Chapter 2
The Third Industrial Revolution

Abstract The Third Industrial revolution is a growing phenomenon characterized by the diffusion of digital fabrication devices and the consequent democratization of production. An alternative open-source fabrication ecosystem is gradually developing and challenging the actual production logics and, as consequence, the social organization. The discipline of architecture is a protagonist of this revolution. The imminent diffusion of new productive systems, along with the development of advanced software, allow new possibilities to connect the domains of design and construction, and to realize components given a certain (algorithmic) description, and to synthetically describe the physical environment and its behaviours within the digital environment. The role of the designer in this phase is to extend the potential of the CAD/CAM procedures, and re-appropriate the control in the design-to-construction process to once again engage in the actual manufacturing of building construction and provide high performance, tailored architecture. The open network of digital production supports new design collaborations and manufacturing logics which are able to reconfigure the urban organization of the industrial system and the interaction with citizens, as in the experimental planning of Fab City Barcelona. The use of open-source software and hardware opens up new horizons for more transparent and collaborative development of interventions at different scales and throughout the various stages of the projects formation.

Keywords Digital fabrication · Fab city · Fab lab · Open-source architecture · Peer production · Third industrial revolution

2.1 Digital Fabrication in Architecture

Davis (1987) coined the term *mass customization* in the book "Future Perfect", which, for the first time, provided a conceptual framework for a then emergent process that six years later Joseph Pine would define as a combination of both craft and mass production elements (Pine 1992). The central theme of "Advanced

Customization in Architectural Design and Construction" is the radical aspect of customization, characterized by the use of advanced digitally controlled machinery. This process is contextualized within a revolutionary industrial shift driven by a novel approach in the production of architecture, in which design and construction are gradually bridging the gap.

Fundamental in this perspective is indeed the evolution of digital design and Computer Numerical Controlled (CNC) machines, as the first prototype was developed by MIT and introduced to the market in 1952. During the 1960s the technology entered the aircraft, shipbuilding and automotive industries. In the 1990s architects started using diffused computer-aided design (CAD) software as a representational tool to improve precision and expand the limits of their creations. It was only a decade later when designers and researchers started a profound study of the materialization of digital models into full-scale architecture and of the exploration of probing the ways in which CAD/CAM technologies could support the design process through digital fabrication.

The concept was firstly theorized by William Mitchell in 1977 when he stated that through

> interfacing production machinery with computer graphic systems a very sophisticated design/production facility can be developed (Mitchell 1977).

Later, in the context of the technological evolution during the 1990s, Bernd Streich at the Department of CAAD and Planning Methods at the University of Kaiserslautern published several works on computer-aided techniques for architectural models. In 1991, he introduced the use of stereolithography as a feasible method for digital fabrication. In 1996 Streich co-authored "Computer-Aided Architectural Model Building", the first complete book describing digital fabrication in the architectural design process (Streich and Weisgerber 1996).

Contemporary to the academic studies, but on a practical level, the first architectural office that experimented with a "paperless" process of construction fabrication was Gehry Partners, LLP in the late 1980s. The turning point was in 1992 with the large fish-shaped pavilion project, located at Barcelona's waterfront. The initial phase of the process involved the creation of a physical maquette from which a corresponding digital surface model was generated and then refined to perform structural analysis. The production and assemblage of the full-scale structural components were completely directed by the digital model (Fig. 2.1).

For building contractors, who were used to the production of orthogonal geometries, complex projects seemed unnecessarily difficult to build. Facing this problem, architects began to realize the need to dialogue directly with fabricators in order to see their experimental architecture materialized. Following the seminal example of Gehry, they understood that digital information could be utilized in the fabrication and construction processes to drive CNC machines, without producing drawings, which in turn would save time-consuming activities and reduce possible mistakes due to information transfer (Kolarevic 2003).
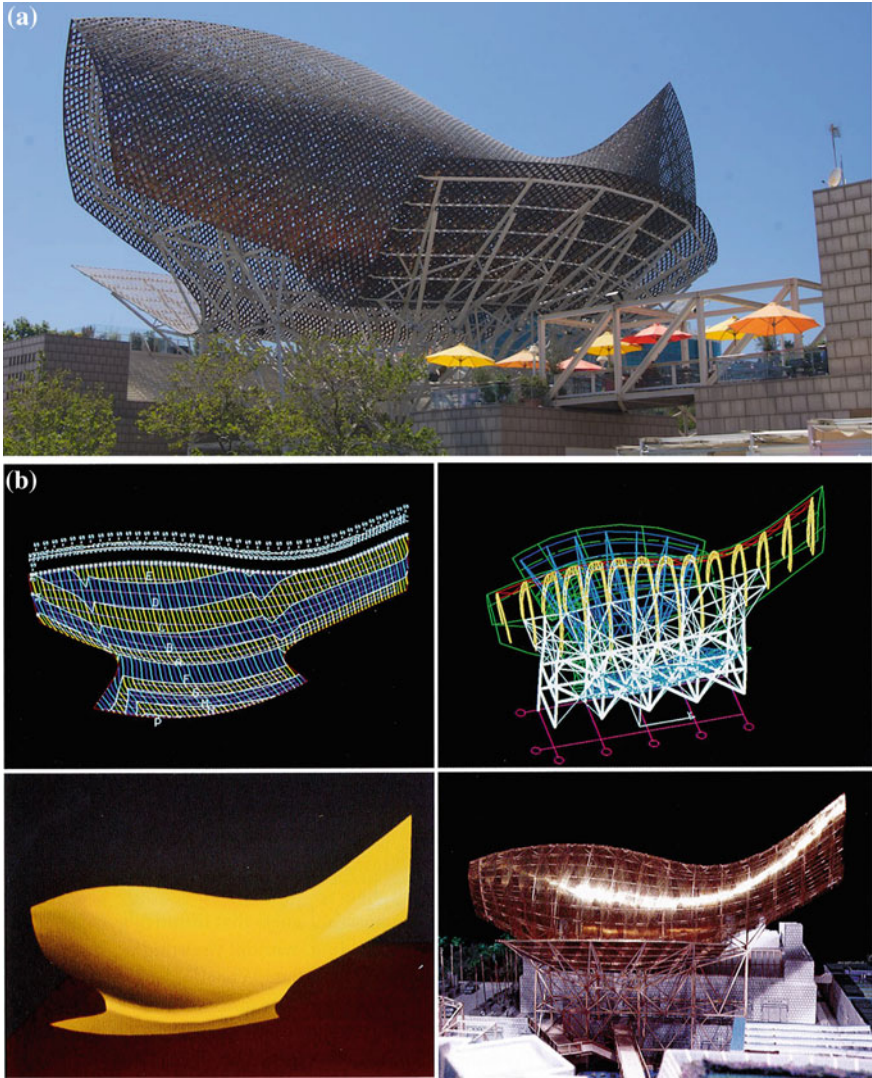
Fig. 2.1 a Fish-shaped pavilion developed by Gehry Associated, Barcelona 1992. **b** The pavilion was completely directed by digital models (Mohammed Afana)

2.2 From Numeric Control to Connecting Bits and Atoms

After about 70 years since the introduction of the first CNC tools, digital fabrication machines have evolved greatly through the years and, at the same time, have become more economically accessible as well. With the conjecture of the mass diffusion of this hardware, it is again at MIT that the history of digital fabrication

Fig. 2.2 Centre of Bits and Atoms, Massachusetts Institute of Technology (Spencer Lowell)

had an important advancement with the establishment of the Center for Bits and Atoms at the Media Lab, ran by Prof. Neil Gershenfeld (Fig. 2.2). This experimental laboratory was founded with the goal to explore the boundary between computer science and physical science which, inevitably, would be central in the case of digital design, in particular, studying how

> to turn data into things, and things into data (Gershenfeld 2012).

Since its creation in 2001, the Center for Bits and Atoms has had a programmatic interest in investigating a territory that is not typically explored due to the rigid classification that academia and industry has developed, separating hardware from software, and computer science from physical science. Gershenfeld realized that emergent opportunities and problems are grounded at the interface where information content meets its physical representation (Katz 2002). It is exactly this interface area that is crucial for the discipline of making architecture, which historically involves two fundamental steps—one of designing and one of fabricating. Nowadays, digital tools of design and fabrication allow us to imagine new ways to connect these two dimensions, defining how to realize elements given a certain (algorithmic) description, and how to synthetically describe the physical environment and behaviour using our computers, for example through advanced simulation tools. In brief, connecting atoms and bits (Fig. 2.3).
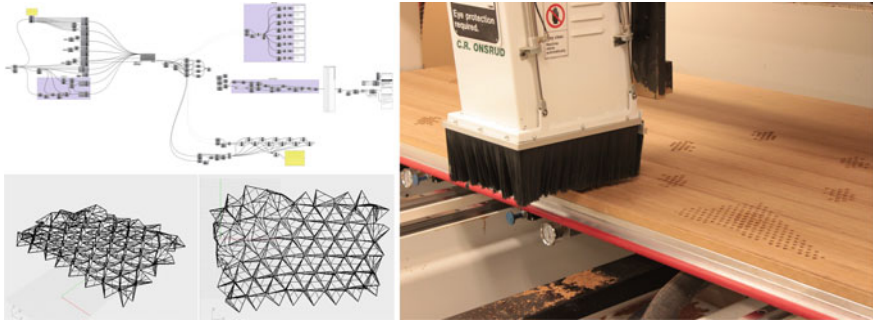
Fig. 2.3 Algorithmic definition and 3D modeling for fabrication (© RVTR)

2.3 How to Make (Almost) Anything in a Fab Lab

Gershenfeld started teaching his class at MIT—"How to Make (Almost) Anything"
—in 1998. The course was open to students from different disciplines: artists,
architects, designers and various science students, offering lectures on the use of
CNC machines employed in industrial production. Despite the lack of profound
technical background, the participants soon developed and materialized complete
functioning prototypes of various customized devices (Fig. 2.4). Observing this
phenomenon Gershenfeld questioned what would be the role of fabrication tools
outside the academic field and if they could make any changes when deployed in a
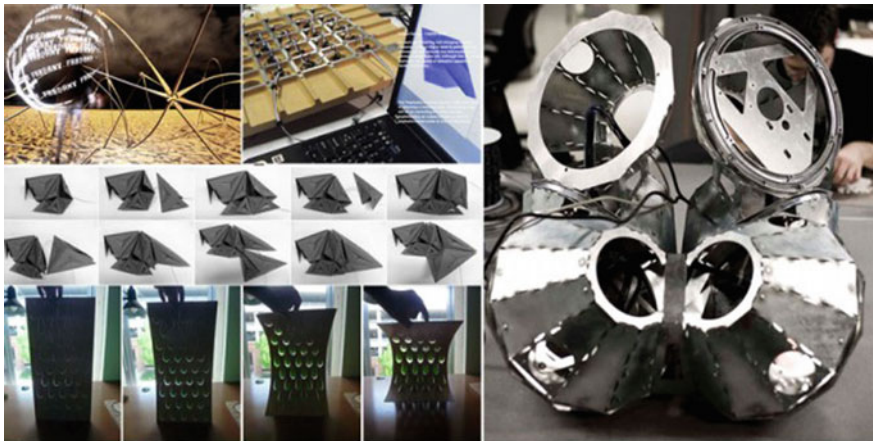different context (Gershenfeld 2005).

Fig. 2.4 The course "How to Make (Almost) Anything" offered the possibility to the students
from different disciplines to develop complete functioning prototypes of various customized
devices (ParaPractice)

Fig. 2.5 Fab Lab in Amsterdam. A Fab Lab is a sort of distributed laboratory for research and invention and usually forms a community of learners, educators, technologists, researchers, makers and innovators (Fab Lab Amsterdam)

This question inspired one of the most iconic projects of the Center for Bits and Atoms, the FabLab—an extension of the research into digital fabrication and computation. A Fab Lab is a prototyping platform which provides economical and accessible fabrication tools and processes for rapid prototyping of any object. The original concept was the development of a digital laboratory that would become a flexible model to be replicated in any part of the world, and that would be self-sufficient and available for the use of local communities. Fab Labs are globally conceived as nodes within a laterally distributed network around which a diversified social formation has emerged,

> a community of learners, educators, technologists, researchers, makers and innovators (FabFoundation 2014).

Within a common ground of tools and processes, the Fab Lab program is building a global network emerging in a sort of distributed laboratory for research and invention (Fig. 2.5).

The first Fab Lab digital workshop was set up in 2001 at the Massachusetts Institute of Technology (MIT). The phenomenon quickly spread from inner-city Boston, first to India and Norway, and in just a 10 year period formed a continuously expanding global network (Fig. 2.6). A typical Fab Lab is supplied with an array of flexible computer controlled tools that work with different lengths, scales and materials. The Fab Labs core shared capabilities include CNC laser cutting

Fig. 2.6 Map of the International Network of Fab Labs in 2014. The Fab Lab network is rapidly and constantly evolving (Fab Lab Japan)

machines for press-fit assembly of 3D structures from 2D components; a larger-scale milling machine for furniture and house-sized elements; a signcutter for printing masks, flexible circuits and antennas; a high precision (micron resolution) milling machine for three-dimensional molds and circuit boards; programming tools for low-cost high-speed embedded processors, and design, assembly and test stations. The range of products that might be fabricated varies from integrated circuit boards to complete customized buildings, from bioprinted cells and tissues to solar and wind powered turbines. The platform has set four fundamental qualities for labs willing to join the community: public access, a common shared set of tools and services, participation in the global Fab Lab network and support of the Fab Lab charter (Fig. 2.7).

Fab Labs are vastly adopted within the educational context. In the last few years many architecture schools have developed design/build programs with the objective of providing direct experience in producing architecture, not just in terms of design, but also in terms of gaining deep knowledge about the overall creative process including machines, materials and tools. The concept of Fab Lab as a global network plays a central role in this book: advanced manufacturing is indeed a multi-faceted phenomenon beyond the technical improvements which stimulates a shift in the industrial system, design collaboration, open access to production and social impact on a global level. The concept of an advanced and open productive eco-system of fabrication is not an utopian provocation but a necessity.
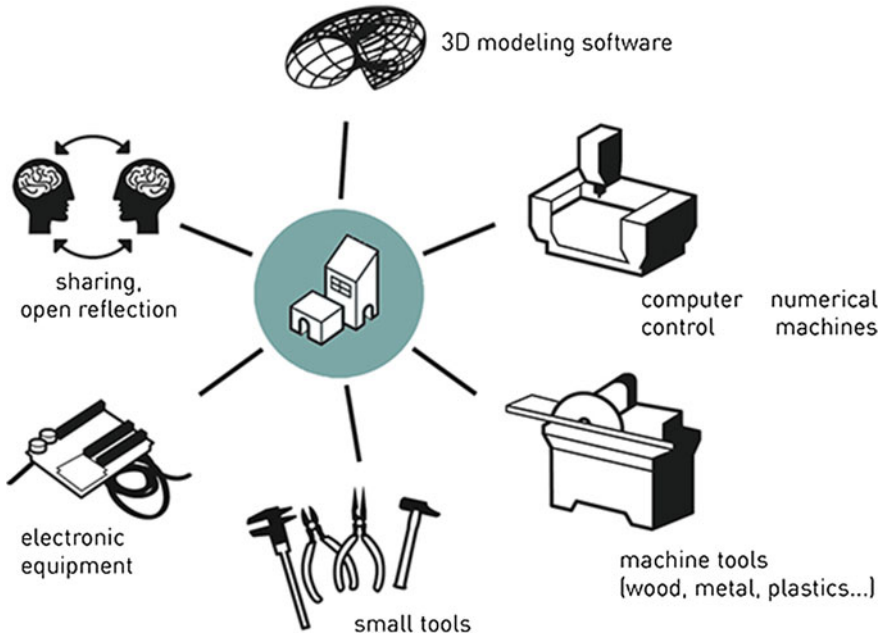
Fig. 2.7 A Fab Lab is both an open source workspace, offering specific machines and tools, and at the same time it is a cultural and social place where people can share ideas (Laboratorio di Progetto e Costruzione per l'Architettura, Faculty of Architecture and Society, Politecnico di Milano, Courtesy of the Students)

2.4 Peer Production and Fabrication Democracy

> We are moving to a future where the factory is everywhere and the design team is everyone (Parvin 2013).

Fab Labs are places of peer production that can potentially challenge the structure of society in the coming years. The sources of knowledge and information are no longer statically located in universities, companies and research centers but they constitute a fluid and adaptive network of servers linked to the Web and its capacity to spread information and innovation. An example of this are online organizations like Kickstarter, which in certain cases is more useful than governmental grants or private funding for the business development of new products. They give the opportunity to novice inventors and designers to use the power of crowd sourcing collaboration in order to support and fund their ideas (Diez 2012). The emergent global peer community requires a lateral, cooperative and decentralized approach, rather than the conventional top-down institutional systems. A common vision between society and institutions is needed in order to make the implementation of the ideas of the Makers' Movement possible on larger scale (Troxler 2013), and also beneficial for the AEC industry.

In spite of this vision, institutions are still playing important roles in providing support and specific competences in the network where individual connections are not yet efficient; with this support, within a decade Fab Labs have developed from isolated initiatives to a global network of labs that spans all the continents. The Fab Lab network is constantly expanding and currently contains about 330 facilities spread over 60 countries among all the continents, increasing accessibility to advanced tools with relatively low economic investments and the diffusing the idea of the "makers" community (a new cultural movement), which is able to cross any type of applied design discipline towards a sort of new "digital craftsmanship" (Anderson 2014).

Nowadays basic desktop 3D printers are accessible to non expert users with a cost of less than $1,000 whereas a couple of years ago they cost several hundred times more. Advanced hardware is getting more flexible, adaptable and customizable. With the advance of 3D modelling software designers have the opportunity to easily conceive or change, and improve the design of any product. Everything, from small everyday objects to building components, can be designed and manufactured, freeing the creative potential towards new forms and embedding new interactive behaviours, thanks to open-source electronic hardware like the pioneering Arduino platform (Fig. 2.8).

The benefits of the first and second industrial revolutions were lower prices and higher quality products, but the consequence was the application of standardization and homogeneity everywhere, which made the market dominated by mass production. Architecture, which is typically a prototypical activity where buildings are designed for a one-client-large market, has been considered in the same way—as a product. The industrial revolutions were indeed a democratization of *products,* while nowadays what is happening is rather the democratization of *production*.

For this reason few companies show interest to invest in rapid prototyping, compared to mass production. Most of the industry considers Fab Labs as toys, in some ways similar to the phenomenon of what has already happened in the transition from mainframes to Personal Computers (Anthes 2006). Conventional companies do not recognize the new means of production as a potential game

Fig. 2.8 Arduino is an open-source physical computing platform based on a simple microcontroller board and on a system of multimedia programming environment that allows to script and control software for the board. Arduino can be used to develop interactive objects, products and prototypes, since it is able to translate inputs from a variety of switches or sensors into a series of physical outputs controlling lights or motors

changer in the next economy of production. In the architecture field the role of the designer has great importance in this phase to directly control the design-to-construction process and engage again in the actual manufacturing of construction systems.

2.5 The Third Industrial Revolution

With the diffusion of Fab Labs and advanced fabrication machines outside the industrial context, several authors theorized the idea of a Third Industrial Revolution (among them Gershenfeld 2005; Anderson 2010; Rifkin 2011; Troxler 2013). The opportunity for a production shift is enabled by a common "computational control" in advanced manufacturing across different fields. Software in any production area, but especially in construction design and engineering, has been strongly developed. Operations that would be difficult to manage just a few years ago are now more and more accessible, reducing the time required to design, simulate, build and test complex manufactured products.

The first industrial revolution began in Britain in the late 18th century with the mechanisation of the textile industry. A single cotton mill could instantly replace hundreds of weaver cottages. In this way a new productive era began based on the concept of mechanization, centralized factories and industrial capitalists. The second industrial revolution occurred later, in the early 20th century. Henry Ford mastered the moving assembly line, opening up the age of mass production. Automation, scientific management and management consultants were introduced and the social effect was the division of society in white-collar and blue-collar workforces (Troxler 2013).

Today we are facing the third industrial revolution, characterized by affordable manufacturing tools connected to the internet. As Troxler notices, this implies two major changes:

> First, affordable tools do not require huge capital investments, they bridge the labour-capital-divide; the owner-maker is re-emerging. Second, digital tools connect designing and manufacturing, they bridge the white-collar-blue-collar-divide; the designer-producer is having a comeback (Troxler 2013).

As for the field of architecture and construction, this determines a new production context where design and construction can be rejoined into a continuous process as it used to be before the Renaissance, when the architect was the "masterbuilder". Nowadays architects can design a building, not only focusing on defining spatial and aesthetic characteristics (important aspects, but not exclusive), but also controlling the whole process "file-to-construction" and actively design building components, fabrication strategies and operative tools.

One of the main concerns and skepticisms is the concrete possibility to produce custom construction components without referring to specialized producers. Workers and owners are historically divided by the possession of the means of

industrial production (Gershenfeld 2005). Thanks to several technological advancements those means of production are becoming more and more accessible, in a "democratization of production" that is following what has already taken place in the software and the music industry:

> Music labels and software companies such as Microsoft or IBM were dominating the market. Now anybody can create music, anybody can create software. It is not one versus the others, but an ecology of market that did not exist. There are still labels, there are still mass market softwares, but the most interesting things happening in these sectors are in the intermediate market (Gershenfeld 2013).

In architecture a similar phenomenon is happening, even though dealing with construction requires a much more intensive material engagement than other industries. In this sense, it is improbable to imagine that advanced fabrication means could completely replace the company's means of production, but they are stimulating the concept of customization and have the potential to create a wide variety of new building components that, having the possibility to be uniquely produced, can achieve higher levels of performance and degrees of personalization, overcoming the stagnation of repetitive production in construction (Gramazio et al. 2014).

Finally, as Anderson stated,

> the Third Industrial Revolution is best seen as the combination of digital manufacturing and personal manufacturing (Anderson 2010),

which suggests a possible answer to doubts on the radical diffusion of customized products. With the propagation of digital tools and advanced means of fabrication, collaborations on design and production become easier, overcoming typical limitations such as distance and logistic concerns. Products and components can be tested in a desktop-scale, eventually in a collaborative manner, and can then be transferred to specialized manufacturing resources able to afford large-scale production.

One of the main questions is what can be the impact of such an industrial revolution upon the construction sector, which is typically more resilient to innovation. It is fundamental to highlight how the "digital revolution" has been led by architects in the 1990s, and just 20 years later the topic is becoming globally recognized as an emergent production shift. Nowadays the potential of advanced manufacturing is no longer a matter for a restricted group of interested actors but a priority for the development of a new industrial paradigm. Proof of this can be seen by the decision of the President of United States, Barack Obama, to invest about $2.9 billion for advanced manufacturing Research and Development, including $1 billion to launch a network of up to 15 innovative manufacturing institutes by 2015 (Sargent 2014).

In many design fields, particularly in architecture, drafting and rendering industries have emerged in generating construction documents and images quicker and quicker. Nowadays inventors are fascinated and interested in the availability of computer controlled machines, instead of large factories, and in open-source

software and CAD tools instead of sophisticated software and high-powered
computers. In the digital age, ideas are conceived as real products traded online
(Sass 2010).

When we contextualize this production shift to architecture, typical concerns
arise. The first one is from a technical perspective: can we realistically build
architecture with Fab Lab facilities? The second concern is in terms of industrial
systems: can the Fab Lab network (or others) develop extensively and support mid-
scale production in a sustainable way? The last one is related to the concept of
open-source: how can intellectual properties and manufacturing production in
constructions be managed? In the following paragraphs we attempt at suggesting
possible answers to these fundamental topics.

2.6 Building with Fab Lab

In order to prove the technical feasibility of the new industrialization model the
main reference is the "Fab Lab House" in Madrid, developed by the Institute for
Advanced Architecture of Catalonia (IAAC), the Center for Bit and Atoms of MIT,
and winning project of the Solar Decathlon Europe 2010. This prototypical house is
indeed conceived to be specifically produced with the use of the international
network of Fab Labs as a base of production, and can be produced with local
materials anywhere in the world.

The objective of the design team was to produce a solar house prototype that is
self-sufficiently generating energy, food and utensils and then to extend this idea
into a connected system of similar units. The prototype was produced using state-
of-the-art digital manufacturing tools, and constitutes an important demonstration of
the potential of the new industrial paradigm. Vicente Guallart, Director of the
IAAC, reflects on the implications of this project emphasizing the embedded idea of
intertwining medieval principles with modern design techniques. He states that
designer and builder should be the same person and that production should take
place again in the cities avoiding the high expenses for shipping materials and
prefab components (Gallanti 2011).

Technologies of personalized fabrication, together with the versatility of para-
metric design techniques, allowed the design team from 25 countries to explore the
vast possibilities of adaptation between the needs of the users and the answers
architecture is able to give (Fig. 2.9).

The dwelling itself represents a curved undulating form which incorporates
organic design and a flexible parametric structure responsive to climate changes and
adaptable to its surroundings, with an external skin characterized by an array of
efficient flexible solar panels. The built prototype consists of 26 cubic meters of
timber components digitally cut and assembled to achieve the complex shape, with
an elevated floor structure allowing for an open kitchen-garden area at the ground
level. The project is conceptually opposed to the typical "box and panel" structure
in favor of an innovative system of distributed intelligence: every component of the

Fig. 2.9 The Fab Lab House is entirely fabricated and assembled according to the philosophy of the Fab Lab (Courtesy of IAAC)

Fab Lab House has equal technological, structural and aesthetic value. The design of the cocoon incorporates a new enriched understanding of technological efficiency that is applied to every layer and system of the prototype, from the structure to the finishes.

The project attracted the interest of architects and producers and has been put up for sale with a starting price of €45,000 and initially developed for different configurations: Cottage (12 m^2), Shelter (24 m^2), Studio (36 m^2), House (60 + 60 m^2) and Villa (96 + 96 m^2).

This example proves that the entire design-to-construction philosophy of the Fab Lab is realistic, since a fully-customized residential unit is built in a collaborative and sustainable way. Moreover, it shows that through this production system we can not only replicate existing models of architecture, but literally reinvent new high performance concepts, in this case, of living. This is probably the major factor to impact on architecture: advanced customization let us design and build innovative concepts in a direct way, overcoming the typical resiliency of the overall sector towards innovation.

2.7 A Network of Production—Fab City Barcelona

The diffusion of Fab Labs is also a start towards a new industrial model, integrated within the urban fabric of the city as

> the tool is shaping the city, and vice versa (Diez 2012).

Providing citizens with a new set of advanced tools will definitely change and redefine cities. However, with this new model of production, the raw material supply logistic will need to be rethought, since, environmentally speaking, it is not sustainable for everything to be made by anyone using traditional material resources which are not available everywhere in the same measure. An important challenge will be, consequently, the development of new materials. The production network will share open source international procedures, and make use of local

available materials, creating an interesting and sustainable combination of global and local culture and artifacts.

Leading the development of the Fab Lab culture is the city of Barcelona, which already owns one of the most popular and successful manufacturing laboratories in Europe. It is settled in the IAAC—Institute for Advanced Architecture of Catalonia. Since the laboratory's foundation in 2008, its team has been exploring the possibility of a digital production ecosystem spread throughout the city. They called the challenge Barcelona 5.0—transforming the city into a factory of goods, knowledge, collaboration, exchange and invention. The project represents an innovative urban platform to be promoted and funded both by the public and the private sectors.

The general plan is based on an interconnected community of neighborhood Fab Labs, able to produce devices and facilities for the local community and even infrastructures for the future development of other hubs (Fig. 2.10). The project fosters the revival of fundamental principles of architecture and urban planning, a recurrent concept advocated by "Fab-Labbers" around the world, like bringing fabrication back to the cities, back to the hands of the citizens. These cases, supported by both software and hardware platforms and therefore networked with peers with common interests and goals, will change their status of city-users or consumers to become *prosumers* of it, becoming active and conscious agents in the city production (Diez 2012). This social metamorphosis is a shift towards a new industrial era of open-source design and production, a revolution of strong bonds between producers and customers. Cities, led by institutions and governments, should provide commodities and means for people to find solutions to their own needs (Alvarellos 2012).

Tomás Diez, the project manager of the Digital Fabrication Laboratory—Fab Lab Barcelona explains:

> Services are associated with the consumption model, which has the service provider in one side and the consumer in the other, in the new scenarios these both ends are merged, and we need spaces and platforms for this to happen at different levels, from the neighborhood exchange, as happened in the past, to the high tech centers to bring digital fabrication to common people, as happened with web publishing, photography or video making. In the

Fig. 2.10 Fab Lab BCN. Citizens, supported by Fab Labs network with peers with common interests and goals, become active and conscious agents in the city production (Fab Lab Barcelona)
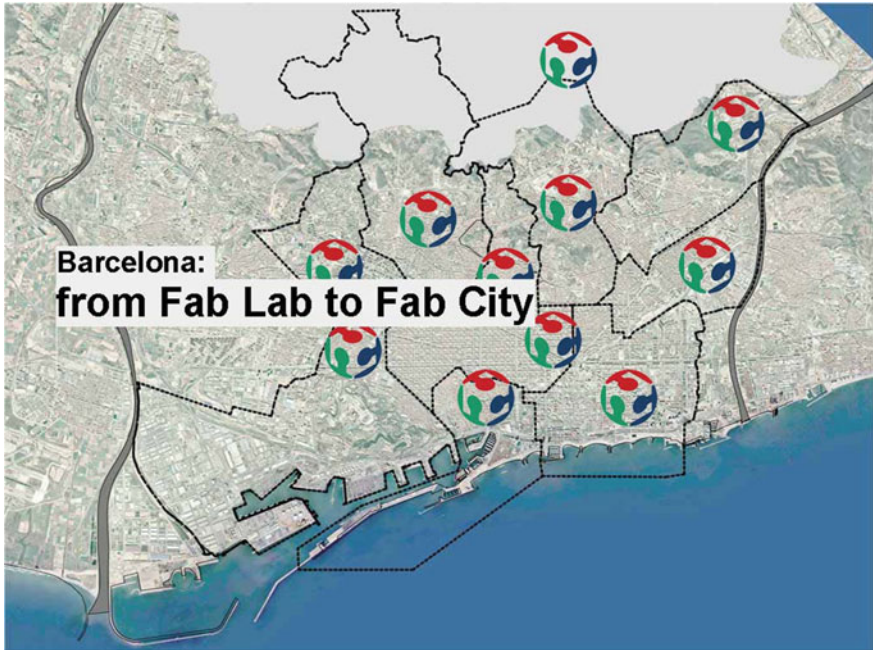
Fig. 2.11 Barcelona 5.0 is based on an interconnected community of neighborhood Fab Labs (Fab Lab Barcelona)

recent past we became publishers, editors and even journalists, now is the time of the makers (Díez and Guallart 2011).

Fab City is a new model which attempts to give back to the cities the ability to produce through micro factories inserted in the urban fabric and connected to the citizens. The project relies on setting bottom-up processes to engage not only professionals but mostly the citizens. Institutions, companies and individuals are also encouraged to participate and to contribute to the project development and expansion, which offers a realistic perspective of an alternative network of production and construction (Fig. 2.11).

2.8   Open-Source Architecture

The topic of open-source architecture is a powerful emerging paradigm unveiling innovative ways for the formation of both virtual and material designs within a common framework. It represents a platform transforming architecture from a top-down irreversible production chain into a democratic, flexible and bottom-up ecosystem. For the first time, architects have the opportunity to incorporate these two seemingly distinct worlds in order to create an emerging reality, synthesis of

data, material, programming, computation and fabrication. Through the implementation of tools and methods for digital fabrication, architects can easily control the data flow and the interaction between hardware and software. Design ideas and concepts permeate the fabrication process in its entirety. This new approach, bridging the gap between digital and material processes, is

> characterized by an unusually large number of precisely arranged elements, a sophisticated level of detail, and the simultaneous presence of different scales of formation (Gramazio and Kohler 2008).

In this transitional era towards open-source hardware and software platforms, personal and mass customization of design and production are blurring the limits between bits and atoms, between designers, producers and the final consumers. The professional scopes of the architect change as well. The collaborative use of open-source software and hardware opens up new horizons for more transparent and liberal development of interventions at different scales and throughout the various stages of the projects realization. The core idea of the open-source architecture is the recognition of the *genius of the mass* involving multiple figures—both amateurs and experienced professionals, clients and communities—working together towards the creation of a powerful networked system solving the issues of our time. This system provides all the actors involved with design tools and methods based on the established and validated principles of open access and collaboration.

Open-source architectural platforms rely widely on digital commons and shared spaces on the internet. The traditional tools, like 2D drawings and sketches, are enriched and sometimes even replaced by the infiltration of interactive 3D software and plugins using relational data and parametric subordination. A fundamental characteristic of the system is the so called *feedback loop* that is established on the basis of the constant interaction between the actors. This approach allows for dynamic and collaborative networking processes that bring design beyond the limits of static geometry. It is described as a complex ecosystem

> distinguished by code over mass, relationships over compositions, networks over structures, adaptation over stasis, life over plans (Bly et al. 2011).

In architecture, interactive sharing tools are still limited within the boundary of a single project, while a more general knowledge diffusion still happens in the classic form of non-interactive media, like printed publications or online documents and forums. A few exceptions, like the Open Architecture Network, aim at collecting and diffusing design knowledge on digital platforms, but without making use of the potential enabled by advanced tools and the predicted next industrial revolution (Stoutjesdijk 2013).

2.9   WikiHouse Project

An experimental implementation of the open-source philosophy in architecture is WikiHouse—an innovative platform that explores the need for democratization of the discipline. It is a nonprofit oriented project lead by Alastair Parvin for the development of an open-source downloadable construction set. The main idea promoted is that everybody might be involved in the design, fabrication and construction of customized houses.

WikiHouse implements a design that is conscious about the needs and the personal preferences of the users, a concept that is in opposition to the construction of whole neighbourhoods of mass-produced units from the type of "one-size-fits-all". This is an important step to promote customized and sustainable design that incorporates the personal values and the identity of the client (Fig. 2.12). Ideally, open-source architecture would give the opportunity to the citizens to participate in planning their cities and building their houses, as well as deciding on the development of their public areas and facilities.

Today we are entering in the Era of the Third Industrial Revolution and a whole new international community of inventors, novice designers and do-it-yourself builders is growing immensely. Using the advantages of open-source software and hardware, this community is ready to plan, materialize and experiment on innovative building design and construction techniques (Parvin 2013).

Fig. 2.12   WikiHouse plywood skeleton (© WikiHouse)

The WikiHouse open-source construction platform is one of the harbingers of this new phase in architecture and construction. It gives architects the opportunity to access an online-shared library and to download 3D models of houses for free. This model can be adapted in a free and easy way to work with 3D software, generating all the files ready to be cut by a CNC machine out of a standard material like plywood sheets. The final result is a fully equipped building kit including all the necessary components for assembling the structure of a house. No additional bolts are needed since it is using a wedge and peg joint typology, and even the mallets might be cut out of the sheets. The construction itself does not require any specific building skills or expertise nor a wide set of building tools. The structure might be erected by a small team of two or three people in just 1 day (Fig. 2.13).

For now, the WikiHouse platform is providing just the main skeleton of the building. Later on, different types of cladding and insulation systems might be incorporated together with the windows, finishings, installations and furnishings. The project introduces a new type of open-house model that could be constantly improved, adapted or extended depending on the needs of the owner. It might be turned into a Fab Lab for the fabrication of other open houses, building up entirely new neighbourhoods of affordable customized housing (Fig. 2.14). This project marks a shift towards non-invasive small scale architecture designed by non-professionals that is

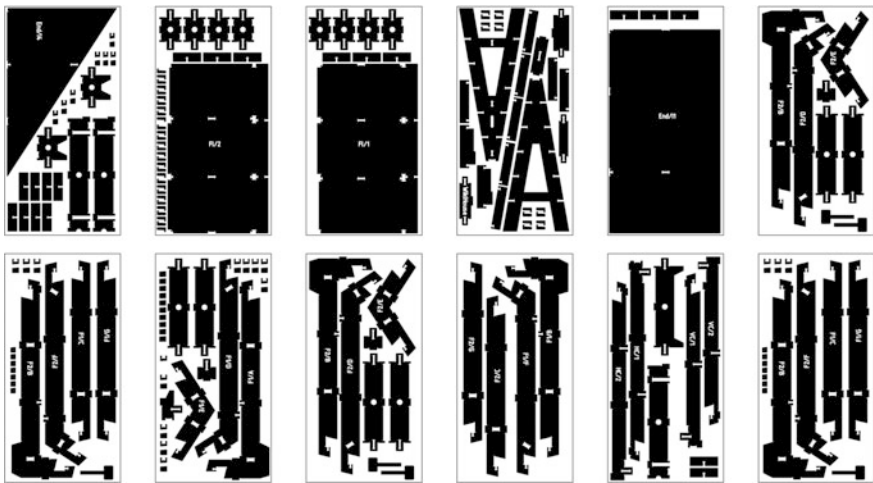radically lowering the thresholds of time and cost and skill (Parvin 2013).

Fig. 2.13 Files ready to be cut by a CNC machine out of standard material like plywood sheets (© WikiHouse)
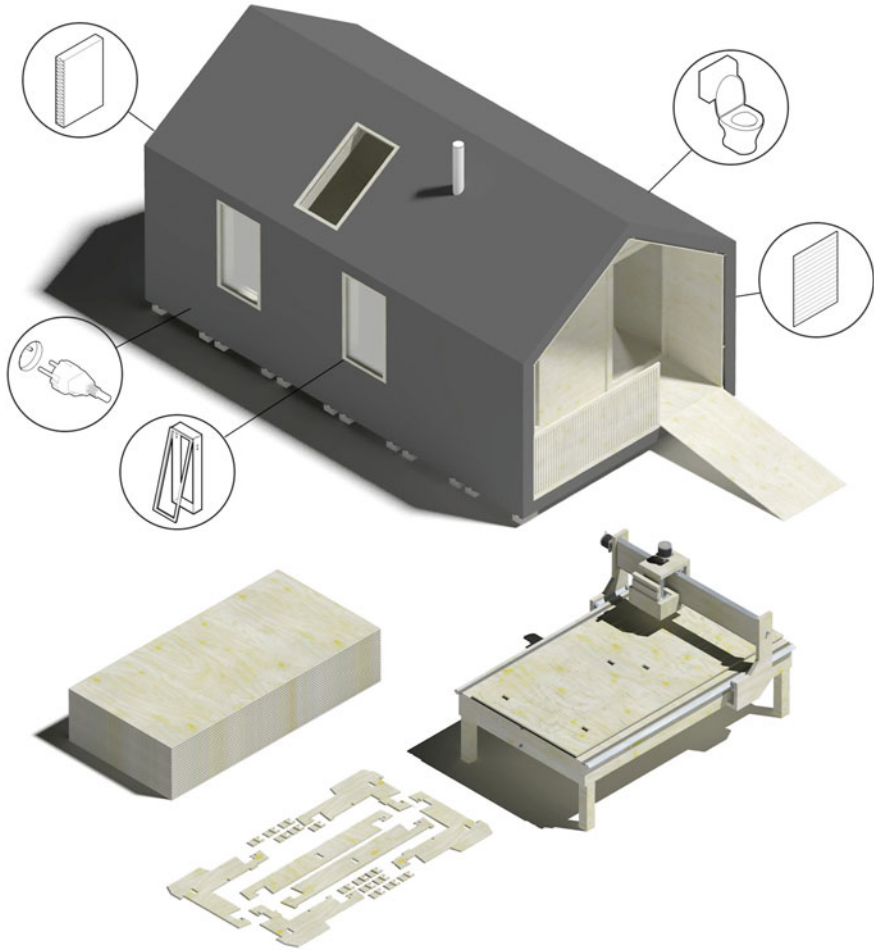
Fig. 2.14 All the components can be quickly digitally designed and produced by a CNC machine (© WikiHouse)

These social and technological advancements are harshly challenging some of the mainstreams of our contemporaneity forerunning a future where open-source factories are everywhere, supporting participative design and construction.

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