Digital Perspective

The 21st century has seen an important technological shift which has profoundly affected product design - from analog to digital technologies. Since the advent of design, manufacturing technologies have affected product form while product technologies have determined functioning.

Today, digital fabrication enables designers to explore complex geometries, inconceivable in the realm of mass production. On the other hand, artefacts are increasingly embedded with sensors, electronics, processors, smart devices and smart materials, making products dynamic and interactive. Thus, «*a domain which was once considered pure industrial design is faced with many interaction design challenges»* (Djajadiningrat *et al*., 2004, p. 294).

The Social Perspective

In parallel with the proliferation of digital technologies, we are witnessing a growing dissemination of social and ethical concerns. This is also affecting a design discipline that, since the very beginning of its history, has been involved in shaping the artificial world we live in and the way we behave in it. While designers' social responsibility remained in the background for over a century, it has now moved to the foreground. The potential for fostering more sustainable user behavior is a growing field of interest, together with a need for a careful evaluation of the ethical issues related to designing smarts objects capable of taking autonomous decisions.

A clear sign of this shift in design discourse interest is offered by the official change in ICSID's name on January 2017, exactly sixty years after its foundation, to World Design Organization. The new name acknowledges the association's social perspective, today focusing on addressing local challenges with global relevance (i.e. rapid urbanization, climate change, and migration) through design.

A Multifaceted Perspective

Specific perspectives typically emerge earlier in some parts of the world than in others, in some social classes than in others, in some industries than in others. Moreover, later perspectives build upon, rather than replace, earlier ones: many of an earlier perspective's tools and methods do not lose their value as the design discourse moves on to a new perspective (Gardien *et al*., 2014). As a consequence, multifaceted perspectives on product design today coexist.

In brief, it might be said that these changes in perspective are simply a matter of zooming out: from a focus restricted to the product itself to a wider focus also including users and an even wider one taking into consideration a complex system of interconnected stakeholders and digital products, and finally one which embraces society as a whole[2].

As sociocultural forces change, people's perception of what constitutes value changes, too. And the design focus changes accordingly.

The Structure of the Book

This book is divided into five parts.

The first part examines the cultural features of the design discipline. It is the sum of these features which gives it its 'subtle' nature: this is the subject of the first chapter. The second chapter focuses on a specific design trait, its being both scientific and artistic without – accordingly to the modern paradigms of science and art – being either an art or a science. The cultural consequences of this twofold nature are debated in this first part.

Once design's 'subtle' cultural statute is understood, we will be ready to address the four perspectives referred to above. Therefore, each of the following four parts of the book describes a specific perspective.

Each part is made up of three chapters. The first chapter describes the main socio-cultural, technological and economic aspects of each dominant economy (industrial, experience, knowledge and transformation), always finishing with a general overview of product design's approaches and tools in this specific economy. The two following chapters deal with specific issues that emerge in a given economy and are particularly significant for the dominant product design perspective: the New Product Development Process and Intellectual Property Rights in the Technical Perspective; the Design Thinking and Human-Centered Approach in the Human Perspective; Digital Fabrication and Dynamic Products in the Digital Perspective; Design for Behavior Change and the Designer's Social Awareness in the Social Perspective.

In conclusion, it is important to stress that, whilst each of the specific issues discussed in the book happened at a given moment in time, none have lost their value today, the only difference being that some are already consolidated while others are emerging. However, even today it is important for a 21st century product designer to know how to design for standardiza-

[2] This idea of zooming in and out of course refers to *The Powers of Ten*, a short film by Charles and Ray Eames which shows that scale greatly changes how we think and feel about what we see. The film examines ideas first expressed in the 1957 essay *Cosmic View: The Universe in 40 Jumps* by Kees Boeke featuring changes in scale from astronomically distant to atomically near.

tion and cost reduction, since most goods are still mass produced. On the other hand, it is equally important that designers are aware of the novel possibilities offered by digital technologies and the social responsibility inherent in design. If they are to be prepared for tomorrow, it is vital that designers have a clear understanding of the past which makes it easier to appreciate the changes that will drive our futures.

References

Brand, R., Rocchi, S. (2011), *Rethinking Value in a Changing Landscape: A Model for Strategic Reflection and Business Transformation*. Philips Design. Retrieved April 4, 2013, from www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/april2011/paradigms.pdf

Buchanan, R. (1992), "Wicked Problems in Design Thinking". *Design Issues*, 8(2), 5-21.

Djajadiningrat, T., Wensveen, S., Frens, J., Overbeeke, K. (2004), "Tangible Products: Redressing the Balance between Appearance and Action". *Personal and Ubiquitous Comp*. 8, 5, 294-309.

Forty, A., Cameron, I. (1995), *Objects of Desire: Design and Society since 1750*. Thames and Hudson.

Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice". *International Journal of Design*, 8(2), 119-139.

Gershenfeld, N.A., Gershenfeld, A., Cutcher-Gershenfeld, J. (2017), *Designing Reality. How to Survive and Thrive in the Third Digital Revolution*. Basic Books

Kimbell, L. (2011), "Rethinking Design Thinking: Part I". *Design and Culture*, 3(3), 285-306.

Overbeeke, C.J., Djajadiningrat, J.P., Hummels, C.C.M., Wensveen, S.A.G. (2002), "Beauty in usability: forget about ease of use!" In: W.S. Green, P.W. Jordan (Eds.), *Pleasure with Products: Beyond Usability*, Taylor and Francis, 9-18.

Oxman, R. (2008), "Digital Architecture as a Challenge for Design Pedagogy: Theory, Knowledge, Models and Medium". *Design Studies*, 29(2), 99-120.

Pine, B.J., Gilmore, J.H. (2013), "The Experience Economy: Past, Present and Future". *Handbook on the Experience Economy*, 21-44.

The Design Discipline

1. A Supple Discipline

by Lucia Rampino

This first chapter analyzes a number of features of design:

> […] a remarkably supple discipline, amenable to radically different interpretations in philosophy as well as in practice. But the flexibility of design often leads to popular misunderstanding and clouds efforts to understand its nature (Buchanan 1992, p. 19).

Indeed, compared to well established disciplines such as engineering and architecture - to remain in the polytechnic field - but also medicine, jurisprudence, economics and so on, design still lacks clear disciplinary boundaries and a shared definition. This chapter looks at a number of the reasons behind design's 'flexibility'.

Between Science and Art

Historically, Western knowledge has been divided into two major areas: the sciences and the arts.

> Modern bourgeois culture made a sharp division between the world of the arts and that of technology and machines; hence culture was split into two mutually exclusive branches: one scientific, quantifiable and "hard," the other aesthetic, evaluative and "soft" (Flusser, 1999, p. 17).

As Flusser implies, this separation of knowledge into two opposite areas is not inherent to Western culture. It was actually a consequence of the scientific revolution in which modern science first emerged and observation replaced religious doctrine as the source of our understanding of the universe.

The scientific revolution began in 1543 with the publication of Copernicus's *De revolutionibus orbium coelestium* and ended in 1687 when Newton published his *Mathematical Principles of Natural Philosophy*, considered the foundation of classical mechanics[1].

Prior to this, art and science were not considered opposites, the main distinction in knowledge being that between the 'liberal arts', worthy of free men[2], and the 'mechanical arts', also called servile, since they were considered unsuitable to free men. The goal of a liberal arts education was creating wise and virtuous men (i.e. members of the social elites), developing intellectual capacities such as reason and judgment. On the contrary, the goal of the mechanical arts was to teach the professional skills needed for a given job, such as blacksmithing.

In the Middle Ages, the liberal arts included both scientific (e.g. arithmetic, geometry and astronomy) and humanities (e.g. music, grammar, logic and rhetoric) subjects. On the other side, the mechanical arts included navigation, metallurgy, medicine and theatrical arts.

Table 1: The historic distinction between liberal and mechanical arts encounters the modern separation between science and art.

	Liberal Arts	**Mechanical Arts**
Science	**Formal Science** (e.g. geometry, arithmetic) **Natural Science** (e.g. astronomy)	**Applied Science** (e.g. metallurgy, medicine)
Art	**Fine Art** (e.g. music)	**Craft** (e.g. pottery, ceramics)

The person who best embodies the historic unity of art and science is Leonardo da Vinci, considered the 'Renaissance man' archetype[3]. Leonar-

[1] An important role in this century of extraordinary developments in science was played by Galileo Galilei (1564-1642) and his Dialogue on the Two Chief Systems of the World. For a more in depth analysis of the modern science paradigm, see Chapter 2.

[2] In Europe the concept of a liberal arts education is still deeply rooted today. 'Gymnasiums' (grammar school) are the educational institutions that maintain this tradition. On the other hand, since European students are considered to have received a comprehensive liberal arts education at high school, the role of such education at universities is often limited as compared to the US educational system.

[3] Also known as a 'polymath', a person whose expertise spans a significant number of different subject areas. Such people were considered capable of drawing on complex bodies of knowledge to solve specific problems. To be considered a polymath, a universal education was essential, hence the word 'university' was used to describe a seat of learning that

do's interests encompassed a great many different disciplines: painting, sculpture, architecture, music, mathematics, engineering, literature, anatomy, geology, astronomy, botany, history and cartography.

However, as knowledge grew and specialized, it was no longer possible to hold together all its different fields. From the seventeenth century onward, science and art began to move away from each other and differentiate more and more clearly.

The Arts versus the Sciences

What are the main differences between the arts and the sciences? In brief, it can be said that the purpose of science is to explain the natural world and doing so requires scientific methods and empirical demonstration using quantitative and objective data. By contrast, the goals of the arts[4] is to evaluate the world, giving it a subjective interpretation based on qualitative aspects and experiences.

Looking at research methods in greater depth, science uses empirical methods, i.e. ways of acquiring knowledge by means of direct observation of the physical world. In observation of this kind, scientists use their senses. Indeed, all the tools developed throughout science's history have primarily been means by which to expand the human senses, to make them capable of perceiving the extremely small as well as the extremely big and faraway. On the contrary, the arts and humanities are interested in what cannot be observed and thus apply analytical methods, creating knowledge by means of reasoning.

The two different objects of study of science and art are well summarized in Immanuel Kant's famous statement: «*Two things awe me most, the starry sky above me and the moral law within me*». While scientists stare at the starry sky, artists look within.

Unsurprisingly, there are also differences in the way these two areas of knowledge measure success. Indeed, science affirms things as either true or false. Such a judgement is appropriate «*for a field in which there can only be one 'true' answer or correct explanation for an observed phenomenon*» (Owen, 2007, p. 22). On the contrary, the arts judge success by means of the categories 'better' and 'worse'. This is appropriate «*for a field in which multiple solutions can be equally successful because the conditions for judgment are culturally based*» (Owen, 2007, p. 22).

did not specialize in specific areas but rather trained students in a broad array of science, philosophy and theology subjects.

[4] The umbrella term 'arts' includes both the arts and the humanities, as opposed to science.

All such differences - in purpose, research methods, objects of interest and measures of success - have led inexorably to a separation between the sciences and the arts and the situation described by Snow (1960):

> I believe the intellectual life of the whole of western society is increasingly being split into two polar groups. […] at one pole we have the literary intellectuals […] at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension - sometimes hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground (pp. 3-4).

Bridging the Two

The first scientific revolution[5] overturned all the certainties of the ancient world: the earth was no longer the center of the universe and consequently neither was mankind.

> The first modernity of the seventeenth century displaced the Earth from the center of the cosmos, showered Europeans with new discoveries, from new continents to new planets, created new forms of inquiry such as field observation and the laboratory experiment, added prediction to explanation as an ideal toward which science should strive (Daston, 2016, p.18).

This epoch making change also affected art: what mattered was no longer an artist's ability to make an exact copy of the natural world but rather the ability to interpret it. Caravaggio (1571-1610) well represents this new generation of artists: born a century after Leonardo, his brief and stormy life matches the modern 'mad artist' archetype.

The divorce between art and science had become official, and there was no way back. On the subject of this divorce, however, Flusser affirms:

> This unfortunate split started to become irreversible towards the end of the nineteenth century. In the gap, the word 'design' formed a bridge between the two. It could do this since it is an expression of the internal connection between art and technology. Hence in contemporary life, design more or less indicates the site where art and technology (along with their respective evaluative and

[5] Daston (2016) argues that there have been three revolutions in the history of science: the first was the seventeenth century's scientific revolution; the second happened at the beginning of the nineteenth century and is known as 'the second scientific revolution'; the last, in the first quarter of the twentieth century when relativity theory and quantum mechanics overturned the achievements of Galileo and Newton and challenged our most profound intuitions about space, time and causation.

scientific ways of thinking) come together as equals, making a new form of culture possible (Flusser, 1999, p. 18).

A notable exception to this divorce still exists: two disciplines, namely design and architecture, continue to be claimed by both science and art, as is demonstrated by the fact that they can be taught at both polytechnics and art schools.

> The question of whether design is science or art is controversial because design is both science and art. The techniques of design combine the logical character of the scientific approach and the intuitive and artistic dimensions of the creative effort (Borja de Mozota, 2003, p. 4).

Being, at the same time, art and science, between two worlds while not fully belonging to either, is the primary reason why design is regarded as «*a remarkably supple discipline*» (Buchanan, 1992, p. 19).

In general, Western knowledge it is not fond of that which escapes classification, of gray areas and halfway houses. In classical logic, indeed, the principle of non-contradiction affirms the falsity of any proposition which implies that a certain statement and its opposite are both true at the same time and in the same way. Borja de Mozota's proposition (2003) that design «*is both science and art*», in a culture that has come to regard science and art as two opposite poles of human knowledge, is a violation of the non-contradiction principle. The consequence is that designers are perceived as artists by engineers and engineers by artists and always feel different and misunderstood:

> There is as much difficulty in communicating between some traditional humanists and designers as between designers and scientists (Buchanan, 1992, p. 14).

A Young Discipline

Architecture, like design, belongs at the same time to both art and science paradigms. However, the *flexibility* that - in Buchanan's words (1992) - often leads to misunderstanding, is characteristic of design alone. Why is this the case? The reason is to be found in the different historical trajectories taken by the two disciplines.

The oldest treatise on architecture is the multi-volume work *De Architectura* written by Roman architect Vitruvius. He himself cites older but less complete works, meaning that architecture was already an established field of knowledge well before the birth of Christ. Vitruvius is the first author in Western history to describe the close relationship between theory and practice, affirming that architects should be interested in both art and science in addition to being well versed in rhetoric and having a good knowledge of history and philosophy. For Vitruvius, then, architects were specialists who had mastered all branches of human knowledge: the liberal and mechanical arts as well as science and art.

Approximately two thousand years later, in founding the Bauhaus School in 1919, Walter Gropius attempted to revive the ancient architect/designer ideal as bearer of art and science and practical and theoretical knowledge at the same time. But during the previous two millennia, Western culture had undergone divisions which were too profound for Gropius's late attempt to gather together branches of knowledge, by then belonging to opposite paradigms (i.e. liberal arts versus mechanical arts, science versus art, fine art versus craft), to be welcomed[6].

To answer our initial question as to why architecture does not share design's flexibility, it is because architecture is a well-established discipline boasting thousands of years of cultural debate rooted in antiquity. Therefore, it is nowadays acceptable for it to overlook the separation between science and art, since architecture itself was born in a period in which Western culture had not yet elaborated such a separation.

The practical outcome of architecture's long-standing cultural status is as follows: an architect's skills and abilities are easily acknowledged with no need of further explanation.

In comparison to architecture, design first emerged in the wake of the Industrial Revolution and is thus a very young discipline. Moreover, the emergence of design as a discipline coincided with a period of accelerated change processes. As Ashton *et al.* (1953) observed, one of the main psychological consequences of the Industrial Revolution was a different, quickened sense of time.

From the nineteenth century onwards, the speed of change has been such that design always lags behind its own theoretical definition. We will return to and expand on this concept in the next section. Here it is sufficient to note that anyone claiming to be a designer today will most likely be asked for clarification.

From a professional standpoint, the difference in status between designers and architects is reflected in Italy by the absence of a professional body for designers. For architects, being listed on a professional register is a precondition for professional practice. But designers are not required to join a professional body or even be graduates. The situation in the UK is similar

[6] For a more in-depth analysis of this issue, see Chapter 2.

with strong professional bodies and strict permission to practice regulations existing in architecture (as well as engineering). These contrast with the design profession based in art schools where communication and fashion design, for instance, are taught without the need for extensive professional accreditation (Wang and Ilhan, 2009).

This marks a significant difference between design, still regarded by many as a mechanical art, and architecture, to which Vitruvius assigned the status of liberal art two thousand years ago.

A Great Acceleration in Change

Design was born just over one hundred years ago, and in this relatively short period the world has changed radically.

Technological progress has dramatically reduced the change time frame: until the nineteenth century, changes were sporadic and took many decades to spread and to be assimilated by the dominant culture. From the twentieth century onwards, single decade have been sufficient for multiple changes.

This acceleration, coupled with the growing complexity of the socio-economic system (i.e. globalization vs. localization, exacerbation of social conflicts, progressive depletion of energy resources, large scale migration, exponential growth of new economies with low social and environmental safeguards, fatigue in mature economies and so on), causes significant delays in cultural assimilation processes. For design this results in a growing delay in redefining its ever-changing matters of interest.

> The age in which a uniform concept of design could predominate now appears to be over once and for all. The reflections of the postmodern age have promoted the dissolution of totality in a variety of disciplines (Bürdek, 2005, p. 16).

While in the past design could be said to be concerned with two- and three-dimensional artefacts, in recent years both these areas of the discipline have undergone significant change and extension. In the communication design field, for instance, the advent of digital communication technologies is alone sufficient to underline this point.

More importantly, designer intervention can no longer be limited to two- and three-dimensional artefacts since new and intangible fields of interest have already been consolidated: strategic design, service design, design for social innovation, to mention just a few of the most prominent. In reference to Manzini (2015), design can be said to have gradually widened out its fields of application from products to services to organizations.

The constant evolution of its disciplinary boundaries is an additional element of design flexibility. Such rapid evolutions result in difficulties finding a stable, shared definition:

> No single definition of design, or branches of professionalized practice such as industrial or graphic design adequately covers the diversity of ideas and methods gathered together under the label. Indeed, the variety of research reported in conference papers, journal articles, and books suggests that design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as understanding (Buchanan, 1992, p. 1).

An Indeterminate Nature

The English verb 'to design' is indeterminate in nature. It means drawing, planning, devising. On the subject of this semantic vagueness, Heskett (2002) argues that:

> Design […] as a word is common enough, but it is full of incongruities, has innumerable manifestations, and lacks boundaries that give clarity and definition (p. 2).

Two pages later, he adds:

> Design has so many levels of meaning that it is in itself a source of confusion (Heskett, 2002, p. 4).

But design's indeterminate nature goes well beyond the semantic level. Indeed, design welcomes contributions from several other disciplines, all needed by designers to address the complexity inherent in any project. A good designer must be knowledgeable in material science, manufacturing processes, marketing, sociology, psychology, art history and so on. For Friedman (2003), the design discipline is located at the point of intersection between the following six domains: natural sciences, humanities and liberal arts, social sciences, proficiency and services, creative and applied arts, technology and engineering. Design integrates and involves all these domains, to different extents and at different times.

Design's natural tendency to crossdisciplinarity[7] can be read as one of its strengths, the very reason why many scholars argue that, in a contempo-

[7] Disciplinary unification can be *interdisciplinary*, *multidisciplinary*, *crossdisciplinary* and *transdisciplinary*. Interdisciplinary collaboration creates a new discipline or project, such as interfield research, often leaving the original disciplines intact. Multidisciplinary work involves the juxtaposition of the processes and aims of the different disciplines in-

rary world valuing multidisciplinarity, project teams should be led by designers:

> In a world of specialists, there is real need for those who can reach across disciplines to communicate and who can bring diverse experts together in coordinated effort (Owen, 2007, p. 24).

In this regard, Bürdek (2005) referred to an interesting statement by Lutz Göbel[8] indicating that companies need neither specialists (i.e. people who know a lot about a little) nor generalists (i.e. people who know a little about a lot), but rather they need integralists, namely people who have a good overview of various disciplines but in-depth knowledge of at least one area. Designers can reasonably be described as integralists.

On the other hand, however, this crossdisciplinarity results in the design discipline often being perceived as lacking a strong core competence:

> In the past, designers have moved between engineering, art, market research, process planning, visual persuasion and consumer advocacy. They had to know a little of everything, without being respected as authorities in any one of these endeavors (Krippendorff, 2006, p. 43).

Buchanan (1992) speaks about the indeterminate nature of design as the most distinctive feature of our discipline:

> We have been slow to recognize the peculiar indeterminacy of subject matter in design and its impact on the nature of design thinking. As a consequence, each of the sciences that have come into contact with design has tended to regard design as an "applied" version of its own knowledge, methods, and principles. They see in design an instance of their own subject matter and treat design as a practical demonstration of the scientific principles of that subject matter. Thus, we have the odd, recurring situation in which design is alternately regarded as 'applied' natural science, 'applied' social science, or 'applied' fine art. No wonder designers and members of the scientific community often have difficulty communicating (p. 19).

Today, Western culture tends to privilege specialized knowledge and the professional training of individuals with a thoroughgoing knowledge of a

volved in addressing a common problem. Crossdisciplinary work involves borrowing resources from one discipline to serve the aims of a project in another. Transdisciplinary work is a synthetic creation encompassing work from different disciplines (Cat, 2007).

[8] Lutz Göbel was the head of the mechanical engineering group of the German company Henkelhausen which manufactures industrial engines and power systems.

well-defined subject area. Because this is the way in which scientific knowledge is built. Indeed, scientists are:

> […] masters of specialized subject matters and their related methods, as found in physics, chemistry, biology, mathematics, the social sciences, or one of the many subfields into which these sciences have been divided (Buchanan, 1992, p. 14).

This is evident in the nature of recent reforms to the Italian university system: in the recent past, Politecnico di Milano had only one degree in architecture within which students could choose one of many specialist subject areas ranging from product design to urban and environmental planning and architectural restoration ('from spoon to town', according to the famous slogan launched by Ernesto Rogers in the mid-1950s). Today, on the contrary, students enrolling on architecture choose right from the start whether they want to be town planners or building designers, as the two degree programs are different.

The same applies to aspiring designers who have to decide when they enroll whether they want to work in product, communication or fashion design. This is one unmistakable sign of Western culture's specialization tendency. Therefore, design's propensity to crossdisciplinarity can also be interpreted as a weakness.

Our focus

After this brief analysis of the features which make design a supple discipline, the focus of our interest here needs clarifying. We are interested in defining design's most traditional and consolidated area, tangible product design. In the age of mass production, this was normally called industrial design. Nowadays, it is more often called product design.

In general, terms, any design activity can be defined as follows:

> Designing is about the easing, filling and resolving of the differential gap between deficiencies and possibilities in situations that are ripe for transformation (Diethelm, n.a., p. 1).

Product designers fill this 'differential gap' with artefacts and their central concern is form. In Owen's words (2007, p. 21) «*Design exists because of the need for Form*». Form is not a trivial concept:

> […] we regard form as a synthesis of what is useful, usable, and desirable - that is, the content and structure of performance, human affordances, and prod-

uct voice. In essence, form becomes a temporal phenomenon of communication and persuasion, as human beings engage with products (Buchanan, 2001, p. 14).

Giving form to an object means according it meaning, or better, supplying it with the potential for interacting with an array of possible stakeholders who make sense of the object itself via this interaction. Indeed, meaning is not an objective attribute of objects, but the result of a sense-making activity which takes place through user innate mindsets, socialized categories, cultural concepts and expectations. In any product, form and meaning are two intrinsically related concepts:

> Something must have form to be seen but must make sense to be understood and used (Krippendorff, 1989, p. 14).

Therefore, Krippendorff (2006) defines products design as «*the creative activity that lends form and meaning to objects*»[9]. This activity is truly a cultural one: it modifies and adapts its approaches and methods in accordance with changes in socio-cultural and technical paradigms, as is demonstrated by the different points of view from which product designers have explored material objects:

> For example, some have considered material objects as communicative yielding reflections on the semantic and rhetorical aspects of products. Others have placed material objects in the context of experience and action, asking new questions about how products function in situations of use and how they may contribute to or inhibit the flow of activities. […] Finally, others are exploring material objects as part of larger systems, cycles, and environments, opening up a wide range of new questions and practical concerns or reenergizing old debates. Issues include conservation and recycling, alternative technologies, elaborate simulation environments, 'smart' products, virtual reality, artificial life, and the ethical political and legal dimensions of design (Buchanan, 1992, p. 11).

These different perspectives underlying modifications and adaptations of the design concept, together with the fixed elements that have characterized product design since its inception during the Industrial Revolution, are the subjects of analysis and discussion in the present book.

[9] While for traditional neo-positivistic interpretations of design, artefacts are the core and meaning is an attribute, for Krippendorff meaning is the core of the design process and artefacts are the media with which these meanings are communicated. For a more in-depth analysis of Krippendorff's thought, see Chapter 8.

References

Ashton, T.S., Barbone, D., Sinha, B.N. (1953), *La rivoluzione industriale: 1760-1830*. Laterza.

Barbaro, D. (1567), *Vitruvio. I Dieci Libri dell'Architettura tradotti e commentati da Daniele Barbaro*, Il Polifilo, 1987.

Bonsiepe, G. (1993), *Teoria e pratica del disegno industriale*, Feltrinelli.

Borja de Mozota, B. (2003), *Design Management*, Allworth Press.

Buchanan, R. (1992), "Wicked Problems in Design Thinking*". Design Issues*, 8(2), 5-21.

Buchanan, R. (2001), "Design Research and the New Learning". *Design Issues*, 17(4), 3-23.

Bürdek, B.E. (2005), *Design: History, Theory and Practice of Product Design*, Birkhauser.

Cat, J. (2007), "The Unity of Science", *The Stanford Encyclopedia of Philosophy* (Fall 2017 Edition), Edward N. Zalta (ed.).

Daston, L. (2016), "When Science Went Modern". *The Hedgehog Review*, 18(3).

Diethelm, J. (n.a.), *A Paradigm Shift in Design Thinking*, Retrieved December 18, 2017, from: http://pages.uoregon.edu/diethelm/A%20Paradigm%20Shift%20in%20Design%20Thinking.pdf

Flusser, V. (1999), *The Shape of Things: A Philosophy of Design*. Reaktion Books.

Friedman, K. (2003), "Theory Construction in Design Research: Criteria, Approaches and Methods", *Design Studies*, 24(6).

Heskett, J. (2002), *Design. A Very Short Introduction*, Oxford University Press.

Krippendorff, K. (1989), "On the essential contexts of artefacts or on the proposition that 'Design is making sense (of things)'", *Design Issues*, 5(2), 9-39.

Krippendorff, K. (2006), *The Semantic Turn: A New Foundation for Design*, CRC Press.

Manzini, E. (2015), *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. The MIT Press.

Owen, C. (2007), "Design Thinking: Notes on its Nature and Use." *Design Research Quarterly* 2.1: 16-27.

Parsons, T. (1951), *The Social System*, Free Press.

Snow, C.P. (1960), *The Two Cultures and the Scientific Revolution*. Cambridge University Press.

Wang, D., Ilhan, A.O. (2009), "Holding Creativity Together: A Sociological Theory of the Design Professions". *Design Issues*, 25(1), 5-21.

2. A Third Area of Human Knowledge

by Lucia Rampino

In chapter One, we saw that design is somewhere between science and art. This ambivalence has profound consequences for the discipline, both theoretically and practically. For a better understanding of these consequences, this chapter will analyze the two modern paradigms of art and science, as they have emerged and consolidated in Western culture, in greater depth.

The aim of this chapter is to discuss the implications for design when it takes shelter under one paradigm or the other. Indeed, several attempts to be accorded science or art status are visible in design history. The chapter's final point is that design is neither art nor science but rather a different and specific area of human knowledge.

The Modern Paradigm of Art

The Latin word 'ars' translates the Greek word 'techne': in antiquity, therefore, artists were technicians, skilled craftsmen who applied technological knowledge to manufacturing artefacts. As a consequence, a work of art was the useful product of skilled work and its appreciation was fully connected with its real life role.

Shiner (2001) has argued that this traditional idea of art dominated Western culture for around two millennia: what we now regard as crafts (e.g. pottery, carpentry, sewing, etc.) were taken more seriously than they are today. At the same time, what we now regard as art (e.g. painting, sculpture, musical composition, dance, etc.) was treated more like craft than it is today.

Then, in the eighteenth century, the modern idea of art emerged:

[…] in this new system, Fine Art (art with a capital "A") was divided from the crafts as the appropriate object of refined taste, and *usefulness* became rather a negative than a positive feature for a work of art (David, 2008).

From our standpoint, this change was not a trivial one. Indeed, while art objects could also be utilitarian until the eighteenth century, in the new art paradigm:

[…] an art object is meant just for aesthetic looking, is a token of art in itself. Art for Art's sake, the Artist as Visionary Genius, and the unique Aesthetic Attitude/Experience emerged as the distinguishing features of Fine Art (David, 2008).

At the end of the eighteenth century, philosophers Kant and Schiller consolidated the definition of aesthetic. Kant, in particular, separated off aesthetic judgment from other sorts of appreciation of a work or a landscape in an enduring analysis of the beautiful and sublime categories[1].

What Shiner calls 'the modern system of the arts' also resulted in the emergence of a new art market among the growing middle classes. Where artists had previously worked for wealthy patrons associated with church or state, in this period art became part of the market economy. New institutions devoted to the arts, such as galleries, museums, concert halls and libraries, were a central part of this new system. In brief, from the eighteenth century onwards, appreciation and enjoyment of art became a preserve of the cultural elites and art itself came to be seen as an artist's personal self-expression.

The modern fine art system, as outlined by Shiner, rests on the distinction between liberal and mechanical arts mentioned above. Indeed, fine art is fully endowed with all the features traditionally attributed to the liberal arts: worthy of a wise and virtuous man from the social elites and, for this very reason, free of utilitarian purpose by contrast with craft which is deeply rooted in the mechanical arts.

Art is supposedly for its own sake and free of other purposes. Of course it may serve a purpose, but in the modern system it only counts as Art (with a capital A) if it is of value in itself, whatever its purpose.

[1] Interestingly, Kant distinguishes between the Beautiful and the Sublime, affirming that beauty "is connected with the form of the object" and has boundaries, while the sublime "is to be found in a formless object" and "boundlessness". Clearly Kant's idea of beauty fits product design, while his sublime concept better fits other forms of art, such as musical composition.

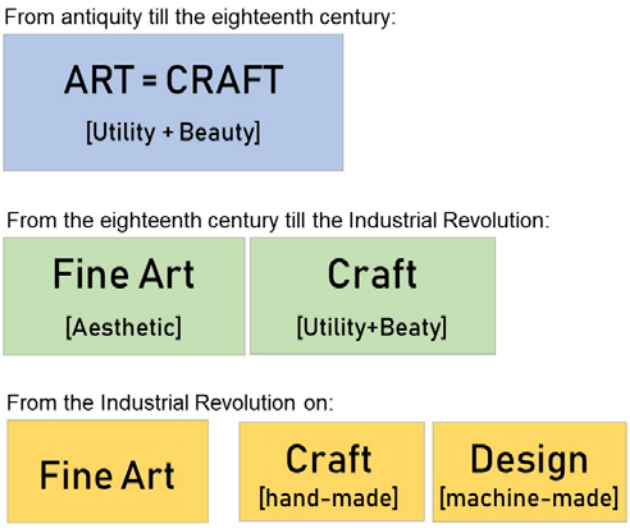


Figure 1: A schematic representation of the three different roles of art in Western culture

Once again for Shiner (2001), the modern system of the arts is so powerful and totalizing that we now see the arts of the past and of other cultures through it.

> So it is not surprising that practitioners of the exiled popular arts and the crafts (furniture makers, potters, popular musicians, movie-makers, graphic novelists, video-game designers, gourmet chefs, hairdressers, and many more) regularly try to climb over the wall and be acknowledged as Artists. It's the only way to be taken seriously. The system responds by stretching the wall to assimilate a few of them who are deemed to have risen to the level of fine art leaving the rest outside (David, 2008).

Design under the Paradigm of Art

Every time we visit a design exhibition at a museum of modern art or an art gallery, every time we read a book on design history, every time we buy a design object, paying much more than its real manufacturing cost, we are confirming the common idea of design as a branch of art.

> Design occupies an interesting and in some ways a contradictory place in the modern art world. It owes a great deal to the vocabulary of modern art. It creates and conveys many cultural messages. The symbolic weight and tech-

nical skill of contemporary design work frequently earn it a place in fine art museums (David, 2008).

The Bauhaus: A Failed Experiment

When he founded the Bauhaus in 1919, Gropius's ideal was to recreate the unity of the ancient world's artist-technician in the new figure of the designer. His motto was: «*art and technology: a new unity*» (Bürdek 2005, p. 37). Several Bauhaus teachers were also well-known artists: Wassilly Kandinsky, Paul Klee, Theo Van Doesburg, Làzlò Moholy-Nagy, to mention just a few[2].

Gropius's intention was to anchor art in society once more, as it had been before the modern paradigm of art emerged.

> In an essay written in 1937, he reflected on the founding of the Bauhaus as an institution grounded on the idea of an architectonic art: «*Thus the Bauhaus was inaugurated in 1919 with the specific object of realizing a modern architectonic art, which like human nature was meant to be all-embracing in its scope*» (Buchanan, 1992, note at p. 2).

It might be said that, having originated in architecture, design longed to return to those ancient times in which architecture was itself born. At that time, art was firmly rooted in everyday life and there was nothing negative about art being utilitarian. However, Gropius's experiment was destined for failure on every front.

On one hand, artists and technicians remained two distinct figures, with designers seen sometimes as artists and sometimes as technicians (i.e. artisans).

> As serially produced functional items for commercial distribution, design products remained part of the lesser arts even when taken into places like the Museum of Modern Art. The textiles, chairs and lamps in these museums are seldom exhibited as the work of those who actually produced them or because they successfully fulfilled their function but as examples of formal stylistic developments or the expressive genius of the artist-designer (Shiner, 2001, p. 262).

[2] If Gropius's educational and design work at the Bauhaus was guided by a vision designed to keeping art and function in equilibrium, his successor, Hannes Meyer, went to the functionalist and technological extreme, demonstrating once again that design has often moved like a pendulum, taking shelter under art and science paradigms respectively at different times.

That designers are seen as artisans is evident in the teaching systems of several European nations (e.g. France, Germany and Switzerland), where design is taught at vocational schools of applied arts and crafts that cannot award PhDs in Design[3]. When design is considered craftsmanship, it is usually not admitted to the modern fine art system. This is confirmed in the following Walter Grasskamp quote:

> No other designation sounds more obscene in the academy classes of painters and sculptors, no slander is more painful there, than the invective 'designer' (cited in Bürdek, 2005, p. 63).

In order to be accepted as a fine art, design is required to leave behind all idea of function, since usefulness is not appropriate to art:

> After design had finally thrown off its functional shackles in the apparent radicalism of the 1980s, it was only a matter of time before it would metamorphose into apparently pure art. […] This was demonstrated impressively in the summer of 1987 at the document 8 in Kassel. There, design was practically seated on art's throne, where - as Michel Erlhoff insisted - it neither belonged nor wanted to be (Bürdek 2005, p. 64).

Every time design is successful in presenting itself as art, designed objects immediately become expensive items for the cultural elites, with the so-called design-system (made up of exhibitions, events, galleries, fairs, magazines and design-stars) assimilating the main features of the modern art system and partially overlapping with it[4]. In this way, too, Gropius's experiment was a failure: this 'artistic' idea of design, progressively consolidated since the 1980s, conflicts with the Bauhaus's social promise of outstandingly designed mass-manufactured objects available cheaply to everyone.

We would argue that the fact that when design finds itself encompassed by the art paradigm its main purpose is aesthetic appreciation may explain why a significant part of the design discipline has always struggled to escape this paradigm. And it has done so both by affirming the superiority of function over form and seeking refuge in the science paradigm. In the Ulm School of Design's Product Design Department, for instance:

[3] As discussed in Chapter 1, the survival of the ancient distinction between liberal and mechanical arts is still visible in the European contemporary educational system.

[4] As an example, in 1982 the Hamburg Museum of Arts and Craft showed its first cross-section of new German design. In 2002 the New York Museum of Craft changed its name to the Museum of Arts and Design.

> […] objects that possessed an artistic or craft character were more or less taboo, nor was the design of prestige and luxury items admitted (Bürdek, 2005, p. 50).

The Ulm School tried indeed to prove the scientific character of design, in particular through the application of mathematical methods (Bürdek, 2005).

The New Unity Tension

In recent years there have been several indications that the modern art system is changing. For David (2008), the change is best described in terms of fine art spreading to fields it was formerly thought to be excluded from, alongside a great high-culture art-world attention to popular art, entertainment, craft and commercial design. As a result, functionality and entertainment value can, to at least some extent, be seen as positive elements of a work's aesthetic value.

This is a significant transformation which sanctions exchange and reciprocal influence between fine art, craft and design. Just as designers entered art's territory in the eighties, many artists had worked on useful objects long before this, from Rietveld's chairs to Dali's sofa. Moreover, postmodern art had significantly broken down the barriers between fine arts, low art and popular culture as early as the 1960s.

For Bürdek (2005), things significantly changed for design in the 1990s, when it won widespread cultural acclaim, with more influence over art than vice versa. All this inspired Italian designer Gaetano Pesce to affirm that «*The true artists of our time are the industrial designers*» (cited in Bürdek, 2005, p. 64).

The Modern Paradigm of Science

The modern science paradigm emerged in Europe in the seventeenth century when science progressively affirmed its autonomy from philosophy and theology and elaborated its own methodological procedure, the experimental method. What primarily distinguishes modern science from the science of antiquity and the Middle Ages is its quantitative nature. The new scientific method rests on the premise that the essence of things goes beyond the aims of science which must rather investigate the relationships between things and express them through objective and universally communicable measurements. This is why mathematics is indispensable to science (Fusaro, n.a.).

As we have seen, the birth and development of modern science was accompanied by consideration of the method to be used to obtain new knowledge. The basis of the modern scientific method is experimentation, namely the artificial reproduction of natural processes under conditions of maximum observability, i.e. in a controlled and therefore measurable environment[5].

A close connection was also established between science and technology. On one hand, scientific progress depends increasingly on technological progress which makes the tools necessary for research available. On the other, awareness of scientific knowledge's potential to enable ever greater dominion over nature, is also affirmed. A new conception of nature is involved, based on a cause-effect relationship: from a scientific point of view, nature is simply a set of laws. The modern idea of science can thus be described as mathematical knowledge of the laws of nature based on observation and experimental verification of hypotheses (Fusaro, n.a.).

In the eighteenth century, the Enlightenment brought the experimental method to philosophy, too, which was to rely on reason alone, independently of any revealed or innate truth. If reason were correctly used, it was believed that indefinite progress in all areas of human knowledge would be possible, progress that would improve both human society and individual lives (Bristow, 2010). Such beliefs were further reinforced by nineteenth century positivist doctrines characterized by attempts to apply the scientific method to all spheres of human life.

Together with economic liberalism, positivism was the ideological elaboration of the emerging industrial bourgeoisie: the ideal of action oriented towards technical and objective rationality was, and is, the driving force behind the West's economic progress (Volonté, 2008).

The Superiority of Scientific Knowledge

Since the Enlightenment, science has established itself as a form of knowledge which is qualitatively different and superior to everyday knowledge (Volonté, 2008, p. 37). The scientific method, i.e. the sum of the practices of induction, observation, experimentation, theory testing and falsification, has, since then, been considered the only reliable way of building new knowledge. As a result, it has been applied to a seemingly endless array of theoretical and practical issues which have, together, added

[5] From the seventeenth century onwards, scientific experiments have used increasingly refined tools of investigation and measurement (e.g. clocks, telescopes, barometers). Earlier science was purely qualitative analysis partly because precise measurement tools were unavailable.

up to a formidable force behind the shaping of the modern world (Tolson, 2016).

Science's cultural success in the Western world has generated problems for rival forms of knowledge (arts and humanities but also theology and religion). Most of these have therefore attempted to make themselves 'scientific', conforming their research activities to the scientific method[6].

Sociologist Max Weber has explicitly spoken of a process of rationalization typical of Western culture: only in the West has this progress had such a significant impact on belief systems, family structures, legal, political and economic systems and even art. For Weber, rationalization means that human beings no longer believe that the world is inhabited by spirits and demons. On the contrary, we believe that, the world's events are always predictable and explicable even when unknown (Volonté, 2008).

The dominion of science is nowadays so ubiquitous that its role in society and culture is sometimes difficult to identify or delimit:

> […] it would be tempting to say we don't see 'science everywhere' in the same way that we don't see the nose in front of our face, but it would be better to say that science is just the face of modernity. It's what we see when we look in the mirror (Shapin, 2016, p. 45).

The story of the Getty kouros, an over-life-sized statue bought by the Paul Getty Museum in 1986, is a significant example of the higher trust we put in science, even in art. Indeed, as science and technology continue their mutually reinforcing development, scientific and technical analysis has often substituted art knowledge in determining whether a work of art is ancient or modern. When it arrived in Los Angeles, the Getty kouros caused heated scholarly and scientific debate as to its authenticity. One Getty trustee, Italian art historian Federico Zeri, energetically insisted that it was a fake. But, relying heavily on scientific evidence from a series of analyses, the museum decided it was authentic and bought it. Later on, a new investigation demonstrated that the scientific findings on which the Getty museum had relied were not as certain as the museum had thought.

> The new evidence has caused the Getty's curator of antiquities, Marion True, who believed in the work's authenticity, to reconsider her position. "Everything about the kouros is problematic", she said. "I always considered scientific opinion more objective than esthetic judgments," Ms. True added. "Now I realize I was wrong." (Kimmelman, 1991).

[6] This has been the case with design, which has struggled to conform to the scientific method in order to be regarded as a fully 'respectable' academic discipline (see also the Design under the Paradigm of Science section in this book).

In what Weber referred to as our ‘rational and disenchanted world’, quantitative and measurable facts take priority over the subjective views of archaeologists and art historians on which museums and collectors once relied.

Scientific Objectivity

The superior trust that Western society has long accorded science stems to a large extent from the view that ‘science is objective’. But this objectivity ideal has been repeatedly criticized in the philosophy of science.

In his book *The Structure of Scientific Revolutions*, Kuhn (1962) argued that scientists always view research problems through a paradigm, defined by a set of relevant problems, axioms, methodological presuppositions, techniques and so forth. In brief, it is a matter of different ‘epistemic positions’ describing scientists belief in how knowledge is created and shared and truth is defined. Moreover, scientists can also be influenced by contextual values, depending on more general cultural contexts. For instance, in the Third Reich, much of contemporary physics, including the theory of relativity, was condemned because its inventors were Jewish (Reiss and Sprenger, 2014). Consequently, scientific objectivity can be threatened both by scientists’ epistemic stances and by the fact that they can be influenced by dominant contextual values.

The science-public policy interface is the place in which the intrusion of values into science is especially salient and in which controversy is greatest: examples are issues such as climate change, diet, vaccination and genetically modified organisms.

Kitcher (1995) has argued that science cannot be objective and value-free because no scientist ever works exclusively in the supposedly value-free zone in which hypotheses are assessed and accepted. Indeed, a great deal of industry-sponsored research in medicine is demonstrably biased toward the interests of its sponsors, usually large pharmaceutic firms.

Therefore, regarding scientific knowledge as truly objective is nowadays naïve. Nevertheless, in order to maintain its epistemic authority, science surely requires some independence from contextual values. We can thus affirm that «*science is objective to the extent that personal biases are absent from scientific reasoning*»[7] (Reiss and Sprenger, 2014).

[7] This markedly distinguishes science from the arts. Indeed, no form of art can be free of the influence of the artist’s preferences, experiences and values.

Science in the Postmodern Era

From a postmodern perspective, a number of scholars have argued that all forms of knowledge should be regarded as equal. Indeed, an awareness that the boundaries between science and rhetoric and rigorous knowledge and arbitrary interpretation are labile and indefinite is a characteristic aspect of modern Western culture. In such a post-modern interpretation, science is no longer given, once and for all, knowledge which is universally true but rather a great narration valid in a given era and a given society (Volonté, 2008).

Postmodernist academics belong mainly to the fields of social sciences and the humanities. They reinterpret past scientific achievements in the light of the influence of politics and economics in the development of scientific theories. For them scientific theories are social constructs: the autonomous subject of modernity, objectively rational and self-determined, gives way to a postmodern subject which is largely influenced by language (Bertens, 1995). Some go so far as to introduce aesthetic playfulness and subversion into science and politics (Aylesworth, 2005).

> From the perspective of this postmodernism, knowledge, which had once seemed neutral and objective to the positivists and politically emancipatory to the left, is inevitably bound up with power and thus suspect (Bertens, 1995, p. 7).

On the opposite side are the scientific realists who argue that scientific knowledge is real and accuse the postmodernists of discussing science with insufficient understanding of it:

> These postmodernists are mounting a last ditch defence of their disciplines by saying that everybody is in the same boat, including scientists - that there are no foundations, and no sand. But it's not true. Science is for real. It has made more changes to the conditions of human life than all the preceding millennia of our history put together. Just think of medicine. Two hundred years ago doctors were still bleeding people for every ailment under the sun. If you had cancer, would you consult a postmodern oncologist who thought reflexology and aromatherapy were on a par with surgery and chemotherapy? (Lodge, 2002, pp. 228-229).

Design under the Paradigm of Science

According to Cross, a first desire to 'scientize' design can be traced back to the modern movement, in the early 1920s. At that time, artist and

Bauhaus teacher Theo van Doesburg expressed his perception of a new spirit in art and design and the need to rely on an objective design method (Cross, 2001).

In the 1950s and 60s, design defined itself as an academic discipline and claimed its own scientific nature. The 'design science' concept was first introduced in 1957 by Buckminster Fuller who defined it as a systematic form of design. At around about the same period (1956-62), the Ulm School of Design took a scientific turn, distancing itself quite clearly from design as it was then taught at the traditional art and crafts schools:

> […] the lectures (Aicher, Maldonado, Gugelot and Zeischegg) pointed out the close relationships between design, science and technology and disciplines such as ergonomics, mathematical techniques, economics, physics, politics, sociology and theory of science grew in importance in the curriculum (Bürdek, 2005, p. 46).

Since Ulm articulated a powerful interest in the relationship between science and design, numerous scientific disciplines and methods were studied in terms of their applicability to the design process.

Ulm's scientific turn is particularly relevant in consideration of the powerful influence that the educational methods developed at Ulm exerted, even after it closed down, not just in Germany, but all over the world. Indeed, Ulm's lecturers and students migrated to Switzerland, France, Italy, South America and India and co-founded several design schools in these countries[8]. This migration contributed to spreading Ulm's rigid scientific thought together with its belief in the superiority of function over form (Bürdek, 2005). The sixties ended with the publication of an influential book by Herbert Simon, *The Sciences of the Artificial*, with its call for a science of design to be developed in the universities.

Already in the 1960s, some scholars were criticizing what they saw as the simplified and outmoded concepts of scientific method and scientific epistemology applied by several design scholars. Indeed, design embraced a positivistic view of science in a period in which science itself, and the idea of scientific knowledge, was undergoing profound transformation (Cross, 1993). In any case, belonging to the science paradigm was seen by many as highly desirable for design, a sort of promotion: «*For the field of design to advance from art to science requires research*» (Dixon and Finger, 1989, cited in Cross 1993, p. 65). Once again, this statement exemplifies the cultural superiority accorded science over art in Western society.

[8] This is of course the case of Tomás Maldonado, one of the founders of the first design degree course in Italy, at Politecnico di Milano

The Design Methods Movement

The Design Methods Movement developed through a series of conferences, mainly in the 1960s and 70s[9]. The movement's founders realized that a change from pre-industrial design to industrial design had taken place (Cross, 1993). In 1964 Christopher Alexander, one of the founders of design methodology, argued that design problems were now too complex to be treated intuitively (Bürdek, 2005). For this reason, the new movement's aim was basing the design process on objectivity and rationality, working through analysis and reducing the complex to the simple.

In the 1970s, a reaction took place against the indiscriminate use of methods in design: Maldonado recognized the danger of what he called 'methodolatry', i.e. uncritically applying problem solving activities (Maldonado, 1984, p. 5). A certain lack of success in the application of 'scientific' methods to everyday design practice also had to be acknowledged (Cross, 2001). Fundamental issues also were raised by Rittel and Webber, who characterized design and planning problems as 'wicked' problems[10], fundamentally unamenable to science and engineering techniques which generally deal with 'tame' problems instead.

In general, it can be argued that scientific methods from other disciplines have been often adopted by design as tools for its own research without questioning why these other disciplines relied on precisely these tools to develop research (Volonté, Rampino and Colombo, 2018).

Recent Developments

The design-science relationship still animates a theoretical debate committed to identifying either the methodological aspects common to the two disciplines or their profound differences.

An example is the verbal crossfire in the pages of Design Issues between two pairs of scholars, Galle and Kroes on one side and Farrell and Hooker on the other. These authors analyzed the science-design relationship, highlighting several issues. Galle and Kroes (2014) examined this relationship in terms of differences while recognizing some similarities. Farrell and Hooker (2013), by contrast, argued that design and science face the same kind of problems and share a common problem-solving (cognitive) process: the differences are a matter of external practical conditions and their immediate cognitive consequences alone. The two scholars are keen to point out that their conception of science, in particular scientific method, differs from that prevailing in the 1970s, when Rittel and Webber defined

[9] The first conference was held in London in 1962.
[10] For a more detailed discussion of 'wicked' problems, see Chapter 7.

'wicked' problems. Assuming that the distinction between poorly structured and well-structured problems is not clear, Farrell and Hooker believe that both design and science face issues of both kinds (Pallotti, 2016).

For Shapin, the presence of science in contemporary design is still pervasive:

> Experts on 'human factors' and 'ergonomics' - with a range of human science backgrounds - are employed in physical product design, in assessing communication in airplane cockpits, and in developing routines to minimize medical mistakes. […] The 'sciences of taste' are all over the late modern world, their practitioners wanting to construct robust, 'objective' accounts of people's tastes - what they like and what their likings are like; what disposes them to consume, to buy, or to bond; how they communicate to others the private subjectivities of taste; how, if possible, tastes can be changed (Shapin, 2016, pp. 43-44).

Neither Art nor Science

> Not everything that counts can be counted, and not everything that can be counted counts (Cameron, 1963).

The previous sections outlined the main features of the paradigms of art and science as they have emerged and been consolidated in modern Western culture. We have also described how design, since its emergence as an autonomous discipline, has participated in both paradigms, being alternatively regarded as an art, a craft or a science[11].

For any designer or design scholar claiming that design is art, an opposing position is as follows:

> Art and design are fundamentally different worlds of discourse. The former is directed toward individual self-realization; the latter toward solving societal problems (Bonsiepe, 2002, cited in Bürdek, 2005, p. 67).

> Design which - unlike art – requires practical justification, finds this chiefly in four assertions: being societal and functional and meaningful and concrete. (Erlhoff, 1987, cited in Bürdek, 2005, p. 16).

[11] As we saw in Chapter 1, design's multi-faceted nature is well exemplified by its educational status: nowadays design is taught in art academies (e.g. Accademia di Brera in Milan), applied arts and crafts academies (e.g. Eindhoven Design Academy) and polytechnics (e.g. TU Eindhoven and Politecnico di Milano).

The same is true for those arguing that design is science. Several scholars agree, but others disagree:

> The attempt to integrate science in design can be regarded as a failure. Science is oriented towards the production of new knowledge; design is invention in practice (Bonsiepe, 2002, cited in Bürdek, 2005, p. 46).

> Most opinion among design methodologists and among designers holds that the act of designing itself is not and will not ever be a scientific activity; that is, that designing is itself a non-scientific or a-scientific activity (Grant, 1979, cited in Cross, 1993, p. 67).

Such divergent scholarly opinions on design's status extend to design research and its methods being grounded in different and divergent epistemological paradigms[12]. However, if there is no disciplinary consensus on whether design should be regarded as an art or a science, how can it in fact be defined?

Several scholars (Cross 1993 and 2001; Buchanan, 1992; Dalsgaard, 2014) have argued that, with its own tradition of knowing, thinking and acting, the design discipline constitutes a third paradigm of inquiry in addition to science and the arts. As such, it should be understood and treated on its own terms, rather than through other paradigms. Indeed, despite many attempts to trace design's foundations to the fine arts, the natural sciences, or most recently, the social sciences, «*design eludes reduction and remains a surprisingly flexible activity*» (Buchanan, 1992, p. 1).

Over the last thirty years, design has sought to develop domain-independent approaches to both theory and research. For Cross (2001), some forms of knowledge are specific to designers' awareness and abilities, «*designerly ways* of *knowing and thinking*» (Cross, 2001 and 2011).

For Buchanan (1992, p. 5) design should be regarded as a «*new liberal art of technological culture*»[13], a new integrated discipline that is neither art nor science but capable of complementing both.

[12] This is discussed in Chapter 7.

[13] Once again, this proposal by Buchanan is evidence of the long-lasting conception of liberal arts as a subject of study for the upper classes and unconcerned with modern distinctions between science and art.

References

Antonucci, N. (N.A.). *Cos'è la complessità... semplicemente?* Retrieved December 4, 2017, from www.complexlab.it/complessita

Archer, B. (1995), "The Nature of Research". *Co-Design Journal*, 2(11), 6-13.

Aylesworth, G. (2005), "Postmodernism", *The Stanford Encyclopedia of Philosophy* (Spring 2015 Edition), Edward N. Zalta (ed.).

Bertens, H. (1995), *The Idea of Postmodernism. A History*. Routledge.

Bristow, W. (2010), "Enlightenment", *The Stanford Encyclopedia of Philosophy* (Fall 2017 Edition), Edward N. Zalta (ed.).

Buchanan, R. (1992), "Wicked Problems in Design Thinking". *Design Issues*, 8(2), 5-21.

Bürdek, B.E. (2005), *Design: History, Theory and Practice of Product Design*. Birkhaüser.

Cameron, W.B. (1963), *Informal Sociology: A Casual Introduction to Sociological Thinking* (Vol. 21). Random House.

Cross, N. (1993), "Science and Design Methodology: a Review". *Research in Engineering Design*, 5(2), 63-69.

Cross, N. (2001), "Designerly Ways of Knowing: Design Discipline Versus Design Science". *Design Issues*, 17(3), 49-55.

Cross, N. (2011), *Design Thinking: Understanding How Designers Think and Work*. Berg.

Dalsgaard, P. (2014), "Pragmatism and Design Thinking". *International Journal of Design*, 8(1), 143-155.

David, C. (2008), "A Third System of the Arts? An Exploration of Some Ideas from Larry Shiner's The Invention of Art: A Cultural History". *Contemporary Aesthetics*, 6.

Farrell, R., Hooker, C. (2013), "Design, Science and Wicked Problems". *Design Studies*, 34(6), 681-705.

Farrell, R., Hooker, C. (2015), "Designing and Sciencing: Response to Galle and Kroes". *Design Studies*, 37, 1-11.

Fusaro, D. (n.a.). *La rivoluzione scientifica e il '600*. Retrieved December 4, 2017, from http://www.filosofico.net/intruma2.htm

Galle, P., Kroes, P. (2014), "Science and Design: Identical Twins?". *Design Studies*, 35(3), 201-231.

Galle, P., Kroes, P. (2015), "Science and Design Revisited". *Design Studies*, 37, 67-72.

Kimmelman, M. (1991), "ART; Absolutely Real? Absolutely Fake?", in *The New York Times*, August 4, 1991. Retrieved December 3, 2017, from: http://www.nytimes.com/1991/08/04/arts/art-absolutely-real-absolutely-fake.html?pagewanted=all

Kitcher, P. (1995), *The Advancement of Science: Science Without Legend, Objectivity Without Illusions*. Oxford University Press on Demand.

Kuhn, T.S. (1962), *The Structure of Scientific Revolutions*, University of Chicago Press.

Lodge, D. (2002), *Thinks*. Penguin.

Maldonado, T. (1984), "Ulm rivisitato", in G. Anceschi (ed.), *Il contributo della scuola di Ulm*, Rassegna, year VI, 19/3.

Pallotti, S. (2016), "Design e scienza. Un approccio comune al problem solving nella complessità." Paper presented at the *FRID 2016 Conference*, Venezia, 16-17 November.

Sarewitz, D. (2004), "How Science makes Environmental Controversies Worse," in *Environmental Science & Policy* 7 (2004), 385-403.

Schulman, A.N. (2016), "Science Anxiety". *Hedgehog Review*, 18(3).

Shapin, S. (2016), "Invisible Science". *Hedgehog Review*, 18(3).

Shiner, L. (2001), *The Invention of Art: A Cultural History*. University of Chicago Press.

Simon, H.A. (1969), *The Sciences of the Artificial*. The MIT Press.

Reiss, J., Sprenger, J. (2014), "Scientific Objectivity", *The Stanford Encyclopedia of Philosophy* (Winter 2017 Edition), Edward N. Zalta (ed.).

Tinti, T. (1998), "La sfida della complessità verso il terzo millennio". *Rivista Novecento*, 18(12).

Tolson, J. (2016), "From the Editor". *Hedgehog Review*, 18(3).

Volonté, P. (2008), *Max Weber. La scienza come professione*. Bompiani.

Volonté, P., Rampino, L., Colombo, S. (2018), "The Specificity of Design Research: How Practice-Based Design Knowledge Can Enter the Great Archive of Science". In Vermaas P.E., Vial, S. (eds.) *Advancements in the Philosophy of Design*, Book series Design Research Foundation, Springer.

The Technical Perspective

Industrial design is a process of creation, invention and definition separated from the means of production, involving an eventual synthesis of contributory and often conflicting factors into a concept of three-dimensional form, and its material reality, capable of multiple reproduction by mechanical means.

Heskett, J. (1980), *Industrial Design*, Thames & Hudson, p. 10

3. Product Design in the Industrial Economy

by Lucia Rampino

After the Second World War, people in Western societies aspired to modernize their lives mainly by buying products that fulfilled functional needs and freed users of manual chores (Brand and Rocchi, 2011). In this regard, the 1960 Hotpoint washing machine advertisement is explicit: «*One touch of your finger gives you proper washing method for every known washable*». With these labor saving devices, more food, cleaner cities and better housing, modernization contributed to a healthier society (Gardien *et al.*, 2014). It was the rise of the industrial economy, with a vision founded on rational and technical culture, which was said to have brought with it the seeds of Western democracy (De Vries, 1994). It all began with the Industrial Revolution,

> by far the biggest transformation in society since the discovery of agriculture. In fact, those two revolutions, the agricultural and the industrial-scientific, are the only qualitative changes in social living that men have ever known (Snow, 1959, p. 12).

Beginning in Great Britain, industrialization spread to continental Europe and the United States at different times and speeds in the nineteenth century, leading Western countries towards the mass production and consumption that has characterized the modern world.

> The Industrial Economy delivered the peak of its economic value contribution between the fifties and the eighties, but is still very large nowadays (Brand and Rocchi, 2011).

The Industrial Revolution

The Industrial Revolution fundamentally changed Western societies from mainly agricultural laboring populations to peoples principally engaged in making goods in factories and then distributing them (Snow, 1959).

Although it was not until the twentieth century that the West became predominantly urban, cities and towns had already grown dramatically in size in the first half of the nineteenth century. Entrepreneurs located their manufacturing plants in urban centers where access to both labor and transport was facilitated. In turn, the presence of large factories encouraged mass population movements from the countryside to urban areas.

The substitution of rural life, with its strong, extended family bonds, by the more impersonal coexistence typical of urban environments, together with the rise of a wealthy industrial middle class and a huge industrial working class, widely transformed traditional social relationships.

The Industrial Revolution seemed to confirm the scientific revolution's underlying assumption: that human beings were capable of dominating nature. Much of the business organization which is still predominant today - based on standardization, division of labor and mass production - is rooted in the modern science paradigm and the Enlightenment in particular. Factories demanded new, rigorous discipline geared to the requirements of its machines. The Enlightenment rational and objective world view was well suited to this purpose.

A number of critical voices began to make themselves heard as well. These are well represented by Charlie Chaplin's 1936 film *Modern Times* which pointed to the dehumanization of the workforce and individual alienation from work.

The Modern Kitchen

The kitchen was the first household space modernity burst into. Already at the end of the nineteenth century, the idea of designing kitchen furniture according to parameters of rationality and efficiency inspired by scientific working management spread through the United States. In Europe, modernist architects engaged with the question of "getting some order into the kitchen" with the aid of time and motion studies (Guillén, 1997).

The appearance of kitchen stoves, with their standard subdivision of burners on top and an oven below, changed traditional images of women's work. Women were no longer required to follow in their mothers' footsteps to the kitchen hearth but invited to precisely calculate movements, distances and timing in order to exploit new space, equipment and tool rationality (Vitta, 2001).

Another important step in the road to modernization was the development of electricity distribution systems in Western countries from the last two decades of the nineteenth century onwards. With electricity in homes in the early twentieth century, small electric appliances such as fans, irons, vacuum cleaners and toasters spread like wildfire. For Vitta (2011) their success was a demonstration of Western society's willingness to embrace innovation, as the tangible fulfilment of the promise of incessant progress and growing wealth.

The Consumer Economy

From the beginning of the twentieth century onwards, for the first time in history, most people in Western countries were no longer working out their lives in local communities but earning a salary for their labor. The money they earned could be used on industrially manufactured goods (Brand and Rocchi, 2011).

A simple example is that in the pre-industrial economy clothing could be made either from home-grown fibers or a market-bought length of cloth. In the industrial economy, clothes are usually ready-made by the clothing industry[1] or, for the wealthy, tailor-made. Therefore, while «*the proverbial preindustrial peasant household*» was characterized by substantial self-sufficiency, the modern household «*is often thought to be simply a unit of consumption*» (De Vries, 1994, p. 257).

This is the basis of the so-called consumer economy which relies heavily on how much people buy and spend. It is an economy that concurrently demands mass produced goods to fuel mass consumption and mass consumption to absorb mass produced goods. The result was to be a cycle capable of guaranteeing prosperity for all, «*creating more well-paying jobs and in turn more affluent consumers capable of stoking the economy with their purchases*» (Cohen, 2004, p. 236).

The advent of the consumer economy was the 1920s, but it came to a halt in the 1930s Great Depression, restarting at the end of the Second World War by which time a great demand had accumulated for almost everything and factories were ready to convert their assembly lines from combat vehicles and munitions to cars and appliances.

[1] From the 1980s onwards, the fashion industry is the phrase most frequently used.

However, just after the war, people were reluctant to spend their savings. Hence, in the United States in particular, business leaders, advertisers and the mass media, but also labor unions and government bodies, conveyed the message that mass consumption was not a matter of self-gratification but a civic responsibility whose goal was to improve national living standards (Cohen, 2004).

> Wherever one looked in the aftermath of war, one found a vision of postwar America where the general good was best served not by frugality or even moderation, but by individuals pursuing personal wants in a flourishing mass consumption marketplace. Private consumption and public benefit, it was widely argued, went hand in hand (Cohen, 2004, p. 237).

To begin with, all over the West, an extensive post-war program of new home building provided the foundation for the rise of mass consumption. A home was an expensive commodity, in turn stimulating a demand for related commodities such as furniture, appliances and cars. By the mid-1950s, in North America the modern consumer economy castle emerged: the shopping mall in which traditional community public spaces were turned into privately owned mass consumption venues maximizing profits (Cohen, 2004).

The 1950 to 1980 period witnessed the emergence of large companies capitalizing on labor organization capability, leveraging mass production technologies and organizing the supply chain to meet growing mass consumption demands (Brand and Rocchi, 2011).

The Social Drawbacks of Industrialization

Although the industrial economy brought better living conditions to many, the urbanization process which accompanied it changed people's social relationships. In rural villages, social status and identity were clear, and family ties strong. All this came to an end with the hunt for better jobs and higher incomes typical of large cities (Brand and Rocchi, 2011).

The early twentieth century saw the rise of the traditional modern family with a male breadwinner and a female homemaker. This was a consequence of a less labor intensive production system almost exclusively oriented to hiring full-time male workers. On the demand side, market structure came to focus increasingly on family rather than individually consumed goods. Within the family,

> the goals of reproduction came, in the inelegant terms of the economist, to focus increasingly on quality (the endowment of children with human capital) and less on quantity (De Vries, 1994, pp. 263-264).

From a general societal perspective, the industrial economy widened the wealth distribution gap in Western countries. According to De Vries (1994), in the early 1990s two percent of the world's richest people owned fifty percent of its assets, while the bottom fifty percent owned less than one percent. Through most of the post-Second World War period in North America, the top one percent of the population earned about ten percent of all income. By 2007, that figure had jumped to 23.5 percent, the highest since 1928.

As we will see, the social and environmental drawbacks of industrialization led to protest movements and, consequently, the profound cultural and social changes of later economies[2].

Industrial Design: Art at the Service of Industry

In addition to the profound changes in Western societies outlined in previous sections, since the mid-nineteenth century the Industrial Revolution has seen the rise of the modern concept of industrial design and sanctioned its breakaway from craftsmanship. Indeed, for mass manufactured goods, design and manufacture were no longer done by the same person (Bürdek, 2005).

Cars are the objects which best represent the mass production era and the birth of industrial design as the first industrial product to profoundly transform the Western lifestyle whilst simultaneously giving rise to a new manufacturing model and the modern factory idea.

It was in 1903 that Henry Ford established his Motor Company in the United States. He was convinced that, as modern functional objects, cars should be designed to fulfil their function at best and last as long as possible. The Ford Model T, designed in 1908, was the outcome of this understanding: it was a straightforward, robust and affordable car conceived for mass consumption. Its rapid spread throughout the United States marked the advent of mass car ownership (Vitta, 2001).

The Standardization of Form

At the very core of mass production is producing a large number of identical items in shorter timeframes and thus at lower cost. These reduced manufacturing costs work to the advantage of both manufacturer and clients.

[2] In further detail, we are referring here to the experience and transformation economies described respectively in Chapter 6 and Chapter 12.

The significant increase in the number of identical items to be produced in a shorter time required standardization, i.e. using a small range of identical components. Therefore, mass production and standardization are two strictly related concepts.

In order to obtain an affordable product, Ford rationalized the car manufacturing process, standardizing components and combining engine and car body manufacture. Until then, while car engines were built by mechanics, a number of artisans (i.e. carpenters, blacksmiths, coppersmiths) built the car body and all its accessories according to specific client requests. As a result, cars were personalized and semi-artisan products.

When the advent of molding technology permitted car body manufacture to be standardized, Ford unified car component assembly. From this moment on, car bodywork was no longer a result of artisan choices and manual skills but of an abstract design drawing used to produce multiple identical products (Vitti, 2002).

In 1913 Ford introduced the first, though still rudimentary, assembly line: the various components of the car were pre-arranged on the factory floor and assembled in a given order over a moving carriage. The carriage was initially moved manually by workmen and later by conveyor belt (De Fusco, 2004). This way, Ford obtained a significant reduction in manufacturing time: from twelve and a half hours to one hour and a half. As De Fusco (2004) has observed, this significant change in production speed was one of the major differences between craftsmanship and industry. This time saving was reflected in car prices. Ford achieved his aim with standardization, labor division and assembly lines, transforming a luxury item into an everyday object accessible to millions of people.

From a design point of view, Ford defined a different relationship between technical and formal design: these two previously separate moments converged in a single perspective obliging them to reciprocal influence. The idea of aesthetic quality no longer limited to a single piece but rather repeated with no variation in an indeterminate number of identical pieces, began to emerge (Vitta, 2011).

Unsurprisingly, a design language appropriate to mass manufactured objects had already become the subject of wide ranging disciplinary debate.

The Unadorned Perspective

In 1907 Germany architect Hermann Muthesius fostered the establishment of the Deutscher Werkbund, an association of artists, architects, designers and industrialists. The Werkbund's purpose was to close the gap which had opened up between industry and the applied arts during the country's recent tumultuous industrial development. It was claimed that industrialization required a new design culture in which the quality of form, materials and manufacturing processes should be appropriate to the function of each project in an attempt to bring all these into line with company strategies. For De Fusco (2014), this was the first time the industrial design issue was addressed in all its complex and contradictory phenomenology.

The Werkbund's was a clear aesthetic stance which was to have a significant influence on subsequent industrial design developments. Regularity, simplicity and formal rigor were seen not simply as functional requirements of machine-made objects but also as expressive and symbolic requirements. Therefore, the dense ornamentation typical of hand-crafted objects was regarded by the Werkbund as inadmissible: superfluous ornamentation was considered to be a waste of money, time and labor.

In January 1908 Viennese architect Adolf Loos gave an influential lecture which was then published under the provocative title *Ornament and Crime*. In this brief essay, which began by comparing the actions of a Papuan native with that of a Viennese citizen, Loos described ornament as corrupt and suppressing it a sign of the moral and cultural superiority of modern Western society.

> I have made the following discovery and I pass it on to the world: The evolution of culture is synonymous with the removal of ornament from utilitarian objects (Loos, 1908, cited in Conrads, 1970, p. 20).

In Loos's view, anyone subscribing to ornamentation was primitive and not 'enlightened'. The influence of the modern paradigm of science on all aspects of Western culture is visible once again here. Loos's essay also well represents the Eurocentric, colonialist worldview of the period, which still dominates design teaching to a considerable extent today[3].

This sense of the immorality of ornamentation had a powerful influence on the Bauhaus design studio, too, and helped to define modernist ideology in both architecture and design.

The Modern Movement

In Guillén words, «*Modernist architecture is the child of industry and engineering*» (2006, p. 1). Modernist architects embraced the technical per-

[3] Because of the strong cultural influence of both the Bauhaus and the Ulm School of Design, the design narrative adopted all over the world by design schools prioritizes European art and design histories. Recently, Toronto's OCAD University challenged this Eurocentric educational paradigm, proposing an alternative named 'respectful design' which valued non-Western design sources, too. Respectful design is part of the more general sociocultural framework of the transformation economy discussed in Chapter 12.

spective and strived to turn both architecture and design into a science, designing buildings and artefacts to look like machines and to be used like machines (Guillén, 1997).

Both the works and the words of certain great architects, including Gropius, Mies van der Rohe and Le Corbusier, were the basis for experimentation and promotion of a new integral planning method driven by standardization in which renouncing the legacy of the past, economic analysis and a trust in architecture and design's commitment to social progress merged ("Movimento Moderno", Enciclopedia Garzanti di Architettura).

> […] throughout much of the Modern Movement, we see a desire to produce works of art and design based on objectivity and rationality, that is, on the values of science. These aspirations to scientise design surfaced strongly again in the 'design methods movement' of the 1960s (Cross, 2001, p. 49).

For the first time in architecture, housing was seen as a mass issue requiring a scientific and egalitarian response. In design, mass produced goods had to be outstandingly designed and cheap.

Interestingly, it was not in the two most advanced industrial countries (i.e. the United States and the UK) of the day that modernism made progress but rather in continental Europe:

> While the American architect of the turn of the century caught up with developments in industry as an individualist and marginal player, and the British architect reacted against the machine age altogether, the architect in the relatively backward Continental European countries actively advocated and planned for a transformation of society. Continental European architecture thus stood in sharp contrast to American architecture in that it was avant-garde, or revolutionary, moving at the forefront of social and economic change rather than following it (Guillén, 1997, p. 685).

Practically speaking, the two principles of standardization and mass production required a pared down language of form. Architects and designers thus developed a visually pure, geometry-based aesthetic. This machine aesthetic suggested that modernist products were suited to mass production and thus available to the masses, reflecting contemporary social democratic ideals (Bürdek, 2005).

European Modernism did not achieve an entirely novel approach to architecture and design until the 1920s with Bauhaus in Germany, Constructivism in the Soviet Union, Rationalism in Italy and Purism in France (Guillén, 1997).

The years after the Second World War witnessed the triumph of the Modernist aesthetic throughout the capitalist world. In the same years, design was accorded the status of an accredited profession and acknowledged as having an important part to play in economic reconstruction. This was reflected in the establishment of professional associations all around the developed world, such as the British Council for Industrial Design, the Italian Association for Industrial Design and the Japanese Industrial Designers Association (Perks, Cooper and Jones, 2005). In 1957 London, the International Council of Societies of Industrial Designers[4] was officially founded with seventeen countries signing up to it.

But very soon, Modernism – born as the language of a design method designed to defeat stylistic academic dogmas once and for all – itself drifted into an academic style, the so-called International Style ("Movimento Moderno", Enciclopedia Garzanti di Architettura). In the sixties, an exhausted Modernist language was challenged by Postmodernism in both architecture and design[5].

Design for Mass Production: Past and Present

Designed in 1859, more than fifty million Thonet number 14 chairs are said to have been sold since 1930 and they are still being made today. The whole range of Thonet chairs embodies an important and lasting design topic: a simplified design aesthetic for high production volumes. This theme was to remain central to the design discipline debate until the 1970s (Bürdek, 2005).

Today design for mass production is a consolidated and still present issue. A more recent example is the Ikea Billy bookcase system, produced since 1980, another mass produced design classic selling more than two million units per year. It is therefore clear that mass production, even if compared with more recent issues such as mass customization and personalization, not to mention new craftsmanship, is an enduring feature of the contemporary developed world.

However, as items of furniture, both Thonet chair and Billy bookcase, are peculiar examples. No electro-mechanical appliance (e.g. washing machines or vacuum cleaners) designed many years ago could possibly be still in production. And this for a very simple reason: with technological progress a dominant force in the capitalist economy, products with technical

[4] On 1 January 2017, ICSID officially became the World Design Organization. This name change acknowledged the association's new social perspective focusing on addressing challenges of global relevance (i.e. rapid urbanization, climate change and migration) from a design perspective.

[5] Postmodernism is discussed in Chapter 6.

components (be they analog or, worse, digital) are destined for rapid obsolescence. However, issues relating to the internal functioning of electromechanical products and the visual form with which products express this functioning, which first emerged in design for mass production, are still relevant today, and perhaps to an even greater extent when applied to digital products.

For companies competing in the durable consumer goods sector (e.g. appliances and cars), quality products that are «*economical to manufacture, simple to operate and easy to service*» (Bürdek, 2005, p. 27) are still crucial to competitivity terms in today's saturated markets. From a technical perspective, the two linked objectives for mass manufacturing companies remain increasingly efficient production for cost reduction (i.e. faster production, less manual labor) and ongoing product improvement to sustain mass consumption. Design plays a role in the achievement of both these objectives. Consequently, few of the design tools and methods that were developed for mass production have lost their value. Indeed, the industrial economy saw the development of many traditional product-centered design techniques still valid today, such as product sketching, technical drawing and model making (Gardien *et al.*, 2014).

On the other hand, in the industrial economy users are considered mainly in ergonomic terms: the predominance of anthropometrics reduces man to a set of measures that products need to fit. This rational, technical perspective on human-beings has recently been surpassed by the rise of a human-centered perspective[6].

Interestingly, a further theme that has attracted much attention since the late twentieth century, the macroeconomic value of design, was present at the advent of industrial design, too. Both Behrens and Gropius, in founding the Deutsche Werkbund and Bauhaus, aimed to improve German industrial competitivity. In Russia, the Soviet leadership believed that Modernist design would improve product quality and the USSR's position in the international trading markets (Guillén, 1997). Design's macroeconomic value, coupled with its microeconomic importance, is a topic that still engages design scholars today, notably in the design management field.

Finally, as we have seen, the theme of design's social relevance also first emerged with the Deutscher Werkbund and was pivotal to the Modern Movement. Whilst not generally in the foreground, this undercurrent has accompanied design throughout its evolution and emerged even more powerfully at the turn of the new millennium[7].

[6] Human-centered design is debated in Chapter 8.
[7] The social value of design is one of the themes discussed in Chapter 12.

In brief, it can be said that several key topics of the design debate were already present at the beginning of the last century. What has changed is mainly the perspective from which such topics are now debated: the original technical perspective has been supplemented by human, digital and social perspectives. But a more in-depth understanding of such topics requires an understanding of their historical roots, too.

References

Ashton, T.S., Barbone, D., Sinha, B.N. (1953), *La rivoluzione industriale: 1760-1830*. Laterza.

Brand, R., Rocchi, S. (2011), *Rethinking Value in a Changing Landscape: A Model for Strategic Reflection and Business Transformation*. Philips Design. Retrieved April 4, 2013, from www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/april2011/paradigms.pdf

Buchanan, R. (1992), "Wicked Problems in Design Thinking". *Design Issues* 8(2), 5-21.

Bürdek, B.E. (2005), *Design: History, Theory and Practice of Product Design*. Birkhäuser.

Cohen, L. (2004), "A Consumers' Republic: The Politics of Mass Consumption in Postwar America". *Journal of Consumer Research*, 31(1), 236-239.

Conrads, U. (ed.), (1970), *Programs and Manifestoes on 20th-century Architecture*. The MIT Press.

Cross, N. (2001), "Designerly Ways of Knowing: Design Discipline Versus Design Science". *Design Issues,* 17(3), 49-55.

De Fusco, R. (2004), *Storia del design*. Laterza.

De Vries, J. (1994), "The Industrial Revolution and the Industrious Revolution". *The Journal of Economic History*, 54(2), 249-270.

De Vries, J. (2008), *The Industrious Revolution: Consumer Behavior and the Household Economy, 1650 to the present*. Cambridge University Press.

Ford, H. (1988), *Today and Tomorrow: Commemorative Edition of Ford's 1926 Classic*. Taylor & Francis.

Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing Your Hammer: The Implications of Paradigmatic Innovation for Design Practice." *International Journal of Design*, 8(2), 119-139.

Guillén, M.F. (1997), "Scientific Management's Lost Aesthetic: Architecture, Organization, and the Taylorized Beauty of the Mechanical". *Administrative Science Quarterly*, 682-715.

Guillén, M.F. (2006), *The Taylorized Beauty of the Mechanical: Scientific Management and the Rise of Modernist Architecture*. Princeton University Press.

Johansson-Sköldberg, U., Woodilla, J., Çetinkaya M. (2013), "Design Thinking: Past, Present and Possible Futures." *Creativity and Innovation Management* 22(2), 121-146.

"Movimento Moderno". *Enciclopedia Garzanti di Architettura*. (1996), Garzanti.

Perks, H., Cooper, R., Jones, C. (2005), "Characterizing the Role of Design in New Product Development: An Empirically Derived Taxonomy". *Journal of Product Innovation Management*, 22(2), 111-127.

Snow, C.P. (1959), *The Two Cultures and the Scientific Revolution: The Rede Lecture, 1959*. University Press.

Vitta, M. (2001), *Il progetto della bellezza. Il design tra arte e tecnica, 1851-2001.* Einaudi.

4. The New Product Development Process

by Lucia Rampino

For manufacturing companies competing in a saturated mass production market, product innovation – i.e. developing new, improved products - is crucial. Therefore studying how manufacturing companies can manage new product development (NPD) processes effectively has been paid a great deal of attention in several marketing, management and engineering fields since the 1970s. The Product Development and Management Association was founded in the USA in 1976.

The NPD process is a topic which has been at the heart of a lively debate in journals such as the Journal of Marketing Management, the Journal of Product Innovation Management and the Journal of Research-Technology Management since the early nineties. Today it is therefore possible to speak of an established NPD literature. The way the topic is addressed within this literature shows the influence of the science paradigm which dominates the technical perspective: NPD processes are each divided up into a well-defined number of steps. Each step involves a number of tasks. Each task is to be carefully verified before moving on to the next one. Everything is described rationally and mistakes are considered a system failure to be avoided by at all costs[1]. This rational logic still permeates Western manufacturing companies today.

This chapter will first examine the main features of the NPD process debate before focusing on the role that product design can play in it. We then discuss the frequently conflictual relationships that design establishes with the other corporate departments involved in new product development.

[1] An approach specifically designed to reduce product defects and improve overall quality is Six Sigma, a concept developed in 1985 by Motorola. In the 1990s Six Sigma's impact on Western industry was a significant one (Linderman *et al.*, 2003).

Innovation Processes within Companies

To achieve innovation, companies need to generate better product ideas and be capable of rapidly implementing these ideas. Implementation must be timely because, in today competitive markets, new ideas age rapidly: taking several months to develop a product can be fatal, since it gives competitors the chance to launch similar products.

How do companies manage the process of conceiving and developing innovative products? Three different approaches are present in the literature. In the first, companies manage innovation through a specific process. In the second, the NPD process is applied both when radical innovation is the desired target and when companies aim to develop an updated version of a product which is already on the market. In the last approach, typical of many small and micro companies, tacit procedures alone are used: the smaller the company, the greater the chance that NPD processes have never been made explicit.

The first approach, involving setting up a specific process when the desired outcome is discontinuous innovation, is typical of large multinational corporations. In SMEs the most common approach is the second, where there is no clear-cut distinction between an NPD and an innovation process. The two processes, however, differ in both structure and priority terms (McAloone, Hansen and Larsen, 2004).

Structurally speaking, while innovation processes are fuzzy, NPD processes are highly structured. In priority terms, while the prime concern of innovation processes is delivering something new, the primary issue of NPD processes is launching a product on the market as quickly as possible.

The innovation process is thus non-linear and interative, lacking a rigid phase structure and well-defined timeframe. Where a valuable new product idea is delivered, companies can decide to protect these with patents[2]. When a convincing new concept is defined, the more step-wise and time-focused NPD process can ensure its timely development into a marketable product (McAloone, Hansen and Larsen, 2004).

Many scholars have focused their attention on the innovation activities preceding the NPD process, the so-called Fuzzy Front End (Khurana and Rosenthal, 1997 and 1998; Koen *et al.*, 2001; Nobelius and Trygg, 2002; Elmqvist, 2006). Rather than referring to two separate processes, thus, the innovation process is best described as the process used by companies to conceive, design and market new products. Two main phases are recognizable: initial Fuzzy Front End (FFE) and the NPD process. The FFE is a

[2] The IP rights protection topic is addressed in Chapter 5.

phase of undefined length that is present only when companies are willing to increase the novelty of the product to be developed.

The Fuzzy Front End

Even where an FFE and NPD process continuum exists, FFE processes are often chaotic, unpredictable and unstructured. Moreover, not all the concepts generated during an FFE directly enter the NPD process: some require prior technological research (O'Connor, 2005). Therefore, when they are asked to identify the greatest product innovation weakness, company managers often indicate the Fuzzy Front End (Khurana and Rosenthal, 1997).

For this reason, several management scholars focus on developing methods and tools aimed at «*taking the fuzziness out*», referring to the title of a journal article by Reinertsen (1999), and more generally, to «*providing clarity and a common language to the fuzzy front end*», another journal article title (Koen *et al.*, 2001). In this latter article, for instance, the aim of the research group was to create a common language for eight large companies enabling their different approaches to managing FFE to be compared.

Once again, the influence of the modern paradigm of science, with the underlying idea that problems need to be well-defined if they are to be effectively addressed, dominates[3].

The Phase Gate Model

The most formalized version of the NPD process is the phase gate model, also known as stage gate model.

> With predefined gates, strict timelines and specific requirements that each project must fulfill in order to move on to the next phase, the stage gate model is a way to reduce uncertainty early on and build control of development progress (Calgren, 2009, p. 9).

In a phase gate process, product development activities are split into a number of phases or stages. Between stages, there is a control checkpoint or gate. Before a project can enter a new stage, a review assesses all activities in the completed stage to determine whether it is worth continuing the development process or otherwise (Valeri *et al.*, 2003). In brief, the work is

[3] For a more in-depth discussion on the specific nature of scientific problems, see Chapter 7.

done in the stages while the gates ensure that quality is adequate (Cooper, 1990).

The first phase gate formalization was used by NASA in the 1960s with its phased review process. This pioneer initiative was popularized in the early nineties, in particular by Robert Cooper (1988 and 1990), a NPD research initiator in the consumer goods sector. Subsequently the stage gate process was adopted by companies all over the West and large corporations in particular (Valeri *et al.*, 2003).

In recent times, the stage gate process has become scalable, adaptable to very different types of project ranging from risky and complex platform developments to lower risk product extensions and modifications (Cooper, 2008). According to the 2010 American Productivity & Quality Center benchmarking study, 88 percent of U.S. companies employ stage gate processes.

Ulrich and Eppinger (2000) have argued that the main advantages for companies in a well formalized NPD process are threefold: explicit decision-making processes enabling each member of the project team to gain a clear understanding of decisions taken; clearly defined project phases ensuring that no details are overlooked; guaranteed information gathering. Indeed, to pass through each gate, the project team has to compile documentation that serves to reflect on results and identify errors, thus avoiding them happening again in the future.

Time Pressures: Concurrent Engineering

NPD processes evolved over time: first generation processes were sequential and linear with each stage requiring completion before the next could begin, second generation processes support the parallel development of several integrated activities. This approach is named concurrent or parallel engineering. In this evolution, a need for greater process completion speed was the decisive variable:

> […] the new product manager is caught between conflicting demands of time efficiency and project effectiveness. Parallel processing compresses the development cycle without sacrificing quality (Cooper, 1990, p. 50).

An essential feature of concurrent engineering is the involvement of several company functions in a multidisciplinary project team. This integration allows constraints generated by industrial dynamics to be anticipated and multiple activities to be performed at the same time rather than sequentially:

> The sequential analogy is that of a relay race: One runner, perhaps the product manager, runs with the baton for a while, passing it to the next runner, likely R&D. He takes over the project and runs with the baton, passing it on to production, who throws it over the wall to marketing, who, if not busy on more pressing matters, carries the baton across the finish line and into the marketplace. […] In parallel processing, many activities are undertaken concurrently rather than in series. The situation is more like a rugby football game than a relay race. A team (not a single runner) appears on the field. […] The play is far more intense than a relay, more work gets done in a given elapsed time period, and many players are involved at any one point in time (Cooper, 1990, p. 50).

Of course, concurrent engineering adds risks to a project such as, for instance, the risk of project cancellation after dedicated manufacturing equipment has been purchased. Thus, deciding to overlap activities and stages requires careful thought: delay costs need to be assessed against the likelihood of mistakes being made (Cooper, 2008).

In general, Cooper and Kleinschmidt (2001) recommend companies guard against considering process completion speed as the only objective. The main goal must always remain introducing a new, successful product to the market and thus shortcuts, especially in the early stages of the process, can be costly in later stages.

The Main Phases of the NPD Process

As we have seen, much has been written about NPD processes in manufacturing companies. Therefore several descriptions of the process, with a varying number of phases and sub-phases, are available.

Differences notwithstanding, every NPD process encompasses the following three phases: a first strategic product definition and idea generation and evaluation phase; a second product development phase; a third product manufacturing and marketing phase.

In the first phase, a project team creates a wide array of alternative ideas. Then, the alternatives are reduced with those remaining gradually acquiring more details until a single alternative is chosen which is then developed into a feasible product. This ongoing alternative reduction explains why the NPD process is also depicted as a funnel.

Another way of looking at the NPD process is to consider it as a way of handling and transforming fragments of information. Seen in this way, the process begins with a series of inputs (e.g. business objectives, available technologies, product platforms and so on). Subsequent activities deal with all product development information (e.g. product specifications and design details). The process ends when all the information required to support production and sales has been generated and communicated[4].

It is important to stress that any way of expressing the NPD process is at the same time a simplification and a generalization.

The real product development world tends to be much more chaotic: as development proceeds, problems can surface or new information to be taken into account can became available. Therefore, design loopbacks occur forcing the project team to retreat to the previous phase. Moreover, the process is not always completed: in the early phases, projects may not pass a gate and be canceled.

The Company Departments Involved

New product development requires the contribution of numerous company departments which vary according to the specific product developed.

However, in any new product development, the three central departments are: marketing and sales, whose role is to mediate between the company and its customers; product development, which designs and develops the new product; manufacturing, whose role is to design, build and manage the new product's manufacturing system.

Usually, it is marketing which is responsible for identifying users' needs and new market opportunities, defining market segments and the price at which the product will be sold and supervising its launch and promotion. The task of actually designing and developing a new product is sometimes done entirely by engineers and sometimes by engineers and designers together.

Traditionally, during the product development process, the three functions work in sequence. Marketing oversees the beginning of the process and defines the project brief by means of market analysis. Product development responds to the brief with a number of proposals that are evaluated and selected by marketing. Once a product concept has been chosen, it is developed and engineered. At this point, manufacturing enters the equation, producing detailed product designs and plans for the production of the quantity required. Finally, it is the task of sales to promote the product on the market.

Many scholars have challenged this sequential model, arguing that integrating employees drawn from various areas into a project team favors a profitable exchange of knowledge and skills, offering all departments an opportunity to contribute to new product ideas (Cooper and Kleinschmidt,

[4] It is evident that this way of looking at the NPD process is profoundly influenced by knowledge management, a field of study that also emerged in the early nineties.

1995; Roberts, 1995). Consequently, several companies are now making use of multi-departmental project teams (Kim and Kang, 2008). In some cases, in addition to internal company staff, teams also include people from partner companies, suppliers and consultants.

The role of Product Design in the NPD Process

Design's role in the NPD process varies. First of all, it is important to stress that some manufacturing companies do not consider design an essential function in new product development[5]. In such companies, the form taken by the product is designed by people (typically, engineers) with no specific training in design. Zurlo *et al.* (2002) define this phenomenon 'implicit' or 'de facto' design. Other scholars call it 'silent' design (Candi and Gemser, 2010).

It should also be noted that design can be both internal or external to a company. Running the risk of oversimplification, it might be said that SMEs tend to rely on external design consultants while large companies tend to have their internal design departments.

When design is present as a company function, depending on which stage of the NPD process it is involved in, its role can range from helping generate and create innovative product concepts to simply defining the form to be taken by a new product (Veryzer and Mozota, 2005).

Research by Perks, Cooper and Jones (2005) on eighteen medium-to-large UK manufacturing companies produced a taxonomy of the three different roles that design can play in the NPD process: specialized function, part of a multi-functional team or process leader.

The first role is the most classic and commonplace, with designers dealing with defining product form based on knowledge and requirements developed by other departments. The latter is the least common. The main features of each role are described below.

[5] Design's role in a company depends on the sector the company works in and its strategic management decisions. While some sectors are design-based, meaning that design is, by definition, a competitive lever (e.g. fashion, furniture and cars), several are design-related (e.g. household appliances and electronic goods), and others are non-design oriented (e.g. health and safety appliances). In this regard, Kristensen and Lojacono (2002) proposed a distinction between context of reference (a fashion company is *by definition* design based) and company strategy (Bang&Olufsen is a design driven company since it has decided to leverage design to differentiate itself from its competitors).

Design as a Functional Specialization

Here design is understood as a function involving deploying a set of traditional design - aesthetic, visualization and technical - skills. Therefore, it is often seen as simply a tool at the service of marketing. It is indeed marketing's responsibility to analyze users and define a product brief to which designers respond. Moreover, checking whether the concept developed by designers satisfies the initial brief is once again a marketing task. This frequently leads to conflict between design and marketing.

For Perks, Cooper and Jones (2005), incremental innovations prevail in companies where design retains this role.

Design as Part of a Multi-Function Team

As we have seen, in some companies internal functions are organized on an integration rather than a sequential model. Therefore, from the beginning of the NPD process, design is part of a multi-departmental project team with marketing, R&D, purchasing and production.

To be effective members of a such a team, designers must be flexible and capable of providing a supporting role to other departments, particularly marketing and production. In this regard, they should possess both creativity and a sound technical background. Indeed, while on one hand designers are expected to be able to envision, imagine, and visualize new products, on the other, to fruitfully interact with engineers, designers must be able to correctly assess product feasibility.

Design as Process Leader

Here, too, design is part of a multi-departmental team, within which it may even take the lead. This is uncommon, however, and occurs only in companies where design is an acknowledged innovation lever.

Since the beginning of the new millennium, scholars have suggested that design is playing a more prominent role in the management of the product development task (Turner, 2000; Von Stamm, 2003). Research by Perks, Cooper and Jones (2005) has shown that design leadership is likely to frustrate marketing.

In order to act as team leaders, designers must have some managerial and leadership skills: an ability to observe and analyze the market, communicate with other departments, negotiate and persuade. With the intention of providing designers with such skills, several Western universities have, in recent years, started offering degree programs that combine managerial and design skills.

Design and the Others: An Uneasy Relationship

By the mid-1990s, manufacturing companies were struggling to integrate separate functions in the NPD process. This integration fueled interest in the interaction between design and other company departments. Nevertheless, once again in recent years, the NPD process has been described as one in which cooperation with design is characterized by an uneasy partnership with interrelated functions (Kim and Kang, 2008).

In this last section, we will analyze the reasons behind the often conflicting relationships between designers and other company departments. In general, the main reason for this is cultural diversity leading to misunderstanding.

As we saw in the first two chapters, design is a discipline with a cultural status of its own influenced by both science and art paradigms. On the other hand, the cultural paradigm of all the other functions in a manufacturing company is science. Engineering is an applied science, managers and marketing staff are used to relying on numbers and quantitative data. Therefore, for all of these, the qualitative and visual approach typical of designers frequently remains incomprehensible.

Of course, to take full advantage of the different skills involved in a multi-departmental team, the company's management must make every effort to avoid misunderstandings and foster communication:

> With the right conditions, this diversity in knowledge in a cross-functional group will contribute to more innovative solutions. However, in order to draw from each other's diverse knowledge and avoid misunderstandings, the persons have to be able to relate to each other through a common language and knowledge overlapping (Calgren, 2009, p. 24).

Hereafter, we will analyze in more detail the most common reasons behind the conflicts arising between design and other company functions.

Design and Management

The cultural differences between managers and designers, which translate into different ways of dealing with problem-solving activities[6], can partially explain the difficulties managers encounter in understanding design's contribution to company success.

Managers are used to thinking rationally, analyzing and measuring, giving precise answers to clear questions with the aim of avoiding risk. By

[6] The specific way in which designers address problem-solving activities is described in Chapter 7.

contrast, designers are used to exploring and experimenting, they have a great tolerance for ambiguities and tend to focus on understanding issues thoroughly rather than giving precise answers. These differences mean that many managers, even today, consider design difficult to manage since it is too close to art. Wherever possible, they try to avoid it.

It is therefore necessary to disseminate a better understanding of design among managers, to convince them of the usefulness of getting designers involved right from the early stages of the NPD process. This is the goal of design management[7].

Design and Marketing

Design and marketing apparently deal with very similar issues, both aiming to satisfy user demands. In actual fact, however, they address the issue in two different ways: marketing carries out market analysis by means of collecting statistical and quantitative data while design employs qualitative tools with which to observe and understand users.

Nevertheless, this illusory overlapping of skills, combined with a lack of familiarity and different languages, results in a great deal of conflict. To make things worse, marketing tends to consider design as a tool at its own service, leading to designer dissatisfaction and frustration.

In general, for design learning to get on well with marketing is very important:

> Not only do designers need to know the product, the competition, the target market and the price, they also need information on the characteristics of the consumer and to be regularly updated on changes in consumer needs (Kim and Kang, 2008, p. 44).

Design and R&D

Research&Development is the company department responsible for the research designed to improve and/or innovate existing products and procedures. It is typical of large companies and staffed primarily by engineers

[7] The Boston Design Management Institute (DMI) was founded in the mid-1970s. Its main purpose was to draw up case studies on the use of design in companies, applying American Business School methodology. The TRIAD project, carried out in collaboration with the Harvard Business School, achieved great international resonance and is now recognized as the first research project on design management. In it, fifteen case studies were collected into a publication. These same cases were also presented in an itinerant exhibition drawing attention to the importance of companies properly managing design activities. Today the DMI regularly organizes seminars and conferences and publishes the Design Management Journal.

and/or scientists (e.g. chemists, biologists). Therefore, R&D staff usually have little confidence in the technical skills of designers.

R&D interacts with design in both the design and development phases of an NPD process. In the former, companies may ask designers to explore possible applications for new technologies developed by R&D. This is the case, for instance, with 3M which often asks designers (both internal and external) to envision possible applications for newly developed materials. In general,

> R&D information is essential to designers working on product design development; they need to know what is happening at the forefront of technology in terms of materials, machines and manufacturing methods. Such knowledge feeds the creative process and enables designers to develop innovative and leading-edge products (Kim and Kang, 2008, p. 45).

On the other hand, when design is involved in the implementation phase of a new product, it tends to be relegated by R&D engineers to aesthetic issues alone.

Design and Manufacturing

Manufacturing aims to simplify the production process. Therefore, manufacturing engineers favor a dominant product architecture, use of standard components and machinery and technologies already owned by the company. For them, the ideal situation is a product remaining unchanged over time or, at most, undergoing minor variation. Attempts to produce completely new products are often opposed because of the disturbance to production flow caused. Consequently, production often conflicts with both design and marketing because of their recurrent demands for product modifications.

Regarding the relationship between manufacturing and design more specifically, once again there are several communications problems:

> Design people commonly believe that manufacturing people should be better/smarter/faster than they are - better able to interpret design methods. Manufacturing people may believe that design people should provide clearer/more consistent/simpler information on their drawings. Or they may believe that specifications are more precise than necessary, resulting in manufacturing processes that are more elaborate or expensive than they need to be (Lynch, 2017).

Overcoming such conflict is important because integrating design and manufacturing contributes to improved product quality, lower costs and a more rapid product development process (Kim and Kang, 2008).

Unsurprisingly, manufacturing is the true guardian of the technical perspective still prevailing in many mass production companies. Since the advent of the industrial economy, indeed, manufacturing's aim has remained simplifying the production process and thereby simplifying the product itself, to save time and money.

References

Calgren, L. (2009), *Early Involvement of Industrial Designers in Product Development. Exploring Motives and Challenges*. PhD Thesis, Chalmers University of Technology, Chalmers Reproservice, Göteborg.

Candi, M., Gemser, G. (2010), "An Agenda for Research on the Relationships Between Industrial Design and Performance". *International Journal of Design*, 4(3), 67-77.

Cooper, R.G. (1988), "The New Product Process: A Decision Guide for Management". *Journal of Marketing Management*, 3, 238-255.

Cooper, R.G. (1990), "Stage-Gate Systems: a New Tool for Managing New Products". *Business horizons*, 33(3), 44-54.

Cooper, R.G. (2008), "Perspective: The Stage-Gate Idea-to-Launch Process-Update, What's New, and Nexgen Systems". *Journal of Product Innovation Management,* 25(3), 213-232.

Cooper, R.G., Kleinschmidt, E.J. (1995), "Benchmarking the Firm's Critical Success Factors in New Product Development". *Journal of Product Innovation Management*, 12(5), 374-391.

Cooper R.G., Kleinschmidt E. J. (2001), "Stage-Gate Process for New Product Success". *Innovation Management*, 3.

Elmqvist, M. (2006), *Enabling Innovation: Exploring the Prerequisites for Innovative Concepts in R&D. Doctoral Thesis*, Chalmers University of Technology.

Khan, K.B., (ed.), (2005), *The PDMA Handbook of New Product Development*, 2nd edition, Wiley.

Khurana, A., Rosenthal S.R. (1997), "Integrating the Fuzzy Front End of New Product Development". *Sloan Management Review*, 38(2), 103-120.

Khurana, A., Rosenthal, S.R. (1998), "Towards Holistic Front Ends in New Product Development". *Journal of Production Innovation Management*, 15(1), 57-54.

Kim, B.Y., Kang, B.K. (2008), "Cross-functional cooperation with design teams in new product development". *International Journal of Design*, 2(3), 43-54.

Koen P., Ajamian G., Burkart R., Clamen A., Clamen, A., Davidson J., D'Amore R., Elkins C., Herald K., Incorvia M., Johnson A., Karol R., Seibert R., Slavejkov A., Wagner, K. (2001), "Providing Clarity and a Common Language to the Fuzzy Front End". *Research-Technology Management* 44(2), 46-55.

Kristensens T., Lojacono G. (2002), "Commissioning Design: Evidence from the Furniture Industry", *Technology Analysis & Strategic Management*, 14(1).

Linderman, K., Schroeder, R.G., Zaheer, S., Choo, A.S. (2003), "Six Sigma: a Goal-Theoretic Perspective". *Journal of Operations Management*, 21(2), 193-203.

Lynch, M. (2017). "Design vs. Manufacturing: Can We All Just Get Along?". In *Modern Machine Shop Magazine*. Retrieved December 30, 2017, from: www.mmsonline.com/columns/design-vs-manufacturing-can-we-all-just-get-along

McAloone T.C., Hansen P.K., Larsen J.H. (2004), "Images of Innovation: An Ontological Approach", *Proceedings of the 8th International Design Conference DESIGN 2004*, Dubrovnik, Croatia, 53-60.

Nobelius D., Trygg L. (2002), "Stop Chasing the Front End Process". *International Journal of Project Management,* 20 (5), 360-377.

O'Connor, P. (2005), "Implementing Product Development". *The PDMA Handbook of New Product Development*, *2nd edition*, Wiley, 59-72.

Perks, H., Cooper, R., Jones, C. (2005), "Characterizing the Role of Design in New Product Development: An Empirically Derived Taxonomy". *Journal of Product Innovation Management*, 22(2), 111-127.

Reid, S. E., De Brentani, U. (2004), "The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model". *Journal of Product Innovation Management,* 21(3), 170-184.

Reinertsen, D.G. (1999), "Taking the Fuzziness out of the Fuzzy Front End". *Research-Technology Management*, 42(6), 25-31.

Roberts, E.B. (1995), "Benchmarking the Strategic Management of Technology Π". *Research Technology Management*, 38(2), 18-26.

Roozenburg N.F.M., Eekels J. (1995), *Product Design: Fundamentals and Methods*, Wiley.

Turner, R. (2000), "Design and Business Who Calls the Shots?". *Design Management Review*, 11(4), 42-47.

Ulrich K.T., Eppinger S.D. (2000), *Product Design and Development*. McGraw-Hill.

Valeri, S.G., Santiago, M.P., Campello, A.D.C., Resende, H.B., Trabasso, L.G. (2003), "Implementation of the Phase Review Process in the New Product Development: A Successful Experience". In *DS 31: Proceedings of ICED 03, the 14th International Conference on Engineering Design*, Stockholm.

Veryzer, W.R., Mozota, B.B.D. (2005), "The Impact of User-Oriented Design on New Product Development: An Examination of Fundamental Relationships". *Journal of Product Innovation Management*, 22(2), 128-143.

von Stamm B. (2003), *Managing Innovation, Design and Creativity*, Wiley.

Zurlo, F., Cagliano, R., Simonelli, G., Verganti, R. (2002), *Innovare con il design*. Il Sole 24 Ore.

5. Protecting Intellectual Property

by Lucia Rampino

Intellectual property is a product of the mind and, as such, it is distinct from the common concept of property applied to tangible items such as buildings, vehicles and consumer goods in general. Such items can be purchased, becoming an individual's personal property, and the latter can decide to retain, lend or sell them. Tangible items can also be compared with similar items and their economic value assessed. Applying this to the intangible output of the human mind is difficult. Therefore, for many centuries, intellectual property rights were neither recognized nor protected by law. Whilst the earliest examples of patents date back to ancient Greece, and Filippo Brunelleschi was granted a three-year patent for a barge design, it was with early industrialization that intellectual property rights were systematically protected by the law in the West (Shippey, 2002).

The actual relationship between the setting up of a patent system in a country and its industrialization pace is a much debated issue. However, it can be said that intellectual property (IP) rights and industrialization have evolved together as two profoundly inter-connected concepts. And indeed, since the 1980s, it has been the pressure of advanced industrial economies, guided by the USA, that has fostered the adoption of more rigorous IP rights protection in developing countries (Chang, 2002). This was designed to protect Western manufacturing industries from imitation and reverse product engineering in these economies (MacLeod and Nuvolari, 2006).

But what is the rationale behind setting up a strict system of IP protection? The general aim is said to be to incentivize innovation while not inhibiting meaningful competition. Therefore, one of the most controversial issues is when the optimal balance between providing an incentive to create and making existing creations available for use by subsequent innovators is reached (Schickl, 2013). There is heated debate on this issue. On one hand, advocates for strong IP protection note that scientific discoveries and technological innovations, as well all literary and artistic work, are often difficult to create but easy to copy. In the absence of IP rights, they argue, imitators will thrive on the efforts of creators, inhibiting future investment in new inventions and artistic work (Raustiala and Sprigman, 2006). On the opposite side are the supporters of free knowledge circulation who point out that there is insufficient evidence of the positive effect of IP protection on innovation rates. Some go so far as to sustain that a complete lack of IP protection would favor innovation rather than hindering it:

> […] interestingly, some of the most innovative industries of the last forty years - software, computers, and semiconductors - have historically had weak patent protection and have experienced rapid imitation of their products (Moser, 2013).

To protect or not to protect IP rights? This is the issue at stake. The debate is today livelier than ever.

Design in general, and product design in particular, has played an important part in this debate, given the importance for many companies of protecting their original designs. But when it comes to classifying design with existing intellectual property tools, its subtle nature hinders legislators from giving it a sharp and definitive legal definition. And in fact, how can legislators possibly do something that the most prominent design scholars have not yet accomplished? As a result, throughout the developed world, different legal interpretations of what an 'original design' is and the proper tools to protect it, exist.

Industrialization and the Desire to Protect Ideas

In the age of the Industrial Revolution, intellectual property rights were increasingly respected. Britain, the country in which the Industrial Revolution began, had had a patent system since 1624. On this basis, a fertile scholarly tradition has argued that intellectual property rights protection played an important part in making Britain the cradle of industrialization: in this view, IP rights are an essential incentive encouraging creative people to invent.

> In the end, the Industrial Revolution was a set of technological improvements, a few large and dramatic, most mundane and incremental. Inventions needed incentives, and IPRs provided incentives for successful inventors (Mokyr, 2009, p. 349).

In general, the dissemination of innovative technical knowledge made it increasingly evident that protection was needed if inventors were to retain an economic advantage. This was manifest in the competition between companies as well as countries. In the earliest phase of industrialization, for instance, a lack of technical knowledge was a major obstacle for continental countries. To obtain the required knowledge, they could simply borrow British techniques and practices. The British tried to prevent this, prohibiting British artisans from leaving the country and forbidding machinery and machine part exports, especially for textile production. These rules were already in place in the first part of the eighteenth century but failed to prevent knowledge spreading: already, by 1825, there were at least two thousand skilled British mechanics on the continent and British equipment was also being sold abroad, both legally and illegally. If keeping knowledge secret can fail, the concept of IP protection via patents is a valid alternative. Patents are intended to disclose technical knowledge, the point being that, for a given amount of years, patent holders are the only people entitled to economically exploit the patented idea. The first 'literae patents' were, literary, «*documents that lie open*», i.e. made public. At a later date, the full content of patents was made available through patent offices.

The notion that patents were an essential part of an 'enlightened' economy had been established by eighteenth century economist Adam Smith. In Smith's view, patents were the price society had to pay for disclosures that were essential to the unrestrained dissemination of useful knowledge (Mokyr, 2009).

Although the British patent system is often described as having been well-established already at the beginning of the Industrial Revolution, until the reform of 1852 access to it was highly restricted due to tortuous application procedures. Charles Dickens ridiculed it in his brief novel *A Poor Man's Tale of a Patent*, the story of a provincial inventor who set off for London to obtain a patent, only to discover that the patent application process was expensive and frustrating. Moreover, many patents were infringed upon, and judges were often hostile to patentees, considering them monopolists (Mokyr, 2009). Therefore, the crucial role of an efficient patent system in the British Industrial Revolution is questionable.

In this regard, Mokyr (2009) has made an interesting point, arguing that what really mattered was not the actual working of the patent system but rather the way it was perceived. As long as a significant number of aspirant inventors believed they had a reasonable chance of becoming rich through their patents, an incentive system would function. And the economic success of a few famous people (for instance, James Watt), provided the evidence required, even if the odds were very low (similar to those of winning the lottery or becoming a millionaire football player today). Moreover, for Sullivan (1990), in the course of the eighteenth century the concept of invention underwent a significant change in perception: while at the beginning of the Industrial Revolution invention was seen as providence, by the end of the eighteenth century it was considered an outcome of human effort.

The British Industrial Revolution was thus characterized by the emergence of a class of inventors capable of exploiting their inventions economically through patent protection. MacLeod and Nuvolari (2006) have argued that these inventors constituted the backbone of a newborn ‘invention industry’ that was soon coupled with the emergence of a market focused on selling patent rights, licensing and establishing commercial partnerships for patent exploitation. In parallel, patents created a market in the legal and technical services required to trade and enforce them.

In developed countries, this extensive market in and over patents is more thriving than ever today.

A Varied Family of IP Tools

As we have seen, since the scientific revolution Western culture has been split into two main areas: the sciences and the arts[1]. In both areas, knowledge advancement is the result of intellectual creation. Therefore, legislators have set up IP protection tools for both these two areas. For scientists’ discoveries and engineers’ inventions, the established tool is the invention patent. For art work, on the other hand, the proper tool is copyright.

The duration of the protection granted by these two IP tools varies significantly: on average, a patent lasts twenty years while copyright protection lasts at least fifty years after the author’s death. Why such a significant difference? This is related to the different degree of social utility accorded by Western society to art and science. In simplified terms, a work of fine art, free from any utilitarian purpose, can be protected without doing much social damage whilst scientific knowledge, regarded as essential to technical progress, cannot be under economic monopoly for too long.

When deciding which IP tool to apply for when protecting a new design, the same old issue applies. Utility patents protect scientific discoveries and technological inventions; copyright protects works of art. Which of these tools best fits design? Unsurprisingly, a coherent and single track answer to the question is absent.

[1] This issue is analyzed in the first two chapters.

Protecting Technological Innovation through Patents

According to the World Intellectual Property Organization (WIPO), a patent is the exclusive right granted by a government to an inventor to manufacture, use or sell an invention for a certain number of years, usually twenty.

Patents are territorial rights. This means that specific legislation regulates the procedure for granting patents, the requirements placed on the patentee and the extent of the exclusive rights in all countries. Whilst differences can be significant, the patent concept arises from a common idea of innovation, typical of the technical perspective. The industrial economy is indeed dominated by a strong belief in the rational progress brought by science and technology. In this context, manufacturing companies identify innovation mainly by researching new technological solutions, the starting point being performance and/or product function improvement. And this is exactly what a patent is intended to protect: a novel, useful and non-obvious solution to a specific technological problem. Such solutions can take the form of new devices or new manufacturing processes. Patents are therefore widely used tools in intellectual property safeguards in goods manufacturing.

Patent statistics have traditionally been used as a measure of countries' inventivity. While such analysis benefits from relying on well-structured data, it is important to stress that patents are imperfect measurements of invention because: «*Not all inventions are patentable, not all inventions are patented and the inventions that are patented differ greatly in quality*» (Griliches, 1990, p. 1669).

Regarding the quality of patented ideas specifically, what proportion of patents are technically feasible and, of this restricted group, how many are commercially exploited? Mokyr (2009) recounts that, as early as 1869, the U.S. Commissioner of Patents suggested that only ten per cent of all patents granted had some commercial value. As confirmation of this, MacLeod *et al*. (2003) examined a sample of 2009 British steam engineering patents for the 1800-1900 period in detail, discovering that a significant eighteen percent of these were granted for perpetual motion machines or other non-technically feasible inventions.

Coming to product design, the 1883 Paris Convention was the first international treaty to regulate patents. Last revised in 1967, it directly addresses the protectability of industrial designs, stating that «*industrial designs shall be protected in all the countries of the Union*». However, the Convention does not regulate subject matter or the requirements or scope of protection, leaving product design IP rights undetermined (Schickl, 2013).

Protecting Works of Art via Copyright

Traditionally, copyright law aims to protect personal expression as incorporated in a creative work of art or literature in a tangible medium (Suthersanen, 2010). For WIPO, even if thoroughgoing lists of work covered by copyrights are not usually legislated for, these range from books, music, paintings, sculpture and films to computer programs, databases, advertisements, maps and technical drawings. The Berne Convention, effective since 1886, was the first major international copyright treaty.

Two types of rights are recognized by copyright: economic and moral. Widely recognized moral rights include the right to claim authorship of a work and the right to oppose changes to it. Most copyright laws recognize an author's economic right to authorize or prevent certain uses of a work or, in some cases, receive remuneration for use of work. Time limits apply to economic rights and these vary from nation to nation. Time limits in Berne Convention member states should be no longer than fifty years *post mortem auctoris*.

Product design is not specifically regulated by the Berne Convention but might fall under the concept of applied art mentioned, but not further defined, in the convention. Interestingly, however, the Berne Convention affirms that industrial design should be protected by copyright law in the event that the signatory state's laws make no mention of the form of protection applying to industrial design (Schickl, 2013).

In the USA, the long established doctrine known as the 'utilitarian doctrine' prohibits the extension of copyright protection to useful items. Therefore, while jewelry and purely ornamental designs have been granted copyright, such protection is almost impossible to obtain for industrial designs (Schickl, 2013).

In this regard, it can be said that U.S. copyright law wholly embraces the modern paradigm of art discussed in Chapter Two. In this paradigm, art objects are, by definition, non-utilitarian. It follows that useful objects cannot be considered truly artistic and therefore do not deserve the copyright protection applicable to art work. Interestingly, architecture is a significant exception to the rule:

> […] already in 1990 with the Architectural Works Copyright Protection Act, the Congress changed the application of the useful articles rule and extended copyright protection to "built" architecture (architectural designs embodied in actual buildings) (Beltrametti, 2010, p. 165).

In this case, too, architecture was granted exceptions to well-established cultural norms that design was excluded from[2].

Protecting Commercial Brands with Trademarks

Trademarks distinguish a firm's products on the market. Traditionally, they consist of a word or a combination of words, letters, and numbers. However, trademarks can also consist of drawings, symbols, three-dimensional features such as the shape and packaging of goods, non-visible signs such as sounds or fragrances and colors used as distinguishing features.

Registered trademarks can be used exclusively by owners or licensed to others for use in return for payment. Trademark registration terms vary but generally last ten years. They can be renewed indefinitely on payment of additional fees. Indeed, a company's right to protect its trademark is intended to last as long as the company survives on the market.

Recently, the EU introduced a three-dimensional EC trademark concept. Consequently, protecting designed objects as trademarks has become an attractive option for companies, since trademark validity has no time limits attached. However, obtaining trademark protection for designed objects is difficult since these must possess two traits: they must be 'distinctive' (i.e. a design must identify the goods it protects as originating from a particular source) and 'non-functional' (Schickl, 2013).

Both Lego and Bang&Olufsen applied for three-dimensional copyright protection for one of their iconic products, the red Lego brick and a loudspeaker. Both applications were rejected. The Lego brick was judged distinctive but did not satisfy the non-functional requirement[3]. Conversely, the shape of the B&O loudspeaker satisfied the non-functional requirement but was considered not sufficiently distinctive.

Defending the Multi-Faceted Value of Design

Design is not a science or a purely technological activity, therefore patents are not the right IP tool to protect it. However, in some cases, patents have been used to protect design objects[4]. At the same time, design is not a

[2] We are referring here to a failed attempt - discussed in Chapter 2 - by Gropius in founding the Bauhaus to claim the ancient unity of art and technology for design.

[3] The European Court of Justice interpreted it as a technical solution.

[4] A famous case is Thonet chairs although it was not the shape of the chairs which was patented but the specific process by which their legs were curved using steam.

fine art, therefore copyright is not the right way to protect it. However, copyright is sometimes used to safeguard design[5].

> Due to this natural ambiguity or hybrid nature of industrial design it is difficult to classify industrial design within existing intellectual property laws. […] Legislators have to decide whether industrial design can be sufficiently protected under copyright, trademark, unfair competition, and patent law, or whether sui generis protection is needed. The definition of industrial design is crucial for that decision. Unfortunately, legislators have not agreed on a generally applicable definition of 'industrial design' (Schickl, 2013, p. 17).

Design is indeed a third area of human-knowledge requiring appropriate IP tools. Such tools have been developed, in the form of design patents, though some significant national differences exist. Different jurisdictions classify industrial design differently. However classifications are essential to determining which international treaties cover industrial design protection (Suthersanen, 2010).

In traditional legal terms, design is identified as the external appearance of items. The U.S. Patent and Trademark Office uses a much stricter definition, interpreting it as «*the visual ornamental characteristics embodied in, or applied to, an article of manufacture*». EU legislation, on the other hand, defines design as the «*outward appearance of a product or part of it, resulting from the lines, contours, colors, shape, texture, materials and/or its ornamentation*». Thus, the appearance of a product that is legally defined as design in the EU does not necessarily constitute a design in U.S. legal terminology. This design definition difference is also reflected in the different forms of protection in each jurisdiction (Schickl, 2013).

EU Sui Generis Protection

Design protection has always played an important role in the EU. European Community Design Regulations came into force in 2002 introducing two kinds of protection: unregistered community design (UCD) and registered community design (RCD). Both provide designers with exclusive rights to use their designs commercially and take legal action and claim damages against those infringing their rights (Beltrametti, 2010).

UCD protection applies to all publicly available design within the EU. Public disclosure can take different forms: presentation at trade exhibitions and fairs or advertisements in various media and, of course, market availability. The UCD, as a tool specifically designed for the fashion industry,

[5] The American system extends copyright protection to design rights, i.e. fashion design items.

lasts for three years from first disclosure and only protects against deliberate copying with the main difficulty proving the existence of rights.

Applying for a RCD is straightforward and inexpensive requiring a single application in a single language and one fee payment for EU-wide protection. It lasts five years and can be renewed up to an additional four times granting maximum protection of twenty-five years (Beltrametti, 2010).

The European laws require design protection to refer to the appearance of a product and it can by no means extend to aspects solely dictated by a product's technical function. Design protection requires two elements: novelty and individual character. A design is new if no identical design has previously been made available to the public and it is considered to have individual character if the overall impression produced by it on an informed user[6] differs from the overall impression made by any design previously available to the public.

Disclosure of the design does not rule out design protection, as long as an application is filed within twelve months of disclosure. For the sake of rapid registration, the Office for Harmonization in the Internal Market does not examine novelty and individual character. Registration is only denied if the design is not covered by the design definition provided by the regulations or does not comply with public policy or morality. Protection requirements are only examined in the event of dispute in a civil court. Should the court find that a design was not eligible for protection, this is deemed to be invalid with retroactive effect. EC design registration can therefore be granted very rapidly, usually within eight weeks of an application being filed.

The US Patchwork of IP Tools

At first sight, U.S., like E.U., legislation would seem to provide a *sui generis* form of protection for designs. A more in-depth analysis, however, shows that design patents are part of the statute and institutional apparatus which encompasses the utility patent system (Dinwoodie, 2008). This is not without consequences for design.

Under design patent law, a design is eligible for protection if it is new, non-obvious, original, ornamental and used for a manufacturing product. Novelty and non-obviousness standards derive from those used for utility patents. The originality threshold is similar to that of copyright law: any

[6] The regulations do not define 'informed user'. In the PepsiCo case, the court established that informed users are better informed than average consumers but are not sector experts in patent law. Informed users know the various designs which exist in a given sector and the features those designs normally include.

design that is not simply copied is considered original. Furthermore, applicants must show that the design for which protection is sought is ornamental, i.e. non-functional. For the majority of designed objects, this is a tricky requirement.

The design patent application examination process, the responsibility of the U.S. Patent and Trademark Office, can take up to eighteen months. This is too long for many fast-paced industries such as fashion for which copyright and trademark are attractive alternatives.

In general, design patents give owners the right to prevent others from making, using or selling products that resemble patented products to such an extent that an 'ordinary observer' might confuse the two. However, several scholars have argued that the U.S. design patent system has never fully fulfilled its promise to protect designs because it is too expensive and time consuming and its protection thresholds, intentionally linked to the thresholds used for utility patent grants, are too high (Dinwoodie, 2008). Furthermore, as compared to copyright (seventy years *post mortem auctoris*) and trademark protection terms (indefinite), the fourteen years granted design patents seems short (Schickl, 2013). Taken together these variables led to very few producers applying for design patents for many years. And those who did frequently had their patents invalidated by the courts. The situation improved somewhat with the creation of the specialist patent appeal court in 1982 (Dinwoodie, 2008).

Nowadays, three major paths are taken by U.S. companies when protecting their designs: copyright, trademark and patent design law. However, although industrial designs can theoretically be protected under all these IP tools, the major threshold remains the non-functionality requirement presently required by all of them. A product's functional elements, where present, are eligible solely for utility patent protection. The rationale behind the functionality doctrine is clear: true art must be detached from utility. But, as we know, design is not true art.

Apple versus Samsung: the Design Patent War

The battle began soundlessly at the end of 2010 when Apple claimed that Samsung smartphones and tablets infringed a number of Apple patents. Apple at first proposed a licensing deal in which Samsung would pay Apple up to 30 dollars per smartphone and 40 dollars per tablet but Samsung declined the proposal. Apple thus sued Samsung, claiming that the latter had 'slavishly' copied its product designs. Samsung immediately counterclaimed over 3G technology patents and expanded the battle internationally, filing claims against Apple in Japan, Germany and South Korea. The disputes then expanded to more than fifty lawsuits in numerous courts around the world, becoming a global patent war (Saardchom, 2014).

In the first lawsuit, Apple alleged that Samsung infringed four utility patents, four design patents and three trademark rights. Despite the number and variety of IP rights under discussion, the heart of the dispute was a 2005 design patent, consisting of a one-sentence claim regarding the ornamental design of an electronic device with a rectangular front face and rounded edges. Another point at stake was a grid of colorful icons on a black screen. Apple argued vigorously that the overall visual impression of the Samsung tablets and smartphones at issue were similar to its patented designs (Carani, 2013). Conversely, Samsung focused on differences in detail, but their defense was unsuccessful: for U.S. design patent law, indeed, detail is *not* supreme since it is an ordinary observer's overall impression that counts.

In August 2012, an American jury returned a largely pro-Apple verdict sentencing Samsung to payment of an around one billion dollar fine. The decision was widely criticized and caused controversy over the potential unintended consequences for consumers and the smartphone industry. Additional concerns were inadequate jury member expertise for such a complex patent case (Saardchom, 2014).

But this was just the beginning of a never-ending court case. In two subsequent verdicts, the fine was reduced to 548 million and then again to 399 million dollars. Then, doubt was cast on the way damages had been calculated. Samsung would initially have had to pay Apple a percentage of each 'copied' smartphone sale, but they argued that this was outdated: since a smartphone is packed with thousands of patented components, infringing design patents should not amount to total smartphone profits. Apple countered that it is actually overall design that sells phones. In March 2016, the case was taken to the U.S. Supreme Court[7] which ruled that Samsung only need pay damages on the copied components, not necessarily on the entire product[8]. The trial has since returned to the U.S. District Court in Northern California where it began. Recently, a five-day retrial was scheduled for May 2018. It is likely that the amount Samsung has to pay will be reduced once more.

Meanwhile, a second U.S. trial, mostly focused on different patents and dissimilar products, began in early 2014. In it Apple demanded roughly two

[7] This is the first time the Supreme Court has examined a design patent case since the eighteenth century.

[8] This ruling has reshaped the value of design, and the sums payable by one company copying the appearance of a competitor's product. Prior to the ruling, under U.S. law an award could be collected on the entire profits of a device which infringed the law.

billion dollars in damages, but the jury decided that the companies had both infringed each other's patents and ordered them to pay damages.

In other countries, the outcome of the design war was slightly different. In August 2011, a German court barred Samsung from selling its Galaxy Tab 10 device in all European countries. After Samsung's allegations of evidence tampering were heard, the court rescinded the EU-wide injunction and restricted it to the German market. Notably, in the UK Samsung applied to the High Court of Justice for a declaration that its Galaxy tablets did not especially resemble Apple's products. Apple counterclaimed, but Samsung won: the court judged Samsung's tablets less 'cool' than Apple iPads. Therefore, Apple had to post a public apology stating that Samsung had not copied its designs. Samsung also won rulings in South Korea and Japan.

The Apple-Samsung battle has been going on for over seven years now, prompting hundreds of comments on a range of aspects. Apple made sure it protected designs with as many layers of intellectual property rights as possible: design patents, utility patents and trademarks[9]. What turned out to be the most effective IP tools? The answers are different in each case and jurisdiction.

> Their common denominator is that legislators and courts see the need to offer protection for industrial design. But especially when it comes to simplistic design having little or no ornamentation, there is a lot of controversy as to whether and under which intellectual property laws protection can be granted (Schickl, 2013, p. 18).

In general, Apple is one of the world's leading global design driven companies and it has therefore carefully worked to shape a world in which design IP rights can effectively be defended in court. Its efforts would seem to have been fruitful. Apple has been generally successful against Samsung in court, with the majority of rulings and court decisions going in its favor. However, Apple has not managed to get Samsung's key products banned in major markets and the latter's fine payments are still being discussed. To date, the only significant result in this case has been a never-ending court case and international litigation that risks acting as a drain on Apple too (Duncan, 2014).

[9] In this regard, in May 2015 the U.S. Court of Appeals for the Federal Circuit in Washington ruled that the iPhone's appearance could not be trademarked.

The Dissemination of Piracy and Counterfeiting: The Fashion Industry

Fashion is one of the world's most important creative industries, and one in which counterfeiting and design piracy are two well-known phenomena. Counterfeiting involves the use of fake trademarks on non-original merchandise, i.e. on clothes and fashion accessories such as bags and sunglasses. Piracy means taking an original design and replicating it in such a way that nobody notices the difference. Therefore, piracy and counterfeiting are interrelated and both involve illicit imitations (Beltrametti, 2010).

Long before the digital revolution enabled music and movies to be downloaded, the Industrial Revolution enabled high fashion garments to be copied easily. Nineteenth century French couturiers were already being targeted by competitors who made sketches at shows and then used local labor to make copies (Hemphill and Suk, 2008). Today, sophisticated counterfeiting strategies operate globally: the widespread use of scanners, laser copiers and the Internet enables counterfeiters and pirates to copy and manufacture products seen on catwalks even before the original items are launched on the market. As a result, thousands of inexpensive copies of new designs can be produced in a few weeks. Design piracy can be efficient and profitable especially in developing countries (Beltrametti, 2010).

The piracy problem mainly relates to small fashion design firms faced with aggressive competition from some notorious fast fashion brands competing in their same market segments, such as Forever 21. On the other hand, luxury fashion brands are well protected by trademark legislation, and also by the relatively small overlap between markets for the original and for the copy (Hemphill and Suk, 2008).

For the International Anti-Counterfeiting Coalition[10], counterfeit goods make up around six percent of world trade. The overwhelming majority of counterfeit goods are manufactured in a small number of countries before being distributed across the global marketplace.

There have been several responses to this global problem. For example, international customs cooperation measures stop counterfeit goods at national borders and the advent of the World Trade Organization (WTO), together with the implementation of its Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), has forced many countries to recognize intellectual property rights (Beltrametti, 2010).

[10] Formed in 1979, the International AntiCounterfeiting Coalition Inc., (IACC) is a Washington D.C.-based non-profit organization devoted to combating product counterfeiting and piracy. The IACC is made up of a business and industry cross-section ranging from cars to clothing, luxury goods and pharmaceuticals to food, software and entertainment.

The Flip Side of the Coin: Free and Shared Knowledge

Since the first establishment of an IP system in Western countries, a question has arisen: are IP tools a «*necessary evil we must put up with to enjoy the fruits of invention and creativity*» or are they simply «*unnecessary evils*?» (Azzarelli, 2009, p. 131).

Mokyr (2009) has argued that a growing conviction that monopolies of all types, however temporary, were bad developed in the eighteenth century. It was recognized that patents could be used strategically to block research by non-patentees, thus actually slowing down innovation, as the classic example of James Watt blocking the development of high-pressure engines attests. Indeed, after the Watt patent expired, more efficient engine production increased (Azzarelli, 2009). There was also a moral sense that inventors, like scientists, were serving the public good and should be rewarded by honors and sponsorship, not necessarily by financial rewards related to IP rights (Mokyr, 2009). As a demonstration of this, very little of the technical knowledge developed in the engineering of bridges, tunnels, cuttings, embankments and so on is reflected in the patent records. Rather, civil engineers tended to share and publish their solutions, partly with a view to increasing their professional reputations (MacLeod and Nuvolari, 2006).

The point made by Boldrin and Levine in their 2008 book *Against Intellectual Monopoly* is that IP rights usually play a limited role in the early stages of new inventions, playing a significant part only when the pace of innovation has slowed. These two authors argue that this demonstrates that patents do not encourage novel discoveries, but simply protect the status-quo sometimes to the detriment of society at large. In the agricultural sector, for instance, the protection of seed varieties through patents held by U.S. corporations has forced poor farmers in under-developed countries to pay licenses in order to earn a livelihood. Therefore, Boldrin and Levine have called for a gradual reform of the IP rights system with the ultimate goal of its complete dismantling: markets can function, and function even better, without intellectual monopolies (Azzarelli, 2009).

As we have seen, critiques such as these of IP rights are neither new nor isolated. Innovation can thrive without inventors needing to claim intellectual rights as is well demonstrated by ‘collective invention’, a phenomenon that was already present at the beginning of the Industrial Revolution (Allen, 1983).

Collective Invention in Early Industrialization

Recent research is increasingly drawing attention to the critical importance of collective invention frameworks in which competing firms freely release technical information on the details of the technologies they have just introduced to one another (MacLeod and Nuvolari, 2006). Allen (1983) has noticed this type of behavior in the UK Cleveland district of the second half of the nineteenth century, where iron producers freely disclosed the construction details and performance of the blast furnaces they had made to their competitors. Additionally, new technical knowledge was usually not patent-protected with the result that competing firms could liberally make use of public domain information when they came to build a new plant. As a consequence of this knowledge sharing, furnace height and blast temperature increased thanks to a series of small but continuous improvements.

MacLeod and Nuvolari (2006) have argued that it is important not to dismiss cases of collective invention as 'curious exceptions'. It is worth stressing that the key-technologies at the heart of the onset of industrialization such as high pressure steam engines, steamboats, iron production techniques and so on were at times developed collectively and consequently not covered by the patent system. For Mokyr (2009) technical knowledge was shared on an even much larger scale than the available cases of collective invention would suggest. At the technical committees of the Society of Arts, for instance, people shared ideas and 'sharpened minds' with others engaged in similar occupations.

As we have seen, from the early Industrial Revolution onwards, it has been strongly argued by some that innovation and creation prosper in a setting in which all (and not just technical) knowledge is freely disclosed and innovators can build on other ideas. This is the case, for instance, with today's open-source movements in the software and hardware computer industries.

References

Allen, R.C. (1983), "Collective Invention", *Journal of Economic Behavior and Organization*, 4, 1-24.

Azzarelli, S. (2009), "Review of the Book by Michele Boldrin & David K. Levine, *Against Intellectual Monopoly"*. In *Syracuse Science &Technology Law Reporter*. 2, 130-145.

Beltrametti, S. (2010), "Evaluation of the Design Piracy Prohibition Act: Is the Cure Worse than the Disease? An Analogy with Counterfeiting and a Comparison with the Protection Available in the European Community". *Nw. J. Tech. & Intell. Prop.*, 8, 147.

Carani, C.V. (2013), *Apple v. Samsung, Design Patents Take Center Stage*. Landside, 5. Retrieved January 6, 2018, from www.mcandrews-ip.com/files/Carani%20-%20Landslide%20-%20Center%20Stage%20-%20Jan-Feb%202013.pdf

Chang, H.J. (2002), *Kicking Away the Ladder: Development Strategy in Historical Perspective*. Anthem Press.

Dinwoodie, G. (2008), "The Protection of Designs under U.S. Law". *IPRinfo* 04/2008.

Duncan, G. (2014), "Why are Apple and Samsung Throwing Down? A Timeline of the Biggest Fight in Tech". In *Digital Trends*. Retrieved January 6, 2018 from https://www.digitaltrends.com/mobile/apple-vs-samsung-patent-war-timeline/

Giblin, R. (2017), "Reimagining Copyright's Duration". In Giblin, R., and Weatherall, K. (ed.), *What If We Could Reimagine Copyright?,* ANU Press.

Griliches, Z. (1990), "Patent Statistics as Economic Indicators: a Survey (No. w3301)". In *Journal of Economic Literature*, Vol. XXVIII, 1661-1707.

Hemphill, C.S., Suk, J. (2008), "The Law, Culture, and Economics of Fashion". *Stan. L. Rev.,* 61, 1147.

Lerner, J. (2002), "150 Years of Patent Protection". *American Economic Review*, 92(2), 221-225.

MacLeod, C., Nuvolari, A. (2006), *Inventive Activities, Patents and Early Industrialization. A Synthesis of Research Issues*. Retrieved on January 3, 2018, from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.442.5813&rep=rep1&type=pdf

MacLeod, C., Tann, J., Andrew J., Stein, J. (2003), "Evaluating Inventive Activity: the Cost of Nineteenth Century UK Patents and the Fallibility of Renewal Data". *Economic History Review*, 56, 537-562.

Mokyr, J. (2009), "Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth". *The American Economic Review*, 99(2), 349-355.

Moser, P. (2007), "Why Don't Inventors Patent?" *NBER Working Papers*. (No. w13294). National Bureau of Economic Research.

Moser, P. (2013), "Patents and Innovation: Evidence from Economic History". *The Journal of Economic Perspectives*, 27(1), 23-44.

Mullin, J. (2017), "After Supreme Court Detour, Apple v. Samsung Goes to a Fourth Jury Trial". In *ArsTechnica*. Retrieved January 6, 2018, from https://arstechnica.com/tech-policy/2017/10/after-supreme-court-detour-apple-v-samsung-goes-to-a-fourth-jury-trial/

Phillips, M. (2013), "Apple vs. Samsung: A Patent War with Few Winners". In *The Newyorker*. Retrieved January 6, 2018, from https://www.newyorker.com/tech/elements/apple-vs-samsung-a-patent-war-with-few-winners

Raustiala, K., Sprigman, C. (2006), "The Piracy Paradox: Innovation and Intellectual Property in Fashion Design". *Virginia Law Review*, 1687-1777.

Saardchom, N. (2014), "Design Patent War: Apple versus Samsung". *South Asian Journal of Business and Management Cases*, 3(2), 221-228.
Schickl, L. (2013), "Protection of Industrial Design in the United States and in the EU: Different Concepts or Different Labels?", *The Journal of World Intellectual Property*, 16, 15-38.
Shippey, K.C. (2002), *International Intellectual Property Rights*. World Trade Press.
Sullivan, R.J. (1990), "The Revolution of Ideas: Widespread Patenting and Invention During the English Industrial Revolution". *The Journal of Economic History*, 50(2), 349-362.
Suthersanen, U. (2010), *Design Law: European Union and United States of America*, 2nd edition. Sweet and Maxwell.

The Human Perspective

If design used to be a matter of physical form, its subject the material object, it now increasingly seems to be about the user and her experiences.

Redström, J. (2006), "Towards User Design? On the Shift from Object to User as the Subject of Design". *Design Studies*, 27(2), 123-139.

6. Product Design in the Experience Economy

by Lucia Rampino

In the experience economy, a Western market full of similar mass-manufactured goods casts doubt on standardization and begins looking for targeted products responding to personal requirements and desires. In the early 1980s, cult objects appeared and lifestyle brands emerged, while new design consultancies boomed all over the developed world:

> The media and business worlds saw design as a placebo for all ills. Brands were frequently associated with design and the designer label. The origins of well-known current designs, such as Alessi or Gucci and Ralph Lauren, can be traced to this decade (Perks, Cooper and Jones, 2005, p. 112).

The eighties can thus be labelled the 'Designer Decade'. At the same time, a substantial shift in focus from products to users took place in design. Users and their experiences became the main concern of the design process: it was the rise of a new human perspective.

> It is now becoming clear, in view of the large number of award-winning designs that have failed the test of use, that the design community's criteria for successful design differs radically from that of design users. Design itself needs to be redefined in terms of peoples' experiences, instead of in terms of objects. This static geometrical criteria of the design of the industrial era must be abandoned in favor of a focus on the dynamic, multisensory experiences of design users (Mitchell, 1993, cited in Redström, 2006, p. 126).

Referring to Bürdek (2005), it can be said that throughout the twentieth-century design was marked by two opposing tendencies: mass-production and standardization on one hand, with a strong product-centered focus, expression of artistic individuality on the other, and a parallel shift towards user-centered design.

The term experience economy was first introduced into everyday language by the success of the 1999 book *The Experience Economy* by Pine and Gilmore. Here, the authors theorized a shift from a service-based economy to an experience-based one in which the goal of consumption is not simply owning a product but using products for memorable experiences. According to the two authors, this shift from ownership to experience is an integral part of a wider trend which they define 'individualization':

> In fact, the megatrend that incorporates both mass customization and the experience economy is best summed up as 'individualization' – creating more and more value for individuals by getting closer and closer to what each individual truly wants and needs (Pine and Gilmore, 2013, p. 33).

Individualization emerged in a special decade, the sixties, that had a wide ranging impact on many aspects of Western social and cultural life.

Sixties Emancipation

The sixties were a distinctive decade in Western history, one in which a profound cultural shift took place:

> […] there was a self-contained period (though no period is hermetically sealed), commonly known as `the sixties', of outstanding historical significance in that what happened during this period transformed social and cultural developments for the rest of the century (Marwick, 2011).

Prior to the sixties, cultural milieus were much more restrictive than they are today and people did not expect their social status to change over their lifetimes. Individual life choices and behaviors were still largely dictated by family, state and church. In the sixties, respect for social conventions began to be questioned: the growing dissemination of wealth generated by capitalism empowered a growing number of more highly educated people with a greater awareness of their social condition and rights. As a consequence, many emancipation movements and demands for individual expression sprang up across the West (Gardien *et al.*, 2014).

Younger generations felt no obligation to follow the rules of bourgeois morality which they viewed as hypocritical. They started to protest against such rules and the institutions which represented them. In both North America and Europe student activists were radicalized, occupying college campuses, parks and other public places and organizing anti-Vietnam war demonstrations. The most extreme even made bombs and set campus buildings on fire (History.com staff, 2010).

At the same time, young, socially subordinate women began fighting for their rights. The female image began to shift from good wives and mothers to single, carefree girls proud of their sexuality and confident of their power. Consequently, numbers of women attending university and entering the workforce increased in the sixties. Women's participation in the paid labor force has since increased: in the United States, from about fourteen percent in 1940 to sixty percent in 1990 (De Vries, 1994). Miniskirts were the icons of this growing women's movement. According to Laurent Cotta, a fashion historian:

> A miniskirt was a way of rebelling. It stood for sensuality and sex. Wearing one was a sure-fire way of upsetting your parents (cited in Taix, 2014).

In the mid-sixties, 'black power' became the focus of the civil rights movement in North America: Martin Luther King was the symbol of non-violent protest aimed at obtaining equal rights for black people. An important milestone was achieved in 1964 with the Civil Rights Act which outlawed discrimination based on race, color, religion, sex or national origins. It also prohibited the unequal application of voter registration requirements and racial segregation in schools, at work and in public areas. The follow-up to the Civil Rights Act was the 1968 Fair Housing Act which prohibited discrimination in house sale or rental.

As the decade wore on, this counterculture became less politically engaged and more eccentric, fueled by pop-music, new tastes and new social norms. The so-called hippies grew their hair long and preached peace and free love. At the same time, new cultural forms and a dynamic subculture celebrating experimentation and other alternative lifestyles, emerged (History.com staff, 2010).

The events of this decade radically changed Western society forever. Was it for good or for bad? The debate is still going on:

> For some it is a golden age, for others a time when the old secure framework of morality, authority, and discipline disintegrated. In the eyes of the far left, it is the era when revolution was at hand, only to be betrayed by the feebleness of the faithful and the trickery of the enemy; to the radical right, an era of subversion and moral turpitude (Marwick, 2011).

Counterculture Shapes the Future

The Summer of Love was a 1967 social phenomenon in which a large number of young people, mostly hippies, converged in San Francisco from all over the USA and beyond. Very few were interested in politics; most were more concerned with art (music, painting and poetry in particular) or spirituality and meditation (The Observer, 2007).

This embracing of creativity was especially notable in music bands, such as the Beatles, and filmmakers whose work was far less restricted by censorship (Cantoral, 2015). Many other creative artists, authors and thinkers, within and across many disciplines, helped define the counterculture movement.

Renowned Italian designer Ettore Sottsass, an exponent of socially critical design for many decades, drew important inspiration for new design trends from his American counterculture contacts (Bürdek, 1995). At the end of the sixties he declared that design is:

> a way to discuss about society, politics, erotism, food and even design. In the end, it is a way to build a possible figurative utopia, a metaphor of life (Antonelli, 2011).

It was not, however, simply a matter of popular arts and design. While the hippie counterculture spread from San Francisco throughout the USA, a group of people were also «*straddling the worlds of the communes and computers*» (Needham, 2016) and willing to change the world through technology. At Stanford University, scientists and engineers worked on the personal computing developments that laid the foundations for Silicon Valley. In 1968 Douglas Englebart made the first public demonstration of a computer mouse and followed this with the first teleconferencing, word processing and interactive computing (Cadwalladr, 2013).

Several successful Silicon Valley companies (e.g. Xerox and Apple) were founded by American counterculture figures. The most forward-thinking and idealistic of these believed that these technologies could potentially usher in a new world in which information could be shared and barriers of geography, race and class overcome (Markoff, 2005; Turner, 2005). One of these was Stewart Brand, the creator of the *Whole Earth Catalog*, a publication which many now see as a precursor of the web.

The Catalog was simultaneously a how-to manual, a literary review and an opinionated life guide offering an integrated, challenging, and comprehensive worldview. It was a thought-provoking and inspiring publication which influenced a generation of young Americans. One of these was Steve Jobs who defined it "one of the bibles of my generation". Jobs's famous message to Stanford's students, "Stay Hungry. Stay Foolish", was Steve Jobs's tribute to the Whole Earth Catalog: this motto was printed on the back cover of its final issue.

Postmodernism in Art

The term Postmodernism is widely used to describe the critiques of traditional values and politically conservative assumptions that took place in Western culture from the sixties onwards. The term was coined in the late 1970s by American literary critics in reference to a generation of writers whose work made powerful use of irony ("Postmoderno", Enciclopedia Garzanti di Filosofia). According to Bertens (1995, p. 22), the earliest Postmodernists were «*early contestants in a struggle over the heritage of the Enlightenment that still dominates our intellectual agenda*».

Postmodernism challenged the notion, typical of neo-positivist science, of universal certainties and reliable truths. Bertens (1995) argued that if there is a common denominator to all the different forms taken by Postmodernism in Western culture, it is that of a crisis in representation, a loss of faith in our ability to represent the real:

> No matter whether they are aesthetic, epistemological, moral, or political in nature, the representations that we used to rely on can no longer be taken for granted (Bertens, 1995, p. 10).

While the Modernists advocated rationality and simplicity in art, Postmodernism embraced complex, often contradictory layers of meaning. Postmodern art upholds the notion that individual experience should be paid more attention than abstract principles:

> It is to the naive and primitive enjoyment of sensations and things for their own sakes that these artists seek to return. We must rediscover the reality and excitement of a sound as such, a color as such, and existence itself as such (Meyer, 1963, p. 175).

Nietzsche in *The Birth of Tragedy* (1872) anticipated many Postmodern concepts, presenting Greek tragedy as a synthesis of natural art impulses represented by gods Apollo and Dionysus. Apollo was the god of beautiful forms while Dionysus was the god of insanity. While Greek tragedy combined these two impulses, modern logic and science were built upon Apollonian representations that have become frozen and lifeless. Therefore, Nietzsche claimed that it was only by returning to Dionysian art impulses that modern society could be saved from sterility and nihilism. As we have seen, this interpretation presages postmodern concepts of art (Aylesworth, 2005).

Another distinctive feature of Postmodernism is denial of the modern fine art paradigm: Postmodern artists refute the distinction between high culture and popular culture, art and everyday life, frequently combining different artistic and popular styles and media ('Postmodernism', Tate). Consequently, in the 1970s, a commercialized version of Postmodernism began to flood the market in the form of rock videos and television commercials.

Postmodern Architecture

Right from the start of the debate, Postmodernism was a particularly unstable concept. For Bertens (1995), the only widely accepted definition of Postmodernism is to be found in the architecture field. Here, Postmodernism is a marked breakaway from the Modernists with their belief in progress and appreciation of the new and original. Postmodern architects fostered a revitalization of historical linguistic traditions and an ironic return to the styles of the past. This resulted in great compositional freedom in buildings and a return to decorative richness.

Postmodern architecture had its own specific character in North America where it was enriched by contact with all those phenomena (e.g. kitsch, advertising, comics, and metropolitan landscapes) which had previously inspired Pop Art. A renewed relationship with local traditions and building codes was the result, in opposition to Modernist language standardization ('Postmoderno', Enciclopedia Garzanti di Architettura). The Bauhaus vision and its later evolution into International Style were identified by postmodern architects as the enemy (Bertens, 1995).

Postmodern architecture was the brainchild of Robert Venturi who, in *Learning from Las Vegas* (1972, with Scott Brown and Steven Izenour), proposed mixing Pop Art with the classical repertoire and combining the whole with the vitality of the Las Vegas scenario. This contamination of different styles and languages was later typical of Postmodernism.

In contrast to Venturi's ironic style, Charles Moore, another influential Postmodern architect, preferred popular affabulation. His Piazza d'Italia in New Orleans represents the triumph of kitsch in the history of contemporary architecture. Here, the shift from International Style could not be more evident: from a simple and rational language to an eclectic, ornate one, borrowing from a wide range of styles from the past (Postmoderno, Enciclopedia Garzanti di Architettura).

Postmodern Design

Postmodernism's influence reached product design with a significant timelag. In the sixties, German designers were accused by architect Werner Nehls of still being trapped in the ideas of the Bauhaus and the Ulm School of Design (Bürdek, 1995, p. 62).

Italy was the first country in which Postmodernism impacted on design. In the mid-sixties, a number of Italian design groups appeared on the scene which were involved in left-wing political movements, particularly in Florence and Milan. The period in which these groups formed coincided with the American hippie movement. These design groups did the groundwork for 1980s Postmodern design. In the early eighties, a group of Italian designers (among them Michele De Lucchi, Ettore Sottsass, Matteo Thun, Alessandro Mendini and Andrea Branzi) grouped together under the name *Memphis* and advocated a new colorful, decorative and ironic design language. Finally released from functionalism's rational aesthetic, this language determined the end of the uniform design interpretation that had dominated the European design scene since the founding of Bauhaus (Bürdek, 1995).

Life-styles and Brands

In postmodern society, brands become a noticeable ingredient in consumer culture's sign system, part of a consumer's identity, indicating a self-appointed claim to a certain status in the social system (Carducci, 2006). Goods have always had cultural significance as communication media in their own right (Douglas and Isherwood, 1979). Indeed, consumption is not simply an economic phenomenon but a cultural one as well: it has as much to do with meaning, value and communication as it has to do with trading, prices and economic relations (Lury, 1996).

For Holt (cited in Carducci, 2006) Postmodern consumer culture was born in 1960s counterculture, when consumption was first regarded as an activity via which identity could be constructed autonomously, and therefore 'authentically'. Brands that were perceived as more authentic began to prevail.

> In the 1970s, for example, Nike captured the running shoe market by embracing a brand positioning of 'authentic athletic performance', gaining legitimacy first and foremost by the fact that all of the company's principals were runners, including one who had coached the 1964 USA Olympics men's track team (Carducci, 2006, p.121).

A key aspect of branding is market segmentation which divides mass markets up into smaller market segments defined by specific tastes and orientations and each to be sold different products, or the same product in a totally different way (Cohen, 2004). As Pierre Martineau argued in a pioneering article in 1958, a member of a market segment is

> profoundly different in his mode of thinking and his way of handling the world. […] Where he buys and what he buys will differ not only by economics but in symbolic value (Martineau 1958, pp. 122-123).

To better differentiate themselves from the multitude of competitors, companies started creating products which were more relevant to the desires of specific market niches. This meant differentiating goods and services and associating them with a recognizable brand, thereby increasing both value and price (Pine and Gilmore, 2013). In the 1980s, this led to a shift in focus from efficiency (a typical industrial economy value) to comfort and even luxury.

In the experience economy, therefore, consumer identities also derive from specific brand affiliations and niche interests. In acquiring branded products, people identify themselves with the values attached to the brands chosen. To exploit this market opportunity, brands began repeatedly renewing product styling. This caused a shift from delivering durable products - as in the industrial economy - to a branded disposable society, ruled by the need for constant renewal to fuel consumption (Brand and Rocchi, 2011). In this scenario, product design acquires greater relevance:

> Through products we communicate with other people, define ourselves in social groups, and thus mark out our individual place in society. In other words, design is a sign of the times (Bürdek, 2005, p. 11).

A good example of the shift from commodities to branded experiences, discussed by Pine and Gilmore (1999), is the coffee market. Coffee beans are a commodity while packaged coffee is a good. For instance, the Italian brand Illy, which manufactures and sells both packaged coffee and coffee machines, offers goods. At the next stage we find brewed coffee, i.e. a typical service product. People can access such services at any Italian bar, simply ordering and drinking coffee. It was, in fact, a 1983 trip to Italy that inspired the creation of a store-chain intended to bring the Italian coffeehouse experience to the United States. We are of course talking about Starbucks, the classic branded experience: not only does Starbucks give its clients a cup of brewed coffee, it also provides them with a comfortable couch to sit on and a free Wi-Fi connection making Starbucks a place where people are willing to spend time.

An up-to-date coffee-drinking experience is Nespresso's. The experience offered is coffee capsules sold in packaging resembling that of haute-patisserie, a full range of trendy coffee machines, numerous coffee boutiques worldwide and a life-style magazine. It is a compelling example of what we will look at in the next section: the total touchpoint approach.

Designing the User Experience

As we have seen, a typical postmodern experience economy phenomenon is the creation of recognizable brands. For companies, brands are a tool with which to mark out their products in a market saturated with lookalikes. But how do brands create value for their users in design terms?

First of all, companies have to design recognizable logos which are unmistakable to users. Nike, Apple, Warner Bros, Toyota and BMW's logos, to cite just a few, all have a strong visual identity.

But designing a recognizable logo is just the first step. Perception of a brand identity is the sum of all the possible touch points[1] between users and brands. When a brand manufactures a product, touch points include the product's advertising, sale-points and product display in it, the product itself with its packaging, the experience of using it, and potentially interaction with post-sales customer support.

The experience economy thus led to a segmentation of design practice and a demand for a new breed of designer whose skills extend beyond objects, shaping the total user experience in a coherent brand identity at different touch points (Gardien *et al.*, 2014).

The pre-purchase experience becomes the field of expertise of graphic and communication design; the purchase experience is the interior and retail design arena; the product experience is the realm of packaging, product and interaction design; the post-purchase experience is the sphere of service design.

All of these need coordinating by a design manager who takes care of all design aspects in the corporate context. In the 1980s a small group of business economists realized that the economic impact of design could be an important one for companies (Bürdek, 2005). The two pioneers were

[1] A touch point is any occasion at which users are aware of a specific brand: noticing an advertising campaign or browsing a company website, going into a mono-brand store and calling a customer support service.

Kotler and Rath (1984, p. 16), who famously argued that: «*design is a strategic tool that companies can use to gain a sustainable competitive advantage»*. This gave design management a considerable boost, fostered by the U.S. Design Management Institute to a considerable extent.

Of course, from a product design point of view, the experience of using a product is a crucial one. It is indeed by interacting with products that users decide whether or not to remain loyal to a given brand. In recent years, the User Experience concept (UX) has become central to several fields, not just design but also architecture and human-computer interaction. The concept was first introduced by Norman, Miller and Henderson in a 1995 article. Here they argued that designing an interactive product requires much more than an exclusive focus on usability attributes (i.e. ease of use, efficacy, effectiveness). Designers must take into account the whole user experience, including their emotional and contextual needs (Gaggioli, 2016).

The demand for differentiated design skills and the increasing importance of user experience has led to a change in design methods and tools.

> […] executives and managers in various enterprises – for-profit businesses, non-profit charities, tourism bureaus, ad agencies, healthcare systems, colleges and universities, political campaigns, and even churches – saw experiences as an untapped means to differentiate. As a result, certain research methods and innovation methodologies – ethnography, design thinking, improvisation skills – that had been largely neglected for decades suddenly found a groundswell of interest (Pine and Gilmore, 2013, p. 21).

Design thinking has thus become a buzzword and we are witnessing the ubiquitous adoption of user-centered design methods. Given their importance for the design discourse, we will discuss these issues thoroughly in the next two chapters.

References

Antonelli, P. (2011), "States of Design 04: Critical Design". In *Domus 949*, Luglio/Agosto 2011.

Aylesworth, G. (2005), "Postmodernism", *the Stanford Encyclopedia of Philosophy* (spring 2015 Edition), Edward N. Zalta (Ed.).

Bertens, H. (1995), *The Idea of Postmodernism. A History*. Routledge.

Brand, R., Rocchi, S. (2011), *Rethinking Value in a Changing Landscape: A Model for Strategic Reflection and Business Transformation*. Philips Design. Retrieved April 4, 2013, from www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/april2011/paradigms.pdf

Bürdek, B.E. (2005), *Design: History, Theory and Practice of Product Design*. Burkhouse.

Cadwalladr, C. (2013), "Stewart Brand's Whole Earth Catalog, the Book that Changed the World". *The Guardian*. Retrieved December 09, 2017 from https://www.theguardian.com/books/2013/may/05/stewart-brand-whole-earth-catalog

Cantoral, M.B. (2015), *Ideology, the Counterculture, and the Avant Grade: Positioning the Filmmaker and the Spectator in Four Films of Late-1960s America*. De Paul University, College of Communication M.A. Theses. Paper 29. Retrieved December 09, 2017 from http://via.library.depaul.edu/cmnt/29

Carducci, V. (2003), "The Aura of the Brand", *Radical Society* 30(3-4), 29-50.

Carducci, V. (2006), "Culture Jamming: A Sociological Perspective". *Journal of Consumer Culture*, 6(1), 116-138.

Cohen, L. (2004), "A Consumers' Republic: The Politics of Mass Consumption in Postwar America". *Journal of Consumer Research*, 31(1), 236-239.

Cross, N. (2001), "Designerly Ways of Knowing: Design Discipline Versus Design Science". *Design Issues*, 17(3), 49-55.

David, C. (2008), "A Third System of the Arts? An Exploration of Some Ideas from Larry Shiner's The Invention of Art: A Cultural History". *Contemporary Aesthetics*, 6.

De Vries, J. (1994), "The Industrial Revolution and the Industrious Revolution". *The Journal of Economic History*, 54(2), 249-270.

Douglas, M., Isherwood, B. (1979), *The World of Goods*. Basic.

Gaggioli, A. (2016). "From User Experience (UX) to Transformative User Experience (T-UX)". *Positive Technology Journal*.

Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice." *International Journal of Design*, 8(2), 119-139.

History.com staff (2010). *The 1960s*. Retrieved December 09, 2017 from http://www.history.com/topics/1960s

Hookway, C. (2008), "Pragmatism", *The Stanford Encyclopedia of Philosophy* (Summer 2016 Edition), Edward N. Zalta (ed.).

Johansson-Sköldberg, U., Woodilla, J., Çetinkaya M. (2013), "Design Thinking: Past, Present and Possible futures." *Creativity and Innovation Management*, 22(2), 121-146.

Kotler, P., Rath, G.A. (1984), "Design: A Powerful but Neglected Strategic Tool". *Journal of Business Strategy*, 5(2), 16-21.

Lury, C. (1996), *Consumer Culture*. Rutgers University Press.

Markoff, J. (2005), *What the Dormouse Said: How the Sixties Counterculture Shaped the Personal Computer Industry*. Penguin.

Martineau, P. (1958), "Social Classes and Spending Behavior". *Journal of Marketing*, 23 (October), 121-130.

Marwick, A. (2011), *The Sixties: Cultural Revolution in Britain, France, Italy, and the United States, c. 1958-c. 1974*. A&C Black.
Meyer, L.B. (1963), "The End of the Renaissance?" *The Hudson Review*, 16(2), 169-186.
Needham, A. (2016), "Acid Trips, Black Power and Computers: How San Francisco's Hippy Explosion Shaped the Modern World". *The Guardian*. Retrieved December 09, 2017 from https://www.theguardian.com/culture/2016/aug/21/san-francisco-exhibition-victoria-albert-revolution-silicon-valley
Norman D., Miller J., Henderson A. (1995), "What You See, Some of What's in the Future, And How We Go About Doing It: HI at Apple Computer". *Proceedings of CHI 1995*, Denver, Colorado, USA.
Perks, H., Cooper, R., Jones, C. (2005), "Characterizing the Role of Design in New Product Development: An Empirically Derived Taxonomy". *Journal of Product Innovation Management*, 22(2), 111-127.
Pine, B.J., Gilmore, J.H. (1998), *The Experience Economy*. Harvard Business Press
Pine, B.J., Gilmore, J.H. (2013), "The Experience Economy: Past, Present and Future". *Handbook on the Experience Economy*, 21-44.
"Postmodernism", Tate. Retrieved December 09, 2017 from http://www.tate.org.uk/art/art-terms/p/postmodernism
"Postmoderno", *Enciclopedia Garzanti di Architettura*. 1996. Garzanti.
"Postmoderno", *Enciclopedia Garzanti di Filosofia*. 1998. Garzanti.
Redström, J. (2006), "Towards User Design? On the Shift from Object to User as the Subject of Design". *Design Studies*, 27(2), 123-139.
Roszak, T. (1986), *From Satori to Silicon Valley: San Francisco and the American Counter-Culture*. Lexikos Pub.
Taix, C. (2014), "How Mary's Miniskirt Conquered the World". *Dawn*. Retrieved December 09, 2017 from https://www.dawn.com/
The Observer (2007), "What Was the Summer of Love?" *The Guardian*. Retrieved December 09, 2017 from https://www.theguardian.com/travel/2007/may/27/escape
Turner, F. (2005), "Where the Counterculture Met the New Economy: The WELL and the Origins of Virtual Community". *Technology and Culture*, 46(3), 485-512.
Venturi, R., Brown, D.S., Izenour, S. (1972), *Learning from Las Vegas.* Cambridge/MA.

7. How Designers Tame Wicked Problems

by Lucia Rampino

In recent years, the term design thinking has been given a great deal of attention.

> When design thinking emerged […] it offered a response to the ebbs and flows of a global, mediatized economy of signs and artefacts; in this context, professional designers play increasingly important roles, less as makers of forms and more as cultural intermediaries (Kimbell, 2011, p. 287).

To a considerable degree, this attention has been due to the success of Tim Brown's 2009 book *Change by Design. How Design Thinking Transforms Organizations and Inspires Innovation*.

Defining design thinking precisely, however, is no simple matter, mainly for two reasons. The first is that Brown himself did not provide a single and coherent definition of design thinking. The second, and more profound, is that when the term 'design thinking' came to the fore, it already had a long tradition within design. Brown did not invent it, although he should certainly be given the credit for having shone a spotlight on it. Nevertheless, the meaning that design scholars have traditionally attached to design thinking is not fully coherent with Brown's and that of his followers in the management field. Moreover, as Rylander (2009) has noted, 'design' and 'thinking' are difficult enough to make sense of separately, let alone together in 'design thinking'.

In this chapter, we will look at the debate on design thinking that has been raging both outside and inside the design discipline. Our aim is to achieve a clear understanding of what 'thinking like a designer' actually entails.

Success Beyond Design Boundaries

Buchanan underlined the growing importance in our culture of the peculiar way in which designers think as early as 1992:

> A common discipline of design thinking - more than the particular products created by that discipline today - is changing our culture, not only in its external manifestations but in its internal character (Buchanan, 1992, p. 21).

Seventeen years later, two books were published at the same time: one we have already referred to, *Change by Design*, by Tim Brown, CEO of Ideo, the world's largest design company and other is *The Design of Business* by Roger Martin, dean of Toronto University's Rotman School of Management. The main idea behind these two books is that the approach of professional designers to problem-solving activities can make a valuable contribution to firms' willingness to innovate. In Brown's words, design thinking is:

> a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity (Brown, 2008, p. 86)

In general terms, design thinking involves an iterative process with a strong user focus made up of three main phases which consist of: understanding users' needs, exploring possible solutions through rough prototyping[1] and materializing ideas through testing and implementation. Therefore, design thinking made the shift that occurred in the eighties in the design discipline, from a product-centered approach towards a user-centered one, relevant to the whole business world.

Design thinking has been incorporated into the managerial sphere, in specific business schools, but also into other fields such as education and health[2]. Its success has crossed the boundaries of the design discipline:

> Design Thinking broke design out of its specialized, narrow, and limited base and connected it to more important issues and a wider universe of profit and non-profit organizations (Nussbaum, 2011).

[1] In recent design processes, the prototyping phase has been empowered by rapid prototyping technologies. For a more in-depth analysis of the impact of digital fabrication on product design, see Chapter 10.

[2] Johansson-Sköldberg, Woodilla and Çetinkaya (2013) have argued that much of the credit for this multidisciplinary success should go to Roger Martin's wide reach as a speaker and author.

For Stewart (2011), design thinking's popularity within an array of non-design sectors can be explained by its suitability to complex and ill-defined problems. A complementary explanation is offered by Nussbaum (2011) when he affirms that the world of large companies, still dominated by the typical industrial economy culture of process efficiency, has seen in design thinking a well packaged process with the potential to deliver the creativity they need.

Nevertheless, not everybody in the design field is happy about the growing popularity of design thinking:

> […] there has been unease expressed within the design community at this popular appropriation of the term 'Design Thinking'; and concern that its uncritical deployment in contexts other than design represents a fad, rather than a real opportunity to explore and extend the possibilities of design for other sectors (Stewart 2011, p. 515).

One Term, Two Discourses

The design thinking debate can be separated into two major currents of enquiry: a mono-disciplinary discourse within the design field and a multi-disciplinary discourse mainly between management and design.

The first current might more appropriately be named 'designerly thinking' (Johansson-Sköldberg, Woodilla, and Çetinkaya, 2013), although those using it mainly refer to it as design thinking. Designerly thinking is a consolidated forty year academic discourse between design scholars which originated in a more general design methodology debate:

> For me, design methodology includes the study of how designers work and think, the establishment of appropriate structures for the design process, the development and application of new design methods, techniques and procedures, and reflection on the nature and extent of design knowledge and its application to design problems (Cross, 1984).

Cross is one of the most prominent scholars in this research current and coined the phrase «de*signerly way of knowing*». He was also one of the organizers, with Roozenburg and Dorst, of the first Design Thinking Research Symposium, held in 1991[3]. Specifically, designerly thinking relates to the design research tradition involving studying non-verbal professional designer competence within classic design disciplines such as engineering and industrial design (Johansson-Sköldberg, Woodilla, and Çetinkaya,

[3] The eleventh Design Thinking symposium was organized in 2016 by the Copenhagen Business School.

2013). It is, consequently, a cognitive style typical of professionally trained designers (Kimbell, 2011; Carlgren, Rauth and Elmquist, 2016).

On the other hand, as explained convincingly by Brown, design thinking is a professional discourse which is mainly oriented towards businessmen and managers. Brown explains that design thinking is an organizational resource by illustrating successful cases from Ideo. Here, rather than being presented as pertinent specifically to the design discipline, design thinking is often depicted as a generalized human-centered approach to problem solving through creativity from which any discipline can take inspiration and learn (Carlgren, Rauth and Elmquist, 2016).

It is thus possible to affirm that a multidisciplinary, popularized version of the academic concept of 'designerly thinking' known as 'design thinking' was created (Johansson-Sköldberg, Woodilla, and Çetinkaya, 2013). It was a transition which did not go entirely smoothly:

> This re-assembling of some of the approaches, knowledge, and practices of professional designers, first within academic design research, and then within business schools and consultancies, has not brought a happy synthesis (Kimbell, 2011, p. 286).

The two debate currents, designerly thinking and design thinking, are not entirely separate. The growing popularity of the managerial discourse reawakened the design academic discourse, retaining the original intra-disciplinary approach, and used it both to define the 'core' of design thinking (Dorst, 2011) and to underline the superficiality of the managerial discourse. For Johansson-Sköldberg, Woodilla and Çetinkaya (2013), for instance, while design thinking is often equated with creativity, being creative is only part of a designer's competence. Moreover, design thinking is often equated to a toolbox in managerial discourse without acknowledging that appropriate use of any tool requires the right knowledge and skills.

In the design management field too, a number of critical voices on design thinking have made themselves heard:

> […] in order to appeal to the business culture of process, it was denuded of the mess, the conflict, failure, emotions, and looping circularity that is part and parcel of the creative process. […] As practitioners of design thinking in consultancies now acknowledge, the success rate for the process was low, very low (Nussbaum, 2011).

In brief, design thinking is a concept which has fostered a great deal of enthusiasm but is not free of inconsistencies and divergence.

The next part of this chapter will build a more in-depth understanding of design thinking in reference to the design discourse from the starting point of a paradigmatic shift in design practice from Neo-positivism to Pragmatism. A better understanding of how designers address complex problems requires indeed recognizing their overall epistemological framework.

A Paradigm Shift in Design Practice

Herbert Simon's *The Science of the Artificial* (1969), the book that built the foundations for the idea of a design science, best represents the rational approach towards problem-solving typical of the technical perspective. Having already made important contributions to economics and organization theory, Simon turned his attention to 'designing' human action in the realm of the artificial (Kimbell, 2011). His book is neo-positivist in paradigm, arguing that an objective reality that can be known and measured using quantitative methods exists.

In the human perspective, we witness a paradigm shift in design from Positivism towards Pragmatism. Pragmatism is a philosophical movement which originated in late nineteenth century America. The most important 'classical pragmatists' were Charles Sanders Peirce (1839-1914), William James (1842-1910) and John Dewey (1859-1952). Their influence waned in the twentieth century but has undergone a revival since the 1970s. In Pragmatism, human experience takes precedence over doctrines: all human activity is situated and the function of thought is to guide action (Dalsgaard, 2014).

In design, the book that best represents this paradigmatic shift is Donald Schön's *The Reflective Practitioner* (1983). Schön was the first to challenge scientific positivism, promoting a model of design as a discipline which builds knowledge through reflective practice. For Cross (2001), Schön was indeed keener than his positivist predecessors to trust in practitioners' ability to deal with complex problems. In an attempt to supply insights into these abilities, he identified two kinds of reflections. The first of these is reflection-in-action, described as practitioners' ability to respond to a challenge by drawing upon their intuition and prior experiences. The second is reflection-on-action, practioners' ability to reflect upon their past experiences in order to acquire new knowledge with which to deal with future challenges.

The rigid design engineering process predominant in the industrial economy refused to acknowledge designer intuition and thus failed to do justice to designers' reflection-in-action capabilities (Gardien *et al.*, 2014). Indeed, Gilles and Paquet (1989) have argued that the prevailing scientific 'technical rationality model' presumed a one-way cascading knowledge production model, from theory to practice. However, as Schön has suggested, in actual fact knowledge evolves in other ways too. For professionals, knowledge production moves in the opposite direction: the problem to solve comes before theory.

> This process is best exemplified by the challenge faced by the designer: the need to search for some kind of harmony between two intangibles: a form which has not yet been designed and a context that cannot be properly and fully described since it is still evolving (Gilles and Paquet, 1989, p. 6).

Schön's vision of designers as competent practitioners has been highly influential both in increasing understanding of the design process and the abilities of skillful designers and also in shaping design education. Moreover, Pragmatism accords well with ethnographic user studies of target groups which typically require designers to observe first, with no preconceptions or prior judgments.

Recently, a number of contributions drawing on Pragmatic aesthetics have joined the debate on experience-oriented aspects of use and interaction in design:

> The pragmatist conceptualization of inquiry can offer insights concerning both how designers approach and explore design challenges, and how users make sense of and employ the products of design. The pragmatist perspective implies a systemic understanding of situations and prompts us to consider users as resourceful actors who, just as designers, draw on interactive artefacts and systems to make sense of and transform their situation (Dalsgaard, 2014, p. 149).

The Nature of Design Problems

A more in-depth understanding of the specific ways designers think now requires taking a closer look at the kind of problems that designer habitually face. The nature of the problems addressed is one of the main reasons confirming a substantial problem-solving difference between design and science.

As we have seen, Simon saw any design activity as a rational set of procedures responding to a well-defined problem that could be solved by breaking it up into a coherent set of sub-problems. By contrast, Schön explicitly criticized Simon's view, affirming that in professional practice, practitioners (and therefore also designers) might have to deal with messy problematic situations (Cross, 2001).

Within the design discipline, the 1970s witnessed a marked reaction against design methodology and its underlying rational approach. As we saw in the previous chapter, it was a period marked by radical political movements and a growing counterculture challenging both conservative values and the predominance of the modern science paradigm. Moreover, Cross (2001) argued that the application of 'scientific' methods to everyday design practice had been unsuccessful.

At the same time, fundamental issues around the nature of design problems were raised by Rittel and Webber, who, in 1973, published an influential article entitled *Dilemmas in a General Theory of Planning*. In this article, they defined as 'wicked problems' all those badly structured problems that are typical of design and planning. Vague and incoherent, wicked problems are difficult or impossible to solve because of incomplete, contradictory and changing requirements. By contrast, scientific problems can be defined as 'tame' because they are well-structured with a clear intent which embraces the precision of mathematical description.

In Rittel and Webber's account, wicked problems include the following features. Firstly, the solution depends on how the problem is framed and vice versa (i.e. problem definition depends on the solution); secondly, the stakeholders have radically different views and different frameworks for understanding the problem; finally, the constraints and resources needed to solve the problem may change over time.

As we have seen, Rittel and Webber's ideas were in line with widespread disappointment in this period with prevailing problem solving approaches which attempted to extend the logic of scientific rationality to design. Buchanan (1992) was the first to take a truly designerly perspective on design thinking by building on Rittel and Webber's wicked problem approach.

Design Thinking versus Scientific Reasoning

Now that we have examined the Pragmatist approach typical of design practice and the specific nature of design problems, we can now try to respond to our initial question: how do designers address wicked problems?

In defining the main features of design thinking, both Cross (2011) and Dorst (2011) built on the concept of abductive reasoning, which is complementary to more familiar concepts of inductive and deductive reasoning.

Deduction and Induction

Deduction is general to specific method of reasoning. In deductive reasoning, conclusions necessarily follow stated premises (e.g. all dolphins are mammals, all mammals have kidneys, therefore all dolphins have kidneys). Deductive reasoning is used to apply general knowledge to specific cases and can thus be defined as predictive. On the other hand, deduction is of little help in generating new knowledge because the conclusions are already implicit in the premises. If the aim is to create new knowledge, the process has to be inverted, moving from the specific to the general, i.e. from observed phenomena to generalization. This process is usually referred to as inductive reasoning.

Scientific knowledge is largely based upon the process of inductive reasoning whereby scientists move from premises about objects they have examined to conclusions about objects they have not examined. In this respect, Okasha (2002) uses the example of the study of Down's Syndrome in which geneticists have established that sufferers have 47 chromosomes instead of the normal 46. In order to determine this, a large number of sufferers have been examined and in each case this additional chromosome has been found. The conclusion has thus been made that having this additional chromosome causes Down's Syndrome. However, geneticists have progressed from premises about sufferers they have examined to conclusions about sufferers they have not examined. Scientists heavily rely on inductive reasoning whenever they move from limited data to more general conclusions[4].

The story of the discovery of Ceres in 1801 by astronomer Giuseppe Piazzi is another good example of scientific reasoning combining induction and deduction. Induction is used to give a tentative explanation (hypothesis) for a given phenomenon; deduction is used to verify the predictive reliability of the hypothesis formulated.

Piazzi noticed Ceres in his observation of the sky and realized it was moving. Ceres' movement implied that it could not be a fixed star and Piazzi thus called it a comet whilst hypothesizing that it could also be a small planet. Some months later, Ceres disappeared from view and Piazzi was unable to determine its orbit. By December 1801, Ceres was found once again by two German astronomers thanks to Carl Friedrich Gauss's orbit predictions. To determine its orbit, Gauss solved a system of seventeen lin-

[4] Philosopher Hume argued that induction cannot be rationally justified. He conceded that we use induction all the time in everyday life and in science, but insisted that this is simply a matter of 'animal habit'. Philosophers have responded to Hume's 'induction problem' in various different ways but none have come up with a definitive answer (Okasha, 2002).

ear equations. After Ceres' orbit was better determined, it was clear that Piazzi's hypothesis was correct and Ceres was not a comet but a small planet. This is an example of the use of scientific reasoning to solve a 'tame' problem, one fostering a mathematical description. Moreover, the explanatory hypothesis formulated by Piazzi using induction (i.e. Ceres is a small planet) was confirmed by deductive reasoning (i.e. Gauss's equation predicting its position). Combining these two forms of analytical reasoning, science helps us to both predict and explain phenomena in the world.

Abduction

Design thinking can best be described using a third concept, introduced into modern logic by philosopher Peirce: abduction.

Pierce defined abductive reasoning as a specific kind of induction which starts with an observed phenomenon, then seeks to find the simplest and most likely explanation based on a previously known working principle. For instance, we usually explain wet grass by abducing that it has rained.

For Pierce, abduction was the true new knowledge creation tool, but it is also the kind of reasoning which is most likely to be wrong. In his view, it is just the Pragmatist approach that offers to abduction the necessary and sufficient logical rule. Indeed, since hypotheses generated through abduction are unreliable, they need plausible practical implications to make them testable and trialable to speed up inquiry.

For Dorst (2011), in the design field as in other productive professions, there is no statement of fact to observe but simply the achievement of a certain value. Therefore, what designers often do is create a design that applies a known working principle in order to reach a desired value. This is an abductive process that can be represented by the following equation (Dorst, 2011):

product (?) + working principle (known) = added value (aspired to)

However, most of the time the real challenge for designers is figuring out what to create while no known working principle leads to the desired value. Designers must thus define both a working principle and a product (be it an object, a service or a system). Therefore, the abduction equation to be solved features two unknown variables:

product (?) + working principle (?) = added value (aspired to)

Performing a creative effort involving concurrent creation of a design solution and its way of working is, according to Dorst (2011), the real challenge of design reasoning. When tackling this challenge, experienced designers tend to develop a new framework:

> In terms of our logical framework, a 'frame' is the general implication that by applying a certain working principle we will create a specific value (Dorst, 2011, p. 524).

Schön was the first to introduce the idea of 'framing' when problem-solving during professional reflection-in-action (Kimbell 2011, p. 292). Since Schön, the term 'framing' has been commonly used in design literature when a new standpoint with which to address a problematic situation needs creating. Complementary to 'framing' is the 'placement' concept introduced by Buchanan:

> Placements are the tools by which a designer intuitively or deliberately shapes a design situation, identifying the views of all participants, the issues which concern them, and the invention that will serve as a working hypothesis for exploration and development (Buchanan, 1992, p. 17).

In applying placements, designers let problem formulation and solutions go hand in hand rather than considering them as sequential steps in rational problem solving. Indeed, no design problem is given *a priori* but rather developed in the first stages of designerly inquiry. From a Pragmatist point of view, these first stages can be described as:

> an experimental process in which the designer draws on all of the resources at hand as well as develops their own understanding of the situation in order to transform it (Dalsgaard, 2014, p. 150).

For Dorst (2011), framing, enabling designers to gain a clearer understanding of a situation, is the core of design thinking. This framing activity is based on a designer's ability to read complex situations in terms of themes also enabling potentially conflicting requirements to be resolved.

Designers begin the design process by exploring the broader situation for clues that can bring out specific themes. These themes are then applied in the development of a frame, enabling the situation to be read from a distinct point of view and transformed to attain the desired value.

To exemplify these framing processes, Dorst describes a city entertainment district which endured nightly drunkenness, fights, thefts, drug dealing and, later in the night, sporadic violence. Unable to solve the problem with increased police presence, the local government asked the Designing Out Crime center to address it. Analyzing the situation, the designers noticed that the people concerned were not criminals but simply young people wanting a good time: this was the key theme enabling them to re-frame the situation. The designers thus proposed a simple analogy: the problem was to be approached as if a large music festival was being organized. Using this analogy, the designers proposed as yet unforeseen solutions to the problem, such as late night public transport enabling young people to return home, chill out spaces and ongoing attractions and friendly staff available to help people and keep an eye on safety.

In design practice, themes are essentially a sense-making tool that, whilst apparently marginal to the situation, actually trigger the creation of new frames. Designers are thus professionals in taming wicked problems, addressing complex situations in creative ways by framing and re-framing problems and solutions in parallel. This, according to Dorst, is the current utility of design thinking:

> […] interest in 'Design Thinking' has been sparked by organisations having trouble dealing with open, complex problem situations. This is where the way design practice deals with themes and frames in the context of open, abductive reasoning could be particularly useful (Dorst, 2011, p. 530).

Design Thinking in Practice

Thus far, we have discussed design thinking from a theoretical point of view. We will now turn our attention to the way design thinking manifests itself within companies.

To gain a more in-depth understanding of design thinking in practice, Carlgren, Rauth and Elmquist (2016) analyzed the way it is used in six large organizations. This led to them identifying five main features characterizing design thinking practice: user focus; problem framing; visualization; experimentation; diversity.

The first of these refers to an inherent user focus, expressed in terms of empathy building, in-depth user understanding and user involvement.

The second stresses that rather than striving to solve problems immediately, designers try to widen out, challenge and re-frame them. Moreover, a specific trait of designers is their being comfortable with ambiguity.

Visualization refers to making ideas tangible as soon as possible in the design process either physically (two or three dimensionally) or enacting them through role-play and storytelling.

Experimentation is a propensity for testing and trying things out in an iterative way, moving between divergent and convergent ways of thinking.

Finally, diversity refers to integrating multiple perspectives in teamwork. This latter brings out the issue of who designs: an individual or a team? As Carlgren, Rauth and Elmquist (2016) have noted, all teamwork and joint-working related issues are present in the managerial discourse on design thinking but absent from the intra-disciplinary design discourse which focuses mainly on studies of professionally trained individual designers. This latter issue would benefit from a more in-depth relationship to existing teamwork theories (Johansson-Sköldberg, Woodilla, and Çetinkaya, 2013).

A last question which generates conflicting answers is whether designers should be professionals or people without a scholarly background in design. Indeed, while the design discourse builds upon the notion that managers' ways of thinking and problem solving are different from designers', in the managerial discourse scholars often assume that managers are quite capable of using designers' ways of reasoning (Johansson-Sköldberg, Woodilla, and Çetinkaya, 2013).

In conclusion, as we have seen, defining design thinking and the specific ways in which designers tame wicked problems is no simple task and leaves certain questions unanswered. Nevertheless, it can be said that:

> The practices of designers play important roles in constituting the contemporary world, whether or not design thinking is the right term for this (Kimbell, 2011, p. 301).

References

Brown, T. (2008), "Design Thinking". *Harvard Business Review* 86(6), 84.

Brown, T. (2009), *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. Harper Collins.

Buchanan, R. (1992), "Wicked Problems in Design Thinking". *Design Issues*, 8, 5-21.

Carlgren, L., Rauth, I., Elmquist, M. (2016), "Framing Design Thinking: The Concept in Idea and Enactment." *Creativity and Innovation Management* 25(1), 38-57.

Cross, N. (1984), *Developments in Design Methodology*. Wiley.

Cross, N. (1993), "Science and Design Methodology: a Review". *Research in Engineering Design*, 5(2), 63-69.

Cross, N. (2001), "Designerly Ways of Knowing: Design Discipline Versus Design Science". *Design Issues*, 17(3), 49-55.

Cross, N. (2011), *Design Thinking: Understanding How Designers Think and Work*. Berg.

Cross, N., Dorst, K., Roozenburg, N. (eds.) (1992), *Research in Design Thinking*. Delft University Press.

Dalsgaard, P. (2014), “Pragmatism and Design Thinking”. *International Journal of Design*, 8(1), 143-155.

Dorst, K. (2011), “The Core of Design Thinking and its Application”. *Design Studies*, 32, 521-532.

Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), “Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice.” *International Journal of Design*, 8(2), 119-139.

Gilles, W., Paquet, G. (1989), “On Delta Knowledge”. In G. Paquet, M. von Zur Muehlen (eds.). *Edging Toward the Year 2000*, Canadian Federation of Deans of Management and Administrative Studies, 15-30.

Johansson-Sköldberg, U., Woodilla, J. Çetinkaya M. (2013), “Design Thinking: Past, Present and Possible Futures”. *Creativity and Innovation Management* 22(2), 121-146.

Kimbell, L. (2011), “Rethinking Design Thinking: Part I”. *Design and Culture*, 3(3), 285-306.

Martin, R.L. (2009), *The Design of Business: Why Design Thinking is the Next Competitive Advantage*. Harvard Business Press.

Nussbaum, B. (2011), “Design Thinking is a Failed Experiment. So What’s Next”. *Fast Company*, 6.

Okasha, S. (2002), *Philosophy of Science: a Very Short Introduction*. Oxford University Press.

Rittel, H.W.J., Webber, M.M. (1973), “Dilemmas in a General Theory of Planning”. *Policy Sciences* 4(2), 155-169.

Rylander, A. (2009), “Design Thinking as Knowledge Work: Epistemological Foundations and Practical Implications”. *Design Management Journal*, 4(1), 7-19.

Schön, D.A. (1983), *The Reflective Practitioner: How Professionals Think in Action*. Temple Smith.

Stewart, S.C. (2011), “Interpreting Design Thinking”. *Design Studies* 32(6), 515-520.

8. The Human-Centered Approach

by Francesca Mattioli

From a human perspective, we have seen that designers should carefully consider that many different people will use the design artefact and interpret them from their unique viewpoint. Moreover, the product-user interaction takes place in situations where users' cognitive and emotional states will influence the interaction itself. Accordingly, designers must be aware that their choices cannot precisely predict and control all the aspects of the interaction mentioned above; they need to take up the challenge of encompassing in the design process the subjectivity inherent to human beings.

The designerly and design thinking discourse presented in the previous chapter already entailed a paradigmatic shift in design practice from Positivism to Pragmatism. This shift assigned a new role to humanity in the design process. While human-centered design (HCD) is widely discussed in the literature, Friess (2010) argues that no two definitions are identical. Still, the author identifies two recurrent features in all HCD:

> 1) conducting research with real people who are likely to use the product, and 2) using that research to drive the design solution (Friess, 2010, p. 41).

HCD is the outcome of a long history of increasing recognition that people are a crucial source of insights into shaping design solutions. It is now an established conception that 'humans matter' while designing, and today's design culture is otherwise hardly conceived. Nevertheless, designers rarely consider the profound consequences of including many different human dimensions in their outcomes or processes. Indeed, we all have individual physical, cognitive, social, cultural, and sensory dimensions. All these factors define the uniqueness of the individual.

How has design, specifically HCD, evolved to consider human beings? The present chapter addresses this question by framing the growth of human-centeredness in design practices.

Three Levels of Design Practice

Many authors address HCD as a group of methods to be applied in design practice. However, the word 'method' is often used interchangeably in literature with other words such as 'approach', 'methodology', and 'tool', creating semantic confusion. Building on Rampino and Colombo's (2012) semantic clarification of those terms in design research and adapting it to design practice in a way which serves to clarify the HCD positioning issue, we here assume that the approach, the method(s) and the tool(s) are three distinct and hierarchical levels of design practice[1].

The highest level is *the approach*, intended as the most profound aim of design practice. In the second level, we find *the method*, defined as the codified procedure to achieve design aims. *The tool* represents the third level and is the instrument or technique specific to a given method. As shown in figure 1, each subsequent level is more specific than the previous one and should be coherently defined. Also, more specific levels inform the higher ones, as they increasingly provide hands-on instruments to collect data that inform the design process.

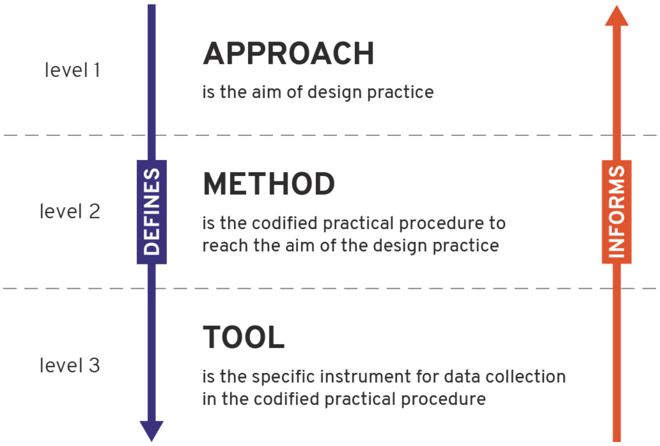


Figure 1: The three levels of design practice.

[1] Rampino and Colombo also defined methodology as the discourse on the research process, a crucial aspect of academic research. In the case of design practice, the methodology level is no longer there because practice does not require discussing the applied method's epistemological soundness. In other words, what counts is the tangible output of the process (e.g., the new artefact resulting from the process) and not how the research process was carried out, as in the case of academic research.

This schematisation is to be understood as a working framework to position HCD within design practice. The definition of these three levels may be subject to objection and does not pretend to provide an exact taxonomy of approaches, methods, or tools. Nevertheless, this framework is helpful to explore in this chapter how HCD can be described at different levels (i.e., as a group of methods or as an approach), identifying different implications for the work and role of the designer.

HCD as a Group of Methods: An Overview

The first sprouts of HCD are already rooted in the technical perspective. Indeed, from the 1950s onwards, it became clear that the human physical dimension plays a crucial role in shaping design outcomes. In the book *Designing for People*, Dreyfuss (1955) advocated the importance of using anthropometric data to design products by considering human physical attributes. Ergonomics was founded to extend knowledge in this field.

> Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance (IEA, 2022).

Ergonomics aims to describe a population in a given context (e.g., geographical area, context of use) by determining standard data and apply it to shape solutions usable by the higher number of people in that context.

Based on a positivistic view, ergonomics describes humans through anthropometrical data, focusing mainly on their physical dimensions. Dreyfuss's work also set the basis for usability studies in terms of behavioral and cognitive dimensions; the usability concept became well known in the 1980s and early 1990s, thanks to developments in the human-computer interfaces field (van der Bijl-Brouwer and Dorst, 2017). The advent of digital technologies prompted several scholars to discuss the methods behind interface design and led to the usability field being founded (Norman, 1988; Nielsen, 1993). Researchers in this field argued that design practice needed to be capable of tackling issues experienced by users and advocated the need for usability testing.

In these same years, the Kansei Engineering field was founded in Japan to address the human emotional dimension and shape products according to users' emotions.

> Kansei Engineering is defined as 'translating technology' of a consumer's feeling (Kansei in Japanese) of the product to the design elements […]. Kansei Engineering aims to produce a new product based on the consumer's feeling and demand (Nagamachi, 1995, p. 4).

Ergonomics and Kansei Engineering are HCD methods «*based on a positivistic approach, as applied in engineering and science*» (van der Bijl-Brouwer and Dorst, 2017, p. 5). Indeed, they rely on data and testing to build fields of expertise that can be categorized as 'scientific'. In other words, the reliability of these methods hinges on the idea that statistical analysis of quantitative data representing a given population of human beings can support the design of artefacts that well match the physical (i.e., Erogonomics) and emotional (i.e., Kansei Engineering) characteristics of that group of individuals. Thus, the scientific method, proper to the hard sciences, ensures that the designer can deduce and include parameters in the design process that aim to handle the human dimension as something objective and measurable. However, if design is a supple discipline between science and art, as discussed in Chapters 1 and 2, scientific methods based on a positivistic paradigm alone can hardly be enough for designers to address wicked problems.

In this sense, the human perspective determined the gradual establishment of human centrality in product development; in terms of HCD, this shift opened the door to sets of methods borrowed by the humanities and social sciences aimed at studying the human dimension not only in quantitative but also in qualitative terms. Among others, the methods coming from ethnography, a branch of anthropology, have been widely adopted in design practice.

> […] the participant observer or ethnographer immersing him or herself in the culture of a group for an extended period of time, observing the behaviour of that group, listening to what is said within the group and asking questions (Rodgers and Anusas, 2008, p. 87).

Several ethnography-inspired methods are nowadays seen as the basis for HCD. They are usually applied to the initial phase of the design process when designers start exploring the context to shape the problematic situation and, at the same time, its potential solution (Dorst, 2011). Ethnographic methods are designed to sample human experience and include participant observation, artefact analysis, photo and diary studies, contextual inquiry (Hanington, 2010) and ethnographic interviews.

Through specific tools, these methods allow designers to collect information about people's social, cognitive, and emotional dimensions in the form of 'rich data', which differs from the analytical data provided by scientific ergonomics methods. Indeed, the methods borrowed from ethnography allow designers to include more qualitative data in their research. However, also these methods are not entirely suitable for design because ethnography, unlike design, does not aim to generate new artefacts.

> […] anthropological methods usually aim at describing what 'is', and design is about creating something new, these methods need to be adapted to the aims and implications of design processes (Celikoglu, Ogut, and Krippendorff, 2017, p. 86).

Moreover, ethnography is applied by designers in ways which are substantially different from the ways anthropologists and social scientists apply it, not only at the objectives level but also in terms of methodology[2]. Designers often have insufficient time, resources, and knowledge to conduct professional ethnographic research (Hanington, 2010). Additionally, the rich data from different kinds of qualitative analysis might be inadequate for shaping design solutions because it does not offer a straightforward answer to designers needing to design valuable outcomes (van der Bijl-Brouwer and Dorst, 2017, p. 5).

Consequently, other HCD methods have been conceived starting from the particular nature of the design practice. Specifically, a new set of methods have been introduced in the design process to create

> […] shared experiences and common reference points among design team members and with other stakeholders while allowing an openness for creative exploration (Mattelmäki, Vaajakallio, and Koskinen, 2014, p. 71).

For instance, approaches such as co-design pushed designers to develop methods to build emotional bridges by inviting the end users as participants in the design process. The co-design approach is based on the idea that designers should involve people in collaborative activities to frame design issues and identify design solutions; therefore, in co-creation methods, people are included as co-creators becoming protagonists of the design process.

The centeredness of humans in the case of co-creative methods resides in the assumption that HCD methods involve users as crucial actors in the design process rather than exclusively studying them (quantitatively or

[2] In applying ethnography, anthropologists and social scientists are doing established research activities; therefore, they aim to produce new and reliable knowledge. On the other hand, in design practice, a designer's aim in applying ethnography is not to produce new knowledge but to obtain insights helpful in devising good design solutions.

qualitatively) to inform design solutions. These methods better serve design because they create an environment to sustain the generative processes. In other words, the HCD methods conceived within the design discipline differ from those previously described because their outcomes are not only data (analytical or rich) but also ideas. Design-specific methods could better support designers' abductive reasoning in the creative idea generation process, a distinctive feature of designers' thinking[3].

Nonetheless, 'participationism', as Manzini defined the growth of methods to involve end users in the design process (2016), is open to criticism because it could prompt designers to build their concepts on emotions or users' ideas alone, disregarding their visions and intuition.

> In its adoption in co-design processes, […] design experts take a step backward and consider their role simply as that of "process facilitators", asking other actors for their opinions and wishes, writing them on small pieces of paper, and sticking them on the wall and then synthesising them, following a more or less formalised process. […] The problem is that, in moving from the intention of giving voice and an active role to different stakeholders, participation-ism and post-it design end up transforming design experts into administrative actors with no specific contributions to bring–other than aiding the process with their post-its (and, maybe at the end, with some pleasing visualisations) (Manzini, 2016, pp. 57-58).

Another critique of these methods is that, if designers are not vigilant, the attempt to be empathic while involving users might lead designers to popular reflections rather than helping identify radical ways of innovating (Mattelmäki, Vaajakallio, and Koskinen, 2014).

Also, such methods force designers into new fields of expertise far from traditional ones, such as concept generation, sketching, modelling, and prototyping, to mention a few. For instance, applying methods aimed at involving people pushes designers to develop soft skills (e.g., group activity leading, empathising skills) in addition to the conventional hard skills already referred to.

The enlargement of the designer's role toward the facilitation of group dynamics could be considered a beneficial evolution of the practice. However, it could also be problematic because it enlarges designers' responsibilities and requires the development of competences far beyond the traditional hard skills.

[3] For an explanation of the concept of abduction, see Chapter 7.

Hanington's HCD Methods Categorisations

Parallel to the increasing recognition of HCD methods within design practice, the academic debate around them also grew. Among others, Bruce Hanington proposed in the early 2000 two categorisations of HCD methods. These categorisations are presented here as two alternative conceptual frameworks to analyse, understand and categorise HCD methods.

Traditional, Adapted and Innovative HCD Methods

Firstly, Hanington (2003) presented a division of HCD methods based on three categories: traditional, adapted, and innovative (Figure 2).

Traditional HCD methods are those research methods used in several disciplines and also adopted by design, such as surveys, interviews, questionnaires, and focus groups. According to Hanington, these methods effectively reach many people and provide data that can easily be analysed and visualised by designers. Nevertheless, «*these methods tend to be better at confirming known entities, yet are less critical in determining as-yet-undiscovered information*» (Hanington, 2003, p. 13).

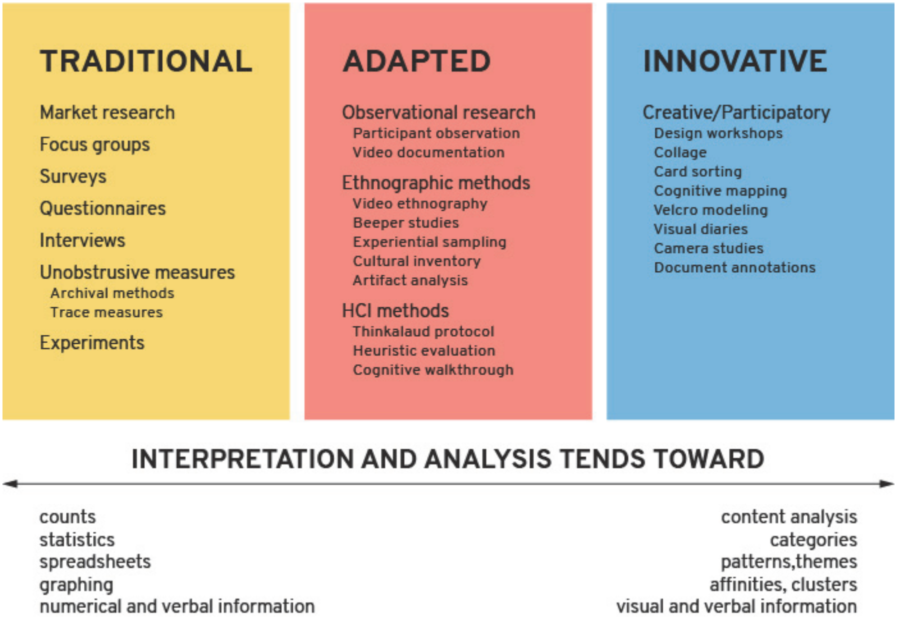


Figure 2: Outline of the first categorisation of HCD methods proposed by Hanington (2003)

Adapted methods are those borrowed by design from the humanities (e.g., anthropology, ethnography) and specific fields of scientific research (e.g., human-computer interaction). The main characteristic of adapted methods is that they are typical research methods used in several fields that have been taken on board by designers and modified to serve design generative purposes.

The third group is that of innovative methods, defined by Hanington as:

> […] design methods now established and continuing to emerge that represent credible ways of collecting user information through creative means (2003, p. 15).

Design researchers and practitioners created these methods to gain valuable insights into the design issue. They are mainly based on organising participatory sessions with multiple stakeholders. The outcomes of these methods seem to be particularly well-suited to design practice because they often rely on visual information, which is self-evident for designers. In other words, the data is collected using a visual design language and can be used by designers to shape solutions without 'translation'.

Exploratory, Generative and Evaluative HCD Methods

The second categorisation of HCD methods proposed by Hanington (2007) is based on their use, according to the phase of the design process concerned. Assuming that any design process can be divided into three main phases, *exploratory*, *generative* and *evaluative,* different HCD methods can be allocated to each phase (Figure 3).

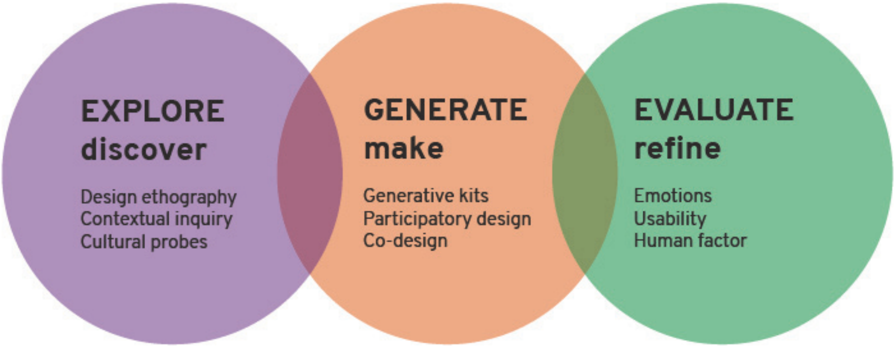


Figure 3: Outline of the second categorisation of HCD methods proposed by Hanington (2007)

The aim of exploratory research is to familiarize designers with new contexts and users, contributing to shaping the designer's understanding.

The methods applied during this phase are primarily adaptive methods borrowed from ethnography.

The generative phase is «*a more focused effort targeted at a deeper understanding of user needs and desires, and concept development through participatory design activities*» (Hanington, 2007, p. 3). Typically, the methods applied are those previously described as innovative because they have been developed to serve the nature of the design process and aim to generate valuable insights into the problematic situation and potential solutions. Moreover, the methods applied in the generative phase can be subdivided into two main categories: projective and constructive methods (Figure 4).

> Early exercises are typically projective in nature, focusing on expressive exercises enabling participants to articulate thoughts, feelings, and desires that are difficult to communicate through more conventional verbal means. Furthermore, the creation of an artefact around which a participant may talk will act as a trigger for engaged and comfortable conversation. Projective methods are typically ambiguously instructed, and will include the creative range of collage, drawing, diagramming, image and text based exercises. Constructive methods such as flexible modeling will occur as a later means of concept development, once some concrete parameters are set for product ideation (Hanington, 2007, p. 4).

Figure 4: Categorisation of generative methods proposed by Hanington (2007)

Finally, in the evaluation phase, generated ideas are tested and evaluated; within this stage, traditional methods and adapted methods (e.g., human-computer interaction tools) are widely used.

From a Group of Methods to an Overall Approach

The methods described in the previous section represent how HCD is most often presented in the literature. Here, HCD is mainly intended as a group of methods aiming to shape wicked design problems and, contextually, generate valuable solutions. This last element is the leitmotif of the dominant literature discourse, allowing conclusions to be drawn on the resulting idea of design practice which dominates the HCD literature concerning the three levels of design practice (i.e., approach, methods, tools). So far, HCD is intended as a solution-oriented group of methods (some borrowed from the sciences or humanities and others specific to design) that effectively contribute to achieving the desired process outcome.

In this view, several tools can be used to gain valuable insights into the people involved in the design context and accordingly shape design solutions that are valuable and usable for them (van Boeijen, Daalhuizen, and Zijlstra, 2020). We define this way of intending HCD as solution-oriented HCD (Figure 5). In this conception, the methods emerge as the key level that characterises HCD because they represent the codified procedures that allow designers to gain insights to inform the design process.

Having presented some HCD methods and having identified their characteristics and possible categorisations, we can now ask ourselves what would happen if we tried to think of HCD as an approach. A possible answer is contained in the book *The Semantic Turn* (2006), where Krippendorff placed HCD on a higher level. In general terms, Krippendorff «*defined design and designers' work as a matter of creating meaning*» (Johansson-Sköldberg, Woodilla, and Çetinkaya, 2013).

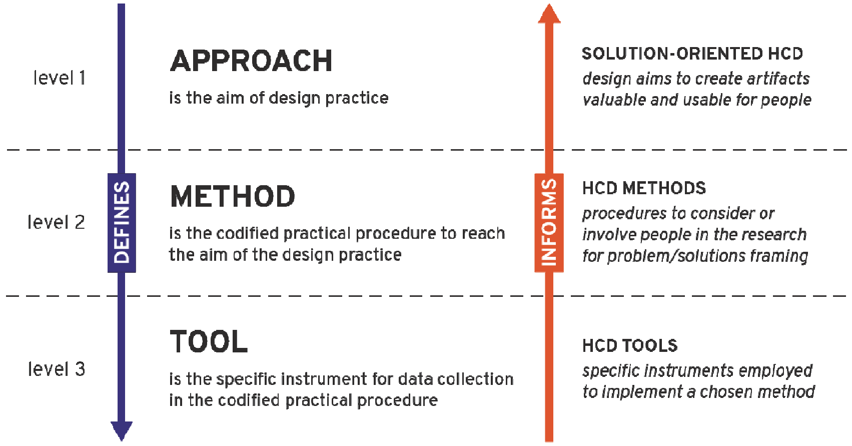


Figure 5: The solution-oriented HCD approach

In this definition, HCD would best be described not as a set of methods but as an overall approach to be embraced by designers within the whole meaning-creation process because meaning itself depends on the human condition. Therefore, Krippendorff suggested that the whole focus of all design activity should move from solutions (i.e., artefacts and systems) to humans because the meaning resides there. Based on this conception, we define meaning-oriented HCD as the approach in which design practice aims to create meaning for others.

The conceptual shift is subtle but not trivial; meaning-oriented HCD poses humans' meaning creation process at the core of design practice elevating human-centeredness to the designers' *state of mind* rather than the methods or tools they use (see Figure 6). *The Semantic Turn* thus argued that the very conception of design research is pervaded by HCD. Discussing the implications of this approach to designers' mindsets rather than displaying the design methods presented by the author is thus valuable[4].

Krippendorff's Turn: Meaning-Oriented HCD Approach

These last sections discuss HCD as an approach rather than a group of methods based on the paradigmatic shift introduced by retracing Krippendorff's logical trajectory.

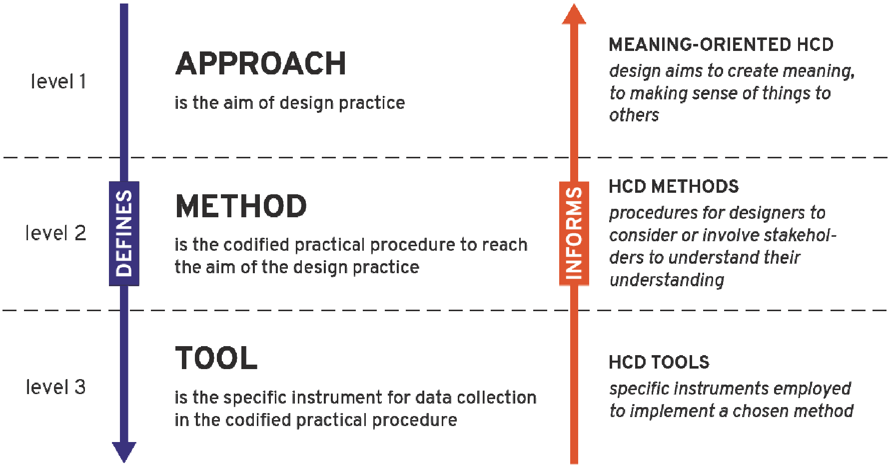


Figure 6: The meaning-oriented HCD approach

[4] Krippendorff devotes Chapter 7 of *The Semantic Turn* to discussing HCD methods in design practice.

Indeed, if design practice is defined as the activity of «*making sense of things (to others)*» (Krippendorff, 2007, p. 3), the role of designers moves conceptually from finding solutions to interpreting others and understanding their way of assigning meaning to things. Krippendorff argues that the outside world cannot be known as such because each person constructs a meaning which is not fixed and is invoked by sense, defined as «*the feeling of being in contact with the world without reflection, interpretation or explanation*» (Krippendorff, 2006, p. 50). The meaning that an individual assigns to things emerges through the use of language and her interaction with artefacts.

> Every design project (just like any human activity or product) exists both in a physical-biological world – where human beings live and artefacts are produced and function – and a sociocultural world – where human beings interact through language and things assume meaning (Manzini, 2016, p. 55).

Designers can try to embed meaning in their artefacts, but given the individual nature of meaning, they should not expect *others* to construct the same meaning. Informed design should abandon the belief that meaning is a self-evident and objective feature of artefacts.

> The difference is that designers often embed artefacts with visual cues and indicators that suggest functionality; however, these artefacts still have multiple affordances – such as repurposing for use as a weapon, or as a doorstop, or as an icon for a social movement – that are not necessarily related to its intended function, or programmed into the object by its designer (Almquist and Lupton, 2010, p. 7).

The core of the HCD approach proposed by Krippendorff is rooted in designers' awareness of the subjectivity of the meaning-creation process. This awareness should guide design practitioners to improve their understanding of *others*, since the meaning-creation process cannot be imagined without moving between *other* and *self* (Steen, 2012).

From Users to Stakeholders

If the *self* is the designer's self, who are the *others*? Krippendorff explicitly refuses the idea of users being the others, arguing that users are an invention of manufacturing companies. The concept of user-centred design was, in fact, an invention within the experience economy, according to the American industrial model's idea of consumers, and therefore it has nothing to do with user emancipation and empowerment (Almquist and Lupton, 2010).

> Product semantics began replacing the concept of an average individual, THE user, by networks of stakeholders (Krippendorff, 2006).

Stakeholders should be seen as people with some stake (interest) in the design development. Each stakeholder has expertise which influences the meaning he/she attributes to the external world. Possible end-users, clients, bosses, co-workers, and opponents are some of the usual stakeholders involved in the design process, and they all deserve respect. This definition of stakeholders shows us how far we are from some of the traditional HCD methods previously described.

For instance, early usability scholars argued that bosses (Norman, 1988) and designers are not users (Nielsen, 1993) to highlight that they cannot interact with artefacts as users might. In Krippendorff's definition of stakeholders, such arguments are misleading since bosses and designers are as many stakeholders as end-users, and consequently, their point of view should be considered too. The assumption, supported by various authors (Manzini, 2016; Steen, 2012), that designers should be considered stakeholders leads us to a last question: *what characteristics distinguish designers from other stakeholders*?

Second-Order Understanding

Similarly to meaning, understanding is always someone's understanding; this applies to designers too.

> Designers and their stakeholders merely understand differently […] (Krippendorff, 2006, p. 67).

The HCD approach implies that designers are also stakeholders of the design practice, with the same limits in sensing, understanding, and assigning meaning as other people. Krippendorff claims that the skill that distinguishes a good designer in the HCD approach is *understanding of understanding*, which means that designers should be able to understand other stakeholders' understanding.

> When artefacts are designed to make sense to others, two intertwined understandings are necessarily involved: (1) designers' understanding of the artefact being proposed and (2) designers' understanding of different users' understanding of the artefact (Krippendorff, 2006, p. 66).

Number (1) is named *first-order understanding*, which is common to all humans. Number (2) is a designer's fundamental ability, called *second-order understanding*, and has some important implications.

In the first instance, observing stakeholders with second-order understanding means considering them knowledgeable agents, which in turn means that everything they do, say, and feel is meaningful according to their own logic. Secondarily, since other people's meaning cannot be exclusively observed as it emerges through language, designers must dialogue with other stakeholders. Nevertheless, the very nature of dialogue implies that designers are themselves part of the conversation and means that they also contribute to second-order understanding construction. The model proposed by Krippendorff empowers designers to become interpreters of other humans, but at the same time, it also forces them to develop excellent understanding and interpretative skills.

Implications of HCD as an Approach

This last section addresses the initial question by summarising how design practice has evolved through HCD to consider human beings.

In the first place, HCD has been framed as a group of methods (i.e., a set of codified procedures) used by designers to include the human dimension into the design process. Therefore, with the introduction of HCD methods, the how-to design has become increasingly structured around humans. This happened by borrowing some traditional research methods, adapting others, and creating innovative ones specifically for the design practice needs. It might be argued that such evolution of design methods to explore human issues, identify needs and solutions, and validate the design output represents a further formalisation of design as a disciplinary field of knowledge. Indeed, HCD methods provide designers with codified and repeatable procedures to include stakeholders in the design process.

This evolution of design practice through HCD finds its culmination in the conceptualisation proposed by Krippendorff. Here the centrality of humans is positioned at the level of design ultimate aims as well as procedures. The subjectivity of meaning-attribution to artefacts pushes designers to become professionals in understanding what is meaningful to other stakeholders.

While this introduction to Krippendorff's influential views has necessarily been concise, we believe that it is essential that readers acknowledge that the HCD discourse has been moving in this direction too. Indeed, in this last decade, the ideal way for designers to create meaning has been widely debated, and the debate is still open.

Being a product designer today means, in the first instance, being aware of the importance of according meaning to designed artefacts. To this extent, designers should be capable of embracing human-centeredness as a necessary mindset to explore others' understanding of the world. Discovering human nature and experience with curiosity, sensitivity, and a critical mindset could be seen as the stance designers must take to build their understanding of others' understanding.

In this conceptualisation, methods are still valuable procedures to be applied within the meaning creation process but not the highest expression of what HCD means. Assuming the meaning-oriented HCD as an approach implies that human-centeredness is achieved when a design solution is meaningful to a plurality of individuals rather than one that is shaped around humans.

References

Almquist, J., Lupton, J. (2010), "Affording Meaning: Design-Oriented Research from the Humanities and Social Sciences". *Design Issues*, 26(1), 3-14.

Celikoglu, O.M., Ogut, S.T., Krippendorff, K. (2017), "How Do User Stories Inspire Design? A Study of Cultural Probes". *Design Issues*, 33(2), 84-98.

Dorst, K. (2011), "The Core of Design Thinking and its Application". *Design Studies*, 32, 521-532.

Dreyfuss, H. (2003), *Designing for People*. Simon & Schuster.

Friess, E. (2010), "The Sword of Data: Does Human-Centered Design Fulfill its Rhetorical Responsibility?". *Design Issues*, 26(3), 40-50.

Hanington, B.M. (2010), "Relevant and Rigorous: Human-Centered Research and Design Education". *Design Issues*, 26(3), 18-26.

Hanington, B.M. (2007), "Generative Research in Design Education". *International Association of Societies of Design Research 2007: Emerging Trends in Design Research*, 12-15.

Hanington, B.M. (2003), "Methods in the Making: A Perspective on the State of Human Research in Design". *Design Issues*, 19(4), 9-18.

IEA (2018), *Definition and Domains of Ergonomics.* Retrieved August 31, 2022, from: https://iea.cc/what-is-ergonomics/.

Johansson-Sköldberg, U., Woodilla, J., Çetinkaya M. (2013), "Design Thinking: Past, Present and Possible Futures". *Creativity and Innovation Management* 22(2), 121-146.

Krippendorff, K. (2007), "Design Research, an Oxymoron?". *Design Research Now*, 67-80.

Krippendorff, K. (2006), *The Semantic Turn*, CRC Press.

Manzini, E. (2016), "Design Culture and Dialogic Design". *Design Issues*, 32(1), 52-59.

Mattelmäki, T., Vaajakallio, K., Koskinen, I. (2014), "What Happened to Empathic Design" *Design Issues*, 30(1), 67-77.

Nagamachi, M. (1995), "Kansei Engineering: a New Ergonomic Consumer-Oriented Technology for Product Development". *International Journal of Industrial Ergonomics*, 15(1), 3-11.
Nielsen, J. (1993), *Usability Engineering*. Elsevier.
Norman, D. (1988), *The Design of Everyday Things*. Doubled Currency.
Rampino, L., Colombo, S. (2012), "Method, Strategy or Tool? A Semantic Clarification". In L. Rampino (ed.), *Design Research: Between Scientific Method and Project Praxis*. FrancoAngeli, 83-94.
Rodgers, P. A., Anusas, M. (2008). "Ethnography and design". In A. Clarke, M. Evatt, P. Hogarth, J. Lloveras, L. Pons (eds.), *In DS 46: Proceedings of E&PDE 2008, the 10th International Conference on Engineering and Product Design Education, Barcelona, Spain*, 86-191.
Steen, M. (2012), "Human-Centered Design as a Fragile Encounter". *Design Issues*, 28(1), 72-80.
van Boeijen, A., Daalhuizen, J., Zijlstra, J. (2020). *Delft Design Guide: Perspectives, models, approaches, methods*. (2nd ed.) BIS Publishers.
van der Bijl-Brouwer, M., Dorst, K. (2017), "Advancing the Strategic Impact of Human-Centred Design". *Design Studies*, 53, 1-23.

The Digital Perspective

The evolution of digital design as a unique field of design endeavor, motivated by its own body of theoretical sources, promulgated by a culture of discourse, supported by new technologies, and producing unique classes of designs is a phenomenon that has been rapidly crystallizing in the past decade.

Oxman, R. (2006). "Theory and Design in the First Digital Age". *Design Studies*, 27(3), 229-265.

9. Product Design in the Knowledge Economy

by Lucia Rampino

The knowledge economy concept was first introduced and then popularized by Peter Drucker in a number of books and articles. As early as 1959, in the article *Landmarks of Tomorrow: A Report on the New Post-Modern World*, Drucker discussed the difference between knowledge and manual workers. The latter use their hands and other manual skills to produce and provide services and other goods. On the other hand, knowledge workers use their heads to deliver knowledge, information, and ideas[1]. For Drucker, in the knowledge economy, the rules and practices that had determined industrial economy success needed rewriting in an interconnected, globalized world where knowledge resources, such as trade secrets and expertise, are as critical as other economic resources such as land, machinery, labor or financial assets (Wartzman, 2014).

This shift toward a knowledge society has been boosted by increasing computer calculation potential, which makes all the other digital technologies possible and more powerful. On the one hand, digital technologies enable a vast amount of data to be collected and analyzed, data that would be impossible for the human mind to process. On the other hand, by the turn of the new millennium, multitudes of people empowered by access to the internet were producing and sharing their knowledge. For Brand and Rocchi (2011), one of the knowledge economy's most profound social transformations was that ordinary people could access social dialogue and exchange opinions across geographical boundaries. All this is the result of two digital revolutions:

> […] over the last half century, two digital revolutions have come to pass, more spectacularly than Moore himself predicted. The first digital revolution

[1] This distinction between manual and knowledge workers is not new in Western culture: it is an up-to-date version of the ancient distinction between liberal and mechanical arts, as discussed in Chapter 1.

> was in communication, taking us from analog phones to the internet. The second digital revolution was in computation, bringing us personal computers and smartphones. Together they have fundamentally changed the world (Gershenfeld *et al*., 2017, pp. 3-4).

A third, more recent, digital revolution is currently underway as well. It is still in its early stages, but its impact on product design is already considerable. We are, of course, referring to digital fabrication.

The Digital Revolution(s)

The term 'digital revolution' denotes technological progress from analog (electronic and mechanical) devices to the digital technology available today. It all started with one fundamental idea: the internet.

The internet is globally interconnected computer networks of different types. It is made possible by a set of standard protocols, the shared language by which all internet-connected computers communicate with each other, despite differences in underlying hardware and software architecture. Since the early nineties, the dissemination of the internet and its services has constituted a technological and socio-cultural revolution.

Today, the internet offers access to various services through dedicated software installed on computers and mobile phones. The two most used services are the World Wide Web and e-mail. The World Wide Web, launched by Tim Berners-Lee in 1989, is the chief interface through which billions of users access a wide variety of content through search engines and web browsers (e.g., texts, images, audio, video, hypertexts, hypermedia).

Web 2.0 and the Human Right to Internet Access

In 2005 the term 'web 2.0' appeared. It denotes a new, or second, phase in internet development and dissemination:

> from a giant billboard of information to an interactive knowledge network and a globally-connected social engagement space (Brand and Rocchi, 2011, p. 11).

Web 2.0 refers to changes in the way web pages are designed and used. First-generation websites typically limited people's internet access to the passive viewing of content. Web 2.0 websites, on the other hand, allow users to interact and work together as content creators in a virtual community.

This second-generation internet phase has three main features: (i) a significant increase in user participation; (ii) more efficient sharing of information that can be easily retrieved and exchanged using peer-to-peer tools or multimedia content distribution systems (e.g., YouTube); (iii) the affirmation of social networks (e.g., Facebook and Twitter).

> What matters most in the case of harnessing the users of Google and Amazon – but also those of Facebook, Twitter, Wikipedia, YouTube, and any number of other Web 2.0 sites – to contribute to the creation and curation of content is that the steps from mere usage to productive contribution are made as granular as possible, easing the transition from passive to active participation. Wikipedia users, for example, may contribute as little as a correction for a spelling error, or as much as the content stub for an entirely new article, with a sliding scale of other possible participation options in between (Bruns, 2013, p. 2).

With the advent of web 2.0, anyone with a computer, access to the internet, appropriate programs, and web space[2] can, in accordance with the law of the country the web server is based in, publish multimedia content and/or provide specific services through the internet. New programming languages allow rapid and constant website updating, even for those without thorough technical preparation. On the other hand, internet content is constantly online and therefore accessible to anyone with a computer and access to the internet. Web 2.0. is characterized by overall accessibility in technical terms too. Indeed, in developed countries, everybody can access it everywhere, thanks to Wi-Fi and the mobile web. Social networks' growing importance is due to these significant technical improvements.

With the advent of web 2.0, the internet has rapidly gained a social and political dimension, creating new forms of participation and democracy and making censorship more difficult for authoritarian systems. Democratic political participation has been given fresh impetus, with social networks allowing spontaneous political movements and collective protest actions on a local and national basis to be activated ("Internet", *Enciclopedia Treccani On-Line*).

Several scholars have much debated this new communication openness. Some have argued that it is a fundamental democratic step. In this respect, Benkler has spoken of:

> the emergence of a new information environment, one in which individuals are free to take a more active role than was possible in the industrial information economy of the twentieth century. This new freedom holds great practical promise: as a dimension of individual freedom; as a platform for

[2] Portion of web server memory storing web content and implementing web services.

better democratic participation; as a medium to foster a more critical and self-reflective culture; and, in an increasingly information-dependent global economy, as a mechanism to achieve improvements in human development everywhere (Benkler, 2006, p. 2).

As the importance of the internet grows, great economic powers and nation states show their interest in controlling it. Technology can provide sophisticated network control tools and, at the same time, applications that can bypass them. The debate on the internet and censorship, the right to freedom of opinion, and the manipulation of consensus is continually enriched by new topics involving many international actors.

In May 2011, the report of the 'Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression' presented to the United Nations Human Rights Council endorsed access to the internet as a fundamental human right. This was because the internet has proved to be an extraordinary tool to promote development, combat inequality, and protect human life and freedom. Consequently, states should prioritize universal internet access by minimizing restrictions on the free flow of information and communication. The report, therefore, denounces the legal action tending to prevent, limit, or pilot access to the web in an overall climate that sees this happening also in some democratic countries ("Internet", *Enciclopedia Treccani On-Line*). It is also important to stress that, in 2017, over half the planet still had no internet access, while billions more had limited or unreliable access (Gershenfeld *et al.*, 2017).

The Negative Aspects of Digital Technology

Like all major changes, the dissemination of digital technologies has also created new and unforeseen problems on various scales.

On an individual level, the internet has generated a need to protect our computers from viruses and our mailboxes from spam, but also our personal data from being stolen and our children from being trapped in dangerous virtual relationships.

Socially, the internet's open and libertarian nature makes 'good censorship' difficult, making it easier to access pedophilia and pornography sites and disseminate propaganda in favor of terrorism, subversion, and racism ("Internet", *Enciclopedia Treccani On-Line*). This is why some now think stricter internet controls are necessary, even at the cost of limiting its openness. Moreover, in much of the developed world, the socio-economic impact of digital technology is significant, taking forms such as growing income inequality, technological unemployment, and social polarization. These are all major challenges to be addressed.

Recently, some voices have been raised against the digital version of western colonialism, with reference to American Big-Tech corporations gaining massive profits through their global dominance over social media and entertainment.

> […] digital colonialism is about entrenching an unequal division of labor, where the dominant powers have used their ownership of digital infrastructure, knowledge and their control of the means of computation to keep the South in a situation of permanent dependency. This unequal division of labor has evolved. Economically, manufacturing has moved down the hierarchy of value, displaced by an advanced high-tech economy in which the Big Tech firms are firmly in charge (Kwet, 2021).

All the unwanted consequences of the digital revolution today require a great deal of attention.

A New Production and Consumption Landscape

The internet has changed production and consumption as we know them from previous economies.

In the knowledge economy, enterprises can be described as «*information organized for productive purposes*» ("Internet", *Enciclopedia Treccani On-Line*) and the internet has led to an incredible reduction in the cost of obtaining and delivering information. This resulted in a general decrease in costs as production processes were reorganized, also outsourcing parts of the business to emerging countries that offered lower labor costs.

The time and space flexibility allowed by digital technologies created a new work organization based on results rather than on employees' presence at the workplace during pre-defined hours. We are, of course, referring to smart working[3], which today represents an «*economically desirable*» (Angelici and Profeta, 2020) opportunity for companies and employees.

The internet has also changed the demand: many consumers use it to buy goods and services, to meet and exchange goods and opinions. This electronic agora generates new manners for exploiting the network's vast potential.

The following paragraphs will describe some of the most relevant socio-economic changes due to the internet advent.

[3] During the 2020 lockdown due to the Covid-19 pandemic, millions of workers suddenly experienced smart working from home, moving all their in-person meetings online. It was an unexpected and powerful demonstration of how digital technologies have impacted our lives.

New Economic Practices: The Sharing and the Access Economy

A certain portion of the knowledge economy that displays specific traits and features has earned the name 'sharing economy'.

Sharing economy is an umbrella term with a range of meanings. Initially, it described economic and social activities involving peer-to-peer online transactions. The Oxford Dictionary added the term in 2015, defining it as:

> An economic system in which assets or services are shared between private individuals, either free or for a fee, typically by means of the internet.

In 2015 another definition of sharing economy was supplied by Botsman, renowned author of the book *What's Mine is Yours: How Collaborative Consumption is Changing the Way We Live*:

> An economic system based on sharing underused assets or services, for free or for a fee, directly from individuals (Botsman, 2015).

Botsman's definition stresses a critical aspect: our interest in sharing with others assets we do not fully exploit. In recent years we have indeed witnessed the birth of several online platforms offering the sharing of different kinds of underused resources: objects (e.g., carpooling, clothes, and book swapping); spaces (e.g., home exchange); skills and knowledge (e.g., tourist information); time (e.g., time banks).

According to Carnevale Maffè, professor of Business Strategy at Bocconi University, in the sharing economy, the traditional distinctions between producers and consumers are no longer valid. A new model emerges where peers exchange goods and services based on mutual promises or penalties when the former are not respected (Camera dei Deputati, 2014). Therefore, services are no longer offered top-down by companies owning all the resources, but people meet online to exchange or share goods that they themselves own. Companies simply create and manage the online platform and the community using it.

From a technological point of view, the sharing economy is based on the internet's potential for online communities where strangers can easily meet, thus eradicating geographical distances.

Typical examples are BlaBlaCar, which enables car drivers going on long-distance trips to share their cars, and Peerby, which supports neighborhoods in goods sharing. Another example is Cohealo, a U.S. company that enables hospitals to share costly medical equipment.

Alongside the many enthusiastic voices that argue that the sharing economy is bringing about a more horizontal and, therefore, more democratic society, some critical voices are making themselves heard. For philosopher

Byung-Chul Han, for instance, the ideology underpinning today's sharing economy is leading to total social capitalization, leaving no room for disinterested friendship. Even picking up a hitch-hiker has been commodified with the result that, paradoxically, nobody willingly gives away anything for free.

Eckhardt and Bardhi (2015) have argued that the sharing economy term does not accurately describe more recent evolutions in the phenomenon. Indeed, most of the sharing which takes place online is mediated by intermediary companies, which link up users who do not know each other. Users are therefore paying to access someone else's goods or services for a specific time, and their main objective is utilitarian rather than social. In other words, users are not seeking out new experiences or social relationships. They simply want convenient services at a reasonable price. BlaBlaCar is a good example of this utilitarian nature: cars are expensive to buy and keep and most of the time travel at least half empty (reason to sell); on the other hand, a lift in a car is less expensive than a taxi and more flexible than a train (reason to buy). Airbnb works according to the same principle: renting an apartment is less expensive for families than sleeping in a hotel. Thus, Eckhardt and Bardhi suggested a better term for the sharing economy in its broadest sense would be 'access economy'.

In the access economy, products or services are exchanged on the premise of access as opposed to ownership. The advantages are convenient and cost-effective access to valued resources, flexibility and freedom from the financial, social, and emotional obligations embedded in ownership. In the access economy, brand perception changes accordingly:

> Consumers think about access differently than they think about ownership. […] When consumers are able to access a wide variety of brands at any given moment, like driving a BMW one day and a Toyota Prius the next day, they don't necessarily feel that one brand is more "them" than another, and they do not connect to the brands in the same closely-binding, identity building fashion (Eckhardt and Bardhi, 2015).

Whatever we call it, either sharing or access economy, what we are dealing with is a new and still changing phenomenon since the socio-economic practices involved in it are evolving rapidly.

New User Categories: Pro-Ams and Lurkers

The knowledge economy has seen a rise in new user categories: amateur professionals and lurkers. Already in the late 1970s, sociologist Stebbins (1977; 1980) described what he called modern amateurs and the Professional-Amateur-Public system. In such systems, amateurs do what is usually work for others, namely professionals. This typically falls into one of the areas (i.e., science, arts, sport, entertainment) in which work was a hobby before the Industrial Revolution:

> More than a century of a professionalized academy has helped obscure the amateur roots of the arts and sciences, which evolved through the accomplishments of men and women who wore the mantle of amateur with great pride, and would have considered being called a professional an insult. Francis Bacon is one of the founding fathers of modern science, the inventor of the scientific method. But science was really something of a sideline for Bacon, who was better known in his time as a lawyer, writer, politician, courtier (Howe, 2008).

As Smith predicted, increasing industrialization finally led to a rational and specialized division of labor with a consequent growth of professionals in every scientific and artistic field.

Web 2.0 is now a powerful tool in the hands of amateurs: an increasing number of users are no longer simply consumers of professionally created content but rather create and publish content themselves which is sometimes on a par with professional ones. The term most frequently used when this happens is ‘amateur professionals’.

> A Pro-Am pursues an activity as an amateur, mainly for the love of it, but sets a professional standard. Pro-Ams are unlikely to earn more than a small portion of their income from their pastime but they pursue it with the dedication and commitment associated with a professional (Leadbeater and Miller, 2004, p. 20).

Amateur professionalism typically occurs in populations with more leisure time, allowing hobbies and other non-essential interests to be pursued at a professional or near-professional level. Today Pro-Ams fields increasingly include astronomy, activism, sports equipment, software engineering, education, and music. Microsoft has estimated that there are six million professional software developers worldwide and a further eighteen million amateur developers (hobbyists, tinkerers, students).

If amateurs have always been an essential part of Western culture, lurkers are a new breed of users. The word lurker is used for people who participate in a virtual community (e.g., a newsgroup, a forum), following all its activities, but without taking an active part, remaining unknown to other participants. Lurkers make up a large proportion of all online community users. For instance, on Twitter, these have been estimated at 65 percent. There are no negative connotations associated with the term. On the contrary, when users first enter a virtual community, netiquette requires a period of lurking to get acquainted with its unwritten codes of conduct and the topics debated. In most cases, however, lurkers remain anonymous indefinitely, simply liking or disliking or making a few sporadic comments.

Even without adding meaningful content, lurkers are considered indispensable to collaborative rating and filtering systems that help online communities to identify quality content. Moreover, since they provide a large audience, their presence is often the justification for advertising sponsorship.

New Outsourcing Modalities: Asking the Crowd to Solve Problems

A valuable asset that people are especially willing to share in the knowledge economy is their knowledge. This free circulation of knowledge, fostered by the widespread dissemination of web 2.0 technologies, has led to a further remarkable phenomenon - crowdsourcing.

The termwas first coined by Howe in a 2006 article in Wired, *The Rise of Crowdsourcing*. In another article that same year, Howe argued as follows:

> Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call (Howe, 2006b).

Crowdsourcing is a problem-solving activity: resolving a given problem is commissioned to an undefined group of potential solvers, a «*motivated crowd of individuals*» (Brabham, 2008), usually gathered into online communities. The 'crowd' comes up with a series of solutions which are then evaluated by the problem's holder, who selects the most suitable. These solutions belong to the institution or individual who initially presented the problem. In some cases, users who helped to generate solutions are rewarded with prizes or awards; in others, the satisfaction is moral alone.

Unsurprisingly, amateur professionals' contributions are highly valued in crowdsourcing, for instance, in software development. Indeed, crowdsourcing was initially based mainly on volunteer enthusiasts' work. The open source community was the first to benefit from this. The free-encyclopedia Wikipedia is considered an example of voluntary crowdsourcing by many.

Today organizations and institutions in several fields use contributions from internet users to obtain the services or ideas they need, launching the challenge themselves or, more commonly, asking an already established online community to do it for them. An example is the InnoCentive organization, founded in 2001 by pharmaceutical firm Eli Lilly to connect with people outside the company to develop drugs. Today, InnoCentive enables companies to publish their unresolved R&D issues, asking experts from various fields to offer possible solutions. Financial rewards are paid to solvers.

As said, crowdsourcing differs from outsourcing in that the solution comes from an undefined public, not a specific, designated group. Therefore, when Lego launched a design challenge in the form of the Lego IDEAS open online call, it used crowdsourcing. On the other hand, when a design consultancy firm (e.g., Ideo) is commissioned a design challenge from a manufacturing company, it is outsourcing.

Some also distinguish crowdsourcing from open source production because cooperation is not, in the latter, commissioned by a specific individual or body with a problem but instead initiated and voluntarily pursued by a group of individuals. Consequently, while some authors (Buecheler *et al.*, 2010) consider Wikipedia an example of crowdsourcing, others (Kleeman, Voss, and Rieder, 2008) argue the contrary.

Not surprisingly, the term crowdsourcing (like all those born with the digital revolution) constantly evolves as new application fields crop up. Currently, more than forty distinct definitions of it can be found in the literature.

Digital Craftsmanship and Makers

Speaking of a return to craftsmanship in a chapter devoted to the knowledge economy may appear somewhat contradictory. The term knowledge economy was coined precisely to stress the growing importance and dissemination of intellectual over manual work. And indeed, as we have seen, the two first digital revolutions encouraged this trend. However, a third digital revolution, enabling both bits and atoms to be exponentially manipulated, is now occurring: digital fabrication. This paragraph will thus look at this flip side of the (digital) coin.

For Gershenfeld *et al.* (2017), digital fabrication shares some, but not all, of the attributes of digital communication and computation. While in the first two digital revolutions, bits changed atoms indirectly by creating new capabilities and behaviors, now bits enable people to use digital design interfaces to manipulate atoms, modifying the physical world directly.

> Despite the enormous changes brought on by the first two digital revolutions, much of the physical world around us – roads, houses, appliances,

> transportation, food – have remained remarkably the same. But in the third digital revolution, the very nature of how the physical world around us is constructed will change (Gershenfeld *et al.*, 2017, p. 7).

The opportunities offered by digital fabrication have nurtured a new social trend whose impact on design is considerable, the rediscovery of craftsmanship, however updated and digital.

Stefano Micelli (2011), a renowned Italian economist, has argued that many modern experts believe that advanced economies will need to rediscover makers, i.e., those who make things, as opposed to thinkers and intellectuals. It is the revenge of the mechanical over the liberal arts, the victory of the craftsman, as described by Sennett (2008) over the reflective practitioner.

Digital fabrication reinforces a profound human desire to make things. Therefore, while industrial mass production remains significant, in recent years, we have been witnessing a return to individualized production practices, as exemplified by the DIY (do-it-yourself) community (Tanenbaum *et al.*, 2013). This community is linked to the amateur professionals' phenomenon looked at earlier.

A technology-based extension of DIY has been called 'maker culture'. Typical interests enjoyed by makers include electronics and robotics, 3D printing, computer numeric control tools, metalworking and woodworking, and traditional arts and crafts. Makers are interested in creating new devices as well as tinkering with existing ones. In general, they support open source hardware.

In 2005, the year in which the *Fab: The Coming Revolution on Your Desktop - from Personal Computers to Personal Fabrication* book was published by Gershenfeld, the director of MIT's Center for Bits and Atoms, a new magazine called MAKE was also published in the USA. It focused on do-it-yourself projects involving computers, robotics, electronics, metalworking, and woodworking and is now considered one of the maker movement's prominent voices.

> […] the explosion in new materials and new small scale fabrication technologies such as 3D printing, laser cutting, and garage-scale CNC mills has given hackers and hobbyists modes of production previously only available to large organizations (Tanenbaum *et al.*, 2013, p. 2605).

But being a maker is not simply an issue of possessing good manual skills and the technical knowledge needed to manufacture objects. It is, overall, a critical stance towards the way we produce and consume in developed countries:

> The Makers described here draw on cutting edge CAD and CNC manufacturing to critique the outcomes of industrial practices. Yet they also rely on industrial infrastructure to provide them with the tools and raw materials that fuel their practice. This tension creates an area of simultaneous participation, critique, and resistance (Tanenbaum *et al*, 2013, p. 2609).

All this is well described in a 2013 book by Mark Hatch entitled *Maker Movement Manifesto.*

At the beginning of the new millennium, maker spaces began emerging worldwide. They are cooperatively organized spaces, equipped with a wide variety of tools that many makers would not be able to afford on their own (Aldrich, 2014). Via an online application, these spaces can be included on the official list of fab labs (see next section).

The openness of this new way of designing creates issues in terms of intellectual property rights (Berman, 2012). It is indeed challenging to safeguard intellectual property in a world where files digitally describing an object can be easily uploaded online, then downloaded, and, in some cases, 3D printed[4].

The Fab Lab Movement

A fab lab is a small-scale fabrication laboratory offering individuals access to digital fabrication tools. It is generally equipped with various flexible computer-controlled tools covering several scales and materials.

Fab labs began as the result of joint research between the Grassroots Invention Group and MIT's Center for Bits and Atoms. The first lab was set up in 2003. Since then, they have doubled in number every year and a half (Gershenfeld *et al.*, 2017), and in 2021 there were over 2000 fab labs worldwide. MIT maintained a listing of all official fab labs until 2014. Today, the fab lab official listing can be found at www.fablabs.io.

The fab lab movement is part of the broader maker movement and closely aligned with the DIY and free and open source movements, sharing philosophy and technology with them.

For Neil Gershenfeld and his brothers (2017), despite the promise of personal fabrication and individuals' ability to make what they consume, digital fabrication is still a long way from being a reality for most people. There are indeed significant challenges to be addressed around fab access and literacy.

[4] To better understand the actual implications of digital fabrication for product manufacturing, see Chapter 10.

Designing for the Fourth Dimension of Products

As a result of the growing availability of digital technologies, today's artefacts are embedded with sensors, electronics, processors, actuators, and smart materials. Thanks to these elements, they can perceive the environment and, through artificial intelligence, understand human language, learn from the data they collect, and make autonomous decisions.

This has profound consequences for product design: while from a technical perspective, products are mainly static objects, under the digital perspective, the form of an object and, more generally, its behavior can significantly change over time[5]. Therefore, the core of product design activity – form giving – can no longer be conceived as similar to sculpting. Static 'technical' sculpture has evolved into living 'digital' robots equipped with new potential for movement and reaction to external stimuli.

Consequently, designers' form-giving activity now shares similarities with what musicians, poets, and filmmakers do. In this regard, Vallgårda *et al.* (2015) introduced the concept of 'temporal form giving'.

From a digital perspective, product designers should possess the skills and knowledge to manage objects' fourth dimension: the time dimension. If, in traditional product design, time was considered relevant only in terms of designing users' actions, where intelligent and dynamic objects are concerned, time is also essential to designing a product's features and behaviors. On a more general level, designers should be able to rapidly explore, analyze, and build interactive products and systems, and their behavioral elements in particular, to evaluate potential solutions (Gardien *et al.*, 2014). In this regard, designers should make the most of the opportunities now offered by rapid prototyping tools (e.g., 3D printers and laser cutters) and electronic prototyping toolkits (e.g., Arduino).

But this is not enough: digital technology's last challenge to designers is the capacity to include artificial intelligence (AI) in their projects.

> In product design, AI can have two main areas of application, both extensively debated: the product itself and the design process. Therefore, we can say that AI can be either the material of design or a design tool. In the first case, the final product is equipped with AI functionalities. In the second case, AI is applied to enhance and optimize the outputs of the design process (Figoli et al, 2022, p. 20).

[5] The dynamic products concept is presented in Chapter 11.

To properly deal with artificial intelligence, designers should gain new knowledge, skills, and competencies[6].

References

Aldrich, H.E. (2014), *The Democratization of Entrepreneurship? Hackers, Makerspaces, and Crowdfunding*. Presentation for Academy of Management Annual Meeting, Philadelphia, PA.

Angelici, M., Profeta, P. (2020). *Smart-working: Work Flexibility Without Constraints*, in DONDENA, working paper, n. 137.

Benkler, Y. (2006), The Wealth of Networks: How Social Production Transforms Markets and Freedom. Yale University Press.

Berman, B. (2012), "3-D Printing: The New Industrial Revolution". *Business Horizons*, 55(2), 155-162.

Botsman, R. (2015), "Defining the Sharing Economy: What is Collaborative Consumption and What Isn't", *Fast Company*. Retrieved November 21, 2017 from www.fastcompany.com/3046119/defining-the-sharing-economy-what-is-collaborative-consumption-and-what-isnt

Brabham, D.C. (2008), "Crowdsourcing as a Model for Problem Solving: An Introduction and Cases". *Convergence: The International Journal of Research into New Media Technologies*. 14(1), 75-90.

Brand, R., Rocchi, S. (2011), *Rethinking Value in a Changing Landscape: A Model for Strategic Reflection and Business Transformation*. Philips Design. Retrieved April 4, 2013, from www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/april2011/paradigms.pdf

Bruns, A. (2013), "Exploring the Pro-Am Interface between Production and Produsage". *Frontiers in new media research*, 15, 241.

Buecheler T., Sieg J.H., Füchslin R.M., Pfeifer R. (2010), "Crowdsourcing, Open Innovation and Collective Intelligence in the Scientific Method: A Research Agenda and Operational Framework". In *Artificial Life XII. Proceedings of the Twelfth International Conference on the Synthesis and Simulation of Living Systems*, Odense, Denmark, 679-686.

Camera dei Deputati (2014), "Sharing economy: rivoluzione tecnologica delle comunità di utenti online per la crescita". In *Comunicati Stampa*. Retrieved January 16, 2018, from www.camera.it/leg17/1131?shadow_comunicatostampa=8374

Cooper, E. (2008) "The Craftsman Richard Sennett". *The Journal of Modern Craft*, 1(3), 435-437.

[6] This issue is treated in the Ph.D. research of Martina Sciannamè titled "*MACHINE LEARNING (for) DESIGN. Towards designerly ways to translate ML for design education*" (Politecnico di Milano, Doctoral Program in Design, XXXV cycle).

Drucker, P. (1959), *Landmarks of Tomorrow: A Report on The New 'Postmodern' World*. Harper.
Eckhardt, G.M., Bardhi, F. (2015), "The sharing economy isn't about sharing at all". *Harvard Business Review*, 28(01).
Ertz, M., Durif, F., Arcand, M. (2016), "Collaborative Consumption or the Rise of the Two-Sided Consumer". *International Journal of Business and Management.* 4(6), 195-209.
Estellés Arolas, E., González Ladrón-de-Guevara, F. (2012), "Towards an Integrated Crowdsourcing Definition". *Journal of Information Science*. 38(2), 189-200.
Figoli, F.A., Mattioli, F., Rampino, L. (2022), *Artificial intelligence in the design process: The Impact on Creativity and Team Collaboration*. FrancoAngeli.
Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice". *International Journal of Design*, 8(2), 119-139.
Gershenfeld, N.A. (2005), *Fab: the Coming Revolution on your Desktop - from Personal Computers to Personal Fabrication*. Basic Books.
Gershenfeld, N.A., Gershenfeld, A., Cutcher-Gershenfeld, J. (2017), *Designing Reality. How to Survive and Thrive in the Third Digital Revolution*. Basic Books.
Howe, J. (2006a), "The Rise of Crowdsourcing". *Wired Magazine* - Issue 14.06. Retrieved January 16, 2018 from https://www.wired.com/2006/06/crowds/
Howe, J. (2006b). *Crowdsourcing: A Definition*. Retrieved January 16, 2018 from http://crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html
Howe, J. (2008), *Rise of the Amateur, Continued*. Retrieved January 16, 2018 from http://www.crowdsourcing.com/cs/2008/02/chapter-two-ris.html
Keating, S. (2014), "Beyond 3D Printing: The New Dimensions of Additive Fabrication". In J. Follett (ed.), *Designing for Emerging Technologies: UX for Genomics, Robotics, and the Internet of Things* O'Reilly Media. 379-405.
Kleeman, F., Voss G.G., Rieder K., (2008), "Un(der)paid Innovators: The Commercial Utilization of Consumer Work through Crowdsourcing", *Science, Technology and Innovation Studies,* 4(1), 5-26.
Kwet, M. (March 3, 2021), *Digital colonialism: the evolution of American empire*. Retrieved August 15, 2022 from https://roarmag.org/essays/
"Internet", *Enciclopedia Treccani On-Line*. Retrieved August 16, 2022 from http://www.treccani.it/enciclopedia/internet/
Leadbeater, C., Miller, P. (2004), *The Pro-Am Revolution: How Enthusiasts are Changing our Society and Economy*. Demos. Retrieved January 16, 2018 from https://www.demos.co.uk/files/proamrevolutionfinal.pdf
Micelli, S. (2011), *Futuro artigiano: l'innovazione nelle mani degli italiani*. Marsilio Editori.
Schön, S., Ebner, M., Kumar, S. (2014), "The Maker Movement. Implications of New Digital Gadgets, Fabrication Tools and Spaces for Creative Learning and Teaching". *eLearning Papers*, 39, 14-25.
Sennett, R. (2008), *The Craftsman*. Yale University Press.

Stebbins, R.A. (1977), "The Amateur: Two Sociological Definitions". *Pacific Sociological Review*, 20(4), 582-606.

Stebbins, R.A. (1980), "Amateur and Hobbyist as Concepts for the Study of Leisure Problems". *Social Problems*, 27(4), 413-417.

Tanenbaum, J.G., Williams, A.M., Desjardins, A., Tanenbaum, K. (2013), "Democratizing Technology: Pleasure, Utility and Expressiveness in DIY and Maker Practice". In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* ACM, 2603-2612.

Vallgårda, A., Winther, M., Mørch, N., Vizer, E.E. (2015), "Temporal Form in Interaction Design". *International Journal of Design*, 9(3), 1-15.

Van Abel, B., Evers, L., Troxler, P., Klaassen, R. (2014), *Open Design Now: Why Design Cannot Remain Exclusive*. BIS Publishers.

Vickery, G., Wunsch-Vincent, S. (2007), *Participative Web and User-Created Content: Web 2.0 Wikis and Social Networking*. Organization for Economic Cooperation and Development (OECD).

Wartzman, R. (2014), "What Peter Drucker Knew About 2020". In *Harward Business Review*. Retrieved January 16, 2018 from https://hbr.org/2014/10/what-peter-drucker-knew-about-2020

"Web 2.0", *Enciclopedia Treccani On-Line*. Retrieved November 12, 2017 from http://www.treccani.it/enciclopedia/web-2-0/

10. Digital Fabrication and Product Aesthetics

by Lucia Rampino and Riccardo Gatti

An indissoluble bond has existed between design and technology since the origin of industrial design. Technological possibilities drive design solution feasibility: manufacturing technologies affect product form while product technologies determine its functioning.

Over the last two decades, design has engaged in-depth with the exploration of complex geometries as well as associated fabrication processes. These developments significantly influence the theoretical and methodological contents of so-called 'digital design' (Oxman, 2008).

From the manufacturing technologies point of view, the shift from the technical to the digital perspective can be described as a shift from repetitive to non-repetitive operations:

> Industrial-era machinery typically achieved efficiency through repetition, mass-production, and economies of scale. In the digital era, numerically controlled machines have allowed similar efficiencies with non-repetitive operations (Mitchell, 2005, p. 48).

The potential for performing non-repetitive operations considerably impacts the product form. While simple forms are typical of mass production demands for repetition, highly complex shapes resulting from non-repetitive operations are made possible in digital production.

In this chapter, we will focus our attention on the evolving family of digital fabrication technologies, additive manufacturing, often referred to as 3D printing. For Gershenfeld *et al*. (2017, p. 5), these technologies are «*bringing the programmability of the virtual world of bits into the physical world of atoms*».

In the first part of the chapter, we will outline the functioning principles and typical process advantages and limits of 3D printing. However, ours is not an interest in digital fabrication *per se* but one driven by an interest in how it impacts product form[1]. From the product design point of view, the main issue connected with the advent of 3D printing is the need to learn a completely different approach to form-giving: substantial changes in the way products are manufactured demand corresponding changes in how they are designed. But that is not all. A second technological leap calls for an update of how designers engage with the design process. We are referring to the advent of generative design enabled by the ever-increasing computation capabilities of artificial intelligence (AI). Indeed, additive manufacturing and AI-empowered software are the two mutually reinforcing drivers of digital design.

Many of today's product designers still apply the rules from injection molding to 3D printing and are unprepared to seize the potential of AI in the design process. This is a mistake since all technologies have pros and cons: it is the designer's task to master and make the most of them.

Therefore, in the second part of this chapter, we will present a tentative taxonomy of the different computational approaches used for designing three-dimensional patterns. In our view, aesthetics based on three-dimensional patterns is the distinctive trait of the current product digital language.

3D Printing Technology

Mass-produced objects are traditionally obtained through formative methods, the most obvious example being injection molding, where a solid material (e.g., a thermoplastic one) is heated until it becomes soft and then pressed into a shape or mold. As it cools, the material retains the shape of the mold. By contrast, additive manufacturing is the construction of objects by adding layers of fabric. All 3D printers use 3D CAD software that measures thousands of cross-sections of each product to determine exactly how each layer is to be constructed (Berman, 2012).

Although the first patents for 3D printing date back to 1986, recent increases in CAD software and the availability of new materials and lower-cost fabrication systems have stimulated new applications.

For Berman (2012), 3D printing has undergone a three-phase evolution. In the first phase, it was seen as a technology for rapid prototyping and used by product designers, architects, and artists to make prototypes and mock-ups. This is still a consolidated application field today.

[1] Chapter 11, on the other hand, focuses on the smart behaviors fostered by digital product components.

In the second phase, 3D printing was applied to direct digital manufacturing and used to create finished goods. Since 3D printing does not require expensive tooling, it is particularly cost-effective for small production runs or self-made production. This phase is now growing and expanding.

In the last phase, desktop 3D printers emerged, leaving maker spaces, and making their way into the homes of final users, just like traditional desktop laser printers. In this scenario, anyone could download a CAD model for a replacement part, for example, and then print the part on a home 3D printer. The number of final users owning home 3D printers is still minimal today. However, for the experts, it is not a question of *whether* these will impact significantly on society but *when*:

> Much as the core elements of the first two digital revolutions were visible in the labs of the mid-1960s, when Gordon Moore wrote his article. All the core elements of the third digital revolution are visible in research labs today. The question is, how long will it take for them to emerge from the lab and impact society? And will we be ready? (Gershenfeld *et al.,* 2017, p. 11).

Additive manufacturing is a family of technologies, each based on a different functioning principle. Therefore, various 3D printing machines employ different materials and print objects with varying degrees of precision and process duration. Despite such diversities – which can also be significant – the overall logic governing the digital production process is the same. For this reason, a series of common process pros and cons can be illustrated.

Process Advantages

There are three main advantages to 3D printing techniques: no tooling and fixturing costs, process agility, and shape freedom.

Regarding the first of these, in contrast to molding processes requiring specific and expensive mold construction, 3D printing entails relatively low fixed costs. Within given dimension constraints, a printer can print any object. Therefore, even when printing processes are rather long, they are still cost-effective for small production runs. This is why current 3D printing applications typically involve low quantity production runs of small and complex items such as dental applications (Berman, 2012).

Traditional manufacturing techniques become more cost-effective as volume increases, and high tooling costs are justified by the large production volumes.

As far as process agility is concerned, designing and modifying products to be printed is relatively easy and fast. Moreover, the absence of a mold also eliminates the need for indefinite repetition of the same form. Indeed, each piece is printed individually, regardless of the form of those which precede and follow. By combining additive manufacturing with computational design systems, each piece can be made from the starting point of a geometric variation in the basic model, allowing one-off pieces to be made. This entails another important benefit: small batches of objects with tiny but significant differences can be printed, thus achieving mass customization.

In shape terms, addictive manufacturing permits great freedom. First, since the product body no longer emerges from a mold, design requirements such as draft angles, undercuts, and tool access do not apply. Moreover, whilst some restrictions on the minimum size features that can be accurately printed exist, most of these limitations revolve around how a print should optimally be orientated to reduce support dependency and the likelihood of print failure. This enables designers to create very complex geometries. Furthermore, cost and time requirements for complex part production are the same as those for simple parts (Conner *et al.,* 2014): form simplification stops being an economic requirement, as it was in the technical perspective.

Process Limits

Before 3D printing can achieve widespread adoption, some issues still need to be addressed.

For Keating (2014), there are three main problematic elements of additive manufacturing. The first is spatial limitations. Since operating large 3D printing machines is difficult, printed objects must be limited in size. Given these spatial limitations, combined with shape freedom, it is unsurprising that jewelry is one of the sectors in which 3D printing's impact is most significant.

The second issue is material limitations, including color and surface finish, compared to traditional molding techniques. In 2022 at least four 3D printing machines able to print in color and one able to simultaneously print materials with different physical properties (e.g., opaque, transparent, rigid, elastic) were launched on the market. However, the gap remains compared to injection molding, where thousands of color variants and materials possibilities are available.

The last issue is printing time. Since objects are printed layer by layer, printing even small objects takes several hours. According to Abdulhameed *et al.* (2019), the printing time primarily depends on the object's height in the z-direction. An object with a greater height will have a longer printing time, independent of the printing process. Therefore, designing for a low overall build height is an excellent strategy to reduce printing time.

Other process limits relate to the accuracy and strength of 3D products. Indeed, additive manufacturing requires compromises between surface finish and mechanical properties. Since objects are obtained via several thin layers, this generally results in poor superficial finishing compared to molded parts. A recurrent issue is the appearance of the so-called ‘staircase effect’ in the fabricated parts. This layering error substantially affects the quality of external surfaces. Although many post-processing methods can be employed to minimize or eliminate this defect, they also increase the time and cost of the overall process (Abdulhameed *et al*., 2019).

However, some addictive technologies, such as Stereolithography and Material Jetting, achieve high levels of superficial quality, up to ten microns, in most cases superior to that obtained by molding technologies. But this accuracy entails significant increases in printing time and piece fragility.

In terms of strength, 3d printed parts are anisotropic in microstructure and mechanical properties. For example, the plates manufactured by FDM technology possess better strength in the x and y direction than in the z-direction (build direction).

Finally, in cost terms, in contrast to injection molding and cutting-based machinery, in 3D printing, variable costs per part do not decrease with large production runs (Berman, 2012).

The limitations of additive manufacturing, such as low surface quality and speed, can be overcome by combining it with other processes such as subtractive manufacturing. This led to the development of hybrid manufacturing processes where different additive manufacturing methods are combined, or subtractive methods are added (Abdulhameed *et al*., 2019).

For the experts, certain of 3D printing’s limits will diminish over time, especially printing times and material choices. However, some issues have yet even to emerge.

The Push of Artificial Intelligence to Generative Design

In a self-strengthening loop, the above described addictive manufacturing possibilities matched with the computation capabilities of artificial intelligence encourage designers to engage increasingly with generative design, representing the natural evolution of digital modeling.

Generative design is associated with multiple aspects of computational design, from topological optimization to algorithmic generation. Today, generative design software can independently create ‘optimal’ design solutions from a set of systemic requirements.

An Updated Design Process[2]

In such a scenario, every design project starts, as usual, from the analysis of needs and constraints to be made explicit and contextualized within a system of relationships. Until now, the designer defined this system of relations based on her capacity for analysis and inventiveness. Nowadays, however, artificial intelligence allows for generating many relationships, some of which are unexpected, without the designer's direct intervention.

> In general, AI systems analyse large amounts of data, aiming to identify patterns and internal relationships that enable the generation of predictions. Today AI is a precious technology in many sectors because it allows machines to perform tasks typical of human operators, and often, thanks to the superior computing power of devices, even faster and with a lower error rate (Figoli et al., 2022, p. 22).

As a result, the designer is no longer in charge of providing a solution to a (wicked and increasingly complex) problem but of analyzing and collecting parameters and constraints that will feed artificial intelligence, permitting it to propose possible solutions.

This new design process resembles the optimization process applied in engineering to solve complex problems. Also in this case, the engineering rule *garbage in - garbage out* remains valid: if the input constraints are wrong or inaccurate, the results will be consistently incorrect. Here the designer takes on a new and fundamental role: that of verifier of the result.

In a generative design scenario, the designer is therefore less involved in the operational project's tasks in favor of the conceptual part and results verification. Overall, the design process changes, passing from being based on the ability of the designer to interpret the constraints to the designer's ability to define the project's conditions. Such a transformation, still ongoing, is radical.

Exploiting the Power of Algorithms

As said, generative design, i.e.designing through algorithms, is becoming more and more feasible.

A first step is using bio-mimetic algorithms inspired by studying natural phenomena and applying them to solving artificial problems. These algo-

[2] For an extended discussion of how the advent of artificial intelligence has been changing the design process, see Figoli, F. A., Mattioli, F., Rampino, L. (2022). *Artificial intelligence in the design process: The Impact on Creativity and Team Collaboration*. FrancoAngeli, freely available at: https://library.oapen.org/handle/20.500.12657/53627

rithms simulate biological processes, particularly structure growth, aggregation of individuals or elements, and natural selection of populations.

As an example, Genetic Algorithms use techniques inspired by evolutionary biologies, such as inheritance, mutation, selection, and crossover. They can be effectively employed for addressing multi-objective design problems and calculating multiple performance criteria, finding close to optimum solutions quickly. However, their application requires deep mathematical and computer programming knowledge, far beyond the domain of most professionals (González and Fiorito, 2015). The creation of the Galapagos calculation module integrated into the Grasshopper plug-in of Rhinoceros by David Rutten in 2013 filled this gap, permitting the exploration of different optimization problems without the need for advanced computing or mathematics skills.

A further step forward is the application of machine learning intended as a statistical process that, analyzing a great variety of elements, can identify the recurring and descriptive values of a specific typology of objects (i.e., pictures, or items of furniture), defining a multitude of elements on the base of a precise numerical variation. This permits, for instance, the use of images to generate families of similar photos. An example is the website '*This sneaker does not exist*'[3] displaying pictures of shoes randomly generated by an artificial intelligence engine. Selecting one, the user can create her variation based on three parameters.

Many machine learning algorithms are today available to designers. Hereafter, we present two examples, offering a more 'artistic' and 'engineering' output, respectively. In both cases, the designer must provide the most detailed, consistent, and accurate possible inputs and choose the output, verifying the quality of the result.

The Midjourney engine[4] can generate images of significant aesthetic impact, starting from a textual description. The more precise the textual description, the more detailed and focused the result. The engine can either support or entirely replace the designer in the generation of a concept design, in the step that brings to its aesthetic formalization.

On the other hand, the generative design module proposed by Autodesk allows visualizing a multitude of three-dimensional geometries starting from the definition of a series of genomes, basic geometries, and constraints the generation must comply with. The software compares multiple variants and intersections of the basic geometries to identify those most responding to the conditions imposed.

[3] https://thissneakerdoesnotexist.com.
[4] https://www.midjourney.com.

These generative systems are radically changing the way of designing and the project result, particularly the aesthetics of the generated objects. We can therefore affirm that a flywheel effect exists, in which powerful algorithms push the adoption of more flexible production technologies, and updated production technologies allow designers to approach generative design, as in the following example.

The Jet Engine Bracket Challenge

In 2013 General Electric launched a challenge designed to exploit software tools for part optimization and the freedom permitted by addictive manufacturing through the GrabCAD community website[5].

The task was to redesign a bracket for an airplane motor, then produced with CNC machining and weighing two kilograms, reducing its weight without diminishing its strength. Riccardo Gatti responded to the challenge with a Politecnico di Milano Design&Engineering M.A. student, Andreas Anedda.

Figure 1: Bone 414 by Andreas Anedda and Riccardo Gatti for the GrabCAD GE Challenge

They used mesh relaxation, a form-finding technique that distributes material in shape according to a balance principle of surface stresses, thus generating shapes inspired by bones. The result was an extremely complex form resembling bone structure that could not have been made with any manufacturing techniques other than 3D printing.

The final titanium bracket, obtained with SLM technology, weighs just 414 grams, around eighty percent less than the original, and still resists all stress tests. This proposal was ranked in the top ten of 638 proposals submitted.

[5] https://grabcad.com/challenges/ge-jet-engine-bracket-challenge.

Product Digital Aesthetics

As said, increased additive manufacturing technology availability coupled with increasingly powerful 3D modeling software has been pushing design towards new languages and impacting the current way products are designed.

In the technical perspective, designers applied reduced and simplified aesthetics to achieve manufacturing optimization and standardization, with the ultimate goal of facilitating mass production [6]. Until 1980s postmodernism, *Form follows Function*, *Ornament and Crime* and *Less is More* were the dominant slogans of generations of product designers, accustomed to reducing design costs and, therefore, details to obtain simple, feasible, affordable mass-produced products.

This dominant design interpretation has been challenged with the rise of postmodern language[7]. However, this language modification resulted from a wider socio-cultural change rather than the advent of new technological possibilities. Today, as we have seen, digital fabrication, in synergy with 3D computational software, has permitted unprecedented shape freedom. This new language is thus mainly driven by a technological leap forward, as it was when mass production began.

Interestingly, as was the case with both Modern and Postmodern movements, the emergence of a digital design language was also pioneered by architects. Already in the late nineties, architects began rethinking building aesthetics thanks to the new possibilities offered by digital technologies. A first famous example is the 1997 Bilbao Guggenheim Museum, designed by Frank O. Gehry, representing «*the most prominent catalyst of theorizing new formal directions and postulating new design, materialization and manufacturing methods*» (Oxman, 2008, p. 103).

As standardization and indefinite repetition of identical forms were the main consequences of the rise of mass production, a form generation based on complex, non-standard, and non-repetitive geometries is now permitted by digital technologies (Oxman, 2006). Significant examples are the 2005 Allianz Arena and the 2008 Beijing National Stadium by Herzog and de Meuron and the 2007 Funicolare Hungerburgbahn by Zaha Hadid. The distinctive patterned aesthetics of these architectures has also driven product design. Indeed, the latest generation 3D printing and CNC techniques allow product designers to control all intricate surface details, treating them as three-dimensional layers.

[6] This topic is discussed at length in Chapter 3.
[7] Postmodernism in architecture and design is discussed in Chapter 6.

Developed thanks to the formal freedom permitted by digital technologies, this non-standard and non-repetitive language has also impacted the world of the mass-produced good where traditional molding technologies are still used. This is thanks to two parallel phenomena: production delocalization to Asia, with dramatic reductions in tooling costs, and an increasingly refined CNC technology, which allows molds with complex decorations to be made at an acceptable price.

The last section of this chapter will focus on the patterned aesthetics that product design inherited from architecture. We believe the three-dimensional pattern design process strongly characterizes the current digital product language.

A Three-Dimensional Pattern Design Taxonomy

Patterns involve the repetition of an element (i.e., a shape) within a space. This repetition can be identical or varied. Moreover, this repetition can have a functional purpose (e.g., product ventilation grids) or be ornamental (*pied de poule* on a fabric). Patterns often combine these two aspects: the flutes on a Greek column reduce the column's weight without compromising its resistance and give it its characteristic appearance.

In digital design, a pattern typically retains a decorative intent. Therefore, we can define pattern design as part of the digital design process that aims to define a three-dimensional patterned decoration. This marks a difference from graphic design, where applied patterns are typically two-dimensional. Moreover, while graphics have always used two-dimensional patterns, in mass-produced objects, even adding a printed two-dimensional decoration was rewarded as an additional cost to be avoided.

As we have seen, with the advent of digital fabrication, production costs are no longer directly linked to the complexity of the manufactured piece. This has led to the potential for producing objects featuring high superficial complexity. This digital trend has, in turn, affected mass-produced goods' aesthetics.

Criteria for Pattern Classification

When designing three-dimensional patterns, an understanding of the way they are generated starting from space is essential. As said, patterns result from the repetition of an element in a space, which in turn is subdivided into a given number of elements.

The first criterion for pattern classification is thus the nature of the subdivided space, which can be two-, three- or four-dimensional. In most traditional cases, a surface (understood as a two-dimensional space) or volume (understood as three-dimensional space) is divided up.

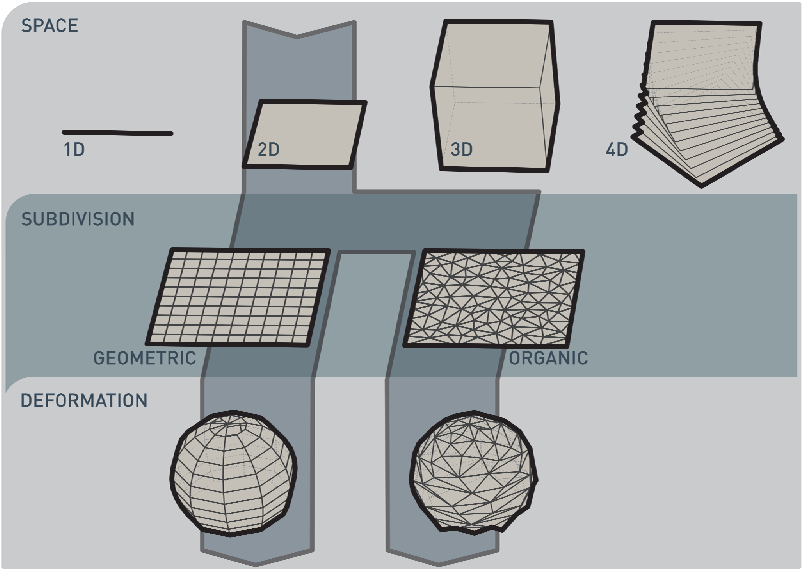


Figure 2: The first three pattern classification criteria

The subdivided space can also change over time, generating the fourth dimension of a moving space.

In two- and three-dimensional spaces, two different kinds of subdivision are identifiable: geometric (i.e., homogeneous) or organic (i.e., random). We will prioritize these two criteria in describing the different approaches to pattern design.

Both geometric and organic subdivisions can then be transformed by applying a deformation in which the subdivision is scaled, stretched, compressed, expanded, or flattened, thus determining non-constant spacing. This spacing can be defined as a grid. A grid is the space subdivision obtained at the end of a pattern design process. To result in a pattern, a grid must be populated with the elements chosen (module) that can be either two- or three-dimensional. These elements can exist on the edges of the grid or fill it, generating what we call a treatment.

At this point, the two- or three-dimensional module can also be modified using a fading or morphing process. Fading is a progressive change in one of the parameters generating the element, while morphing is a progressive transformation of one element's form into another.

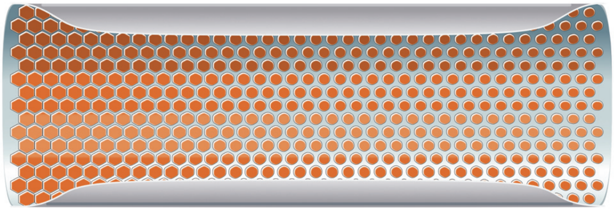


Figure 3: In this morphing example, the circles transform into hexagons

Figure 4 shows the complete pattern design process with all its variables. It represents our proposal for a taxonomy of the different computational approaches toward three-dimensional pattern design.

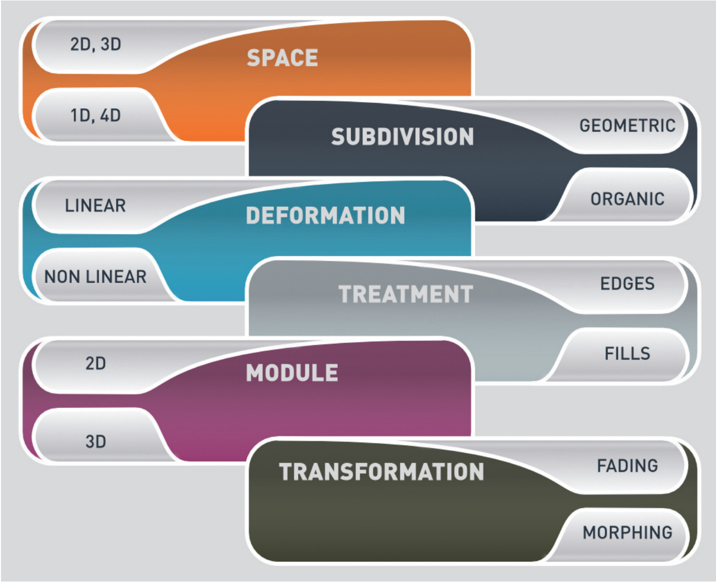


Figure 4: A pattern design process taxonomy

Geometric Patterns: Triangles, Hexagons, and Circles

The first and most straightforward way of subdividing a space is via triangular faces. This technique reduces any three-dimensional shape to the simplest geometric element capable of describing it in sufficient detail: the triangle.

The popularization of the triangular aesthetic, often referred to as ‘low poly’, was also due to STL, the standard print format used by all 3D printers. In this format, all geometries are represented by triangular faces (meshes). As a result of the dissemination of low-cost desktop 3D printers[8] and the success of the Thingiverse portal[9], a growing number of designers started designing (and sometimes also self-producing) small 3D printable objects. The Twisted Six-Sided Vase Basic, published on Thingiverse in 2012[10], is an example of these first-wave 3D printing aesthetics.

In product design, however, several multifaceted products had been designed prior to this. In particular, the Lockeed Martin F-117, the first ‘stealth’ military aircraft in service since 1983, features a multifaceted shape capable of diverting radar waves. It remains a one-off example of a faceted vehicle with flat triangular faces. A more recent example is the 2003 One Chair by Costantin Grcic for Magis. In it, the designer applied triangular faceting in an apparent contradiction with the object’s function. It should also be noted that all the products obtained by folding a metal sheet show multifaceted aesthetics resembling those of low poly.

However, it is 3D printing that favored the widespread success of aesthetics marked out by triangular patterns. An exciting and fully digital result, the kinematic dress, was designed in 2014 by Nervous System. They exploited the triangle’s capacity to act as a fulcrum for the movement of the three adjacent faces. Therefore, each side of each triangle was turned into a hinge, allowing a well-fitting dress to be made. Taking advantage of SLS Nylon printing which does not require supports, the dress in compacted into a relatively small printing volume whose hinges enable it to be opened after printing[11].

In recent years these multifaceted aesthetics have also affected traditional mass-manufactured products. Interesting examples are the cutter Maketicus[12] designed by Lebedev Studio and the Orime Mouse[13] designed by Elecom for Nendo.

A hexagonal grid can easily be obtained from a triangular grid by connecting the center of each triangle to those adjacent to it[14]. As bee hives

[8] Part of the credit for this diffusion should go to the RepRap movement that made self-replicating 3D printers available free and open source.

[9] Launched in 2008, Thingiverse is the largest open source website sharing 3D models designed for 3D printing.

[10] www.thingiverse.com/thing:18672

[11] https://n-e-r-v-o-u-s.com/projects/sets/kinematics-dress/

[12] www.spicytec.com/2011/10/utility-knife-maketicus-is-cutting-tool.html

[13] www.thecoolist.com/orime-mouse-by-elecom-x-nendo/

[14] The result is a quasi-hexagonal subdivision. Indeed, a perfectly hexagonal subdivision is geometrically impossible to obtain.

demonstrate, hexagonal structures offer an optimal packing factor with a consequent excellent strength-weight ratio. For this reason, hexagonal patterns can be employed when a structure's strength and weight are an issue. One example is the Air Cell line shin guards manufactured by Mitre and others are several cell phones covers. A purely ornamental but highly innovative example is the concept developed for the bonnet of the Renault Trezor, which features hexagonal air intakes. Here, the hexagons are no longer simply a two-dimensional decoration but moving (i.e., four-dimensional) objects.

A circle can be inscribed in each hexagon, thus obtaining so-called circle packing. This type of pattern has been used since the advent of industrialization. Indeed, a compact hexagonal packaging base means excellent efficiency, and using circular shapes allows for great manufacturing simplicity. While grills with circular holes have always been standard, today's digital technologies enable grid holes to be deformed, faded, and transformed. One of the first 3D printed examples was the 2012 Dentelle Lamp by Bernier[15], which exploited the rounded surface of the lampshade to deform the size of the circles accordingly.

Other interesting examples can be found in mass-produced goods. The smoke detector Nest Protect[16] grid shows how traditional drilling can be made contemporary using shading, with smaller and closer holes in the center and larger and more distant holes towards the edges. The Kiko Wanderlust limited cosmetic product edition, designed in 2016 by Ross Lovegrove, pushed the limits even further. Each make-up packaging has a three-dimensional pattern embossed onto it, transforming and fading from hexagons to circles. Produced by traditional mass manufacturing techniques (i.e., injection and blow molding), this make-up packaging features the complexity typical of digitally fabricated objects.

Organic Patterns: Voronoi, Topological Optimization and Particles

In 1908 Russian mathematician Voronoj defined the mathematical law called after him. In computational design, the Voronoj law can be used to determine the growth of a three-dimensional form from its center as far as the point at which it encounters another growing form. At the meeting point, a line appears. The result is a highly organic and natural appearance, as in soap bubbles. Using any line as an axis, the Voronoj pattern can create a structure that, if smoothed out, would remember a bone skeleton. For this reason, this kind of pattern is also known as 'exoskeleton'.

[15] www.behance.net/gallery/4299349/3d-Printed-lamp-shade-collection.
[16] https://nest.com/smoke-co-alarm/overview/.

An exoskeleton shape is also obtained by applying topological optimization (TO), a mathematical method that optimizes the shape of an object according to a given set of loads and constraints to maximize system performance, typically weight and resistance. The Generico Chair[17] designed in 2014 by Hemmerling and Nether is one of the earliest examples of applying TO in a product. In 2015, a group of students from the Art Center College of Design in Pasadena designed and manufactured a rubber band remote-controlled car. The car frame is the result of a TO process. This example is fascinating because the purely technical result was reinterpreted aesthetically by the design students, softening the shapes to make them more visually pleasing[18].

Digital fabrication's rapid evolution have prompted some pioneers to experiment with highly inventive forms obtained by applying the same principles that regulate natural growth. The primary example here is Nervous System's Floraform. Starting from a computational simulation of differential growth on a thin surface resulted in a commercially available series of products, including vases, lamps, and jewels[19].

The 2013 project Collagene by MHOX demonstrates the expressive potential of digital fabrication combined with natural growth processes[20].

While geometrical patterns are now widespread and have also influenced traditionally manufactured object aesthetics, the non-repetitive and non-standard three-dimensional form of organic patterns pushes the limits of digital product aesthetics even further.

References

Abdulhameed, O., Al-Ahmari, A., Ameen, W., Mian, S. H. (2019), "Additive manufacturing: Challenges, trends, and applications". *Advances in Mechanical Engineering*, 11(2)

Berman, B. (2012), "3-D Printing: The New Industrial Revolution". *Business Horizons*, 55(2), 155-162.

Conner, B.P., Manogharan, G.P., Martof, A.N., Rodomsky, L.M., Rodomsky, C.M., Jordan, D.C., Limperos, J.W. (2014), "Making Sense of 3-D Printing: Creating a Map of Additive Manufacturing Products and Services". *Additive Manufacturing*, 1, 64-76.

[17] https://www.spade-studio.de/projects/generico-chair/.

[18] www.designboom.com/design/max-greenberg-sameer-yeleswarapu-ian-cullimore-cirin-rubber-band-powered-rc-car-art-center-college-of-design-01-25-2015/.

[19] https://n-e-r-v-o-u-s.com/projects/tags/3dprint/albums/growing-objects/.

[20] http://www.mhoxdesign.com/collagene-en.html.

Dimitrov, D., Schreve, K., De Beer, N. (2006), "Advances in Three Dimensional Printing-State of the Art and Future Perspectives". *Rapid Prototyping Journal*, 12(3), 136-147.

Gershenfeld, N., Gershenfeld, A., Cutcher-Gershenfeld, J. (2017), *Designing Reality. How to Survive and Thrive in the Third Digital Revolution*. Basic Books.

González, J., Fiorito, F. (2015), "Daylight design of office buildings: optimisation of external solar shadings by using combined simulation methods". *Buildings*, 5(2), 560-580

Keating, S. (2014), "Beyond 3D Printing: The New Dimensions of Additive Fabrication." In J. Follett (ed.), *Designing for Emerging Technologies: UX for Genomics, Robotics, and the Internet of Things*. O'Reilly Media. 379-405.

Leach, N. (ed.), (2002), *Designing for a Digital World*. John Wiley and Sons.

Mitchell, W. (2005), "Constructing Complexity". In *Proceedings of the Tenth International Conference on Computer Aided Architectural Design Futures*. Vienna, Austria, 41-50.

Oxman, R. (2006), "Theory and Design in the First Digital Age". *Design Studies*, 27(3), 229-265.

Oxman, R. (2008), "Digital Architecture as a Challenge for Design Pedagogy: Theory, Knowledge, Models and Medium". *Design Studies*, 29(2), 99-120.

Rutten, D. (2013), "Galapagos: On the logic and limitations of generic solvers". *Architectural Design*, 83(2), 132-135

11. Sensory Communication Through Dynamic Products

by Lucia Rampino and Sara Colombo

The world is increasingly digital. Many objects today are embedded with some kind of intelligence or connected with sensors, data, and environmental computational abilities. Most of the artefacts that surround us have been imagined, shaped, produced, transported, distributed, or sold with the help of computers or digital systems, networks of data, and information that have affected their current state and specific form.

> The physical world is tangible, static and persistent, while the digital world is intangible, dynamic and transient. Both worlds' characters are each other's opposites, and contrast in more than one way (Campenhout et al., 2020, p. 6).

The heavy presence of digital technologies in our world poses new challenges to the design discipline, which needs to evolve with the context it operates in. The digital revolution which has taken place over the last two decades has already generated major changes in both the design process and its outputs.

From a process point of view, artificial intelligence systems are increasingly replacing traditional computational tools, enhancing and optimizing the outputs of the design process (Figoli *et al.*, 2022). Moreover, as we saw in the previous chapter, product design has been challenged by digital fabrication technologies, which paved the way for totally new production modalities, new design methods, and unprecedented artefact shapes and appearances.

From an output point of view, products today are rarely pure inert matter and increasingly lively, smart, and connected. If products are no longer simply physical, designers need to acquire new skills that allow them to handle different, emerging object qualities.

The original quality of the new generation of products generated by digital technologies consists of their being dynamic, i.e., capable of changing their appearance, behavior, and features over time. Indeed, products embedded with sensors, actuators, and controllers can change their sensory appearance (shape, light, color, position, but also sound and smell) over time and in an autonomous way.

In addition to this, products are becoming more and more intelligent and connected. Artificial intelligence transforms artefacts into interactive and conversational agents capable of naturally interacting with people, reasoning, and making decisions themselves. Products can learn over time, evolve and adapt to external conditions, and act independently in the physical world by interacting with it. Progress in connectivity infrastructures has enabled objects to exchange information and data with other network nodes faster and access remote data storage and processing systems.

As products become more and more interactive and connected, the boundaries between product and interaction design have begun to blur. Moreover, in the shift to intelligent and interactive agents, products require a language with which to communicate with people. Should these artefacts express themselves by voice and text alone, as is the case with chatbots[1] like Siri and Alexa, or is there a more implicit, instinctive language that products can use based on their physical and sensory appearance?

In this chapter, we investigate how products' sensory qualities can become a new language to communicate dynamic messages and emotions to users.

The Need to Communicate Digital Data

The world of digital technologies has expanded at an impressive speed in recent years, bringing new forms of communication to the fore and disseminating them. Computers, digital devices, smart products and systems generate vast amounts of data, which need to be converted into readable messages for users.

Traditionally, digital data is translated and displayed through digital interfaces (e.g., screens or displays) that use alphanumerical and iconic language (Krippendorff and Butter, 1984). Today product appearance, intended as a combination of their sensory features, can assume a dynamic quali-

[1] A chatbot is a program capable of simulating a 'natural' conversation via voice or text with a human being. Such programs are used either to simulate chat users or answer users' FAQs, for instance in customer services.

ty: thanks to electronics, informatics, and material technologies, products' sensory features – e.g., shape, temperature, color, light, smell, sound, etc. – can be controlled and modified in an active and reversible manner over a product's life, changing over time. For instance, One by Vessel Ideation is a kettle that informs users of water boiling with a colored texture on its surface. This chapter explores precisely the potential for communicating bits of information to users through an alternative language based on dynamic changes in product appearance.

On the one hand, then, in our digital world, an increasing amount of information needs to be conveyed to users. On the other, designers can also rely on dynamic product appearance to perform this communication.

We believe dynamic sensory features might, within certain limits, constitute a new language with which to communicate information by performing a simplified and implicit, but potentially more engaging, type of communication.

Dynamic Products as Information Channels

As we have seen, technological progress now means that objects' traditional static appearance (a whole of visual, tactile, auditory, and olfactory features) can become dynamic, automatically transformed by electronic controllers, intelligent devices, and smart materials. Product color, shape, tactile properties (like texture and temperature), sound, and smell can change proactively and reversibly. This results in artefacts with multiple and dynamic appearances, which we have defined as 'dynamic products'.

In addition to aesthetic and expressive purposes (e.g., for interactive installations, like Vancouver Aquarium's Jelly Swarm[2]), dynamic products can convey messages similar to those transmitted by screen-based displays, but via a different medium, that is a change in their sensory features. For instance, a household's electricity consumption may be displayed in numbers and verbal language on a digital screen. Still, it can also be communicated by changes in a lamp's shape, such as the Swedish Interactive Institute's Flower Lamp that changes shape, opening up like a flower to display a household's energy consumption.

Design researchers have developed many dynamic products in the form of research prototypes and concepts. Still, few theoretical studies truly address the issue of communicating by non-verbal language in a dynamic way.

[2] www.tangibleinteraction.com/artworks/jelly-swarm.

The potential for communication through dynamic product features is the topic we intend to investigate here. We believe this field is replete with potential, particularly from the user experience point of view, and thus worthy of further exploration.

State of the Art Analysis

To determine if and how dynamic products can be used to communicate digital messages to users, we will start here with an analysis of the state of the art. Forty-eight samples of dynamic products have been collected and analyzed as case studies. These samples, chosen from amongst design concepts, prototypes, and commercial products, were selected on the basis of their novelty factor. Indeed, products that adopt standardized dynamic signals, such as common embedded warning lights or sound alarms, were ruled out.

The entire procedure involving collecting, selecting, and analyzing the samples is described in detail in a previous publication by the authors (Colombo, Bergamaschi and Rampino, 2013). The outcome of this first analysis confirmed that dynamic products are being adopted by designers as alternative media with which to display messages or information. Moreover, all sensory modalities were revealed to be capable of conveying messages. Although sight remains the most common, olfactory, tactile, and auditory transformations are also used to display information.

The second stage was qualitative interviews with users. Indeed, analyzing the potential and limitations of this new kind of communication requires considering the end user's viewpoint. The goal of this study was to perform a preliminary analysis of users to extrapolate insights into their impressions and propensity for this particular kind of communication. To this end, the most appropriate method would be letting users interact with genuine dynamic products. However, as few dynamic products are available on the market – as most take the form of concepts or prototypes – direct interaction turned out to be non-feasible. For this reason, since the aim was to perform a preliminary explorative investigation of user experience, we opted for semi-structured qualitative interviews (Drever, 2003) supported by pictures and brief product explanations.

Five users were interviewed (two men and three women), ranging in age from 19 to 60. The interviews aimed to assess both perceived communication effectiveness and the quality of the experience elicited by dynamic products.

Hereafter, the interview results are presented and critically analyzed to highlight and summarize the potential and limitations of employing dynamic sensory features to communicate messages from products to users.

The Potential of Sensory Communication

Directness

The first element that emerged from the interviews was the concept of directness. Users reported that messages conveyed by sensations are more direct and immediate than verbal ones. Moreover, they stated that such messages are easier to interpret.

An example in the automotive sector is the door panel equipped with strip lights of the S-class Mercedes. The user can set a preferred color, but when she opens the door and the car reads an obstacle, the lights become red to underline the dangerous situation.

Given the directness of this kind of messages, they are better suited to situations where users cannot pay too much attention to decoding a message (e.g., they are under physical or psychological stress).

For instance, Cambridge Consultants' I-dration[3] is a bottle that tells users when they need to drink water while exercising by emitting a flashing blue light. One of the interviewees reported that getting a flashing light message is very useful since the interpretation of sensations is effortless compared to reading something while doing physical activity. She stated that «*this kind of sensation is easy to interpret and requires less effort and concentration*».

Moreover, in some cases, users report that sensations are more intuitive than verbal language. For instance, users perceived the message conveyed by the Hug Shirt[4], a shirt that reproduces the feeling of a hug to those wearing it, as highly intuitive and immediate.

Finally, sensations can clearly display a range of data, especially when they are related to an element's intensity (e.g., electricity consumption, air pollution levels, temperature), where the information gradient can be represented by a gradual change in the stimulus (e.g., the intensity of a color, the density of a texture) which is not achievable with the same degree of effectiveness with verbal language.

Referring to the Noi concept (Figure 1), a user affirmed: «*the denser the texture becomes, the more polluted the air is. It is very useful to have a continuous range, because I can perceive all the in-between steps*».

[3] https://www.trendhunter.com/trends/i-dration-water-bottle.
[4] http://cutecircuit.com/collections/the-hug-shirt/.

Figure 1: Noi by design-people is a home indoor climate maintenance concept. The more polluted the air, the denser the surface texture becomes.

Evidence

Their physical nature means that dynamic products are evident and noticeable. Moreover, the concept of evidence can also be related to certain sensations that are unavoidable since they can reach users from a distance beyond their active, conscious involvement. Users do not have to look for information actively or pay too much attention to it.

For instance, sounds and smells also reach users when artefacts are a long way away. Moreover, as they are difficult to avoid, they are very effective in specific contexts (e.g., when information is urgent or when we are too busy to pay attention to messages spontaneously). Furthermore, changes in light and color can easily be perceived from a distance. In commenting a lamp emitting different colors corresponding to different external temperatures and weather conditions, one user stated that *«if [the product] was an interface, it would not have the same visibility of a colour change. I would not go and read a thermostat every time».* The lamp's color change was judged more immediate and evident than a screen-based display.

An exciting application is the Sense Five[5] white cane that proposes using smart surfaces to transmit explicit information. The tactile response is immediately evident, given that the user's palms are always in contact with the handle. It is also way more effective than an audio cue, which could get missed in a noisy environment or be disturbing in a quiet one.

[5] http://www.werteloberfell.com/project/sensefive/.

Discretion and Intimacy

An interesting element reported by users is the concept of discretion. Communicating via dynamic products requires less explicit language than verbal communication. This element has been assessed as highly positive in specific situations when users wanted to be informed subtly and covertly. For instance, one user commented that communication with Bubelle Emotion Sensing Dress[6] «*is more discreet compared to the verbal language*».

Moreover, sensations were assessed as very positive in human-human communication as a less explicit language. Reliance on more discreet communicative methods was much appreciated and perceived as more suitable for personal forms of interaction. Indeed, changes in an object's light, color, smell, or temperature can communicate emotional states, moods or just that your partner is thinking of you in a more gentle and implicit way.

An example is the three pairs of concepts 'Saying things that can't be said' aimed at strengthening long-distance relationships[7]. For instance, the second pair of concepts includes a paper pinwheel and a machine to make soap bubbles. When the pinwheel is blown and rotates, the machine's electronics are activated, and soap bubbles float throughout the room in a connected place.

The Power of Exhortation

Another dynamic product communication potential is the power of exhortation of some sensations. Indeed, certain stimuli have a remarkable ability to alarm, with users interpreting vibrations, sounds, and flashing lights as conveying urgent information requiring immediate action. They felt that products were asking them to do something and were strongly motivated to act.

This is an advantage in situations where users need to be encouraged or reminded to take action, i.e., take a pill at the right time.

Fascination, Surprise, Attraction

Users were asked to report the emotions elicited by dynamic products, choosing the most appropriate ones from a list of 14 emotions (seven positive and seven negative emotional states, based on Desmet, 2005). To describe their experiences, users cited positive emotions 31 times and negative emotions only eight times. The most frequently cited positive emotions

[6] Philips' Bubelle Emotion Sensing Dress is a dress that senses the wearer's emotions and displays them with light colour changes: https://vimeo.com/32964255.

[7] https://www.designboom.com/design/daniel-sher-saying-things-that-cant-be-said-08-19-2014/.

were fascination (11 times) and pleasant surprise (eight times), followed by admiration, desire, amusement, and inspiration.

Users were also asked to rate their perceived level of attraction to products on a five-point scale. Results showed high ratings (equal or above three points) in all but two cases.

It would seem that their unusual way of communicating means that dynamic products elicit positive emotional reactions in users. Emotional responses can be described in terms of fascination and pleasant surprise. Attraction is also part of the experience generated by dynamic products, thus confirming the idea that communicating by sensations can positively affect users' experiences.

The Limits of Sensory Communication

Ambiguity

As reported by users, the first limit of dynamic products concerns ambiguities in message interpretation: in some dynamic products, the link between message medium and content is not immediately apparent. In some cases, when messages were not explained clearly, users interpreted them very subjectively, according different meanings to the product transformation.

As dynamic products rely on sensations rather than verbal language to communicate with users, messages are implicit and open to users' subjective interpretation. They can thus be ambiguous and information content easily misunderstood.

Inaccuracy

Another difficulty, which can be understood as one of the causes of ambiguity, concerns simplification and inaccuracy in the message itself. Sensations are less detailed and precise than verbal language. While, as we saw previously in relation to message 'directness', this simplification can be seen as an advantage, it can also sometimes be a problem for users. For instance, this element emerged in reactions to a lamp that communicates external temperatures through color changes. One user stated, «*it would be useful to have numbers showing the exact temperature in addition to colour*».

In order to be conveyed by sensations, quantitative data is necessarily simplified. If this can be an advantage in some cases, it is also a limitation since accuracy is reduced and data available to users is approximate.

Nuisance

Unavoidable sensations, such as smells, sounds, vibrations, and light, can be perceived as disturbing and invasive by users. Especially when users are not interested in receiving information, dynamic products can be perceived negatively.

For instance, this emerged in relation to DetectAir[8], which one user commented: «*Since I am not interested in the information the product conveys, I would be disturbed by light and vibration, if I was focused on doing something else*».

However, in general, negative emotions perceived by users were seldom related to the sensation concerned but resulted from either product aesthetics or the message conveyed. In one case, boredom and disappointment were expressed in reaction to the use of (a pleasant tweeting) sound by a kettle, defined as neither new nor surprising.

A more thoroughgoing analysis of dynamic products and their advantages and limitations is to be found in Colombo (2016).

A Promising Alternative

We analyzed the potential for using changing sensory features of objects (color, light, smell, sound, temperature, etc.) to communicate bits of information to users. To this end, we collected and analyzed several samples of dynamic products and assessed some of them through user interviews to gain first impressions of this type of sensory communication.

Study outcomes demonstrated dynamic products' communication potential and their advantages and disadvantages from the user perspective. The main benefits are dynamic products' capacity for direct, immediate, and also subtle communication. Moreover, these products would seem capable of eliciting positive emotions and pleasant, attractive experiences. On the other hand, the disadvantages of this implicit form of communication regard interpretation difficulties, message inaccuracy, and the intrusiveness of certain sensory media. This analysis summarizes the current dynamic product development, popularization, and user acceptance status quo.

While new forms of artificial intelligence are spreading, creating new interaction modalities between users and intelligent objects, it is also essential to look at what languages these interactions should be based on. Voice

[8] DetectAir, by Genevieve Mateyko and Pamela Troyer, is a vest that detects the ambient air quality and displays data with a LED light pattern. It also vibrates to alert users when they have entered a particularly unhealthy environment.

and text, enabled by Natural Language Processing technologies, are crucial when communicating complex content between people and intelligent agents. However, we would argue that, in many cases, more subtle and sensory forms of communication may be just as effective and engaging.

As Vallgårda and Sokoler (2010) put it:

> digital processes in their original form are not perceivable for us. In order to become perceivable, they need to be translated to a perceivable form. We state that how this translation is realized, is up to the designer (cited in Campenhout *et al*., 2020, p. 6).

Given the increasing amount of information to be conveyed to users from the digital world, enquiring into alternative forms of communication may help to reduce information overload involving using more sensory – and less cognitive – languages.

References

Colombo, S. (2016), Dynamic Products: Shaping Information to Engage and Persuade. Springer.

Colombo, S., Bergamaschi, S., Rampino, L. (2013), "What Are You Telling Me? How Objects Communicate Through Dynamic Features". In *Proceedings of xCoAx Conference on Computation, Communication, Aesthetics and X*, Bergamo, Italy, 129-137.

Crilly, N., Moultrie, J., Clarkson, P.J. (2004), "Seeing Things: Consumer Response to the Visual Domain in Product Design". *Design Studies*, 25(6), 547-577.

Desmet, P. (2005), "Measuring Emotion: Development and Application of an Instrument to Measure Emotional Responses to Products". In M.A. Blythe *et al*. (eds.), *Funology*, Kluwer Academic Publishers Norwell, 111-123.

Drever, E. (2003), Using Semi-Structured Interviews in Small-Scale Research. A Teacher's Guide. Scottish Council for Research in Education.

Eikenes, J., Morrison, A. (2010), "Navimation: Exploring Time, Space & Motion in the Design of Screen Based Interfaces". *International Journal of Design*, 4(1), 1-16.

Figoli, F.A., Mattioli, F., Rampino, L. (2022), *Artificial intelligence in the design process: The Impact on Creativity and Team Collaboration*. FrancoAngeli.

Gaver, B., Martin, H. (2000), "Alternatives: Exploring Information Appliances Through Conceptual Design Proposals. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 209-216.

Hallnäs, L., Redström, J. (2002), “From Use to Presence: On the Expressions and Aesthetics of Everyday Computational Things”. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 9(2), 106-124.

Holman, D., Vertegaal, R. (2008), “Organic User Interfaces: Designing Computers in Any Way, Shape, or Form”. *Communications of the ACM*, 51(6), 48-55.

Ishii, H., Ullmer, B. (1997), “Tangible Bits: Towards Seamless Interfaces Between People, Bits and Atoms”. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems*. ACM, 234-241.

Jafarinaimi, N., Forlizzi, J., Hurst, A. Zimmerman, J. (2005), “Breakaway: an Ambient Display Designed to Change Human Behavior”. In *CHI’05 Extended Abstracts on Human Factors in Computing Systems*, 1945-1948.

Jones, L.A., Sarter, N.B. (2008), “Tactile Displays: Guidance for their Design and Application”. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 50(1), 90-111.

Jung, H., Stolterman, E. (2011), “Form and Materiality in Interaction Design: A New Approach to HCI’”. In *CHI’11 Extended Abstracts on Human Factors in Computing Systems*, 399-408.

Khambete, P., Athavankar, U. (2010), “Grounded Theory: An Effective Method for User Experience Design Research”. *IDC Design Research Journal-Design Thoughts*, 11-24.

Krippendorff, K., Butter, R. (1984), “Product Semantics: Exploring the Symbolic Qualities of Form”. *Innovation: The Journal of the Industrial Designers Society of America*, 3(2), 4-9.

Mankoff, J., Dey, A.K., Hsieh, G., Kientz, J., Lederer, S., Ames, M. (2003), “Heuristic Evaluation of Ambient Displays”. In *Proceedings of the SIGCHI Conference on Human factors in Computing Systems.* ACM, 169-176.

Matthews, T., Dey, A.K., Mankoff, J., Carter, S., Rattenbury, T. (2004), “A Toolkit for Managing User Attention in Peripheral Displays”. In *Proceedings of the 17th Annual ACM Symposium on User Interface Software and Technology*. ACM, 247-256.

Pedersen, E.R., Sokoler, T. (1997), “AROMA: Abstract Representation of Presence Supporting Mutual Awareness”. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems*. ACM, 51-58.

Pousman, Z., Stasko, J. (2006), “A Taxonomy of Ambient Information Systems: Four Patterns of Design”. In *Proceedings of the Working Conference on Advanced Visual Interfaces*, 67-74.

Van Campenhout, L., Frens, J., Overbeeke, C., Standaert, A., and Peremans, H. (2013), “Physical Interaction in a Dematerialized World”. *International Journal of Design*, 7(1).

Van Campenhout, L., Frens, J., Vaes, K., and Hummels, C. (2020), “The aesthetics of coupling: An impossible marriage”. *International Journal of Design*, 14(2), 1-16.

The Social Perspective

Designers no longer can hide behind the needs and wishes of the consumer; instead, they have to take responsibility as “shapers” of society. Doing so entails a shift from a user-centered approach to a society-centered one.

Tromp, N., Hekkert, P., Verbeek, P.P. (2011),
“Design for Socially Responsible Behavior”. *Design Issues*, 27(3),3-19.

12. Product Design in the Transformation Economy

by Lucia Rampino

Many social and environmental issues are growing in extent, affecting people in both advanced and less advanced economies. Scientific evidence and increasing public debate are leading people to cast doubt on how we produce, consume, and distribute wealth (Brand and Rocchi, 2011).

> The West may have thought it could predict, control, and lead the way, but most if not all of the postnormal crises we are facing are the result of precisely this hubris, this obsession with certainty, control, and the one right way to progress (Montuori, 2012, p. 67).

Moreover, the potential for open and peer-to-peer debate offered by digital technologies is transforming our mindsets, with people demanding higher levels of stakeholder accountability, participation and consultation in socio-economic development. In this novel scenario, the transformation economy is driven primarily by a systemic mindset shift towards new ways of doing business and engaging stakeholders.

The term 'transformation economy' was first employed by Pine and Gilmore in their famous 1998 book in which they argued that the experience economy would not be the last step in what they called the «*progression of economic value*». Speculating about the future, they identified the transformation economy as a likely next step. In their view, while experiences are essentially memorable events that act as sensory and emotional stimulants, transformations result from a series of experiences intended to guide user learning, action and achievement of their aspirations and goals (Gaggioli, 2015). In a more recent article, Pine and Gilmore (2013) confirmed this forecast: people are now choosing products and services not only according to how closely they match their tastes and interests but also how they will transform their lives and appearance (health and fitness, relationships, work life or well-being) and their mindsets (political, social, moral and self).

This last set of features was taken on by Brand and Rocchi (2011) in their interpretation of the transformation economy as one in which companies are required to provide meaningful proposals built around business practices that are at the same time profitable, ethical, fair and based on multiple stakeholder collaboration. This is also the meaning we attach to the term transformation economy and, more generally, to the social perspective incorporating it. All this has significant consequences for the design discipline:

> As design expands into the social sector, and engages with problems within complex socio-technical systems, it is vital that we reflect on the basic assumptions that have underpinned earlier methods, models, and frameworks, and consider the relevance of emerging social theory (Forlano, 2017, p. 18).

Human-centered design is founded on understanding human beings as individuals. In the social perspective, our new relationships with the natural world and socio-technical systems question this prior understanding (Tromp, Hekkert, and Verbeek, 2011). For design, the focus of attention shifts from finding the best solution, whilst considering an artefact and its individual user, to finding the right balance in each project, considering society as a whole.

Reaction Against the Flaws of Previous Economies

Although industrialization has brought significant progress in living standards in the West, there is a downside to progress, as is amply demonstrated by the environmental, social and economic dilemmas facing us today (Brand and Rocchi, 2011). Developed countries are increasingly worried about the negative facets of the industrial economy: climate change, energy consumption, water scarcity, loss of biodiversity, resource depletion, waste, air pollution, obesity, wealth disparity, poor overseas labor conditions. Consequently, an increasing awareness that multinational brands often hide ethically questionable practices from view arose.

Naomi Klein's 2000 book *No Logo* well represents the criticism of, and loss of faith in, leading brands. The book echoed the sentiments of an increasing body of people who argued that brands are diminishing fair choice and the way they manage jobs and share value and profits is unethical. Mass manufacturing companies habitually take a money-saving approach to everything that remains invisible to the public, taking advantage of poor working conditions in developing countries, child labor, deforestation, animal cruelty, and so on.

The growing environmental concern of western people has been embodied by the then fifteen-year-old Greta Thunberg, who, in 2018, organized a protest action every day of August, sitting outside the Swedish parliament with a sign that read 'School climate strike'. Her decision stemmed from the abnormal heat waves and fires in Sweden in the summer of 2018. On September 7, she announced that she would continue demonstrating every Friday until Sweden aligned with the Paris agreement on reducing climate change. Her slogan 'Fridays For Future' has attracted worldwide attention, inspiring school students worldwide to strike for the climate. Today Fridays for Future is a global movement aimed at raising awareness of the importance of an environmentally sustainable human footprint[1].

Alongside the environmental concerns, recurrent social and economic crises, exacerbated by the Covid-19 pandemic (the last one being the outbreak of war between Russia and Ukraine), are sweeping the West.

But the industrial and experience economies are not the only ones to be blamed for the West's current social tensions. The digital revolution is playing a part too:

> The toxic blend of technologically driven unemployment, income and wealth inequality, and constant change driven by digital technologies, have left many people feeling unmoored and angry, driving nationalist movements throughout the world (Gershenfeld *et al.*, 2017, p. 8).

Moreover, the knowledge economy firms (e.g. Google, Facebook, Amazon), though less involved in the negative consequences of industrial production, retain ethical responsibility for the data they harvest. People are often unaware of what happens to the information they share on search engines and social networks (Gardien *et al.*, 2014).

> News that Cambridge Analytica exploited the data of 50 million Facebook users without their awareness is the latest and most shocking example of our data used in damaging ways. But it is by no means singular. There has been a steady drumbeat of stories that reveal the hidden cost of "free" platforms. Uber tracks the data in such detail that it knows people will pay surge pricing if their phone battery is running low (Cababa, n.d.).

For companies willing to operate in the transformation economy, the challenge is that sustainability and well-being require behavioral change at individual but also societal levels (Brand and Rocchi, 2011). There is increasingly

[1] https://fridaysforfuture.org

widespread acceptance that effectively pursuing sustainability requires linking governments and market players with civil society organizations and engaged citizens often on multiple scales from local to global (Gibson, 2006).

While the industrial economy was dominated by the idea that applying 'superior' Western knowledge could alone resolve any issue anywhere in the world, in the transformation economy, local communities are accorded sole responsibility for taking care of themselves, their evolving culture and their environmental health and justice.

Some of the differences between the industrial and transformation economies are well exemplified by the functioning of an industrial apple sorting site in which thousands of apples are automatically moved around to be visually analyzed by software and sorted into the suitable selling class (Kleinert, 2018). This is an example of how the standardization idea – so characteristic of the technical perspective – has become a guiding model for handling natural things too. On the other hand, in the transformation economy, clean, 'fair' locally produced food reducing food miles and shortening the food chain are the most important values.

The Three Pillars of Sustainability

In general terms, sustainability is a process's ability to remain indefinitely stable and productive. The environmental sustainability concept was the first to be defined and is still frequently seen as the leading one. It is the essential prerequisite for ensuring the stability of an ecosystem, namely the latter's ability to preserve environmental processes and biodiversity.

Later on, the concept of sustainability was expanded to encompass the economic and social spheres, providing a broader definition according to which the environmental, economic and social sustainability triumvirate together contribute to well-being and progress.

This interrelated view of sustainability was first proposed in 1987 by the World Commission on Environment and Development (Brundtland Commission), which defined sustainable development as «*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*» (p. 43)[2].

[2] In 1983, the United Nations General Assembly set up the World Commission on Environment and Development, an independent committee of twenty-two members headed by Gro Harlem Brundtland, the Prime Minister of Norway. The agenda of its report entitled 'Our Common Future' (1987) promotes the growth of economies based on policies that do not harm and can even enhance the environment. The report recognized that the time had come for an economy-environment marriage to ensure the growth of human progress through development without bankrupting the resources of future generations.

Gibson sees the concept of sustainable development proposed by the Brundtland Commission as having become popular because of and despite the tension it embodied:

> Critics called it an oxymoron or an illusion. But its genius lay in recognition that combating poverty (which is not just economic) and protecting the environment (which is not just biophysical) were necessary to each other and both were likely to fail if not addressed together (Gibson, 2006, p. 261).

Post-Brundtland sustainability is even more thoroughgoing. Today sustainable development is widely understood as an indefinable (Moldan and Dahl, 2007) and multi-dimensional integrated concept (Gibson, 2006) consisting of three interlinked pillars: economic, environmental, and social. If any of these pillars is weak, the whole system is unsustainable. Weakness in the economic pillar directly undermines the environmental pillar: when finances are scarce, countries cut back or postpone stricter environmental laws or investments. The same goes for the social pillar: when war breaks out, environmental sustainability is downgraded.

For Gibson (2006), the three pillars approach fits well with: (i) the assessment and review capabilities of the experts trained in any of the three fields (social, economic and environmental); (iii) the organization of much of the relevant information; (iii) the usual division of social, economic and environmental mandates between government bodies. But this advantage can easily be turned into a disadvantage due to the evident difficulties generated by integrating these three fields, which tend to be dealt with separately.

In sustainability literature, the three pillars are mainly represented as three overlapping circles.

Where the social and economic pillars intersect, the issues of business ethics, fair trade and workers' benefits arise. And indeed, consumers more and more appreciate ethically produced and traded products.

Where the economic and environmental pillars overlap, the issues of energy efficiency, renewable energy sources and green technology arise. This is the area of sustainability traditionally nearest to product design since designers can either design more efficient and recyclable products or encourage users towards resource-saving behaviors.

Finally, at the intersection of the environmental and the social pillars lies the concept of environmental justice, defined by the U.S. Environmental Protection Agency as follows:

> Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (www.epa.gov/environmentaljustice).

In its most common connotation, environmental justice is a movement which grew from the recognition that a disproportionate number of ecological burdens fall on poor communities, as does the importance of working to ensure a healthy environment for all.

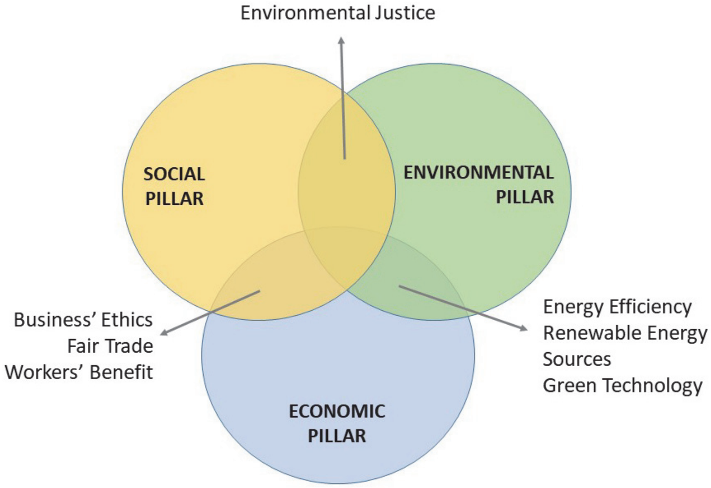


Figure 1: The three overlapping pillars of sustainability

An interesting phenomenon relating to all three pillars is the Benefit Corporations (B Corp) movement. B Corps are for-profit companies certified by the non-profit U.S. B Lab. To obtain this title, corporations must satisfy rigorous social and environmental performance, accountability, and transparency standards[3].

An Emerging Social Innovation Archipelago

The need to tackle the pressing social challenges of our times, and the rising demand for economic growth that enhances human relationships and well-being, has focused growing attention on a specific kind of innovation: social innovation. The concept was first mooted in the non-profit sector, but examples are also to be found in the private and public sectors. Mulgan *et al.* (2007) offer the following definition:

[3] https://www.bcorporation.net/en-us/

> […] innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly developed and diffused through organizations whose primary purposes are social (p. 8).

This definition aims to differentiate social innovation from standard business innovations, which are generally motivated by profit maximization and are typical of for-profit organizations. Of course, many borderline cases exist, such as models of distance learning pioneered in social organizations and then adopted by businesses or for-profit businesses developing new approaches to help disabled people find work.

For Mulgan *et al.* (2007), there are several fields in which the opportunities to develop social innovations are considerable: rising life expectancy; growing diversity between countries and cities; marked inequality; increasing incidence of long-term illness (e.g., arthritis, depression, diabetes); affluence-related behavioral problems (e.g., alcohol, drug and gambling addictions); difficult transitions to adulthood; well-being.

Manzini (2015) stresses that any change in human societies is, at the same time, social and technical. This applies to social innovation, too, which he argues should be more precisely defined as «*innovation in the sociotechnical system triggered by a social change*» (p. 16). Therefore, social innovation is reinforced today by a fundamental socio-technical change: the dissemination of digital technologies, permitting new distributed forms of knowledge, decision making and fabrication. The result is that the rigid, vertical models once central to industrialized societies have begun breaking down into fluid and horizontal models.

Manzini (2015) also lists some features that are typical of the majority of social innovations: a re-evaluation of the notion of work, seeing human beings no longer simply as consumers but rather as individuals carrying out meaningful activities; a parallel re-evaluation of the value of collaboration and the search for dynamic relationships; being rooted in a place (i.e., local) but at the same time globally connected and open. Consequently, successful cases of social innovation (from the rediscovery of neighborhoods to the resurgence of local crafts and food) are rooted in a specific place but are also nodes in global networks.

An excellent example is the Fab City movement, an initiative set up jointly by the Catalan Institute for Advanced Architecture and M.I.T., designed to exploit digital fabrication to empower cities to be more sustainable. The Barcelona Fab Lab was set up under the aegis of this initiative to make Barcelona the first self-sufficient city in the world.

In 2014, Barcelona's mayor officially declared that within forty years (i.e., in 2054), Barcelona would substitute its global supply chains with sustainable local production. In doing so, he challenged all the other cities worldwide to locally produce everything they consume: energy, food, and material. For Gershenfeld *et al.* (2017), this declaration sets out a vision for a postindustrial city in which bits travelling globally can control atoms that remain local: a fundamental shift towards sustainability. Following the Barcelona declaration, several other cities and a few regions and countries have signed up, from Santiago to Shenzhen and Boston to Bhutan[4].

To describe the ongoing emergence of novel examples of social innovation, Manzini utilizes the fascinating metaphor of an emerging archipelago:

> All these ideas seem to me beautiful islands of applied cultural and socioeconomic wisdom. They are islands in the sea of unsustainable ways of being, and doing that is, unfortunately, still mainstream throughout the world. The good news is that the number of these islands is growing and generating a wide archipelago. An archipelago that could be seen as the emerging dry land of a rising continent: the already visible expression of a new civilization (Manzini, 2015, p. 26).

Design, Social Responsibility and Sustainability

Back in 1972, when the industrial economy was unleashing its full potential, Victor Papanek wrote his influential book, *Design for the Real World*, in which he affirmed: «*[t]here are professions more harmful than industrial design, but only a very few of them*». It was perhaps the earliest alarm bell ringing for change in the design profession.

Papanek pointed out designers' social and environmental responsibilities, arguing that socially responsible designers must organize their work outside the mainstream market, which flourishes around producing large quantities of unnecessary products (Margolin and Margolin, 2002).

Papanek's call remained largely ignored since the dominant design perspectives (i.e., technical and human ones) remained powerfully market logic driven for several years. The alternatives received little attention, although since then, a small group of designers has begun proposing socially responsible solutions, facing problems ranging from the needs of developing countries to the particular needs of the elderly, the poor and the disabled (Morelli, 2007).

The common perception of industrialization's downsides today is focusing growing attention on all design fields concerned with one or more of the three pillars of sustainability. Each field is known by a specific label. The following is an overview of the most relevant.

[4] A complete list of signatories is available on the Fab City movement website (http://fab.city/). The count-down to self-sufficiency is also there.

Eco-Design

In the 1990s, manufacturing companies started working on developing eco-efficient products, and eco-design gained prominence as a way of diminishing companies' environmental impact. The goal of eco-design is eliminating or reducing adverse environmental effects through using renewable resources and recycled or recyclable materials, enhancing product efficiency and durability and designing for easy recycling.

Typically, eco-design adopts a lifecycle approach in which environmental impact is considered across the whole of a product's life, from material extraction through to disposal.

Design for Sustainability

At the turn of the new millennium, eco-design started to be regarded as too narrow in scope and thus evolved into the broader concept of design for sustainability, integrating environmental concerns with social and economic ones.

As we have seen, sustainability is a complex, multi-dimensional, integrated concept. An exciting example which addresses all three pillars of sustainability is Fairphone, a Dutch company founded in 2013 to make ethical smartphones. First, in contrast to most electrical devices, the phone is modular for ease of repair. For instance, replacing the screen is a simple operation that end users can even do themselves. Moreover, Fairphone declares that all its materials are fair trade. The labor conditions of the workers involved in making it (all based in China) are one of the company's primary concerns. Finally, to address the increasing electrical waste, Fairphone recalls used products to recycle them correctly[5].

Design for Behavioral Change[6]

In general terms, design for behavioral change deals with the way design can shape and influence human behavior. The areas in which it has been most commonly applied are health and well-being, environmental sustainability, safety and crime prevention. At the intersection between the economic and environmental pillars, there is a specific sub-category of design for behavioral change: design for sustainable behavior. It aims to reduce products' environmental and social impact by moderating how users interact with them (Bhamra, Lilley, and Tang, 2011).

[5] https://www.fairphone.com.
[6] For a more in-depth description of this approach, see Chapter 13.

Social Design

In literature, social design is broadly defined as a design process that contributes to improving human livelihood and well-being, focusing on situations in which the people involved cannot generate their own demand because they are not regarded by companies as an interesting market niche either because they are too poor or because they are too small a market segment. For Manzini (2015), this is social design's central limit: since the people involved cannot sustain the costs of design, designers are required to work for free or within a charitable framework. This makes social design altruistic but relegates it outside the market, focusing exclusively on the social sustainability pillar and missing out on the economic one.

In 2008, the label social design was adopted by Tromp and Hekkert to name their holistic approach to more sustainable and ethical design practices. In their 2018 book *Designing for Society,* they state:

> What do we mean when we say 'social design'? […] social design for us means designing for society. Society is what we share – the places we meet, work, debate, laugh, learn and forget, and the systems that enable this. […] We see social design as a field that primarily aims to achieve social impact by creating interventions that foster community life in the long run, instead of solving people's everyday problems (p. ix).

In Tromp and Hekkert's version of social design, traditional design thinking skills are applied to address social challenges and promote appropriate and practical solutions. Intended this way, social design largely overlaps with design for social innovation as described hereafter.

Design for Social Innovation

Design for social innovation can be defined as applying design methodologies to solve complex social problems such as poverty, climate change, food insecurity, social inequity and human health. For Manzini (2015), design for social innovation is not a new discipline but simply «*the application of what, today, design as a whole should be*» (p. 59). A few pages later, Manzini gives his definition:

> Design for social innovation is everything that expert designers can do to activate, sustain and orient processes of social change towards sustainability (Manzini, 2015, p. 62).

Manzini's intention is to stress that design for social innovation is a large field including, on the one hand, the entire range of social innovation phenomena and, on the other, all the multiple forms that the design profession takes on today.

An excellent example is Brown and Wyatt's 2010 article *Design Thinking for Social Innovation* which presents many cases in which a design thinking approach could generate enhanced solutions to social challenges, from safe water distribution in India to the distribution of mosquito nets in central Africa.

> Nonprofits are beginning to use design thinking as well to develop better solutions to social problems. Design thinking crosses the traditional boundaries between public, for-profit, and nonprofit sectors. By working closely with the clients and consumers, design thinking allows high-impact solutions to bubble up from below rather than being imposed from the top (Brown and Wyatt, 2010, p. 32).

As Brown and Wyatt's article shows, rather than eliminating earlier design perspectives, later perspectives can build on these: the social perspective can borrow from the well-developed human-centered approaches.

Skills and Tools for Sustainable Design: toward System Thinking

While design in the technical perspective was a 'deterritorialized' activity, meaning that the question of where production took place and where products were to be used was less significant for designers, in the social perspective, designers are converging towards designing for and with the local (Manzini, 2015).

In this new situation, the traditional range of design clients is widening to include local networks of small companies, local institutions (e.g. banks, hospitals, local administrations), associations, cooperative groups and individual customers (Morelli, 2007). For this novel breed of clients, designers are asked to produce scenarios, platforms and operational strategies to enable customizable solutions to be co-produced. Moreover, they must be skillful storytellers to support communication between stakeholders with different cultural and technical backgrounds.

To fulfil these tasks, designers are required to develop a specific sensitivity, learn a new language and acquire new conceptual and operational tools. In a 2019 journal article, *Design Beyond Design*, Dorst emphasizes that applying design thinking tools and techniques to «*areas of great complexity, such as in the social realm*» (p.117) requires design to adapt and change.

> Social design requires designers to manage multiple stakeholders in the problem space as well as in the solution space, and it requires the combination and eventual integration of multiple fields of professional knowledge into what are often very complex product-service combinations. This hyper-complexity has to be dealt with in a situation where there often is no clear user and/or clear (single) client to guide the designer through the design process. This later point is important: early attempts to do 'social design' by directly applying conventional design practices to societal issues often led to simplistic and naïve solutions (Dorst, 2019, p.119).

Addressing complex issues requires giving up the traditional problem-solving approach that served design well under the technical perspective to create a new paradigm based on complexity theory and systems thinking.

> Complexity theory inspires us to think that in situations of true complexity, the challenge is to intervene in a way that makes the whole system move to a more desired state. This potentially upends our view of what designing is, beyond the notion of a problem, or a solution that is the outcome of a project (Dorst, 2019, p. 123).

To find instances in design practices at the cutting edge of complexity, Dorst (2019) suggests searching in the social design projects of design agencies and design labs. According to him, the Dutch design consultancy Reframing Studio[7] is an excellent example of this new systemic approach to designing.

I.D.E.O. as well has entered the social perspective, evolving its famous design thinking approach into 'design thinking for social innovation'. To guide designers applying this new approach, a *Circular Design Guide* has been developed jointly with the Ellen MacArthur Foundation[8]. The Guide aims to help designers explore «*new ways to create sustainable, resilient, long-lasting value in the circular economy*»[9].

The Last Mile: Non-Western Humans, Non-Human Species

Driven by an ethical assessment of Western actions in the ancient and recent past, scholars of different disciplines increasingly engage in discour-

[7] https://www.reframingstudio.com/.

[8] The Ellen MacArthur Foundation works with business, government and academia to build a framework for an economy that is restorative and regenerative by design (www.ellenmacarthurfoundation.org/).

[9] www.circulardesignguide.com/.

ses on cultural decolonization. At the core of decolonization stands the deconstruction of dominant Eurocentric forms of intellectual production (Zembylas, 2018). In opposition to the conventional Western conception of the world as a single, moral universe, with a dominant group of 'us' and minority groups of 'others' (McLeod *et al.,* 2020), decolonial theory affirms the need to make sense of the world from different viewpoints.

Another emerging discourse, the posthuman one, shares with decolonial thinking the rejection of human exceptionalism, namely «*the assumption that humans are unique and should be the main focus of our concern*» (Zembylas, 2018, p. 254). Posthumanism critiques the use of the (western) human as «*a normative ontological, epistemological, and ethical category*» (Zembylas, 2018, *ibidem*) and supports a greater acknowledgement of the interconnections with other, also non-human, beings.

In the entanglement of decolonial and posthuman thinking, design is called to investigate, understand and promote the interdependence that keeps humans and non-humans in continuous and precarious balance rather than being human-centred. Some areas of the discipline that have embraced these discourses are described hereafter.

Respectful Design

It is an educational approach developed by O.C.A.D. University in Toronto. Focusing on the social pillar, respectful design aims to get different values and ways of knowing in design education recognized. Indeed, the design narrative that many schools have adopted worldwide prioritizes European design histories as key pedagogical sources.

In a 2013 book chapter entitled *Decolonizing Design Innovation*, Turnstall, the O.C.A.D. dean of the Design Faculty[10], illustrates how Western values and categories are often used to describe and understand 'others' rather than integrating people's self-definition. Furthermore, these narratives often present a hierarchy in which universal, rational, scientific and civilized Europeans occupy a dominant position compared to the local, subjective and primitive 'indigenous' peoples (Forlano, 2017). For Turnstall, teaching design from a Eurocentric perspective fails to reflect the diversity in the student body and to prepare students to fully understand the profound cultural implications of what they will be designing.

[10] Turnstall is the first black dean of a faculty of design worlwide.

Interspecies Design

Interspecies Design is a participatory approach to design promoting the beneficial coexistence of both human and non-human lifeforms on earth (Roudavski, 2021).

Since cities are the main drivers of ecological degradation, many studies in interspecies design focus on urban environments. In this regard, Roudavski (2021) regrets that leading literature in urban ecology still sees the urban environment as «*a dynamic interaction between the natural environment and human culture*» (p. 157) where human culture gets a privileged position. But culture is not just human. Recent scientific works demonstrate that «*many forms of life have rich cultures that are definable in terms of outcomes such as survival and well-being*». (Roudavski, 2021, *ibidem*).

Moreover, human and non-human cultures evolve in constant interaction within ecosystems. Thus, cultures are always interspecies. Therefore, interspecies design can have non-human clients, consider non-human stakeholders and seek participatory contributions from non-human parties. As an example, Roudavski mentions the adaptation of existing seawalls into friendly habitats for marine life, responding to the needs and preferences of both human and non-human inhabitants.

Design tools and methods need to be reoriented to include more-than-human stakeholders. An Interspecies Design Toolkit has been developed as part of Alan Hook's research activity at ImagineLancaster, exploring how to design for and with animals. The aim is to propagate interspecies empathy and understanding[11].

The latest research strand in interspecies design focuses on investigating plant-human collaboration, but researches and practices in this context are still at the embryonic stage[12].

Posthuman Design

In a 2017 journal article, Forlano introduced the concept of posthuman design. The author starts by acknowledging that technological progress has blurred the boundaries between the notions of human and non-human, culture and nature that have dominated Western thinking since the Enlightenment. She gives driverless cars and voice-activated personal assistants as examples.

[11] https://www.interspeciesdesign.co.uk/.

[12] The Ph.D. research of Francesco Vergani (Politecnico di Milano, Doctoral Program in Design, XXXVII cycle) is worth a mention. Vergani intends to create "The Plant-Centered Atlas", in order to «*grant the design role of plants in participatory design practices of public urban spaces*».

According to Forlano, posthuman ideas are already being incorporated into the design field, as is demonstrated by many discussions around decentering the human, non-anthropocentrism, and human/non-human relations. The idea of leaving behind the human perspective to embrace the posthuman one is well described by Wendt:

> The crux of human-centered design is that human needs should be considered before business and technological needs. […] This tendency has to do with emphasizing the individual over the collective, thus reinforcing deep-seated notions of anthropocentrism that run through the history of western epistemology. […] If humans are at the "center," then things like environmental sustainability, social justice, care for ourselves, economic equality […] most political aspects of design, cannot be adequately considered (Wendt, 2017).

However, the posthuman perspective has raised some eyebrows from scholars in the field of critical race studies who argue that design has historically incorporated an understanding of the human based on the notion of a universal subject (usually white, male, privileged, well-off and young) that does not exist. Speaking of posthuman when so many people (e.g. non-white, less privileged, female, older, indigenous, the disabled) have not historically been welcomed into the human category in the first place is thus premature (Forlano, 2017).

In conclusion, under the social perspective, design has finally taken Papanek's call seriously, recognizing its own responsibilities in the current environmental and social crisis and taking action to contribute to solving them:

> The world is working exactly as we designed it. And it's not working very well. Which means we need to do a better job of designing it. Design is a craft with an amazing amount of power. The power to choose. The power to influence. As designers, we need to see ourselves as gatekeepers of what we are bringing into the world, and what we choose not to bring into the world (Monteiro, 2019).

References

Bhamra, T., Lilley, D., Tang, T. (2011), "Design for Sustainable Behaviour: Using Products to Change Consumer Behavior". *The Design Journal*, 14(4), 427-445.

Brand, R., Rocchi, S. (2011), *Rethinking Value in a Changing Landscape: A Model for Strategic Reflection and Business Transformation*. Philips Design. Retrieved April 4, 2013, from www.design.philips.com/philips/shared/assets/design_assets/pdf/nvbD/april2011/paradigms.pdf

Brezet, J.C., Van Hemel, C. (1997), *Ecodesign: A Promising Approach to Sustainable Production and Consumption*. UNEP.
Brown, T., Wyatt, J. (2010), "Design Thinking for Social Innovation I.D.E.O.". *Stanford Social Innovation Revie*w, 12(1), 29-31.
Brundtland, G.H. (1987), *Report of the World Commission on Environment and Development: "our common future"*. United Nations.
Cababa, S. (n.d.), *It's time to start designing for transparency*, Retrieved August 2, 2022 from www.artefactgroup.com/ideas/design-for-transparency
Cash, P.J., Hartlev, C.G., Durazo, C.B. (2017), "Behavioural Design: A Process for Integrating Behaviour Change and Design". *Design Studies*, 48, 96-128.
Dorst, K. (2019), "Design beyond design". *She Ji: The Journal of Design, Economics, and Innovation*, 5(2), 117-127.
Forlano, L. (2017), "Posthumanism and Design". *She Ji: The Journal of Design, Economics, and Innovation*, 3(1), 16-29.
Gaggioli, A. (2015), "Mind, Brain, and Emerging Technologies". *Positive Technology Journal*. Retrieved November 26, 2017 from http://gaggio.blogspirit.com/archive/2015/04/05/from-the-experience-economy-to-transformation-economy-3042057.html
Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice." *International Journal of Design*, 8(2), 119-139.
Gershenfeld, N., Gershenfeld, A., Cutcher-Gershenfeld, J. (2017), *Designing Reality. How to Survive and Thrive in the Third Digital Revolution*. Basic Books.
Gibson, R.B. (2006), "Beyond the Pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision-making". *Journal of Environmental Assessment Policy and Management*, 8(03), 259-280.
Hosseini, H.M., Kaneko, S. (2012), "Causality between Pillars of Sustainable Development: Global Stylized Facts or Regional Phenomena?". *Ecological Indicators*, 14(1), 197-201.
Kleinert, J., (2018), "The apple sorting site: A case of design of living things". *International Journal of Food Design*, 3(1), 21-39.
Manzini, E. (2015), *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. M.I.T. press.
Margolin, V., Margolin, S. (2002), "A 'social model' of Design: Issues of Practice and Research". *Design Issues*, 18(4), 24-30.
McLeod, K., Ozkul, D., Moore, R., Vincent, K., Ciftci, S., Robinson, D. (2020), "Using the pluriverse concept to critique Eurocentrism in education". *Journal of Applied Learning and Teaching,* Vol.3 Special Issue No.1
Moldan, B., Dahl, A.L. (2007), "Challenges to Sustainability Indicators". In T. Hak, B. Moldan, A.L. Dahl (eds.), *Sustainability Indicators: A Scientific Assessment.* Island Press, 1-26.

Monteiro, M. (2019), *Ruined by design: How designers destroyed the world, and what we can do to fix it*. Mule Design.

Montuori, A. (2012), "Creative Inquiry: Confronting the Challenges of Scholarship in the 21st Century". *Futures*, 44(1), 64-70.

Morelli, N. (2007). "Social Innovation and New Industrial Contexts: Can Designers" Industrialize" Socially Responsible Solutions?". *Design Issues*, 23(4), 3-21.

Mulgan, G., Tucker, S., Ali, R., Sanders, B. (2007), *Social Innovation: What it is, Why it Matters and How it Can be Accelerated*. The Young Foundation.

Murray, R., Caulier-Grice, J., Mulgan, G. (2010), *The Open Book of Social Innovation*. National Endowment for Science, Technology and the Arts.

Needham, A. (2016), "Acid Trips, Black Power and Computers: How San Francisco's Hippy Explosion Shaped the Modern World". *The Guardian*. Retrieved December 9, 2017 from www.theguardian.com/culture/2016/aug/21/san-francisco-exhibition-victoria-albert-revolution-silicon-valley

Papanek, V. (1972), *Design for the Real World: Human Ecology and Social Change*. Thames and Hudson.

Pine, B.J., Gilmore, J.H. (1998), *The Experience Economy*. Harvard Business Press.

Pine, B.J., Gilmore, J.H. (2013), "The Experience Economy: Past, Present and Future". *Handbook on the Experience Economy*, 21-44.

Roudavski, S. (2021), "Interspecies Design". *Cambridge Companion to Literature and the Anthropocene*, 147-162.

Thompson, J.D., MacMillan, I.C. (2010), "Making Social Ventures Work". *Harvard Business Review*, September Issue.

Tromp, N., Hekkert, P. (2018), *Designing for society: Products and services for a better world*. Bloomsbury Publishing.

Tromp, N., Hekkert, P., Verbeek, P.P. (2011), "Design for Socially Responsible Behavior: a Classification of Influence Based on Intended User Experience". *Design Issues*, 27(3), 3-19.

Turnstall, E. (2013), "Decolonizing Design Innovation: Design Anthropology, Critical Anthropology, and Indigenous Knowledge". In W. Gunn, T. Otto, R.C. Smith (eds.). *Design Anthropology: Theory and Practice*. A&C Black, 232-250.

Wendt, T. (2017), "Empathy as Faux Ethics". *EPIC People*, Retrieved January 10, 2018 from: www. epicpeople.org/empathy-faux-ethics/

Yunus, M. (2010), *Building Social Business: The New Kind of Capitalism That Serves Humanity's Most Pressing Needs*. PublicAffairs.

Zembylas, M. (2018), "The entanglement of decolonial and posthuman perspectives: Tensions and implications for curriculum and pedagogy in higher education". *Parallax*, 24(3), 254-267

.

13. Designing Products to Foster Socially-Responsible Behavior

by Lucia Rampino and Sara Colombo

Product design has long been concerned with social and environmental sustainability. Initially, sustainable design focused on designing products requiring less energy in manufacture and use, which were more recycling friendly[1]. At present, there is a growing understanding that bringing about meaningful change requires sustainable design to be capable of intentionally affecting users' behavior.

> Because many, if not all, social issues involve behaviors that play a crucial role in initiating a desired change, the power of design as a deliberate means to change behavior has garnered increased interest. This interest is currently and prominently present in the field of sustainable design (Tromp, Hekkert and Verbeek, 2011, p. 3).

From a technical perspective, the approach typically used to change user behavior has long been based on limiting users' choices through product optimization and automation. An example is electronic devices (i.e., computers and smartphones) which automatically go to sleep when not in use or heating systems that turn themselves off when optimal temperatures have been reached. However, some studies have shown that this technical approach cannot alone sustain significant behavioral change (Herring and Roy, 2007). There has thus been a recent push toward influencing users to make the right choice instead of simply limiting choice: this is the field of 'design for behavior change' (Cash, Hartlev and Durazo, 2017).

Several approaches have been developed under this umbrella term: design for socially responsible behavior (Tromp, Hekkert and Verbeek, 2011); design for sustainable behavior (Wilson, Lilley and Bhamra, 2013); behavioral design (Cash, Hartlev and Durazo, 2017); persuasive technolo-

[1] This approach can also be referred to as 'eco-design'.

gies (Fogg, 2003); persuasive design (Redström, 2006); design with intent (Lockton, Harrison, and Stanton, 2008), to mention just a few of the most prominent. All these approaches acknowledge that artefacts play an essential role in influencing human behavior. However, they also feature specific traits and different behavioral strategies ranging from fully conscious (where users are knowingly involved in attitude change) to unconscious (where users are not fully aware of the product's effect) or combinatory.

In this chapter, we present the most relevant approaches by means of a framework based on the four different strategies to influence user behavior illustrated by Tromp, Hekkert and Verbeek (2011). Finally, two examples of speculative designs for sustainable behavior developed in the authors' research activities are presented.

Design for Behavior Change

Design for behavior change is a sub-field of design concerned with the way design can be used to influence human behavior.

In everyday life, there are numerous situations in which the way we behave is intentionally designed by someone else. This often happens, for instance, in commercial enticements. It is widely recognized that retail environments are designed to tempt us to buy things.

For Redström (2006), this influence is valid in a more general sense: in the Western world, we are used to living in an artificial environment made up of objects in which modes of use are inherent. As an example, Redström explains how chairs can be designed to influence how people sit. A classic case in point is the Stokke Balans chair which requires users to sit partly on their knees to remain erect, which is intended to be beneficial to their backs. A completely different example, taken from the world of gambling, is offered by Fogg (2003): a slot machine manufacturer features on its product interface two characters, a cartoon orangutan and a monkey, which celebrate when gamers win. Such characters are designed to encourage users to keep playing by providing a supportive audience.

In many cases, users are given a choice between accepting and disregarding the way of doing things proposed.

> The fact that a given design represents a certain perspective on the issues dealt with, does, of course, not imply that the user is bound to think the same way. Thus, there is a certain dialogue going on: the designer proposes certain things through the designed thing, and the user then accepts, refutes, or modifies these in relation to her own position (Redström, 2006, p. 115).

However, even though all design activities are inherently linked to behavior change, Redström (2006) argues that a more in-depth understanding of how to effectively and deliberately affect user behavior is still work in progress. Moreover, research is also required to understand the ethical dimensions[2] of behavior change strategies. From a manufacturing company's point of view, for instance, finding an appropriate level of product behavioral influence and ensuring the moral acceptability of such influence is crucial (Lilley, 2009).

Even if, as we have seen, design's persuasive power can be applied to almost any area of human life, when we speak of 'design for behavior change', a social benefit is usually implicit, ranging from encouraging users to take exercise to energy saving. Indeed, the areas in which design for behavior change is most frequently applied include health and well-being, sustainability, safety and social issues as well as crime prevention.

In the broader 'design with intent field', on the other hand, the objective is often business profits. Commercial and social aims are not always mutually exclusive: for instance, a recycling company encouraging users to recycle can have both social and commercial benefit goals (Lockton, Harrison, and Stanton, 2008). However, from a social perspective, the focus is on collective benefits and design with intent will thus not be considered further here.

In general, when designers are called on to design products intended to change user behaviors, there must be some reason why the desired behavior is not the norm. This divergence between socially desirable behavior and actual behavior creates conflict: what is best for the community is not always experienced as optimal for the individual. In this regard, Tromp, Hekkert, and Verbeek (2011) use sustainable behavior as an example. Socially speaking, connecting collective concerns with a set of resulting desirable behaviors such as commuting to work by train rather than taking the car is straightforward. Still, sustainable behavior like this can be overridden by an individual's desire for flexibility and/or convenience. The designer's task is thus to deliberately address individual interests to stimulate socially desired behaviors (Tromp, Hekkert, and Verbeek, 2011). However, influencing users' behavior can be challenging. Despite several years of campaigns encouraging people to act sustainably, users are slow to adopt more sustainable behavior (Lilley, 2009).

In design for behavior change, human-centered design techniques are usually applied for a better understanding of the intervention context, behavioral background and corresponding action and effects. This infor-

[2] The ethical issue is discussed in Chapter 14.

mation is then used to select and frame desired behavior in order to determine the most appropriate behavior-changing strategy (Wilson, Lilley, and Bhamra, 2013).

Four Different Strategies Used to Influence Users

This section proposes a classification of the various ways of influencing user behavior based principally on the four strategies described by Tromp, Hekkert, and Verbeek (2011).

Broadly speaking, acting on users' behavior can be 'antecedent' or 'consequent' (Cash, Hartlev, and Durazo, 2017). Antecedent action precedes behavior, influencing users to act in a desired way. It thus attempts to motivate, educate, facilitate or constrain individuals to specific behaviors. Analysis by Abrahamsen *et al*. (2005) in the energy saving field demonstrates that providing users with information on the consequences of a given behavior tends to result in higher knowledge levels but not necessarily behavioral changes. Consequent action relates to the positive or negative impacts of behavior and usually includes feedback and/or rewards (Lilley, 2009). For Abrahamsen *et al.* (2005), rewards effectively encourage energy conservation, but their effects tend to be ephemeral. Feedback has also shown to have a positive effect, especially when it is frequent.

Strategies can be further grouped into 'informational' and 'structural'. Informational strategies include the most current design and persuasive approaches and emphasize freedom of choice (Kelders *et al*., 2012). De Young (1993) has broken down general informational strategies into purely informational and positively motivational. Purely informational approaches increase awareness of a problem and inform users as to how future behavior will affect it. Positive motivational strategies encourage people to perform specific actions.

Structural strategies aim to alter contextual factors such as the accessibility and convenience of behavioral alternatives. They can either reward good behavior or penalize negative behavior and are often linked to the adoption of legal measures (for instance, closing off town centers to motorized traffic). Pricing policies can also be adopted, for instance, charging more for less environment-friendly alternatives or decreasing the costs of pro-environmental behavior (Steg and Vlek, 2009).

A designed object's influence on how users behave ranges from weak to strong and from implicit (i.e., unconscious) to active (i.e., conscious). On this basis, Tromp, Hekkert, and Verbeek (2011) have distinguished four types of influence: coercive, persuasive, seductive, and decisive (Figure 1).

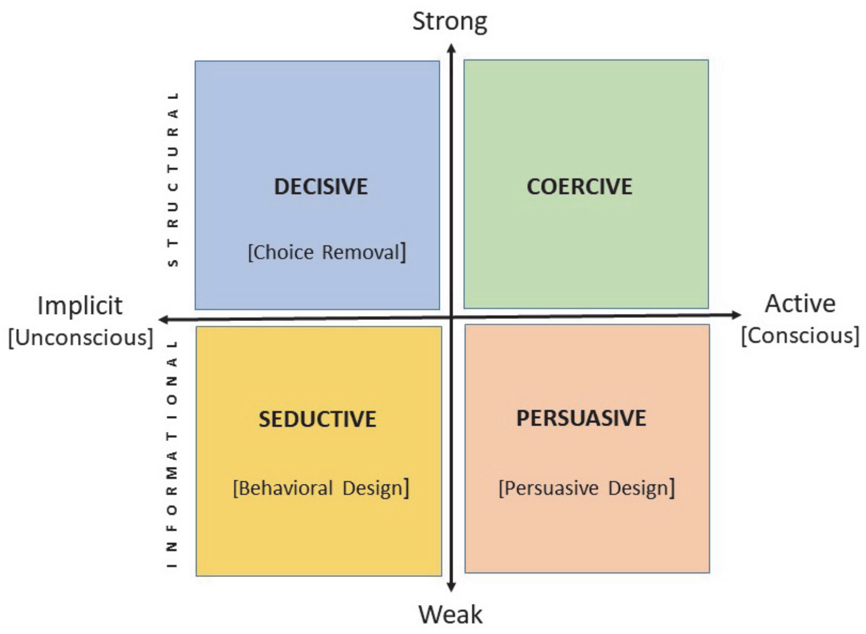


Figure 1: Four types of user behavior influences

We can therefore affirm that products can coerce, persuade, seduce or decide for users. Understanding the relationship between collective and individual interests, whether they clash or coincide, helps to identify what type of influence might be effective. It is important to stress that different people assign the same product to other categories, and the effect on users can thus differ from that initially imagined by designers.

Hereafter, we briefly analyze the main features of each kind of influence.

Decisive Influence

An influence is referred to as decisive when design makes the desired behavior the only possible one (Tromp, Hekkert, and Verbeek, 2011).

Infrastructure and building design are typically decisive: if we want to oblige people to exercise, we can remove elevators from buildings (or make these impossible for 'standard' users to access) so that people will be forced to use the stairs.

Although removing freedom of choice can be effective, it is often associated with negative consequences such as poor user experience or subversion of intended behavior. Manufacturing companies are therefore very cautious in this respect because giving products an autonomous decision-making ability, however sporadic, can annoy users and prompt a decline in sales. This is why the application of a decisive influence in products on the market is minimal. Some compelling examples are indeed concepts but not actual products. One for all is the wireless computer mouse Balance[3], designed by Samsung in collaboration with Korean creative agency Innored to advocate for proper work-life balance. At 6 pm, the mouse literally runs away from the user, setting the end of the working day.

For Lilley (2009), further investigation is needed to determine where automation is acceptable and where choice should remain the only possible option. Research indicates that it may be easier for manufacturers to justify the use of more forceful action where target behaviors threaten personal or public safety or are illegal, for example, the use of mobile phones while driving (Lilley, 2009). In some specific instances, however, users may respond positively to the automation of particular actions, citing convenience and time savings as benefits. Think, for example, of the heating system that turns off and on automatically referred to above.

A final issue with decisive strategies is that users learn nothing new since they are not consciously thinking about their own behavior. Without any feedback on cause and effect, users may be less likely to adopt socially responsible behavior of their own accord in the future (Lilley, 2009).

Coercive Influence

Like decisive influence, also coercive influence is often experienced as conflicting with individual freedom and is thus applicable only to contexts in which the desired behavior is almost unanimously agreed upon. As a result, the public and institutional domains are fields to which coercive design can be well suited because government and managers have the authority to implement such action (Tromp, Hekkert, and Verbeek, 2011).

Typical examples are speed cameras and speed bumps. Intelligent speed bumps filled with non-Newtonian fluid apply a structural strategy that rewards slow drivers and penalizes fast ones. Indeed, the fluid parts when a vehicle passes slowly, allowing the car to pass through as if nothing was present. On the contrary, the fluid hardens when a vehicle at high speed tries to pass through.

As with the decisive strategy, some compelling examples of coercion are concepts but not actual products. We can mention the ‘energy aware’ set of concepts designed, prototyped, and tested by Loove Broms as a part of his Ph.D. research. Among them, for example:

[3] https://girlstyle.com/sg/article/75260/samsung-balance-mouse.

> a radiator handle serrated with sharp edges that slightly hurt the hand of the user when the latter turns the knob in the direction of highering the temperature (Broms, 2011, p. 35).

Persuasive Influence

Persuasive design is an informational strategy, weak and active in its influence (Figure 1). Much of the action which uses persuasion deals with encouraging healthy, safe, and environmentally responsible behaviors, such as campaigns to promote healthy eating.

Nowadays, persuasive strategies are broadly adopted in a growing field of research focused on the persuasive power of technology, which is seen as having an essential role as an experience medium and creator (Cash, Hartlev, and Durazo, 2017). In 2003, Fogg introduced the term 'persuasive technology' in relation to human-computer interactions designed to alter users' attitudes through persuasion. A few years later, in 2009, he observed:

> […] persuasive technologies are ubiquitous; we are surrounded by digital products designed to change what we think and do. Persuasive technology experiences come to us through the web (from commerce sites to social networking), video games (e.g., Wii Fit and Dance Dance Revolution), mobile phones (e.g., health applications for iPhone and commercial texting services), and specialized consumer electronic device, from "talking" pedometers to bathroom scales that track body mass. […] As for automobiles, one feature of the Toyota Prius is a miles-per-gallon meter that motivates owners to adopt more eco-friendly driving habits (Fogg, 2009, p. 1).

According to Torning and Oinas-Kukkonen, what distinguishes persuasive systems from other systems is that the formers deliberately attempt to generate a cognitive and emotional change in users to transform one mental state into another.

> In using technology as a vehicle of persuasion, we touch upon a central part of being human, namely intentional communication. Whenever we communicate deliberately with a clear purpose and outcome in mind, we are engaging in persuasion. This is not new; but building devices that conduct persuasion on our behalf is (Torning and Oinas-Kukkonen, 2009, p. 1).

Persuasive design embeds deliberate messages in systems. For this reason, Torning and Oinas-Kukkonen (2009) stress the importance of designers taking responsibility for the ethical aspects of their designs when they are intended to encourage specific behaviors.

Seductive Influence

Seductive influences are weak and implicit. They are subtle influences that can be very useful in eliciting desired behaviors in social fields that do not deal with matters of 'life and death' and, therefore, do not allow for structural strategies based on enforcement. Typical domains are domestic energy saving, well-being, and waste management.

An example is the garbage bins designed to resemble a basketball basket whose goal is to invite people to try a shot rather than leaving their garbage lying around. The 'Lucerne Shines' program offers a similar example: the Swiss municipality depicted mazes and hopscotch boxes around public trash bins to make the act of trash disposal more fun[4].

In 2009, in collaboration with the advertising agency NORD DDB, Volkswagen did an experiment at the Odenplan metro station in Stockholm. Fuelled by the idea that having fun can «*change behavior for the better*», they decided to encourage commuters to use the stairs instead of the escalator, turning stairs into a fully functional piano keyboard. During the Piano Stairs Experiment, the stairs were used 66% more than usual[5]. Inspired by this experiment, a Taiwanese hospital has installed a 'piano staircase' to encourage patients and staff to do more exercise.

An earlier example of seductive influence mentioned by Fogg (2003) is the Nintendo's Pocket Pikachu, a digital pet released in 1998. The device contained a pedometer that could register its owner's movements. For the digital pet to remain well-disposed and happy, its owner had to be physically active, walking and running to activate the pedometer.

This strategy category encompasses the so-called 'behavioral design' approach as defined by Cash, Hartlev, and Durazo:

> We offer an initial characterization of Behavioral Design as: designing for antecedent behaviour change strategies using implicit interventions to impact behaviour. This is complementary to, but distinct from, the range of approaches described by persuasive design or technology, and physical removal of choice. […] Behavioral design targets automatic response, eliminating possible counteraction through implicit effect whilst retaining freedom of choice (2017, p. 97).

When adopting a seductive influence approach, designers should be aware that some potential ethical abuses are inherent, even for the best intention designer (Cash, Hartlev, and Durazo, 2017).

[4] https://inhabitat.com/the-city-of-lucerne-turns-taking-out-the-trash-into-a-fun-game/.
[5] https://www.classicfm.com/discover-music/instruments/piano/musical-staircase-experiment/.

Designing for Sustainable Behavior

Within the broader field of design for behavior change, design for sustainable behavior is a research area centered on defining strategies to influence the use of products in the direction of decreased resource consumption. In the view of Wilson, Lilley, and Bhamra (2013), design for sustainable behavior is based on a combination of user-centered design methodologies, user consumption behavior studies, and behavioral action strategies. The aim is to offer companies a systematized behavioral perspective that can be integrated into their existing product development processes. Indeed, promoting technical innovation to increase products' energy efficiency has proven to be a questionable energy-saving strategy.

In this respect, Herring and Roy (2007) have argued that, in the long term, increasing product energy efficiency will not lead to energy savings but to overall increases in energy use:

> For instance when we replace a 75W incandescent bulb with an 18W compact fluorescent bulb (C.F.L.), a reduction in (wattage) power of about 75% we could expect over time a 75% energy saving. However this seldom happens. Many consumers, realizing that the light now costs less to run, are less concerned about switching it off, indeed they may leave it on all night, for example for increased safety or security (p. 3).

For Lilley (2009), the factors influencing users' attitudes to use domestic appliances are complex. Studies have shown that, on average, energy consumption issues inspire limited individual interest. In addition, it has been recognized that users' energy consumption mindsets stem from real interaction with products and their understanding of the associated benefits. Therefore, understanding energy consumption requires comprehending the complex behavioral processes that drive user interactions with energy-consuming products (Lilley, 2009).

In the final part of this chapter, we present two speculative design proposals whose objective is to foster home energy-saving user behaviors. Both concepts adopt informational strategies but use two kinds of influence: persuasive and seductive, respectively.

'Peace Time': Persuading Users to Save Electricity

The first design activity presented here is a case of persuasive strategy. Indeed, its approach is weak and active, with users being encouraged to change their habits by engaging in sensory experiences that prompt them to consciously shift electricity-consuming activities to different times of the day[6].

Preliminary research

A change in users' behavior is essential in the smart grid scenario, based on the idea that the electricity grid load should remain balanced over time to avoid consumption peaks. Peaks are due to a high electricity demand, forcing energy companies to use alternative sources – like coal – to supply users with the extra energy that renewable sources would otherwise provide (e.g., wind, solar, etc.). Coal burning causes high CO_2 emissions into the atmosphere, with harmful consequences for the environment.

Load management is one of the strategies adopted in the smart grid scenario. It requires active involvement by users who are asked to shift domestic activity timeframes (typically from day to night) to meet overall electricity grid demands and balance consumption. However, encouraging users to change or alter their habits is no easy task. Because habits are automatic and require no effort whilst changing them does (Graybiel, 2008).

Ethnographic research was done to understand users' habits and their willingness to adopt a more flexible attitude toward electricity consumption consisting of interviews with ten Swedish households (Wessman, Colombo, and Katzeff, 2015). The results guided and inspired the design of an ambient interface connected to a mobile application, the Peace Time concept.

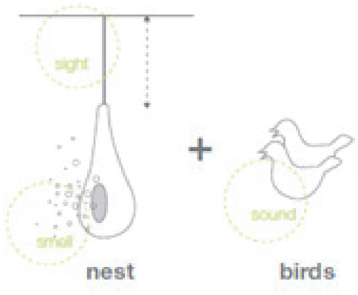
Concept Description

Peace Time focuses on making 'negative' hours (when peaks occur) in some way positive for users, highlighting peaks as times when users can relax and do other things, i.e., 'peace hours.' When a 'peace hour' begins, an ambient sensory interface notifies users that it is time to take a break and unwind.

The ambient interface consists of a 'nest' hanging from the ceiling and a set of wooden birds. When a peace time starts, a fragrance is released into the house from the nest. Fragrances are selected by users from a set of natural aromas (e.g., wood, flowers), which create a connection with nature. A pleasant sound of tweeting birds (emitted by the wooden birds) signals peace time thirty and fifteen minutes before it begins. The birds can be placed in the nest or other places in the house.

[6] This design activity was part of the RISE Interactive Energy Design studio's FlexibEl research project jointly developed with Cecilia Katzeff and Stina Wessman. Co-author Sara Colombo participated in the project as the group's visiting Ph.D.

The nest drops from the ceiling when a peace time starts to notify users how long it will last. The remaining distance from the ceiling indicates how much peace time is left as the peace time unfolds. A connected mobile/web application informs users about forecast peace times, allowing them to plan electricity-free activities around future peace times.



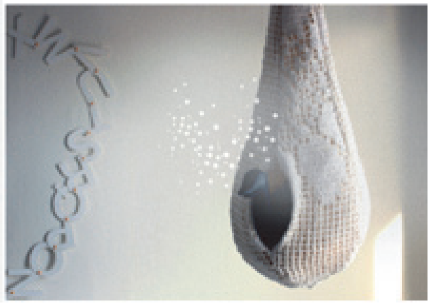


Figure 2: The Peace Time prototype

User tests

The concept was tested in focus groups with users. Four people were involved, two men and two women, aged 30 to 60. Participants were divided into two groups. After presenting the concept and explaining the prototype, the leader guided the discussion through open-ended questions which addressed a range of topics: concept clarity, potential, problems, and suitability for users' everyday lives. Each session lasted one hour, and the discussion was recorded for subsequent analysis. A summary of findings is reported below.

Results

From the two focus groups, it emerged that the artefact conveys feelings of relaxation and calm and nature associations. Participants defined it as cozy, botanical, relaxed, and safe. Its sounds and smells were much appreciated to alert users and encourage them to change behavior.

Participants believed the concept would trigger discussion within their families and change behavior patterns at home, at least during the first use period. It emerged that the artefact could effectively encourage users to think about being flexible in their electricity use. However, it also emerged that interest might fade after the initial period. Participants also pointed out that the sound signal might get dull over time and suggested varying it. All in all, the concept was judged helpful as a learning tool that could persuade users to be more flexible in their electricity use.

After this phase, the concept was further developed, modified, prototyped, and tested with users in the field in real households. The results of this study are reported in Katzeff, Wessman, and Colombo (2017) and show that the concept can be effective in fostering behavior change, at least during the two-week test period. Users enjoyed planning electricity-free activities and performing them during peace times, demonstrating that households can potentially reorganize their practices and behave in new ways to adapt to external conditions, such as renewable energy source intermittence on the electrical grid.

'FEEL': Seducing Users into Saving Water

In the second design activity[7], a seductive influence was adopted. The concept development applied the principles of embodied interaction[8]. These principles are based on the notion of a circle of influences among products' physical properties, users' interaction with the product, and the creation of meanings in users' minds (Dreyfus, 1991; Ingold, 2000). The sense-making process is not just based on decoding information conveyed by product features but is also made possible by the creation of personal dialogue between users and the product itself. Such dialogue encourages reflection-on-action and the creation of new meanings.

To test this approach, a shower water consumption focus was chosen to concentrate on the tactile stimuli provided by shower trays. The aim of this second design activity was thus to create meaningful tactile experiences with an interactive shower tray capable of promoting water-saving behaviors in situ.

Preliminary research

User behaviors when showering were observed, and their feelings were investigated. In particular, three short tests with users were conducted to gain insights into (i) user behaviors, (ii) tactile feelings, and (iii) users' emotional experiences. Video recording was used to observe users' foot

[7] This design activity was part of Sara Bergamaschi's Ph.D. thesis, supervised by Lucia Rampino and discussed in March 2017 at Politecnico di Milano. Sara developed the FEEL concept during her period as visiting Ph.D. at Twente University (NL), under the guidance of Jelle van Dijk.

[8] The concept of embodied interaction belongs to the Pragmatism paradigm in design practice. For a description of this paradigm, see Chapter 7.

behavior in the shower and their tactile interaction with the shower tray. Moreover, testers were asked to write a week-long diary to keep track of their experiences and feelings while showering.

Concept Description

The preliminary research supplied valuable insights for developing the FEEL (Feelings and Experiences for an Embodied Learning) concept, a squared shower tray capable of changing shape to generate a novel shower experience. The tray consisted of an external case and several soft pins, which popped up randomly at different rhythms, creating a tactile experience resembling a foot massage every time.

The data collected in the week-long diary showed that users' reasons for showering are usually one of two alternatives: taking a short refreshing break, or relaxing, and pampering themselves.

Following these two scenarios, FEEL is designed to change shape in a fast and more marked way in the initial minutes of the shower, for the average amount of time users usually spend on a short shower. The speed of the soft pin movements then slows before stopping altogether when the maximum average shower times are reached, i.e., the 'natural' moment at which people feel they have finished, and it is time to get out.

Over time, FEEL creates a dynamic coupling between users' actions and the temporal choreography on the responsive shower floor. Once this coupling is in place, the temporal pattern decreases over time to lead users to reduce the time spent under the shower.

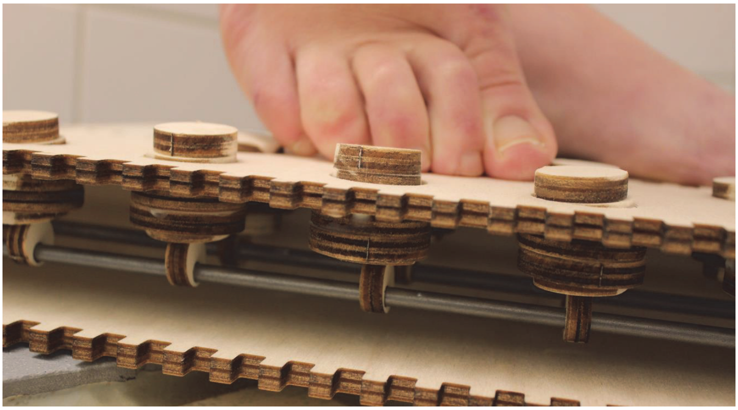


Figure 3: FEEL prototype

The size of the decrease is small and barely noticeable. Indeed, it is essential that users feel their showers are the same. After several weeks users will get a ‘natural finished feeling’ in a shorter time, thereby saving water without being forced or persuaded to make a conscious decision to ‘do the right thing.’

A raw prototype in wood, steel, and soft materials was created to represent the product’s features (Figure 3); its functioning was simplified.

Focus Groups

A focus group was set up to collect qualitative feedback. It was not intended to be a traditional user-evaluation focus group, asking users whether water consumption would decrease. Instead, it was intended to extract some insights from users’ sense of the product’s design. The focus group involved four people (two men and two women, aged 25-36). None of the testers were designers since the aim was to gain feedback from non-experts.

During the session, videos and pictures were shown to describe FEEL in its actual context. Then, participants were invited to a discussion, guided by open questions aimed to enquire into the following aspects: (i) engagement with the concept, (ii) concept potential and limitations, and (iii) how the concept would fit into their everyday lives.

Results

The participants focused on two main aspects of the concept: the novelty factor and the clarity of the communicative intent. FEEL was evaluated as novel, original and unusual: «*It proposes an unusual experience*»; «*This project is cool*»; «*I have never seen anything like that*!».

During the focus group, the novelty factor was observed to impact user enthusiasm for prototype trials in the real world.

The concept was perceived as capable of supporting and motivating user behavior change since the learning process was judged subtle and linked to personal awareness. A user says, «*FEEL helps me to relax and enjoy my shower. Water consumption is up to me*».

Different Strategies for Different Aims

Behavioral design strategies aim to encourage, change, and sometimes constrain or force user action. Four approaches have been presented, consisting of decisive, coercive, persuasive, and seductive influences. The two projects reported above represent two ‘weak’ approaches to behavioral design: persuasive and seductive. Although both projects focus significantly on sensory experiences, they show that design can affect people's behavior by asking users to take on conscious change or subtly leading them to react to changing environmental conditions by adapting their behavior over time. More robust approaches may be needed in certain situations, e.g., when users must be discouraged from performing unsafe, dangerous, or illegal actions.

It is crucial that designers understand the context and conditions in which they are operating. To this end, they must analyze the specific context constraints, the degree of persuasion required, the nature of users' roles (more or less active and conscious), and the reasons behind the need to modify users' behavior which ultimately also connects to the need for ethical considerations.

Overall, especially when working in the 'weak' influence domain, designing positive user experiences can create effective solutions that can impact users' actions.

> Perceived added values such as usefulness, aesthetics and joyful types of interaction could act as motivators to change behaviour (Broms *et al*., 2010).

This is also true of 'stronger', i.e. coercive and decisive, approaches where strategies such as *reward* and *positive feedback* (e.g. showing how an individual's actions have contributed to a greater positive result) can help to make the overall experience acceptable, encouraging a more socially-responsible attitude in return.

Working on users' emotions and experiences may not generate immediate results but still prompts powerful reflection on relevant problems and issues, which is the first step towards actual behavioral change.

References

Abrahamsen, W., Steg, L., Vlek, C., Rothengatter, T. (2005), "A Review of Intervention Studies Aimed at Household Energy Conservation". *Journal of Environmental Psychology*, 25(3), 273-291.

Broms, L. (2011), *Sustainable interactions: Studies in the design of energy awareness artefacts* (Doctoral dissertation, Linköping University Electronic Press).

Broms, L., Katzeff, C., Bång, M., Nyblom, Å., Hjelm, S.I., Ehrnberger, K. (2010), "Coffee Maker Patterns and the Design of Energy Feedback Artefacts". In *Proceedings of the 8th A.C.M. Conference on Designing Interactive Systems,* A.C.M., 93-102.

Bruns, M., Hummels, C.C.M., Keyson, D.V., Hekkert, P.P.M. (2013), "Measuring and Adapting Behavior During Product Interaction to Influence Affect". *Personal and Ubiquitous Computing*, 17(1), 81-91.

Cash, P.J., Hartlev, C.G., Durazo, C.B. (2017), "Behavioural Design: A Process for Integrating Behaviour Change and Design". *Design Studies*, 48, 96-128.

Daae, J., Boks, C. (2015), "A Classification of User Research Methods for Design for Sustainable Behavior". *Journal of Cleaner Production*, 106, 680-689.

Darby, S. (2006), The Effectiveness of Feedback on Energy Consumption. A Review for D.E.F.R.A. of the Literature on Metering, Billing and direct Displays. Retrieved February 18, 2017 from: http://www.usclcorp.com/news/DEFRA-report-with-appendix.pdf

De Young, R. (1993), "Changing behavior and making it stick: The conceptualization and management of conservation behavior". *Environment and behavior*, 25(3), 485-505.

Dreyfus, H.L. (1991), *Being-in-the-world: A Commentary on Heidegger's Being and Time, Division I*. Mit Press.

Fogg, B.J. (2002), "Persuasive Technology: Using Computers to Change What we Think and Do". *Ubiquity*, 5.

Fogg, B.J. (2009, April), "Creating persuasive technologies: an eight-step design process". In *Proceedings of the 4th international conference on persuasive technology* (pp. 1-6).

Fogg, B.J. (2009), "A Behavior Model for Persuasive Design". In *Proceedings of the 4th International Conference on Persuasive Technology*. A.C.M.

Froehlich, J., Findlater, L., Landay, J. (2010), "The Design of Eco-Feedback Technology". In *Proceedings of the S.I.G.C.H.I. Conference on Human Factors in Computing Systems*. A.C.M., 1999-2008.

Graybiel A.M. (2008), "Habits, Rituals, and the Evaluative Brain", *Annual Review of Neuroscience*, 31, 359-387.

Herring, H., and Roy, R. (2007), "Technological Innovation, Energy Efficient Design and the Rebound Effect". *Technovation*, 27(4), 194-203.

Ingold, T. (2000), "Making Culture and Weaving the World". In P.M. Graves-Brown (ed.), *Matter, Materiality and Modern Culture*, Routledge, 50-71.

Katzeff, C., Wessman, S., Colombo, S. (2017), "Mama, It's Peacetime!: Planning, Shifting, and Designing Activities in the Smart Grid Scenario". In *Proceedings of the Conference on Design and Semantics of Form and Movement, DeSForM 2017*. InTech.

Kelders, S.M., Kok, R.N., Ossebaard, H.C., Van Gemert-Pijnen, J.E. (2012), "Persuasive System Design Does Matter: a Systematic Review of Adherence to Web-Based Interventions". *Journal of Medical Internet Research*, 14(6).

Lilley, D. (2009), "Design for Sustainable Behaviour: Strategies and Perceptions". *Design Studies*, 30(6), 704-720.

Lockton, D., Harrison, D., Stanton, N. (2008), "Design with Intent: Persuasive Technology in a Wider Context". In *International Conference on Persuasive Technology*, Springer, 274-278.

Niedderer, K., MacKrill, J., Clune, S., Evans, M., Lockton, D., Ludden, G., Hekkert, P. (2014), *Joining Forces: Investigating the Influence of Design for Behavior Change on Sustainable Innovation*. Retrieved February 17, 2017 from: https://research.utwente.nl/en/publications/joining-forces-investigating-the-influence-of-design-for-behavior

Nodder, C. (2013), Evil by Design: Interaction Design to Lead us into Temptation. John Wiley & Sons.

Redström, J. (2006), "Persuasive Design: Fringes and Foundations". *Persuasive Technology*, 112-122.

Selvefors, A., Pedersen, K.B., Rahe, U. (2011), "Design for Sustainable Consumption Behaviour: Systematising the Use of Behavioural Intervention Strategies". In *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces*. A.C.M.

Steg, L., Vlek, C. (2009), "Encouraging Pro-Environmental Behaviour: An Integrative Review and Research Agenda". *Journal of Environmental Psychology*, 29(3), 309-317.

Torning, K., Oinas-Kukkonen, H. (2009), "Persuasive System Design: State of the Art and Future Directions". In *Proceedings of the 4th International Conference on Persuasive Technology*. A.C.M.

Tromp, N., Hekkert, P., Verbeek, P.P. (2011), "Design for Socially Responsible Behavior: a Classification of Influence Based on Intended User Experience". *Design Issues*, 27(3), 3-19.

Ulrich K.T., Eppinger S.D. (2000), *Product Design and Development*. Irwin McGraw-Hill, International Edition.

Van Dijk, J. (2013), *Creating Traces, Sharing Insight: Explorations in Embodied Cognition Design*. Unpublished Phd thesis. Eindhoven University. Retrieved February 18, 2017 from: www. jellevandijk. org.

Wendel, S. (2013), *Designing for Behavior Change: Applying Psychology and Behavioral Economics*. O'Reilly Media, Inc.

Wessman, S., Colombo, S., Katzeff, C. (2015), "Please mind the balance. Using Design to Engage Households in the Smart Grid Scenario". In *Proc. of 11th European Academy of Design Conference*.

Wilson, G.T., Lilley, D., Bhamra, T.A. (2013), *Design Feedback Interventions for Household Energy Consumption Reduction*. Retrieved January 9, 2018 from: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/12522/3/ERSCP-EMSU%25202013%25201.0%2520GTW.pdf%0D

14. Morals, Ethics, and the New Design Conscience

by Sara Colombo

The growing presence of digital technologies in our world is posing unprecedented challenges to the discipline of design. Such challenges require designers to gain new skills and sensitivities to properly shape future digital-physical landscapes. The aim of this chapter is to investigate the new scenarios that technologies are creating, the consequences of emerging digital technologies on people and society, and the compelling need for designers to sharpen their consciences and start considering the ethical implications of their solutions.

The transformations caused by ubiquitous digital technologies require designers to operate in a dynamic, ever-changing landscape in which technology acts as a disruptive force, permeating virtually every aspect of human life and transforming, at an increasing pace, all of the cultural framework's designers are used to operating in. Such frameworks include the way people interpret and interact with artifacts, as well as the influence of artifacts on people and society.

The technologies that cause these societal and cultural changes have also become the new material designers work with. Given the huge impact technologies have on people and society, it is no longer possible for designers to overlook the consequences of these technologies' future applications at all scales.

If so far design researchers and practitioners have investigated how artefacts affect users' experience and behavior, now they need to explore a more complex question. How do new artificial and technical solutions - hybrid physical-digital systems - impact and transform our nature as humans at the individual and societal levels? What role can and should designers play in this transformed landscape?

Contributing Technologies

The digital transformation is enabled and accelerated by a number of new and emerging technologies. Miniaturized, wearable, and implantable sensors, as well as augmented reality devices contribute to what has been defined as 'human augmentation' (Raisamo *et al.*, 2019), which refers to the ability to enhance our minds, senses, and bodies (e.g., by smart prosthetics or 3D-printed bio tissues).

At the same time, the overlap of biology, biotechnology, computer science and design is opening up entire new territories. These include biosensors – i.e. using engineered bacteria as sensors, as well as DNA engineering and human genome analysis, which enables ever faster, more accurate, and accessible ways to discover more about ourselves (e.g. our genetic diseases or geographical origins).

Flexible and stretchable electronics, with their ability to equip products, spaces, and even human bodies with increasingly smaller and adaptable sensors can collect huge amounts of data on environments and people. All these trends contribute to the creation of digital, quantitative representations of both the physical world and ourselves, which are well described by the concepts of 'digital twin' (Jones *et al.,* 2020) and 'quantified self' (Lupton, 2016).

In addition to these trends, recent developments in AI – including improved neural networks and deep learning applications for, among others, image recognition and natural language processing – have contributed to the creation of high-performing specialized artificial intelligence (Shanahan, 2015). More recent advancements, such as *local* neural networks (Chen *et al*., 2017) have opened the possibility to develop autonomous off-the-grid devices, such as robots, drones and conversational agents. These systems use super-powerful chips that allow machine learning models to operate locally. In other words, they do not need to be connected to the internet in order to process and interpret incoming data (e.g. speech or images).

Deep learning, machine learning and AI are all strictly connected to the rise of big data, which is defined as:

> […] a set of techniques and technologies that require new forms of integration to uncover large hidden values from large datasets that are diverse, complex, and of a massive scale (Hashem *et al.*, 2015).

Big data is accelerated by cloud computing, which has transformed the access and exchange of virtual and digital resources. A plethora of platforms and computing systems have emerged in this area, including *fog computing*, an extension of the cloud which allows for more distributed systems, thanks to increased connectivity and new services at the edge of the network (Bonomi *et al.*, 2012).

Finally, digital technologies such as blockchain are enabling the creation of digital tools and applications for certified online transactions and secure information exchange (Chen *et al.*, 2022). Blockchain, which originated in the field of cryptocurrencies, was projected by some to be one of the technologies that would change the world (Tapscott and Tapscott, 2016).

All these technological advancements contribute to – and are reinforced by – what has been defined as the Internet of Everything (IoE), which «*represents a more evolved and advanced state where physical and digital worlds are blended into a single space*» (Greengard, 2015, p. 18). According to Greengard, the IoE is the result of the melding together of the Internet of Things and the Internet of Humans.

New Landscapes for Design

A Change in Scale

As a result of these impressive technological advancements, products are no longer static but rather connected, dynamic and interactive. More importantly, they are becoming increasingly intelligent, independent, and self-learning, thanks to technologies like big data, machine learning, and new generations of sensors. Over the coming decades, it is not too unrealistic to think that designers will be called on to design for complex, autonomous and unpredictable digital ecosystems made up of connected elements capable of sensing, learning, adapting, and evolving over time.

In this emerging scenario, interactive, smart, and connected physical products are already becoming the tangible manifestations of much broader digital-physical ecosystems. They are turning into bridges between the material world and a massive, dynamic substratum of immaterial data, information, and services. The very nature of products is indeed changing, as they become inseparable from their computational intelligence and the underlying flow of data, information and connections between systems, people and spaces.

This is leading to a change in scale in the design activity – from the single artifact to the hybrid ecosystems it belongs to. Will it still be relevant to talk about product design in a few years' time? Or will the ability to shape matter and experiences become just one of many more complex competencies that future designers will need to develop? In order to take up this challenge, designers need to see the products of the future as material culminations and manifestations of an interconnected, changing, growing and evolving network of information that links everything and everybody. They will need to take on a more *systemic* approach, by focusing on the dynamic nature of materials, services, and data, their interconnections, as well as how humans experience and interact with them in future techno-human societies.

A Change in Focus

In light of these upcoming transformations, designers should no longer focus their attention on just the object of their design activity. Rather, they should begin to carefully assess how their designs will impact and modify the mutual relations between different components of an ecosystem (humans, artifacts, data, computational, natural, and biological systems) as well as what consequences they will have on the evolution of the ecosystem as a whole. Every new solution that is added to a physical-digital environment immediately creates new and profound interconnections that may affect other areas of the ecosystem – these resultant effects need to be a part of designers' purview. Adjusting the focus of designers' activity means leveraging their visioning skills to anticipate problems and risks connected to the adoption and spread of certain solutions.

By looking beyond the mere solutions they design to consider their large-scale effects on other interconnected elements, designers will more likely be able to keep up with new technological developments, take part in designing their applications, and affect their evolution where necessary.

This approach is more important than ever as the futures we are presented with are primarily created by big tech companies, which are driven by a technology push, rather than a human-centered perspective. However, the design discipline is struggling to adapt to and to find suitable tools to operate in this new scenario. What is needed is an active effort to help technologists shape a world in which humans – and the environment they live in – are still at the heart of technological choices. More than two decades ago, Dertouzos (2001) described the transformations generated by computers as an unfinished revolution and advocated the need to shift the focus from machines back to humans. Today, many of the problems he pointed to have been solved, but new and more compelling challenges are emerging. Machine and artificial intelligence pressurizes our world and many aspects of our lives. The socio-digital transformation is starting to hint at its darker sides, such as more superficial and virtual relationships and a lack of privacy (Carr, 2014; Turkle, 2012).

Design has the tools and sensitivity required to combine the human and technical perspectives and is therefore in a privileged position to take a prominent role in the creation of our future.

Moral and Ethical Considerations

> When technologies are always influencing human actions, we had better try to give this influence a desirable form (Verbeek, 2006).

In the near future, the information layer that nowadays connects people, objects and environments will permeate our reality even more profoundly. We will be less aware of – and probably care less about – the data that is collected from us, where that data goes, and who uses it. We will be fed information that will affect our behavior, mindsets, values and beliefs in a subtle way. This is already happening, for instance when our web searches are monitored to provide companies with information about our preferences, which are subsequently used to select the best ads and create customized offers to influence our purchases.

The way these digital ecosystems are designed (their structure, appearance, and behavior) will have a great impact on our lives. For this reason, it is important that humans remain center-stage in this design activity. Designers' ability to operate in the space between technology and people's needs, perceptions, emotions, and values is even more important in the new digital landscape. In this scenario, considerations about the effect of emerging physical-digital ecosystems on human health, behavior, relationships, social development and evolution become compelling. As products are augmented with an ability to sense, reason, and make decisions independently, we should start thinking about the ethical consequences of these systems on two different levels: *machine morals* and *design ethics*.

Machine Morals

Machine morals concerns the direct effects that machine and artificial intelligence can have on humans. As machines such as self-driving cars, conversational agents and robots in homes, hospitals or factories become capable of reasoning and making decisions by themselves, it will be essential to consider what guides their choices and behaviors and the effects their actions may have on people.

A well-known example of the study of morals connected to machines is the MIT Media Lab's Moral Machine project:

> The Moral Machine is a platform for gathering a human perspective on moral decisions made by machine intelligence, such as self-driving cars. We generate moral dilemmas, where a driverless car must choose the lesser of two evils, such as killing two passengers or five pedestrians[1].

[1] http://moralmachine.mit.edu.

Another example of undesirable behaviors connected to artificial intelligence is Tay, an AI chatbot, or conversational agent, which Microsoft built in 2016. The creators' goal was to generate an AI agent trained online by users, especially by Twitter posts. However, by interacting with users and learning from them, the chatbot soon started saying "awful, racist things" (Metz, 2016), forcing the company to take it offline. Simply put, the design team had not taken into consideration the possibility that the system would learn from users who showed inappropriate language and online behavior.

The undesirable societal consequences of machine thinking and acting should be controlled, and scholars are debating ways of embedding morals into machines in an effort to teach them how to make the right decisions (Noothigattu *et al*., 2017).

Designers working on these systems can contribute to the debate and to the design of such systems by analyzing human values with the help of experts in the social sciences, and by placing such values at the center of the design activity. This has the potential to help technologists shape more acceptable and less dangerous machines.

Design Ethics

The second level to consider in analyzing the possible impacts of physical-digital ecosystems on humans is ethics. This level does not concern evident and direct consequences of digital systems or machines on users. Rather, it refers to more hidden, often unintended and unforeseen effects. This includes how these systems impact an individual's identity, cognitive processes, relationships and values in an indirect manner, as well as how they influence social development, growth and evolution.

Every time a new technology application emerges and spreads to a degree that affects social behaviors, debates arise about its potentially harmful effects on society. These debates have become more and more intense with the emergence of a plethora of new technologies that have completely transformed the ways we interact with other humans. More and more people are concerned about the way digital technologies are impacting and undermining human nature:

> I'm not saying that many of these tools, apps, and other technologies are not hugely convenient. But in a sense, they run counter to who we are as human beings (Byrne, 2017).

Indeed, physical-digital systems like Uber for transport, Spotify for music listening and sharing, or Eatsa for eating[2] have decreased the time spent engaging in real-world social interactions and have profoundly affected their quality.

Scholars have been investigating the effects of large-scale technological revolutions, such as those prompted by social media, since their advent. However, it is only recently that it has been possible to evaluate their real impact on people's happiness and satisfaction, and on their ability to collaborate with, understand, and accept others (Shakya and Chistakis, 2017a; Østergaard, 2017):

> For us as a society, less contact and interaction - real interaction - would seem to lead to less tolerance and understanding of difference, as well as more envy and antagonism […]. While these technologies claim to connect us, then, the surely unintended effect is that they also drive us apart and make us sad and envious (Shakya and Chistakis, 2017b).

Moreover, the impact of these new technologies is not only on human relationships, but also (and to an even greater extent) on social institutions and infrastructures. Work automation has been at the heart of political debate ever since governments started to realize that millions of people risked losing their jobs and being replaced by robots or intelligent systems[3]. Amazon Go, the AI-equipped Amazon store with no checkout that opened in January 2018 in Seattle, is emblematic of this. People can just walk in, pick up products and walk out again. Within a few years, this could eliminate cashiers, baggers and stock clerks from all supermarkets. We are called to reflect on what the widespread use of such systems will mean to our society.

Of course, there is no simple answer to the question of whether these systems are more beneficial than harmful to users. However, a critical approach should guide the design and development of such systems and services, if we want to limit the unwanted effects of new digital systems.

The Designer's Role

Designers are not expected to influence the development of new technologies. Nevertheless, by operating in the space between social and tech-

[2] Etsa is a healthy, customized fast-food service "engineered to get you in and out fast", thanks to online ordering and food pickup in personalized cubbies, with no human interaction. https://www.eatsa.com

[3] The White House released a report on Artificial Intelligence, Automation, and the Economy in 2016:
https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF.

nological disciplines, they can contribute to a more human-centered technological development on three levels.

The first level consists in performing a preliminary *critical assessment* of new technological solutions in order to anticipate their potential indirect effects. This step requires forecasting the impact of new systems on people's everyday lives, relationships and value systems. Working with scenario generation (Dorrestijn *et al*., 2014) and collaborating with other disciplines like the social sciences might be helpful at this stage.

The second level requires working together with technology experts on the actual development and *implementation* of new systems and applications. Indeed, technology in itself is neither inherently good nor bad. Most of its effects lie in the way it is embedded into real-world applications and in the details that makes it usable by people. Designers should keep this in mind and try to limit the possible negative effects of new digital-physical systems at different scales of society (individual, relational, infrastructural). Reflecting on such consequences while designing would expand the nature and number of aspects that designers need to consider when developing digital systems.

The third level consists in *communicating* the potential negative effects, or risks, of digital technology applications to users. Indeed, users should not be passive consumers of solutions, rather they should take an active role in their relationship with technologies, through conscious decisions. Achieving this goal requires raising awareness and making people more conscious of the possible impacts of new digital solutions on their lives in both the short and long term, ultimately making them more knowledgeable and responsible in their choices.

A simple example of increasing people's awareness could be adding a timer to social media interfaces, to show the time we spend on these platforms. This would make users more conscious of their behavior while using these apps and it would encourage them to think about the actual benefits of such habits. Of course, such an approach would likely run contrary to companies' interest in keeping people on their platforms as long as possible. But increasing society awareness might call for new regulations or guidelines and 'socially sensitive' tech companies might start to emerge. Overall, this could lead to a positive change in people's and society's mindsets.

Seeking a Symbiosis Between Humans and Technology

In our envisioning of future societies and world states, we should strive for a balanced evolution of technology and humanity. Richard Yonk talks about co-evolution, which is the potential for humanity to grow together with computers so that both evolve in the most positive manner, to mutual benefit (Yonck, 2017).

Following this idea, designers should imagine, pursue and encourage the creation of hybrid digital-physical ecosystems that embrace the idea of *symbiosis*. Digital symbiosis would allow technologies and humans to co-habit and mutually reinforce and enhance each other. This mutual dependence would be neither necessary nor imposed. The two should ideally be able to live independently, but their increasingly inevitable interconnections and fusion should be guided by attempts to create a balanced, synergetic hybrid society.

The Risk of Digital Dystopias

The initial phases in this co-evolution have already exposed some of the risks connected to it. The indirect, negative consequences of digital technologies on humans have been underlined by scholars and technologists, who define them *digital dystopias* (Pillan, Varisco, and Bertolo, 2017).

Some of these digital dystopias concern the ways digital systems and data transform our identities (Pillan, Varisco, and Bertolo, 2017) or lead to social exclusion (O'Neil, 2016), privacy issues, and the misuse of user data (Isaak and Hanna, 2018), as well as how they can negatively affect people's actions and relationships.

Some of these dystopias, such as social exclusion, are connected to the spread of AI applications and biased algorithms. Algorithmic bias occurs when:

> The outputs of an algorithm benefit of disadvantage certain individuals or groups more than others without a justified reason for such unequal impacts (Kordzadeh and Ghasemaghaei, 2022).

Although intrinsically connected to technical aspects of AI datasets and algorithms, algorithmic bias was soon recognized as a major societal issue in AI development, one that would have serious negative consequences for marginalized and poorer communities. (Knight, 2017)

In her renowned book 'Weapons of Math Destruction' O'Neil (2016) highlights the way AI algorithms can lead to social exclusion. An example is a facial recognition system trained on biased datasets that was unable to recognize some Asian or African facial features, therefore preventing entire groups of people from using the service.

Blodgett and O'Connor (2017) point out that natural language processing (NLP) algorithms are incapable of interpreting certain dialects or slang. The authors claim that this limitation may prevent the opinions of certain groups of people from emerging, for instance when social media posts are analysed through NLP to detect what people think of e.g. climate change or American politics. This leads to results based on partial views, which in turn can affect the public opinion, as well as political decisions.

Another problem regards these systems' lack of empathy. What happens when a self-tracking device prompts a person suffering from eating disorders to consume more calories? Can a system that promotes physical activity transform a mild interest in body fitness into an obsession? According to a study on college students, Simpson and Mazzeo (2017) argue that, in some cases, such devices do more harm than good, especially in young populations.

Moreover, there is an increasing tendency to use big data collected by wearable devices to determine the average behavior of classes of people (e.g. average burned calories or sleep duration in people aged 25-30). Even though such data may provide valuable information to scientists, these systems often encourage users to compare – or even adapt, their own behavior to the one of their peers, even when such comparisons is not relevant (Figure 1). Attempts to standardize individual behaviors could lead to personal needs, features, and habits being disregarded. Moreover, averages do not necessarily represent healthy standards to aim to, as they may stem from a large number of unhealthy behaviors. Self-tracking systems providing peer comparison or recommendations based on ideal standards tend to see people as anonymous entities who should be encouraged to conform to a norm, rather then individuals who would benefit from customized, tailored, and context-aware suggestions.

Another example of the problems big data and algorithms can cause are DNA testing services, which provide users with a geographical map of their ancestors by calculating the percentage of users' genetic traits belonging to different areas of the world[4]. Many stories have surfaced of people who received unexpected results, which did not match with what they knew about their family history. People started to question their origins and their sense of belonging to the cultures they had grown up in, but which were not reflected in their DNA (Kolata, 2017; Brown, 2018). It was later discovered that this technology was not reliable yet, because companies' datasets missed data from certain populations, making it impossible to detect their genetic characteristics in users' DNA. Once again, this example shows how data, algorithms, and their biases and have the power to affect people's personal and cultural identities, if not transparently explained and communicated.

[4] Companies like by 23andMe (https://www.23andme.com) or Ancestry (https://www.ancestry.com) provide these services.

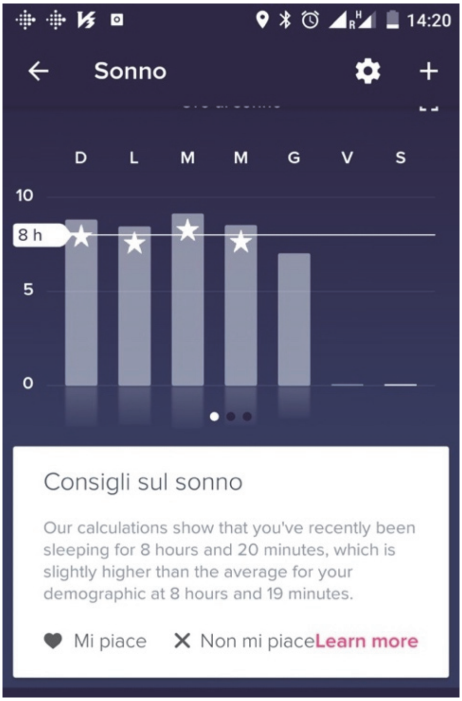


Figure 1: A screenshot from a self-tracker app that shows how the system encourages users to compare their sleeping patterns to their demographic, although they differ only by one minute. (Author's courtesy)

Critical Tools: Sharpening the Designer's Conscience

By anticipating the potential negative effects of new technologies, designers can attempt to limit their impact and increase users' awareness, thereby encouraging more responsible behaviors. But what can designers concretely do in their practice to limit the risk of digital dystopias? What kind of critical tools should they adopt when developing new digital-physical solutions?

Observing the negative consequences of emerging technologies on humans enables us to identify at least eight dimensions that designers should analyze when considering the ethical implications of their work. Such dimensions are described below, together with questions that designers should ask themselves during their design processes to anticipate and avoid the undesirable effects of their solutions. Whilst not complete, these eight levels give an idea of the new ethical mindset designers should adopt.

- **Body**: What effects does the designed technology have on users' bodies? How will it transform them, and with what foreseeable consequences? How is it dangerous or beneficial to users' health? What new meanings will be attached to the body, once it is augmented with this technology?
- **Mind**: How does the designed solution affect users' cognitive abilities? How does it enhance them? What abilities will people use less and what new abilities will they gain? What is the balance between potential cognitive empowerment and associated risks? How does it affect users' mental wellbeing?
- **Self-perception**: How does the designed solution change users' identities? How does the artefact affect users' self image? How does it affect users' perception of their social relationships, their tastes, and preferences?
- **Behavior**: How will the designed solution influence users' behavior? Are users given enough freedom to choose how to relate to the product/system, and if so, when and under what circumstances? Can the system create forms of addiction and/or obsession?
- **Relationships**: How does the product affect users' relationships with others (family members, friends, strangers)? How can users be made conscious of this influence? Can the system marginalize individuals? How can it be designed to limit negative effects on social interactions and improve the way users relate to others?
- **Values and Beliefs**: What meta-messages does the product convey? (E.g. a product that provides feedback on users' domestic energy consumption will likely convey the message that energy saving is important). Does the system filter or overexpose users to information in a subtle way, which may covertly influence users' values and opinions? Does it inadvertently reinforce stereotypes or biases?
- **Cultural and Social Identity**: How does the solution influence users' cultural and social identities? How will it impact users' perception of their own culture? Does it consider the features and needs of minorities? Does it encourage respect and cohesion among different cultures and social groups?
- **Societal Structures**: How can the spread of this solution impact societal structures at a higher level (e.g. the economic, labour, healthcare, and political systems)? What impact might it have on small and large communities? Can these consequences be harmful to society, and how can they be limited?

In addition to laying the ground for a deeper reflection on the ethical implications of digital solutions, these questions can lead to the creation of specific tools for each dimension. Such tools should be used by designers to improve their outcomes, enable discussions and critical reflections among different stakeholders involved the design process, and engage with other experts from the applied and human sciences.

From 'possible' to 'favourable' futures

In the transformation economy (Gardien *et al.*, 2014), people are increasingly concerned with social injustice, environmental sustainability and the idea that we should all contribute to build a fairer, more just and safer world. Designers need to consider these elements in developing digital artefacts and meet this increasing sensitivity toward a more sustainable global society.

However, this is not enough. Our landscape has undergone profound transformations over the years, and new technological revolutions promise to generate even more profound changes. New compelling challenges are coming to the fore, whose resolutions will determine whether human society will evolve positively or will struggle even more as a result of an uncontrolled proliferation of potentially harmful emerging technologies.

Designers need to move faster and redefine their tools, frameworks and skills in order to keep pace with these transformations. Doing so will enable them to interact properly with other disciplines in the development of innovative solutions that keep individuals, cultures, and society at the core of technological development. In brief, designers must adopt a new design conscience, one that shifts the focus from 'possible' to 'favourable' futures.

It is only thus that a hybrid society can be created in which technology and humanity will live symbiotically, each for the good of the other - a society in which technological development will be driven by human values and a critical, ethical approach will be central to the design of the next connected, augmented human and social environment.

References

Blodgett, S. L., O'Connor, B. (2017), "Racial Disparity in Natural Language Processing: A Case Study of Social Media African-American English". *arXiv preprint arXiv:1707.00061*.

Bonomi, F., Milito, R., Zhu, J., Addepalli, S. (2012, August), "Fog Computing and its Role in the Internet of Things". In *Proceedings of the first edition of the MCC workshop on Mobile Cloud Computing* (pp. 13-16). ACM.

Brown, K. (2018). "How DNA testing botched my family's heritage, and probably yours, too". *Gizmodo* (January). Retrieved January 30, 2018 from: https://gizmodo.com/how-dna-testing-botched-my-familys-heritage-and-probab-1820932637

Byrne, D. (2017). Eliminating the human. *MIT Technology Review*. Retrieved January 20, 2018 from: https://www.technologyreview.com/2017/08/15/149854/eliminating-the-human/

Carr, N. (2014), *The Glass Cage: How our Computers are Changing us*. WW Norton & Company.

Chen, Y.H., Krishna, T., Emer, J.S., Sze, V. (2017), "Eyeriss: An Energy-Efficient Reconfigurable Accelerator for Deep Convolutional Neural Networks". *IEEE Journal of Solid-State Circuits*, *52*(1), 127-138

Chen, Y., Lu, Y., Bulysheva, L., Kataev, M. Y. (2022), "Applications of blockchain in industry 4.0: A review". *Information Systems Frontiers*, 1-15.

Dertouzos, M.L., Narrated By-Hecht, P. (2001), *The Unfinished Revolution: Making Computers Human-Centric*. HarperCollins Publishers.

Dorrestijn, S., van der Voort, M., Verbeek, P.P. (2014), "Future User-Product Arrangements: Combining Product Impact and Scenarios in Design for Multi Age Success". *Technological Forecasting and Social Change*, *89*, 284-292.

Forlano, L. (2017), "Posthumanism and Design". *She Ji: The Journal of Design, Economics, and Innovation*, *3*(1), 16-29.

Gardien, P., Djajadiningrat, T., Hummels, C., Brombacher, A. (2014), "Changing your Hammer: The Implications of Paradigmatic Innovation for Design Practice". *International Journal of Design*, *8*(2).

Greengard, S. (2015). *The Internet of Things*. MIT Press.

Hashem, I.A.T., Yaqoob, I., Anuar, N.B., Mokhtar, S., Gani, A., Khan, S.U. (2015), "The Rise of "big data" on Cloud Computing: Review and Open Research Issues". *Information Systems*, *47*, 98-115.

Isaak, J., Hanna, M. J. (2018), "User data privacy: Facebook, Cambridge Analytica, and privacy protection". *Computer*, *51*(8), 56-59.

Jones, D., Snider, C., Nassehi, A., Yon, J., Hicks, B. (2020), "Characterising the Digital Twin: A systematic literature review". *CIRP Journal of Manufacturing Science and Technology*, *29*, 36-52.

Knight, W. (2017). Biased algorithms are everywhere, and no one seems to care. *MIT Technology Review*. Retrieved September 29, 2017 from: https://www.technologyreview.com/2017/07/12/150510/biased-algorithms-are-everywhere-and-no-one-seems-to-care/

Kolata, G. (2017). With a simple DNA test, family histories are rewritten. *The New York Times*. Retrieved February 14, 2018 from: https://www.nytimes.com/2017/08/28/science/dna-tests-ancestry.html

Kordzadeh, N., & Ghasemaghaei, M. (2022), “Algorithmic bias: review, synthesis, and future research directions”. *European Journal of Information Systems*, *31*(3), 388-409.
Lupton, D. (2016), *The quantified self*, John Wiley & Sons.
Metz, R. (2016). Why Microsoft Accidentally Unleashed a Neo-Nazi Sexbot. *MIT Technology Review.* Retrieved January 20, 2018 from: https://www.technologyreview.com/2016/03/24/161424/why-microsoft-accidentally-unleashed-a-neo-nazi-sexbot/
Noothigattu, R., Gaikwad, S.N.S., Awad, E., Dsouza, S., Rahwan, I., Ravikumar, P., Procaccia, A.D. (2017), “A Voting-Based System for Ethical Decision Making”. *arXiv preprint arXiv:1709.06692*.
O'Neil, C. (2016), *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*. Crown Books.
Østergaard, S.D. (2017), “Taking Facebook at Face Value: Why the Use of Social Media May Cause Mental Disorder”. *Acta Psychiatrica Scandinavica*, *136*(5), 439-440.
Pillan, M., Varisco, L., Bertolo, M. (2017), “Facing Digital Dystopias: A Discussion about Responsibility in the Design of Smart Products”. In *Proceedings of the Conference on Design and Semantics of Form and Movement-Sense and Sensitivity, DeSForM 2017*. InTech.
Raisamo, R., Rakkolainen, I., Majaranta, P., Salminen, K., Rantala, J., & Farooq, A. (2019), “Human augmentation: Past, present and future”. *International Journal of Human-Computer Studies*, *131*, 131-143.
Shakya, H.B., Christakis, N.A. (2017a), “Association of Facebook Use with Compromised Well-being: a Longitudinal Study”. *American Journal of Epidemiology*, *185*(3), 203-211.
Shakya, H.B., Christakis, N.A. (2017b), A New, More Rigorous Study Confirms: The More You Use Facebook, the Worse You Feel. *Harvard Business Review*. Retrieved September 24, 2017 from: https://hbr.org/2017/04/a-new-more-rigorous-study-confirms-the-more-you-use-facebook-the-worse-you-feel
Shanahan, M. (2015), *The Technological Singularity*. MIT Press
Simpson, C.C., Mazzeo, S.E. (2017), “Calorie Counting and Fitness Tracking Technology: Associations with Eating Disorder Symptomatology”. *Eating Behaviors*, *26*, 89-92.
Tapscott, D., Tapscott, A. (2016), *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*. Penguin.
Turkle, S. (2012), *Alone Together: Why we Expect More from Technology and Less from Each Other*. Basic books.
Verbeek, P.P. (2006), “Materializing Morality: Design Ethics and Technological Mediation”. *Science, Technology, & Human Values*, *31*(3), 361-380.
Yonck, R. (2017), *Heart of the Machine: Our Future in a World of Artificial Emotional Intelligence*. Skyhorse Publishing, Inc.

Authors

Lucia Rampino is a Ph.D. in Industrial Design and a Full Professor at the Design Department of Politecnico di Milano. Her core field of research is product design, with a focus on theories of design and the nature of design processes, in particular as they pertain to innovation. In recent years, her attention has focused on the impact of AI and digital technology on both the design process and the outcome. She has participated in various research projects and serves as a reviewer for Design Journals and Conferences. She is currently leading the Doctoral Programme in Design at Politecnico di Milano

Sara Colombo is an Assistant Professor at the Department of Industrial Design, Eindhoven University of Technology. Her research currently explores the role of design in envisioning and developing human-centered solutions enabled by AI, with a focus on their societal and ethical implications. Sara holds a Ph.D. in Design from Politecnico di Milano. She has previously worked at RISE (Sweden), Massachusetts Institute of Technology (USA), and Northeastern University (USA).

Riccardo Gatti is a product designer with expertise in 3D modeling. Since May 2005, he has been an Authorized Rhino Trainer. He lectures at several Milanese Design Schools (Politecnico di Milano, NABA, SPD, and IED) and offers 3D modeling professional training to large manufacturing companies and design practitioners. In the last few years, he concentrated on 3D printing technologies.

Francesca Mattioli, is a Ph.D. and a research fellow in the Department of Design at Politecnico di Milano. Her research aims to study design learning and teaching practices through collaborative projects in academic contexts characterised by cultural plurality. She is an adjunct professor in the Master of Science in Design & Engineering of Politecnico di Milano, a lecturer in the specialised Masters in Industrial Design Engineering and Innovation and Industrial Design for Architecture at POLI.design.

In a time when profound sociocultural and technological changes are affecting the design discipline, this book presents a number of consolidated and emerging issues in product design under four dominant perspectives: technical, human, digital and social. It might be said that these changes in perspective are mainly a matter of zooming out. Indeed, while the initial focus of the book is restricted to the product and its technical features, it soon becomes wider, also including users, then taking into account a complex system of interconnected stakeholders and digital products, and, finally, embracing society as a whole. Like all perspectives, each clarifies some aspects and stresses some features of the design discipline, at the same time making other features less relevant.

Specific perspectives typically emerge earlier in some parts of the world than in others, in some social classes than in others, in some industries than in others. Moreover, later perspectives build upon, rather than replace, earlier ones: many of an earlier perspective's tools and methods do not lose their value as the design discourse moves on to a new perspective. As a consequence, multifaceted perspectives on product design today coexist.

These different perspectives underlying modifications and adaptations of the design concept, together with the fixed elements that have characterized product design since its inception during the Industrial Revolution, are the subjects of analysis and discussion in the present book. In it, the author uses different disciplinary references, not just from design, but also from history, marketing, engineering and even law. The book results in a read useful to design students and practitioners, but also to other professionals interested in product design.

Lucia Rampino is a Ph.D. in Industrial Design and a Full Professor at the Design Department of Politecnico di Milano. Her core field of research is product design, with a focus on theories of design and the nature of design processes, in particular as they pertain to innovation. In recent years, her attention has focused on the impact of AI and digital technology on both the design process and the outcome. She has participated in various research projects and serves as a reviewer for Design Journals and Conferences. She is currently leading the Doctoral Programme in Design at Politecnico di Milano.

FrancoAngeli
La passione per le conoscenze