Universities, Enterprises and Maker Communities in Open Design & Manufacturing across Europe: An exploratory study

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The present Report contains the results of an action-research developed in the context of the OD&M Project (A Knowledge Alliance between Higher Education Institutions, Makers and Manufacturers to boost Open Design & Manufacturing in Europe), funded by the European Commission under the Erasmus+ Programme, Knowledge Alliances strand. The main objective of the research was to analyse how and to what extent the emerging open design and manufacturing paradigm (OD&M) is currently becoming the ground of progressive convergence and synergy between Universities, enterprises and maker communities, and how this ‘knowledge triangle’ is collaborating towards the creation of effective and meaningful value chains of innovation.

The research started by investigating the key competences and skills that presently characterise the ‘maker profile’, in order to draw a general picture of how these are developed, in which contexts, and through which particular teaching and learning processes. Further, the research explored existing experiences of making-related initiatives promoted or partnered by Universities, and discussed with Higher Education’s representatives the drivers, barriers and possible scenarios stemming from the introduction of making education within formal learning. Then, the research involved professional makers and OD&M enterprises (i.e. enterprises that show strong and direct connections with the open design and manufacturing paradigm) in order to get an in depth understanding of how making-related values, skills and competences are contributing to shape and inform their businesses. Lastly, the research explored the perceptions and opinions of ‘traditional’ companies regarding these topics, and discussed with them the potential risks and benefits that may emerge for them from the OD&M paradigm.

Indeed, the different levels of maturity of the maker movement – and, more generally, of the open design and manufacturing paradigm – in the different countries, poses clear challenges in the implementation of this type of research; on the other hand, it reflects the reality of an emerging phenomenon and points to both the challenges of a common path, and the opportunities of building common experimentations at European level.
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Often, new professions and jobs emerge from transformations in the market. They tend to remain in a grey zone where they mostly take shape through progressive adaptation and training on-the-job, until institutional education and training systems are able to recognize, codify, embed and scale them up into coherent learning journeys and learning outcomes, understandable by the labour market and the wider society.

Manufacturing in Europe is going through a major, transformation. While it is suffering heavily from the effects of the global crisis and ongoing globalization, we are witnessing the emergence of a social technology-based movement, the Maker movement, spreading fast across the globe. Supported by ICT networks and by the establishment of physical spaces such as Fablabs, this movement is expanding its outreach across the globe, involving people with different backgrounds and mindsets that converge around common values such as ‘sharing’ and ‘openness’, generating a multi-faceted and complex knowledge.

The maker movement has opened the way for a new paradigm of production, called from time to time open manufacturing, p2p production, social manufacturing, maker manufacturing; although the plurality of definitions hints at the lack of maturity of the sector, its keywords - open hardware, open software, distributed networks, collaboration, transparency, among others - all point to the movement’s vocabulary and narrative.

These new forms of production are enabled by open source ICT and rooted in social innovation principles, they adopt open-ended business models and act at the level of ecosystem, they harness distributed networks and ubiquitous communities to unlock the inventive of peer to peer collaboration, and are able to imprint production processes, products and organizational forms with social purposes and outcomes. Considered in its potential to infuse production processes with social innovation principles and values, open manufacturing opens room to cultivate radical changes in the economy and society, able to preserve and grow the public good (Johar et al., 2015).

Open manufacturing has already reached a stage that offers the prospect of new jobs and businesses, but education and training systems across Europe are still stuck in the grey zone of unaware and fragmented intervention.

Within this framework, the OD&M project (A Knowledge Alliance between Higher Education Institutions, Makers and Manufacturers to boost Open Design & Manufacturing in Europe) works to create a trust-based and collaborative Alliance between Higher Education Institutions,
traditional manufacturers, and innovation communities of digital-savvy makers and open manufacturing businesses across Europe and beyond. The Alliance’s ultimate goal is to build a European enabling ecosystem that fully embeds the key approaches, values and principles underlying the open manufacturing paradigm, and turns them into drivers for a more competitive, sustainable and socially innovative manufacturing in Europe. Focussing on the co-creation of new teaching and learning processes, as well as on new methods of knowledge exchange and capacity-building between the nodes of the Alliance, OD&M works to unleash a new generation of highly skilled and entrepreneurship-oriented designers and manufacturers, able to boost open design and manufacturing towards meaningful impacts. The present report contains the results of an action-research carried out by OD&M between March and August 2017. The core objective of the research was to analyse how and to what extent the emerging open design and manufacturing paradigm is currently becoming the ground of progressive convergence and synergy between Universities, enterprises and maker communities, and how this ‘knowledge triangle’ is collaborating towards the creation of effective and meaningful value chains of innovation. The research started by investigating the key competences and skills that presently characterise the ‘maker profile’, in order to draw a general picture of how these are developed, in which contexts, and through which particular teaching and learning processes (formal, informal, non formal). Further, the research explored existing experiences of making-related initiatives promoted or partnered by Universities, and discussed with Higher Education’s representatives the drivers, barriers and possible scenarios connected to the introduction of making education within formal learning. Then, the research involved professional makers and OD&M enterprises in order to get an in depth understanding of how making-related values, skills and competences are contributing to shape and inform their businesses. Lastly, the research explored the perceptions and opinions of ‘traditional’ companies regarding these topics, and discussed with them the potential risks and benefits that may emerge for them from the OD&M paradigm as a whole.

1 The OD&M project is funded by the European Commission under the Erasmus+ Programme, Knowledge Alliances strand. The project started in 2017 and will run over three years. It actively involves the following organizations: University of Florence - DIDA, University of Dabrowa-Gornicza, University of the Arts London, University of Deusto - Faculty of Engineering, University of Tongji, Furniture and Furnishing Centre Tecnalia, Fablab Lodz, Fablab London, P2P Foundation, LAMA Agency. The project also involves a number of Universities, SMEs, Foundations, local innovation communities and networks across Europe as associate partners.
The overall goal of the action-research was ultimately to identify gaps and opportunities for strengthening connections and collaborations within the OD&M Knowledge Triangle, enabling in particular Higher Education Institutions with new capacities and assets to play a valuable role in this field.

The action-research has been coordinated by LAMA Agency and has actively involved teams of researchers from: University of Florence - DIDA (Italy), University of the Arts London (UK), University of Deusto - Faculty of Engineering (Spain), University of Dabrowa-Gornicza (Poland), University of Tongji (China), P2P Foundation (Netherlands), Furniture and Furnishing Centre (Italy). The other partners of the project (i.e. Fablab London, Fablab Lodz and Tecnalia) have contributed as key informants and hubs of connection with relevant stakeholders in the targeted countries.

As the report will highlight, the research confirmed that the maker movement is a complex phenomenon that is nurtured by a continuous serendipitous melting-pot among cultures, skills, knowledge, learning styles, languages and attitudes. If this richness represents a fertile ground for innovations across manufacturing sectors - and probably beyond them -, it also represents a challenge for the codes through which Higher Education Institutions embed new topics and shape new mindsets on the one hand, and through which companies demand and search for innovation-oriented skills on the other hand.

More research is needed to further encompass and systematize the wide geography of knowledge, competences and skills underlying the maker movement, as well as to better understand how and to what extent they can be encoded in a framework that is portable across life’s domains, and recognizable by different actors. However, the OD&M research represents an important step in this direction, providing insights and identifying a possible scenario of education, training and business innovation built upon an unedited Alliance between Higher Education, manufacturing businesses and maker communities, able to spur innovation – and, in particular, social innovation – across the whole open design and manufacturing value chain.
The action-research has been carried out between March and August 2017 in the four main partner countries of the OD&M project, i.e. Italy, Spain, United Kingdom and Poland. The main objective was to analyse how and to what extent Universities, maker communities and enterprises – the OD&M Knowledge Triangle – are currently engaging with the emerging open design and manufacturing paradigm (OD&M), and to shed light on the main drivers and barriers that enable or limit the creation of a true OD&M ecosystems involving all these actors in a solid and vibrant environment of collaboration.

The action-research was structured into the following main operational steps:

- First, we analysed the key competences and skills that presently characterise the ‘maker profile’, and investigated how these are developed, in which contexts (formal, non formal and informal) and through which particular teaching and learning processes;
- Secondly, we analysed a number of experiences of making-related initiatives promoted or partnered by Universities in the four pilot countries of the project, and discussed with Higher Education’s representatives the main drivers, barriers and possible scenarios connected to the introduction of making education within formal learning;
- Third, we explored how making-related values, skills and competences are contributing to shape and inform the approach to business shown by both professional makers and OD&M enterprises (i.e. companies that are integrating open source ICTs and openness-driven approaches within their own business models, production processes and/or products);
- Lastly, we investigated the perceptions and opinions of traditional companies (that are currently not involved in open design and manufacturing, and often are unaware of the existence of this movement and of the opportunities for innovation connected to it) regarding these topics, and discussed with them the potential risks and benefits that may emerge for them from the OD&M paradigm.
In order to investigate the above mentioned topics, the research employed a broad range of data collection and analysis tools, that we briefly summarise below:

- **Desk research**: used in particular to analyse the main features of the international maker movement, to characterise the key trends and distinctive features of the phenomenon in each country involved, to review the state of the art of the integration of making principles, approaches, and tools into the formal system of HEIs, and to identify the most relevant case studies and success stories of the application of open design and manufacturing principles into innovative businesses. Academic, grey literature, web sources and other materials were used to collect information on all the above mentioned topics.

- **Survey**: an online survey was distributed in each country by the respective partners; the survey targeted 50 makers in each country, to be found both in makerspaces and in other relevant environments. With a set of detailed questions, the survey aimed to investigate their key values and principles, their skills and competences, and the contexts and processes through which they acquire such competences, in what formal, non-formal, and informal educational settings.

- **Semi-structured interviews**: interviews were carried out with different stakeholders to collect additional information and perspectives on the maker movement and the maker’s profile. Interviews with coordinators of makerspaces were used to go more in depth into the values and principles of the maker movement, to get their specific opinions regarding the most important skills and competences associated with the ‘maker profile’, and to analyse the nature of learning processes within makerspaces. Interviews with representatives of innovative companies aimed to understand the reasons why they adopted an ‘open’ approach, and the key competences that, in their view, are needed by these types of businesses. Interviews with traditional companies were on the other hand carried out to gather their perspective of the issue. Lastly, interviews with academics were carried out to support the mapping and analysis of HEIs in relation to their present or potential incorporation of open design and manufacturing contents and approaches. For this latter target-group, we mainly involved academics from design, social sciences, engineering and economics disciplinary areas, selected also for their particular interest and engagement in social innovation and open innovation topics. In total, 25 interviews were carried out by the partners in each country.
• **Focus groups**: 3 focus groups were carried out in each country, involving groups of makers from different makerspaces, which represent different typologies of such spaces and communities (e.g., makerspaces that have a link with Universities, with companies, community-based makerspaces, etc).

• **Participant observation**: qualitative observation of processes and dynamics in the context of workshops, events and makers gatherings was also important to complement the views collected through the application of the other research methods.

It is important to notice that, when looking at the skills, competences and learning contexts of the makers, we used the concepts of formal, informal and non-formal learning, which helped us better understand in what specific contexts, when, in what ways, makers are presently developing the analysed skills and competences, and what they think is the most effective way to strengthen each aspect of their profile.

This action-research effort was globally aimed at getting an empirical state of the art picture of the existing synergies and potentials between the making culture and its movement, Universities and businesses, seen from the direct experience of makers but also from the perspectives of HEIs and companies that may look at them as valuable resources for innovation.

The main limitations of the methodology lay in the relatively limited number of people involved, and on the difficulty to apply perfectly shared and standard definitions in the different country contexts. Therefore, the analysis presented in this report cannot be considered as exhaustive, but rather as an attempt to draw a first picture about how the maker movement, and by extension open design and manufacturing, is actually pervading the Higher Education and business worlds.

The different levels of maturity of the maker movement and of the open design and manufacturing paradigm in general, which characterise the different countries, poses clear challenges in the implementation of this type of research; on the other hand, it reflects the reality of an emerging phenomenon and points to both the challenges of a common path, and to the opportunities of building common experimentations at European level.
CHAPTER 1

The Maker Movement: Values and Principles

By Vasilis Niaros, Alekos Pantazis, Christina Priavolou | P2P Foundation
Laura Martelloni | LAMA Agency
During the last two decades, the wide distribution of Information and Communication Technologies (ICT) and the growing accessibility of desktop manufacturing technologies have opened up new opportunities for experimentation and value creation through collaborative environments (Bauwens, 2005). Groups and individuals have been increasingly socializing, researching and co-creating, harnessing the potential created by new open technologies in the field of digital fabrication and craftsmanship.

The availability of open digital platforms and low cost tools such as 3D printers, computer numeric control (CNC) machines, CAD software and electronics allow individuals to produce objects quickly and cheaply. Web-based collaboration, open source design, internet distribution and the possibility to scale prototypes into market products have contributed to shape unedited profiles of maker manufacturers. In turn, thanks to the establishment of regular meet-ups, dedicated fairs and physical spaces for collaborative working and co-creation such as fablabs and hackerspaces, a true maker movement has progressively taken shape at global scale, involving people from all walks of life, as well as firms, educational institutions, foundations and policy-makers at different levels. Definitely, the maker movement is now global and built upon an open, peer to peer and collaborative model supported by and suitable to ICT networks.

Lacking unique and commonly agreed definitions, the term maker and its correlated concepts, such as hacker, tinkerer or crafter, can be observed from different points of view, each providing additional knowledge. For instance, the term hacker entails types, such as the white-hat (benevolent), the black-hat (malicious) or the grey-hat hacker (ambiguous), which hold different or even opposite connotations (Kostakis et al., 2015; Parker, 2005). Dating back to the 1950s, the hippie culture inspired the hacker movement that was progressively organized into community-run physical spaces in the mid-1990s, the so-called hackerspaces (Niaros et al., 2017).

Plurality concerning the identity of the maker exists internationally. According to Mark Hatch (2013), maker is anyone who develops and creates products, bringing positive changes to the society and obtaining an economic benefit from it. As Mauro Lombardi, Professor of Political Economy and Economics of Innovation at the University of Florence, explains, makers are the units - individual or collective - that have the know-how to realize the productive process of a good or service (OD&M, Italy Country Report). A more elaborated definition is given by Chris Anderson (2012), who defines a maker as anyone who uses a combination of digital tools and computers to develop projects and prototype them autonomously, sharing them online and cooperating with the community. The flexibility of the term has contributed to its rapid diffusion and popularity, but it has also led to endless discussions. However, Anderson highlights that, although anyone can be a maker, the digital and community dimensions are key points.
The physical spaces where makers meet and collaborate - the makerspaces - facilitate practices ranging from traditional manufacturing and fabrication, to digital manufacturing and production. They supply a variety of tools and equipments, including 3D printers, CNC machines, laser cutters, sewing machines, potter’s wheels, traditional hand tools and bench mounted equipment. Moreover, in addition to manual skills and handcraft, specific training is often offered within the spaces by coordinators and trained members, dealing with digital contents such as Arduino, Cura, AutoDesk Fusion 360, Raspberry Pi, among others.

In alignment with the commons movement (Bauwens et al., 2017), the equipment and products are cared for by the community and used in a shared way. Following David Bollier (2014), commons are defined as a shared resource which is co-governed or co-managed by a community of users, who follow specific rules and norms. Thus, a model of social construction has emerged in which people can feel engaged (Troxler, 2011). Communities are able to communicate, experiment and self-organize, democratizing the means of making (Kostakis et al., 2015).

A specific feature of the tools in makerspaces is their characterization as prosumer tools, meaning that they both consume and produce with self-fabrication capabilities. Moreover, digital fabrication technologies are usually supported by open-source software, which is a strong evidence of the ‘Do It Yourself’ and the hacking culture within the movement. The ability to hack or customize demonstrates sophisticated levels of competency and understanding of the tools. Analogies can be made to professional craftsmen who might traditionally make their own tools, demonstrating control over processes.

The maker movement is generating interest among industry, educators, funding bodies, third-sector agents, cultural institutions and government bodies, with a proliferation of support in terms of funding, strategic projects and research both nationally and internationally. Given that economic sustainability is a common challenge, the rules and thematic intention of makerspaces may vary. Likewise, makerspaces’ models may differ significantly, spanning from more business-oriented models often sustained or partnered by corporations and foundations, to public-sustained ones. An example of the private sector supporting maker initiatives is illustrated by the relationship of Fab Lab London with Barclays bank. The rationale for such an investment is that these spaces operate as incubators for early stage sole traders and start-ups, offering important benefits like shared spaces that can save traders’ costs in equipment, rent, insurance and storage, while supporting cross pollination of ideas and collaboration (Capdevila, 2015). Further, the global interest in funding grassroots communities becomes evident through financial support from local authorities, such as the municipality-supported MediaLab-Prado in Madrid (Niaros, 2016).
Although it has been noted that individuals feel more committed when they are engaged in local makerspaces (Moilanen, 2012), international networks of makerspaces have also been organized. A research project of MIT launched a global network of manufacturing laboratories in 2001 to explore the potential of grassroot communities to create things by means of digital technologies (Mikhak et al., 2002). The growth and communication among the laboratories are supported via forums or associations, such as the Fab Foundation. Thus, a global social movement of making and sharing is organized, connecting active individuals and spaces.

Nowadays, there are hundreds of hackerspaces and fablabs across the globe, as well as a much larger number of community labs and social innovation labs promoting peer-to-peer culture and open innovation. Doubtless, this vibrant movement reflects a new and increasingly shared desire for meaning that citizens manifest vis-à-vis pressing societal challenges, calling for an active role in shaping what is needed and meaningful to them, and reformulating the same concept of innovation around social and environmental instances.

Shifted to production, this vision builds on the maker movement to boost a radically new paradigm of production - the Open Design and Manufacturing paradigm -, capable of turning manufacturing into a participatory, collaborative and open process in which all agents share risks and benefits and, ultimately, increase the value of production (Johar et al., 2015).

Future scenarios are not clear, since neither the dynamics nor the impact of this emerging paradigm have been sufficiently investigated yet. However, open design and manufacturing has already reached a stage that offers the prospect of new jobs and businesses, with disruptive models, products, production processes and governance frameworks that attempt to be both sustainable and socially innovative. Spanning across open source, distributed networks, collaborative platforms and open innovation combined with big data, sensors, artificial intelligence, robotics and IoT, such models, products and processes demand a completely new generation of entrepreneurs, practitioners and professionals, positioning the ‘maker’ as the bedrock of new meaningful profiles within the ongoing fourth industrial revolution.
Due to its nature, the maker movement shares the basic values and principles of the open source movement. Although there is plurality among makers in terms of values, motivations and practices internationally, some of them are recurrent and imprint the maker movement with recognizable features, if not with an identity. Among these, intrinsic positive incentives, collaboration, sharing, openness and community resilience stand out.

First, the therapeutic effects of making seem to motivate individuals. Echoing Jarkko Moilanen (2012), people use makerspaces mainly for socializing and learning. Individuals with diverse backgrounds and skills come together, self-organize according to their needs and take decisions collectively on issues that appear throughout a project’s life. Through activities such as workshops, software and hardware development, prototyping of new products and processes or improvement of existing ones, the overall aim is to facilitate collective discovery and experimentation, enabling the community to participate actively by means of peer to peer learning and horizontal knowledge exchange (Smith et al., 2017).

Further, collaboration and sharing serve as the bedrock of makerspaces. The key feature of social interactions within these spaces is to maintain egalitarian relationships. The maker movement connects people interested in sharing designs and making products in collaboration with others. Anyone can access information and create products, replicate elements and develop prototypes via online manuals and digital desktop tools. Makers are united by a shared belief in the importance of prosumer tools, spaces and collaborative consumption of the equipment during the implementation of projects.

Openness and free distribution of designs, objects and of their instructions and modifications are fundamental. Makers are committed to the principles of commons-based peer production and shared ownership of the infrastructure, without being susceptible to the commercialized culture. Motivated by the power of collaboration and the struggle for social innovation and community development, they experiment, create and share their personal or community-based projects under commons-oriented licenses.

Achieving resilience at the level of the community is another crucial aspect of makerspaces (Kostakis et al., 2015). Many makers aim to tackle specific issues of their local community, such as addressing unemployment, developing urban food production, providing an alternative to school education or mitigating local complex challenges including overcrowded living.
The pluralistic profile of the makers include people from all walks of life and experiences who may use the space to orient or reorient their career, or to spend time in a collegial environment. According to a number of interviews with designers, academics and makers conducted in Italy in the framework of this research, three main maker profiles can be outlined: the designer, who makes its own projects without the brokerage of firms, but rather through its own brand and autonomous management of all processes; the digital hobbyist, who embraces sharing and collaboration mainly for experimentation and discovery purposes; and the Fablab manager, an expert maker who caters to the activity of all possible makers (OD&M, Italy Country Report). In the same vein, the research strand developed in the UK has attempted to personify the maker in light of the plurality that exists within the culture, identifying 14 profiles: the agonist, who looks for plurality in design/making education and actively pursues multi-disciplinarity and plurality of learning contexts; the autonomous student maker, who engages the makerspace culture to augment and complement university provision; the DIYer, who may refer to people from all walks of life and experience, and who typically has a strong passion in making and crafting; the educator, who is a skilled person in a range of making contexts, and shows commitment to train others; the entrepreneur, who is driven by industry trends to give life to sustainable making businesses; the extracurricular student maker, who work on collaborative projects initiated by the university but out of curricular activities; the inspired co-worker, who primarily uses the makerspace as a co-working space; the pro-maker, who owns high level making skills and actively embraces technologies to add scale and efficiency to production; the self-learner, who learns through principles of effectuation; the shift-surfer, who experiments and creates connections across different learning sites; the socialiser, who is motivated by strong social values; the strategist, who plays a key role in the development of the space; the student maker, who works on collaborative projects set by university courses within curricula; the thinkerer, who focuses on self-actualisation (OD&M, UK Country Report).

However, claims around the potentialities of makerspaces are still speculative and depend on how individuals associate themselves with such places. While makerspaces have been built in ethnically and geographically diverse environments, there is yet a lack of racial and gender diversity within many of them (Niaros, et al., 2017). Despite the ideal of openness in makerspaces, social inequalities that impede access and participation are often ignored, and privilege or domination over some groups of people are not acknowledged. For instance, in the UK the gender balance is 70-80% male and 18-30% female across the field (Kirk & Morgan-Hatch, 2015), while 77% of China’s makers are male (Saunders and Kingsley, 2016). Additionally, according to a study conducted by Make magazine and Intel (2012), 81% of U.S. makers are male with an average income of $106,000. These are indications that participation in the maker movement may be heavily dominated by affluent men.
It should be highlighted that people do not depend on their engagement with makerspaces for their livelihood (Dellot, 2015).

However, although the profit motive is not totally absent, it is often relegated to a peripheral concept. For instance, according to the survey directed to makers realized in the framework of the research, Spain seems to show a relatively weak focus on the business world; the core values are mostly related to collaboration, openness, accessibility and social impact, while the capacity of the movement to drive new business models is perceived as not particularly relevant (OD&M, Spain Country Report). Similarly, many interviews with makers realized in Italy have reported the presence of a sort of ambiguous relation between the maker movement and the business world, since the commitment to principles of democracy, accessibility and openness in making manufacturing often collides with the need of achieving sustainable and viable business models (OD&M Italy Country Report).

Nevertheless, bearing in mind the variability of makerspaces around the world, it is common to create projects with entrepreneurial intentions. Especially in the UK, and increasingly in Italy and Spain, many makerspaces focus on the incubation of start-up ideas, supporting members in developing innovative and disruptive entrepreneurial projects.

In some cases, makerspace members find employment as a direct result of the skills they gained on site. The values that makers bring to their work environments are linked to creativity, innovation, collaborative practices, critical thinking and specific technical knowledge in design and manufacturing.

According to Raffaella Fagnoni, Associate Professor of Industrial Design at Genoa University, five different relationship models between designer, maker and industry may be envisaged: the open model explores the open-source dimension of design in order to expand its boundaries and applications; the craft model places the maker at the service of craft manufacturing to create new synergies between innovation and tradition; in the distributed model, the maker is a key figure for industrial change and works in a frame of distributed and decentralized manufacturing, where the physical production process is segmented and distributed across territories; in the enterprise model, the general principles and methods of making are incorporated within traditional enterprises to create a new and alternative way of producing, inspired also by the principles of industry 4.0.; lastly, in the social model, makers use new technologies mainly for social purposes, developing new models and processes to tackle societal challenges such as urban degradation, unemployment and social exclusion of marginalized groups of people (OD&M, Italy Country Report).
To date, 2,186 makerspaces are listed in the hackerspaces.org wiki. Among them, 1,355 are marked as active, 351 as planned, while the rest appears to be inactive or closed (Hackerspaces.org, 2017). Although the majority of makerspaces is located in the North-Western world with a recent expansion to the East and South, the phenomenon has a global spread, as depicted in the figure below.

Due to the perpetual transformation of makerspaces and their diverse models, organizational and regulatory structures, it seems wise to approach them on a case-by-case basis. Specific characteristics exist in different countries as well as among makerspaces of a particular country. In the following section, an overview of makerspaces and making-related initiatives is provided with reference to the 4 main countries involved in the research, namely Spain, Italy, UK and Poland.
In Spain, makerspaces have mainly developed around the two most important cities of the country: Barcelona and Madrid. The growth of the network has been constant since the opening of the first Fablab in Barcelona approximately 10 years ago, which now aims at becoming a Fab City. The latter is a new urban model which allows cities to turn into locally productive and globally connected self-sufficient places, with citizens that are actively involved as co-creators of this innovative governance framework. To date, Barcelona and its metropolitan area host about 25% of fablabs, makerspaces and hackerspaces in the whole country.

With relation to the development of the maker movement in the country, three main stages can be outlined: during the first stage (2010-2011), spaces with a markedly institutional character were set up, mainly linked to private institutions or universities.

From 2011 to 2013, pushed by the increasing need of economic sustainability, makerspaces started to explore and take shape around membership-based models, with pioneering cases such as Makerspace Madrid and MADE BCN Makerspace. From 2013 onwards, makerspaces multiplied thanks to the direct support from regional initiatives and municipal institutions, as well as to the growing interest and investment from educational institutions and technology centers. Nowadays, makerspaces are more than 40 throughout Spain, and due to their infancy, most of them devote their time and effort to define and build sustainable models.

In terms of thematic connotation, makerspaces do not usually focus on specific topics, and seem to mostly involve entrepreneurs and professionals from different domains and sectors that want to innovate by giving life to new product lines or services.

According to the results of our survey, makers’ professional background goes from the educational field, to industrial sectors such as electronics, ICT and furniture.

Importantly, the making culture in Spain is contributing to create a new generation of self-employed entrepreneurs who design and produce from craftsmanship, but also from advanced technology. Furthermore, young people and citizens use makerspaces to co-create innovative cultures for local development, with an overall purpose of increased employability and social cohesion. On the other hand, projects developed in makerspaces may be linked to specific areas of specialization of schools and faculties, mainly related to engineering and technical education.
Makerspaces in Italy: a dynamic yet fragmented landscape

Compared to other European countries, Italy experienced a late rise of the maker movement, and the first makerspaces were launched relatively late. Nonetheless, starting from 2012, it has been growing rapidly and consistently: to date, Italian registered fablabs are 134, only surpassed by the United States and France².

According to a number of previous researches about the maker movement in the country³, and consistently with the results of the OD&M research, makerspaces have been crucial in boosting the creation of a true maker movement in Italy, and have heavily contributed to increase awareness and recognition of this phenomenon by stakeholders such as educational institutions, foundations and policy-makers.

In terms of professional profiles, the majority of Italian makerspaces seems to be characterized by a strong presence of designers, even if we can still find makers with technical and engineering backgrounds, as well as with social and economic ones. Makerspaces are widely perceived as valuable learning contexts mainly for the acquisition of technological skills and competences needed to master machines, equipments and programmes, but also as places for developing and sharing new cultures of collaboration and contamination among disciplinary and sectoral domains. Rapid prototyping is the most diffused activity, that occurs both as a professional service for external organizations and actors, and as an internal activity of discovery and experimentation among members; however, makerspaces that offer structured services of consultancy and research for businesses and other types of external actors seem to be few.

From the geographical point of view, makerspaces in Italy can be primarily found in the main urban areas of Milan, Turin, Rome, Naples and Florence, and are particularly concentrated in the Central-Northern regions, the latter characterized by the presence of plenty of small and medium sized companies that constitute the core of the ‘made in Italy’ system. Regions in the South, instead, see a lower presence of makerspaces, even if we can still find pioneering initiatives of making and open source education, as in the case of Città della Scienza in Naples (Naples Science City) and the Open Source School in Bari.

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² See: www.fablabs.io
Indeed, the maker movement in Italy has primarily affected the education and training system, with specific policy measures and investments from the national government that have been launched since 2014, mainly within the framework of the National Digital Agenda⁴. Through such measures, many schools have embarked in the creation of internal fablabs and makerspaces, with the overall aim of supporting alternative and complementary teaching and learning, especially in creative and scientific disciplines. Higher Education has been impacted as well, with new makerspaces created inside universities, in particular in technical ones. At the same time, the Higher Education offer has experienced a progressive transformation, introducing new courses related to digital and advanced manufacturing, especially within design, engineering and hard sciences degrees. However, this transformation may be interpreted in light of the recent Industry 4.0 Plan launched by the national government⁵, and of the new status of Competence Centres 4.0 acquired by several Italian universities. In fact, most of this new courses are conceived and positioned within a scenario of advanced manufacturing that needs highly specialized professionals.

When shifting to the maker movement and its relationship with established enterprises, our study identified two main types of synergies: on the one hand, there are enterprises founded by makers, who are therefore strongly informed by the key values and principles of the movement; on the other hand, we found enterprises that, although not founded or participated by makers, are fully aware of the phenomenon and activate structured collaborations with makerspaces and maker communities. These companies adopt the open approach in a number of different ways, primarily over production processes and products, and secondly over business models.

Importantly, the current debate on the maker movement in Italy strongly focuses on its potential contribution to a renewed innovation governance, able to reformulate the typical districts-based economic system of the country according to empowered distribution, decentralization and openness of manufacturing production brought about by the maker movement. Within this framework, the role of design - the leitmotif of the Italian excellence in manufacturing - would play a pivotal role, experiencing a new season of relaunch at the crossroads between digital technologies and craftsmanship.
In the UK, the maker movement is indeed well developed. To date, there are over 200 makerspaces across the country, with nearly every city having at least one makerspace. Such a significant spread has much to do with growing interest and support from industry, educators, investors, third-sector agents, cultural institutions and government bodies. Funding, projects and research implemented both at national and international levels are heavily contributing to the creation of a vibrant and active making environment in the country, that equally affects educational, social and business domains.

Although there is much plurality among makers in terms of values, motivations, competency levels and practices, community and communities of practice are key principles, and they surround the movement with a strong ethos of collaborative working, sharing and democracy. Co-working, time-banking and bartering are common, with time, resources and know-how often used as currency in exchange for access to makerspaces, use of existing facilities and services. Educational institutions of almost all ranks and degrees are increasingly exploring meaningful synergies with the making culture, often under a renewed political interest and investment in STEM education (Science, Technology, Engineering and Maths). Partnerships between schools/universities and makerspaces are common, and frequently used as levers to complement formal teaching and learning processes with more informal-situated ones, as well as with opportunities of career orientation. At the same time, makerspaces opened inside educational institutions are frequent.

On the business side, the movement appears to be healthy as well, exhibiting many cases of pioneering start-ups and companies that adopt disruptive business models, and the rise of incubators and accelerators dedicated to this world. Corporate Social Responsibility (CSR) budgets from large corporations also help sustain the development of the maker movement. An example of this virtuous relation is provided by Barclays Eagle Labs, whose aim is to help companies embrace emerging technologies that are considered critical for their success.
A key feature of the UK maker movement lies in its strong connection with social innovation. Makerspaces frequently operate as collective experimentation sites for socially-driven projects, particularly in domains such as urban regeneration, unemployment and social inclusion of marginalized groups. In this context, many incubators and co-working spaces work as platforms for social impact oriented making businesses, leveraging network-based strategies to develop structured connections among a plethora of actors and stakeholders.

The Central Research Laboratory, Maker Mile and Machines Room are - among many others - champion examples.

As for practices in the makerspaces, new thematic areas in design and making are more and more explored. This is specifically exemplified in green and bio design spaces, that are endowed with specialist equipment required for growing and designing in biological contexts. Green Lab is an example of makerspace specifically focused on food and urban agriculture, while Cambridge Biomakespace is an innovation space for biology and biological engineering. Finally, the maker network in the UK is connected internationally, both through bilateral projects and research and knowledge exchange consortia. Some recent examples include the UK-China bilateral residency exchange programme promoted by the British Council, and the Maker Library Network project, which connected designers and makers around the world to facilitate knowledge and skill exchange amongst professionals in this field.

See: http://creativeconomy.britishcouncil.org/projects/hello-shenzhen/

See: http://design.britishcouncil.org/projects/makerlibraries/
The maker movement in Poland seems to be at an initial stage of development, especially if considered in light of its contamination with both the educational system and the business world.

While official data show that there are about 50 registered makerspaces across the country, only half of them can be considered as fully active (Belica, 2017). During the last few years, the implementation of projects for the urban regeneration of post-industrial districts has favored the creation of makerspaces in the country. Nowadays, the most active makerspaces are located in industrial centers in Warsaw, the Upper Silesia agglomeration, the Tri-City (of Gdańsk, Gdynia and Sopot), Łódź, Kraków and Poznań.

The majority of makerspaces in Poland started their activities less than five years ago, and most of them operate as foundations, associations, cooperatives and student circles. While activities and services offered may differ across makerspaces, a common factor is related to the need of identifying sound and consistent business models, able to sustain them in the long term. According to our research, makerspaces in Poland provide three main types of activities, mainly related to: education, mostly focused on sharing technical and technological knowledge; innovation, focused on producing innovative prototypes of devices and products; culture, aimed at reconstructing and archiving digitally those specific techniques and knowledge of ‘traditional manufacturing’.

A guiding principle of makerspaces in Poland is ‘openness’. Many makerspaces aim at creating open environments able to foster collaboration among makers and allow them to initiate a project. ‘Openness’ is also linked with the characteristic feature of social interactions within makerspaces in the country, that is to maintain egalitarian relationships among members. This means that all members should have equal rights in terms of access to spaces, facilities and activities, regardless of any difference in the educational level, gender, age or professional background. Furthermore, representatives of several makerspaces in Poland strongly expressed their non-political nature and the lack of any relationship with broad ideologies.

Within the movement, originality and innovation that result from hard and persistent work are strongly valued, together with positive attitudes towards sharing and knowledge exchange among peers. Indeed, such values contribute to inform both a kind of language and narrative that challenge the creation of
meaningful synergies and collaboration with the business world. Of particular interest is also the fact that the involvement of Polish makerspaces in the global movement is relatively low, as they rarely have direct contacts with makers and makerspaces from abroad. In the majority of cases, activities are locally oriented and involve narrow groups of makers and organizations. At the same time, makers themselves are not usually aware of the global nature of the movement and of its socio-political goals.

Thus, it follows that a major challenge for a significant development of the maker movement in Poland is related to the achievement of greater integration with local communities on the one hand, and to increased connections and relations with the global movement on the other hand.

Despite the generally declared adherence to the value of openness, a person who wants to join the movement could be rejected or ignored by others. Moreover, makerspaces are often perceived as hermetic by traditional companies, preventing from building stable and valuable connections between the two worlds. On this ground, makerspaces across the country seem to manifest a shared need of developing more consistent and solid visions and positionings, in particular by upgrading the profile of makerspaces’ founders and coordinators with strategic skills and competences able to drive this transition. In this respect, the most active makerspaces in Poland such as Putlab in Poznan, Fablab Lodz and the Fablab at the Copernicus Science Centre are increasingly committed to the creation of a fertile ground for connection and collaboration among makers, academic figures, researchers and entrepreneurs, in particular through the organisation of events such as Hackathons and Makers’ Nights. Lastly, the creation of structured connections and collaborations with the wider global network of makerspaces emerge as a vital factor to sustain the movement in the country and increase its own identity and self-awareness, as well as its relevance vis-à-vis educational institutions, companies, funding bodies and public institutions.
CHAPTER 2

Makers: skills, competences and learning contexts

By Angela Lobascio | LAMA Agency

This chapter provides an overview of the key competences and skills that presently characterize the makers, linking them to the three main learning contexts - formal, non-formal and informal - recognized at European level.

The analysis is built on the results of the research conducted in the four pilot countries of the OD&M project (UK, Italy, Spain and Poland), which in turn was based on a combination between desk research, focus groups with makers, semi-structured interviews with academics and makerspaces’ coordinators, and an exploratory survey addressed to makers. In particular, in the survey makers were asked to express their opinion about skills and competences significant to them and relevant in a scenario of open design and manufacturing.
The exploratory survey was distributed to 200 makers in the four countries involved in the project. The overall objective of the survey was to investigate the main learning patterns of the makers, as well as the ways in which they gained relevant skills and competences vis-à-vis their professional careers and lives. In this context, it should be highlighted that the results of the analysis are based on individual perceptions of makers, and that the research sample includes both professional makers and ‘hobbyst makers’ with different educational levels; therefore, the perceptions on the relevance of different learning contexts in the acquisition of significant skills and competences should be interpreted in light of their previous educational paths and of how they relate themselves to the making activity.

The sample examined by the survey consists of a majority of men (approximately the ¾ of the total number of respondents), and ¼ of women. About half of them deal with making and open manufacturing as hobbies, while the other half do it as a profession.

Moreover, in terms of educational levels, the sample shows a prevalence of makers with an university degree level (45%), followed by secondary school level (33%) and postgraduate level (22%).

After having identified a starting set of skills and competences, mainly related to technical/technological and relational aspects, these have been further synthesized and simplified through exploratory interviews with makers, in order to select the most significant ones. In addition, technical and technological skills have been further detailed as it follows: IoT (e.g. proprietary RFID, NFC sensory, etc.), IoT OSH Open Source Hardware (e.g. Arduino, etc.), Digital Manufacturing (3D printer, laser cutters, CNC, etc.), 3D Computer Graphics and Design (CAD, CAM) with proprietary or open source software (Sketchup, Slic3r, Rhynoceros, etc.), digital modeling, crowdsourcing (co-design, crowdfunding, etc). As far as transversal skills are concerned, the survey also focused on problem solving skills, research skills, collaborative making skills, entrepreneurship, leadership, communication and networking skills.

The study focused on three learning contexts:

- **Formal learning**, which takes place through education at school, university and recognized educational institutions;
- **Non-formal learning**, which takes place through organized activities outside the formal education system, and which normally does not lead to any recognized qualification or degree;
- **Informal learning**, which mostly happens through everyday life activities, family, work and leisure time.
In general terms, the research has shown that most of the skills and competences that makers feel to possess have been developed within informal learning contexts. With relation to soft skills, leadership, entrepreneurship and problem solving are the ones that are mostly acquired unconsciously, therefore without following activities specifically devoted to their development.

Compared to the other two learning contexts, the role of formal education emerges in the case of research skills, and secondarily, for the acquisition of technical/technological skills and the ability to collaborate with others. The role of non-formal education appears to be more significant in the case of communication and networking skills, and in the acquisition of technical/technological skills.

<table>
<thead>
<tr>
<th>Ability/Competence</th>
<th>Learned through education at high-school/university</th>
<th>Learned through planned activities, such as training/courses in the makerspaces/other organization; in-company training</th>
<th>Learned from daily activities related to work, family or leisure</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical/technological skills (use of tools, machine, digital skills)</td>
<td>28,3</td>
<td>23,3</td>
<td>48,3</td>
<td>100,0</td>
</tr>
<tr>
<td>Problem solving</td>
<td>23,0</td>
<td>13,2</td>
<td>63,8</td>
<td>100,0</td>
</tr>
<tr>
<td>Research skills</td>
<td>43,6</td>
<td>12,8</td>
<td>43,6</td>
<td>100,0</td>
</tr>
<tr>
<td>Collaborative making skills</td>
<td>26,7</td>
<td>18,6</td>
<td>54,7</td>
<td>100,0</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>17,0</td>
<td>17,0</td>
<td>66,0</td>
<td>100,0</td>
</tr>
<tr>
<td>Leadership</td>
<td>14,9</td>
<td>18,7</td>
<td>66,4</td>
<td>100,0</td>
</tr>
<tr>
<td>Communication and networking</td>
<td>23,8</td>
<td>24,4</td>
<td>51,9</td>
<td>100,0</td>
</tr>
</tbody>
</table>

Chart 1 – Abilities and skills: comparison between the three learning contexts (percentages)

Source: own elaboration
In the survey, we have further detailed the section dedicated to the most common techniques and technologies in open design and manufacturing, asking makers whether they actually know, practice and in what context they have learned to use them. From the chart below, it emerges that digital manufacturing and 3D computer graphics (both through proprietary and open source software) are the most known and used among the techniques/technologies listed; moreover, the informal learning appears to be as the most relevant learning context also for these hard skills.

Importantly, data should be interpreted in light of the strong relevance of learning by doing and learning by making approaches that can be found across the movement, which often take place through offline and online communities of practice, as well as through discovery and experimentation of techniques, technologies and materials via collective and collaborative projects in the makerspaces.

<table>
<thead>
<tr>
<th>Tot</th>
<th>Learned through planned activities, such as training/courses in the makerspaces/other organization; in-company training</th>
<th>Learned from daily activities related to work, family or leisure</th>
<th>I don’t know/practice this</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOT (e.g. proprietary RFID, NFC sensory, etc.)</td>
<td>5,9</td>
<td>13,8</td>
<td>34,9</td>
<td>45,4</td>
</tr>
<tr>
<td>IoT OSH Open Source Hardware (i.e. Arduino, etc.)</td>
<td>10,2</td>
<td>20,4</td>
<td>43,1</td>
<td>26,3</td>
</tr>
<tr>
<td>Digital Manufacturing (3D Printing, Laser cutting, CNC, etc.)</td>
<td>13,6</td>
<td>26,6</td>
<td>53,3</td>
<td>6,5</td>
</tr>
<tr>
<td>3D Computer graphic and design (CAD, CAM) with proprietary or open source software (i.e. Sketchup, Slic3r, Rhynoceros, etc.)</td>
<td>24,8</td>
<td>21,2</td>
<td>44,2</td>
<td>9,7</td>
</tr>
<tr>
<td>Digital modeling (with scanners, etc.)</td>
<td>12,7</td>
<td>14,0</td>
<td>27,4</td>
<td>45,9</td>
</tr>
<tr>
<td>Crowdsourcing (co-design, crowdfunding, contests, etc.)</td>
<td>5,9</td>
<td>16,3</td>
<td>37,8</td>
<td>40,0</td>
</tr>
</tbody>
</table>

Chart 2 – Technological skills and learning contexts (percentages)

Source: own elaboration
2.2 - Makers and formal learning

By definition, formal learning is delivered in an organized and structured context (schools and universities, in first instance), and it is specifically designed in terms of objectives, times, resources and learning outcomes. Moreover, formal learning is intentional from the learner’s point of view, and it usually results in a validation and a recognized certification.

Through the survey, we have investigated the kind of skills and competences acquired by makers inside the Higher Education domain. The survey has shown that, according to makers, the ability to conduct research is certainly the competence for which the university plays the most significant role. Following, in order of importance, technical/technological skills in the use of tools and machines, and the ability to collaborate with others. Instead, entrepreneurship and leadership are two skills that makers feel aren’t significantly learnt in this context.

Indeed, the maker phenomenon is relatively new in Europe, and reflections on its specific identity and potentials are still ongoing. On this ground, although educational institutions of every rank and degree are increasingly showing interest and engagement with this topic – also witnessed by the growing number of makerspaces opened inside schools and universities across Europe –, a structured and consistent educational offer is yet to come, especially in terms of new qualifications and profiles that could better match the needs of a fast changing market.

<table>
<thead>
<tr>
<th>Learned through education at university</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical/technological skills (use of tools, machine, digital skills)</td>
</tr>
<tr>
<td>Problem solving</td>
</tr>
<tr>
<td>Research skills</td>
</tr>
<tr>
<td>Collaborative making skills</td>
</tr>
<tr>
<td>Entrepreneurship</td>
</tr>
<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Communication and networking</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Chart 3 - Skills, abilities and formal learning (percentages)

Source: own elaboration
In the four pilot countries of the project, we have observed different forms of relationship between Higher Education and the making culture. As we will better see further on, the UK seems to have developed a true enabling environment, with making-related contents and teaching/learning processes that are increasingly inspiring and pollinating the academic offer; likewise, UK makerspaces are fastly evolving towards platforms of highly specialized knowledge, capacity building and propellers of projects in specific areas such as social innovation, urban planning, and bio-design. Although still in a fragmented way, Spain and Italy are more and more riding the wave of the maker movement, with unedited synergies between cities, makerspaces and Higher Education Institutions in the framework of the 4.0 paradigm that are showing promising directions, especially in their combination with digital social innovation. Finally, Poland is still looking for its own root, showing the traits of a maker movement which is emerging at slower pace, with weaker connections with the wider global network.

According to our study, it is possible to identify three main types of Higher Education initiatives that are connected to the maker culture. Importantly, such initiatives often tend to focus on technological aspects and on the development of specialized technological skills and competences, as crucial factors for the creation of high level professionals in a scenario of advanced manufacturing. On the other hand, attempts to shape teaching and learning processes according to multi-disciplinarity, horizontal exchange and collaborative working with external actors, and integration with the local communities can indeed be found. Instead, specific connections with the open source and ‘open’ topics are less present, especially when it comes to new entrepreneurship.

Below, we provide an overview of the three main types of initiatives found by our research within the Higher Education domain:

- **Dedicated courses**, within university programs, especially in Faculties of Art, Design, Engineering and Architecture, both compulsory and optional;
- **Structured projects of research and experimental extracurricular activities**, often combined with innovative students’ internships within companies in the first case, or focussed on complementary learning approaches in the second case;
- **Makerspaces** and thematic laboratories inside universities.

In the United Kingdom, formal design and making education is delivered primarily through the Higher Education system, and specifically through Art and Design courses. Higher Education courses focused on making and OD&M can be found typically in the 3D design area, with courses such as Industrial Design, Product Design, Three-Dimensional Design, Designer Maker Courses, 3D Design and Craft, Decorative Art, Innovation Design Engineering, Design Products, Model Making, Ceramic Design, Design and Innovation. Importantly, the country is increasingly investing in Science, Technology, Engineering and Maths (STEM) subjects; as a consequence, the uptake of creative subjects at secondary school and Higher Education is being challenged. To date, in the UK there are no courses at the undergraduate level that specifically focus on open design and manufacturing; however, many universities are fostering making culture and training through extracurricular activities, often via dedicated projects and communities of practice.
For example, the Institute of Making at University College London is a multidisciplinary research club for students and staff, devoted to innovation and experimentation with all aspects of materials. The Shed at the University of Kent’s School of Computing is a stand-alone open access workshop allowing students to work on concrete projects. The Fablab Plymouth at Plymouth College of Art is used by students across their range of study programmes, and it is also open to students aged 9-16, as well as to businesses and the wider public. The Digital Maker Collective at the University of the Arts London is an open group of staff, students and alumni working together on emerging technologies in arts, education, society and the creative industries; the Collective has recently carried out a project with the Tate Exchange dedicated to explore the connections across digital projects, concepts and technologies through creativity, digital experiments and performances. Importantly, all these examples show the effort to infuse arts and creativity domains with the making culture, as a viable, more inventive-based alternative to STEM education. Moreover, they highlight a strategic use of makerspaces as places of continuity and meaningful transition across educational levels, where students experience a proximity learning which is particularly relevant for the acquisition of soft skills and key competences for life. Structured collaborations with external makerspaces are also widely present; an example is provided by the University of the Arts London, that has ongoing collaboration with the Fablab London, Blackhorse Workshop and, as already mentioned, the Tate Exchange. Although often not-accredited, these initiatives are fully aligned with the strategic goals of universities, and meaningfully feed into student experience through an open and distributed learning that gathers staff, students, alumni and external actors in a community of interest and, by extension, of practice.
In Spain, consistently with an exponential growth of the network of makerspaces across the country, the maker culture in Higher Education has started to take its root. A recent example is the Master course of Rapid Prototyping and Digital Fabrication at the University of Cantabria (MasterFAB), realized in collaboration with Fablab Santander. By relying on a modular approach, the Master can lead both to an expert diploma (Expert in Digital Fabrication or Expert in Rapid Prototyping), or to a full Master’s Degree in Digital Fabrication and Rapid Prototyping. Barcelona, the city that first opened a Fablab in Spain around ten years ago, offers several Higher Education courses that revolve around the making culture; in this respect, we can mention the postgraduate course in Advanced Interaction at the IAAC (Institute for Advanced Architecture of Catalonia), the Advanced Design and Digital Architecture at Elisava (Barcelona School of Design and Engineering), the course of Digital Creation inside the Design Degree Course at Eina (University of Art and Design) and the summer course of Digital Fabrication Techniques for soft materials at Bau (Design College of Barcelona).

Moreover, Barcelona is a strategic hub of the Fab Academy, which provides an innovative example of distributed Higher Education driven by a global network of HEIs and fablabs. The Fab Academy offers a course on principles and applications of digital manufacturing open to everyone, and is divided into videoconference lessons and practice in the fablabs that belong to the network.

In these spaces, students are trained by local instructors, who in turn have studied at the Fab Academy and therefore can better orient and support students throughout their learning experience.

Barcelona deserves to be mentioned also for its pioneering Fab City project, initiated by the Institute for Advanced Architecture of Catalonia, the MIT’s Center for Bits and Atoms and the Fab Foundation. Fab City aims at boosting a new urban model based on locally productive and globally connected self-sufficient cities. However, it is important to notice that to date, most of the educational offer takes place outside universities, and is mainly conceived in line with STEM-related disciplinary domains, in particular for young people. As examples, we can mention the Aulab-LABoral (Laboral, Center of Art and Industrial Production) that offers complementary training and resources to schools. The Xtrene Makespace Almendralejo has carried out several digital fabrication workshops for young people, unemployed and elderlies to foster digital fabrication and address the digital divide.
Italy shows a particular situation, mainly characterized by a diffused perception of the maker movement as driver for an empowered and renewed role of design in manufacturing, and therefore for a better competitiveness of the sector in the global arena. Indeed, Italy’s leadership in design is known all over the world, especially in high end industries. However, increased competition, rising costs, technological progress, higher standards and the global crisis have heavily hit the sector, challenging not only established business models, but also the districts-based organizational form that characterizes the Italian productive structure. Within this framework, the maker movement and the network of makerspaces are increasingly looked as innovative frameworks for radical innovation in manufacturing, combined with strong connections and interactions with the Industry 4.0 paradigm on the one hand, and with the existing industrial districts on the other hand. Thus, Italy is currently experiencing a vibrant season of experimentations and innovations that span across local administrations, universities, businesses, schools, incubators and makerspaces, even if still in an uncoordinated fashion. An exception is represented by the city of Milan, that has recently started the Manufacture 4.0 initiative with the goal of turning Milan into an enabling environment for new ideas, projects and businesses in the domain of digital manufacturing and smart cities. The Italian Higher Education system is impacted as well by this ongoing vivacity, with new courses and training offers born in recent years, particularly around topics of advanced manufacturing and digital manufacturing. Some examples are: Makers Approach to Electronic Design (Faculty of Engineering, University of Genoa), Digital Interaction design (Polytechnic University of Turin). In addition, there are examples of postgraduate courses such as Digital Manufacturing at IUAV in Venice, and the D.re.a.m. Academy (Design and Research in Advanced Manufacturing), created by the Science and Technology Park of Naple. The latter offers a structured program on advanced manufacturing and digital fabrication that connects specific industries (biomedical, design and fashion, advanced architecture and manufacturing, cultural heritage) with technological domains (advanced robotics manufacturing, digital fabrication, data mining, IoT).

The Luiss University in Rome offers the course Openness, Makers and Personal Digital Fabrication within its Degree Courses in Economics and Finance, Law and Political Science. This represents a pioneer case of a course that, although not compulsory, does not fall into a technical/technological degree, but rather in a social science and economic one.
Within the recent Industry 4.0 Plan promoted by the Italian government, it is worth mentioning the new status of Competence Centers 4.0 acquired by several Italian universities, which will work in close collaboration with companies willing to explore technological transformations in their models, processes and products. The Italian Higher Education landscape is also characterized by growing investments in innovative laboratories and internal makerspaces. In this respect, we can mention the Advanced Manufacturing Laboratory of the Milan Polytechnic University, created to become a benchmark in the sector of research on technologies for transforming and processing advanced materials.

The Polifactory of the Polytechnic University of Milan is a space for professors, researchers, PhD and university students, and it mainly develops four activities: research and consulting for companies and institutions, pre-incubation and professional growth of young talents, advanced and experimental teaching, cultural and dissemination initiatives around design and new production models. Further, we can mention the DIDAlabs system of the University of Florence, which constitutes the scientific and technical support to teaching, research and higher education, as well as to the transfer of knowledge in the areas of architecture, industrial design, urban planning and landscape.

Finally, the Open Source School in Bari deserves to be mentioned. Although it cannot be considered properly as a Higher Education Institution, this school is a unique example in the country of an educational institution entirely focussed on the open source topic, presenting a structured and multidisciplinary didactical offer targeting not only makers, designers and professionals of digital manufacturing, but also young people, senior citizens and passionate people.
In **Poland** the maker movement is moving at slower pace. A weaker and fragmented positioning of makerspaces across the country, few and almost random connections with the global movement, a debate on open design and manufacturing which is yet to emerge, and the lack of institutional support, all affect negatively the construction of sound and structured relations between the movement and the Polish Higher Education system. However, some attempts of making-related courses and projects can definitely be found. At the University of Lodz, there are two semesters dedicated to industrial design, which also include topics related to digital prototyping techniques. Moreover, although not accredited as an official partner, Fablab Lodz provides students from local Universities with an additional learning resource for developing and prototyping new ideas and projects autonomously. Another example is the PutLab at the Poznań University of Technology, which is to date the only Fablab in Poland created by students for boosting horizontal and peer to peer collaboration in the making domain. As we have seen, the breath of the relationship between Higher Education and the maker culture varies significantly in the four countries considered, and it actually takes different forms and specific patterns, adapting from time to time to contextual factors. Indeed, the values of openness, learning by making and by failing, horizontal and peer to peer collaboration, flexibility and sharing typical of the maker movement represent a challenge for the codified structure of Higher Education. The risk might be that of sacrificing the creative and experimental spirit of the maker culture on the altar of university credits and exams-oriented performances, impoverishing its potential of unexpected learning outcomes.
Nevertheless, also considering many champion experiences from the UK, a number of innovative approaches to teaching and learning can be highlighted, based on a meaningful relation between Higher Education and the making culture:

- **Learning to learn and learning through doing**: Students actively participate in their learning paths, and are supported in defining questions and looking for answers and solutions, leveraging a distributed network of actors. This approach stimulates students’ critical skills through project-based and self-initiated research, developing goal-oriented approaches and mind-sets.

- **Learning through situated projects**: the use of situated ‘live’ projects may represent a valuable approach to the combination between Higher education and the maker movement, to the extent that they may help shape the experiential learning process into structured deliverables and learning outcomes, as part of a specific curriculum.

- **Mentorship and tutorship**: typically, learning processes within makerspaces are based on a horizontal relationship between learner and teacher, the latter acting more as a mentor or tutor. Often, facilitation skills are crucial to orient and support the members throughout their experience in the makerspace, as well as to create meaningful connections and interactions among makers.

- **Collaboration**: team working is crucial for makers to share knowledge, interact with the community, and pro-actively solve problems. When combined with strategic partnerships with external actors - be they companies or other organizations -, team working can become a powerful tool for entrepreneurial learning.

- **Distributed learning**: makers learn across the city and its distributed resources, therefore signposting and directing the learner to relevant resources is key. Local makerspaces can be accessed as platforms for collateral learning, while acting as spaces of socialization and career orientation.

- **Online resources**: online learning plays a meaningful role in personal development and knowledge exchange. Open resources, tutorials, videos, conferences, forums and MOOCs (Massive Open Online Courses) are typically used across maker communities, as additional sites and tools for deepening down contents and techniques, collaborating on common projects and share knowledge.
2.3 - Makers and non-formal learning

Non-formal learning normally takes place through planned activities, but outside the formal educational context. For example, it can take place during adult courses, business conferences or volunteering. The results of non-formal learning do not lead to a qualification; sometimes it is also referred to as ‘semi-structured learning’.

From interviews and focus groups with makers in the four pilot countries of the project, and consistently with the characteristics of the movement described in the first chapter, it emerges that makerspaces represent fertile grounds for non-formal learning. An exception is represented by Poland, where the perception of makerspaces as valuable contexts of non-formal learning appears less significant compared to the other countries targeted. This may be due to the emergent nature of the maker movement in the country, and therefore to the lack of structured and consistent training offers across makerspaces.

In these places, makers generally experiment, research and innovate using machines, technologies and materials, often through courses, workshops and collective projects. Moreover, makerspaces often build on the presence of a multi-disciplinary and varied community of individuals that infuses learning and discovery processes with original and unexpected features, unleashing a sort of serendipitous contamination among different skills, knowledge, languages and approaches that evolves and takes new forms over time. The open, horizontal and often unstructured collaboration that takes place within makerspaces is also supported and empowered by the use of digital platforms, through which makers can exchange resources and collaborate on common projects.
Although makerspaces’ equipment may vary depending on the model adopted, the thematic area and the financial availability, the following technologies are relatively common (Menichinelli, 2016):

- Subtractive technologies, such as laser cutting and laser engraving machines;
- Additive technologies, such as 3D printing;
- Digitalization technologies, such as 3D scanning;
- Casting technologies;
- Forming technologies;
- Welding technologies;
- Hardware technologies;
- Software technologies, often available in open source or free formats;
- Sewing and embroidery technologies, less common but important for the fashion world and electronic circuits included in accessories and clothing;
- Other manual, analog or traditional processes.

The exploratory study has highlighted that, according to makers, non-formal learning serves primarily to strengthen their technical and technological skills. This aspect, predictably, is related to the use of machines and tools in the makerspaces. Communication and networking (18.8%) is another domain of competences and skills developed within non-formal learning environments.
Activities in makerspaces are often open to any type of educational background and professional profile, and not necessarily limited to people with engineering or technological trainings. On the one hand, this may lead to longer times for carrying out the activities, so to allow all learners to approach them.

On the other hand, interviews have highlighted how those who do not have prior technical/technological trainings are nonetheless strongly passionate, curious and enthusiastic, and often self-taught from the young age. Furthermore, the coexistence and proximity among people with different backgrounds and mindsets create a special multidisciplinary and culturally complex environment that stimulates the contamination among different knowledge and skills, and eventually unleashes new ideas and projects.

The common goal of these spaces is to allow individuals to realize any kind of object and process through the use of various tools and technological equipments, as well as through exchange in the community. Thus, makerspaces give life to more horizontal teaching and learning methods between educators and learners, based on a pro-active and participatory learning that transcends any hierarchical relationship. Moreover, the learning process is often based on the research of concrete solutions to pre-defined problems, and driven by curiosity and personal interests; therefore, emphasis shifts from the learning outcomes to the learning process itself, transforming the latter into a discovery experience where every previously owned skill and competence becomes important, and where such skills and competences - be they hard or soft - are displayed and reassembled with new meanings. In other words, makerspaces appear as learning contexts where learning to learn, learning through making and learning through collaboration blend and nurture each other, on the ground of a proximity learning that revolves around interactions among peers, liquid exchange and transfer of knowledge, and mutual inspiration among the members of the community.

Free access to machines and equipment is another aspect that stimulates participation to the life of the makerspace. Sharing machinery and space brings users to interact and inspire each other, exchange ideas and experiences, and learn from difficulties and mistakes. Space for failure is very important and often seen as an essential value in the community: not only it plays a key role throughout the learning process, but it also acts as engine of resilience and adaptation for the entire community, which based on the mistake, will reorganize itself looking for new resources and assets.
Importantly, by using high-tech design and manufacturing tools, makerspaces provide users not only with basic construction equipment, but enable them to meet high design standards with their fabrications, exploring them in a diversity of use situations and contexts. Such an approach takes its root in agile prototyping and project management methods developed in software and web 2.0, and challenges the divergent and convergent design processes typical in Higher education design programmes.

Enabling users to experiment with fully functioning prototypes creates an explorative space for evaluating and reflecting on their performance and interactions with technological installations and objects that moves beyond what may be anticipated from a purely conceptual design process. However, precisely because of the ‘quick-and-dirty’ approach and the scaffolding provided by the experts in the maker community, users are enabled to focus on the effects of their prototypes rather than their technical detail, and essentially develop an understanding through making. This speed and agility is something that is increasingly in demand in industry


To sum up, non-formal learning in makerspaces follows two complementary directions: one is related to the acquisition of technical/technological skills, linked to the use of tools and programs needed to develop high-tech design and digital manufacturing; the second direction is related to the strengthening and development of soft skills, such as the ability to collaborate and work in teams, communicate effectively, solve problems, pursue pre-defined objectives and acquire an entrepreneurial attitude and mindset.

The emphasis on the democratization of making and DYI stimulates makers’ self-taught spirit, which can also rely on online communities of practice and open resources such as tutorials, repositories and open-source codes. Through these, makers can further develop and deepen down abilities and skills around the tools previously described.

Ultimately, makerspaces work as connection platforms not only for individual skills and competences, but also for life stories and personal aspirations. In this way, they acquire a social value and contribute to achieve social outcomes, working as collective experimentation sites that take people together under a common desire of meaning. Acting simultaneously as personal and professional development agents, as engines of conviviality and sociality, and often as stimulus for career orientation and reorientation, makerspaces appear as fertile places of social innovation that can function as transitional bridges between training, work and leisure.
2.4 - Makers and informal learning

Informal learning results from daily life activities related to work, family or leisure. It is not structured in terms of learning objectives, time or resources. In most cases, informal learning is not intentional from the learner’s point of view, and is often referred to as ‘experiential learning’.

The results of the survey and focus groups, and the analysis of the values and principles of the maker movement, show that informal learning plays an important role in the maker world. Indeed, makers involved in the research emphasised the role that different stages of life and different life experiences and contexts had for the development of their skills. In this sense, the various hacker and ‘open souls’ that populate the movement, the values of openness and sharing, the sense of community belonging, and a common interest in self-production and learning by doing, all contribute to give a very broad connotation to the learning process, which spans across life times and life experiences.

The chart below highlights how informal learning affects all skills and competences in a balanced way.

The only one that emerges slightly from the others is the attitude towards problem solving (17.6%), which according to makers, is practiced and learnt better within an informal context. As explained previously, compared to the other two learning contexts, informal learning proves to be more effective for each of the skills considered in our survey. Makers believe that both formal and informal learning are equally significant only when it comes to the ability of conducting research.

<table>
<thead>
<tr>
<th>Learned from daily activities related to work, family or leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical/technological skills (use of tools, machine, digital skills)</td>
</tr>
<tr>
<td>Problem solving</td>
</tr>
<tr>
<td>Research skills</td>
</tr>
<tr>
<td>Collaborative making skills</td>
</tr>
<tr>
<td>Entrepreneurship</td>
</tr>
<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Communication and networking</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Chart 5 - Skills, abilities and informal learning (percentages)

Source: own elaboration
Based on their direct experience, the participants of the focus groups clearly underlined that many of the personal characteristics that subsequently played a role in their being ‘makers’ (such as curiosity, imagination, preference for manual work, and interest in assembly and disassembly of objects) were the results of their life experience starting from early childhood, and were developed inside the family environment, through play time (a recurring example is Lego), sport, as well as through contact with nature. During adolescence, some of the abilities gained earlier were strengthened, others evolved by adding complexity.

The aptitude for manual work, for example, was strengthened and enriched by the will to experiment, as well as by the development of imagination and creative thinking. Relational aspects also played an important role in this phase: openness to dialogue and interaction with others, collaboration, competition and problem solving are, according to the makers, the most relevant in the path of a maker. Even at this stage, the family represents one of the main informal learning environments, together with activities in volunteering, sports and, in some cases, the first practical experience in artisan laboratories.

In adulthood, sport and volunteering emerge again as contexts of informal learning. However, much importance is also given to experiences abroad and to working experiences, as well as to the use of the Internet in daily life. Among the skills and competences acquired informally makers mentioned in particular: team working, entrepreneurship and research, digital skills, goal-oriented attitudes and planning capacities. Finally, aspects that mostly concern personal skills - such as concentration, patience, determination, time and stress management -, are equally considered significant within the maker’s path.

The transversal and relational skills that emerge from informal learning contexts are relevant to the maker’s identity, which is that of a curious, imaginative and creative person who is constantly experimenting for the sake of learning, disassembling an object to understand its functioning, discovering new topics and connections between devices and machines. The set of skills that come from experiences abroad, as well as from practicing sports and/or volunteering, are instead important in the conscientious choice of an open approach or in the sharing of the same values of the maker movement, such as the propensity to share, collaborate and discover according to new stimuli.
In this chapter we present companies’ views and perceptions about the maker movement and, by extension, open design and manufacturing. Through a series of interviews carried out in the partner countries of the project, we asked companies about their awareness and degree of knowledge about these topics, whether they share the values of the movement and/or of the ‘open’ approach, and what kind of connections or collaborations exist between them and the world of makers.

Semi-structured interviews were addressed to two groups of companies. In the first group we included ‘innovative’ companies, that is, companies that are exploring the integration of new technologies, tools, approaches and values typical of the maker movement within their own models, production processes and/or products. Importantly, while some of them are adopting disruptive or incrementally innovative models, processes and products, others seem to attest on more cautious levels. Instead, in the second group we included those companies that appear less connected with innovative technologies and models, and do not adopt an open approach. The involvement of these latter companies has played a relevant role in the research, to the extent that it has allowed to understand the point of view of actors who still represent the mainstream.
As mentioned above, among the innovative companies we included those who integrate new technologies in their business models, production processes and/or products, eventually embedding - to different scales and scopes - the open approach inspired by the maker movement. Most of them are deeply connected to the digital world, and are or have been in contact with the maker community. Interviews with these companies were carried out in the four reference countries of the project, and involved approximately 40 companies.

In the previous chapters, we have generally presented the different levels of affirmation and diffusion of the maker movement in the national contexts analyzed, and explained how this difference affects the development of open design and manufacturing.

Below, we briefly present some of the shared characteristics among these innovative enterprises, primarily found in Spain, Italy and the UK:

- Founded in the last five years, mainly by young entrepreneurs,
- Small or medium size;
- Operating internationally;
- Having partnerships or sponsorships by large companies or foundations, or have successfully embarked in a crowdfunding campaign to fund their business.

In order to describe the core business of the innovative companies interviewed, we have divided the group into three main subgroups; however, this division should not be considered rigidly; in fact, these areas may overlap.

- Companies that focus on research, consulting and educational services;
- Companies that work on design, development and production of physical objects;
- Companies that work on design, development and production of technologies.

Research and consulting activities carried out by innovative companies can be devoted to the transformation and improvement of existing products or processes, or alternatively to the development of entirely new products and services. Often, amongst the services offered, we find rapid design and prototyping of objects/solutions; this is becoming particularly important, given that it represents an increasingly recognized opportunity for companies to boost innovation in their processes and products. Rapid prototyping frequently involves technological solutions, such as the development of new systems for connecting physical objects (Internet of Things), while the research is generally focused on the study of digital-to-physical object applications, as well as on the dynamics stemming from human-machine interactions.
The educational activities performed by these enterprises are often a distinctive trait of their philosophy and worldview, since they often manifest a strong, human-centered vision around the relationship between people, technology, and models of production and consumption. For example, the Raspberry Pi Foundation (UK) promotes a vision of digital democratization by making computers as cheap as possible, and by promoting the study of computer science across schools in disadvantaged areas. SAM Labs (UK) focuses on empowering children within STEM fields, making coding and programming skills fun and engaging through creativity.

In the second group of companies (manufacturing of physical objects), we find companies that combine technology, open design and self-production. Playwood (Italy) provides a modular system for the production of shared workspace furnishings, using 3D-printed connectors that allow anyone to self-build the furniture advertised by the company. OpenDesk (UK) operates as a global platform for local making, adopting a ‘workspace furniture on demand’ philosophy that leverages decentralization and distribution as levers for more sustainable and responsible production processes. The Open Shoes (Spain) promotes the idea of democratization of the wellness footwear, by making the design of midsoles available to the public so that everyone can make its own midsole using 3D printers and complementing it with the Open Shoes line of footwear.

The third group is represented by companies involved in the creation of technological products, be they software or hardware. This group is mainly characterized by the massive use of emerging technologies such as Internet of Things, automation and robotics, and by the research of new applications among existing devices, making them more smart and responsive.

A well-known example is Arduino (Italy), a rapid-prototyping open-source platform based on flexible hardware and software that facilitates the creation of interactive objects. Thanks to Arduino, it is possible to create in a relatively quick and simple way, small devices such as light controls, engine speed controls, light sensors, temperature and humidity regulators, and many other projects that use sensors, actuators and communication among devices. The Raspberry Pi of the Raspberry Foundation (UK) is a low-cost mini-computer that can be used to create or be connected to various types of technological devices, from robots to domotics. Volumio (Italy) produces a free and open source Linux distribution designed for music playback; it can run on a variety of devices, and thanks to Volumio’s UI, users can rely on easy and intuitive control of playback sessions.
The innovative companies targeted by the research are involved in the maker culture in many ways. In order to describe this relationship, we can imagine a continuum that spans from **companies that are fully rooted in the open design and manufacturing paradigm**, to **companies that are curious and attracted by this world, but have not yet experimented concrete patterns of openness**.

In this latter group, we find several realities who directly know the maker movement and that are or have been in contact with it; however, their business strategies and models do not reflect any contamination with the ‘open’ model, since this is often considered unrealistic and unsustainable in the market.

It is also worth highlighting that some members/owners of these companies claim to have initially acquired technical/technological skills through makerspaces, and appreciated and benefitted from the enthusiastic attitude of the community towards experimentation and making. These entrepreneurs often share the values and principles of the maker movement, but feel that when it comes to doing business, these are not sustainable nor economically viable. In particular, they underline the fact that for them, patents registration represents a way to be perceived as trustworthy subjects, and to access funds from investors, therefore it is hard to imagine to quit it.

At the other end of the continuum we find the ‘pioneers’, namely companies that adopt an ‘open’ approach and are consciously linked to the maker world, often because the same founders are makers, or because they master machines and equipments in the makerspaces, or because they maintain strategic relationships with the maker community. These companies have attempted to infuse their businesses with an open approach, searching for a viable balance between economic sustainability and market competitiveness on the one hand, and features of openness in their business models on the other hand. Moreover, these companies often put environmental sustainability under their spotlight, and promote a positive social impact. Often, these open models are ready to change, adapting quickly to ongoing market transformations coherently with the agile and lean approach that is typical of the web 2.0 and User Experience (UX) culture.

Between the two poles of the continuum, there are indeed intermediate positions of companies that apply some of the makers’ principles and approaches, but are not fully aware of it nor completely invested in it.
But what does an ‘open-featured’ business actually mean? Among the targeted companies, we can find various examples. Some of them allow the maker community to access a shared platform and download files with interior furnishing designs (such as Open Desk in the UK or Plywood in Italy); others openly share the model of an ‘adaptive midsole’ for footwear that takes into account the shape and well being of the feet (such as The Open Shoes in Spain). Examples like Arduino (Italy) and Raspberry Pi (UK) allow free access to hardware or software, or, as in the case of Volumio (Italy), offer the possibility to download their own music application for free and private purposes. In other cases, the companies themselves have founded a makerspace, as in the case of Slow-d and Lottozero in Italy.

Motivations and drivers towards openness highlighted by these enterprises are many. First, a key driver relates to the possibility to harness open innovation processes, and make the most of crowdsourcing to boost innovation at scale. Makers who access information shared by companies are often a great source of experimentation, since they explore codes and technological applications in different settings, thus suggesting possible improvements and upgrades to specific products and services.

Companies tend to consider this pro-active dialogue with makers as an important input for their R&D development, as it contributes valuably to study and anticipate the market in light of a new product or service. In particular, one of the interviewed entrepreneurs affirmed that he does not start a new production line without an early, positive feedback from the maker community (OD&M Italy Country Report). Another outlined the importance of new applications developed by makers built on existing top products; in particular, this last company has created a specific toolkit to stimulate makers’ creativity and innovation, given that makers represent an important portion of its potential and actual customers.

“We appreciate when our clients want to take up a challenge to create something from our products. I see how they dissemble our product, each one of them is different and has his own mentality, they produce different results. Understanding our clients encourages us to improve. When they create something new from FABtotum we are proud! The community of makers is very useful for our research and development objectives.”

(OD&M, Italy Country Report).
Another beneficial aspect relates to a more meaningful positioning against societal challenges like environmental sustainability and social sustainability; rather than being relegated to compensative CSR (Corporate Social Responsibility) strategies, these challenges are often deeply embedded within open design and manufacturing businesses, and tackled through models based on provenance transparency and traceability, local supply chains and recycle and reuse of materials. Importantly, this does not only contribute to the transition towards the circular economy, but it also allows to strategically target that part of the market that, although still a niche, is getting more and more aware of its own consumption style. Therefore, ‘openness’ acts as lever of reputation and positive narrative, and shapes marketing strategies profoundly.

There are two kinds of reasons why an enterprise can be interested in being ‘open’: one is marketing (the product circulates more easily, many people come to know it and love it, especially when these makers will start to use it at professional level); the other one is reputation, because the maker is a ‘geek’, but it is important, to do business, that he has a managerial, philosophical and relational culture.

(Volumio, Italy)
The **social innovation potential** rooted in many open design and manufacturing companies equally plays a major role. Often, these businesses unleash collective experimentation dynamics that pave the way to valuable social outcomes, rethinking deeply the way through which manufacturing is conceived and experienced by final users. Especially when it comes to urban regeneration and inclusion of marginalized areas and groups, making businesses are often able to act at the crossroads between manufacturing and social service, unlocking unprecedented models of social and economic organization.

In the UK, **Social Enterprises** and **Community Interest Companies** are common business models in the maker culture. Italian and Spanish public institutions at the city level are increasingly investing in a new, socially driven entrepreneurship rooted in the making culture, with champion initiatives such as Fab City and Milan Manufacture 4.0, mentioned above.

Openness may also inform the approach to **external relationships and partnerships**.

The dimension of horizontal and open community that typically characterizes the maker movement is often reflected in how making businesses build new relations and access new assets and capacities. Increasingly, networks and networked communities are harnessed to boost new collaborations and business projects, and to mobilize information in more effective and efficient ways.

Under this lens, we can mention the spread of spaces that specifically aim at enabling vibrant communities of makers, making businesses, investors and stakeholders, providing business advice, mentorship and other facilities. **Makerversity** in the UK, **Hirikilabs** in Spain, **Lottozero** and **WeMake** in Italy are all examples of enabling spaces for making businesses in the cultural and creative industry.

However, like any other business model, making businesses have to deal with economic sustainability and the presence of opportunistic behaviors. That is why, even the most innovative and open businesses are continuously looking for an effective balance between the ‘open’ and ‘closed’ parts of their model. For example, one of the interviewed companies remarked the need to protect a crucial part of their project through a patent, while another underlined the need to select the users of their platform in order to exclude ‘those who only want to take from others without sharing, having profit as the unique goal, regardless of ideas and projects that can improve the world in which we live’ (OD&M, Italy Country Report).
The most widespread professionals among the companies targeted by the research are designers across different fields. We also found several architects and engineers, as well as ‘computer geeks’ with education in humanities and social sciences.

The strong interest in technology and in the digital world is a distinctive feature shared by the majority of professionals working in these companies, independently from their previous areas of study. Generally, this interest takes the shape of a true passion for coding, and for the use and experimentation of machines, also within makerspaces. Human-machine interaction and User Experience (UX) is another common domain of interest.

Multidisciplinary research is another fundamental aspect shown by these enterprises. Often, professionals with a technical/technological profile work alongside staff with humanistic and social backgrounds, and with communication experts. This not only helps to facilitate integration and hybridization among different skills, but it also contributes to build common languages and strengthen personal skills. Many professionals with a background in social studies have explicitly highlighted the need to better understand coding elements, while those with a more technical background find themselves forced to deal with social aspects. In general, for many of them, the access to makerspaces has been crucial for developing specific skills in the use of 3D printers, laser cutters and advanced materials. Interviews have therefore confirmed the key role played by makerspaces for complementary learning, as well as for inspiration.

A specific reflection concerns the role of the designer, which is a recurrent profile in both making companies and makerspaces. In these contexts, the designer presents unedited features; the centrality given to user experience (UX) and to the democratization of technology typical of the maker world, have influenced the designer’s profile and led to greater openness of this profession. This process has been nurtured by a progressive, incremental contamination between makers and designers, which has made the distinction between these two figures ever more faint. Thus, in the last few years, the first has developed a more design-oriented approach, while the latter has acquired more practical and technological skills (OD&M, Italy Country Report).

Finally, although any generalization should be treated carefully and eventually considered in light of the specific model and size of enterprises, the following attitudes, skills and competences have been frequently highlighted by making businesses as ‘must have’:

- Entrepreneurship-oriented mindset and approach;
- Multidisciplinary team working;
- Strategic development competences;
- Bureaucracy management;
- Resilient attitude and ability to handle complex issues in fast changing contexts.
In this section, we illustrate the point of view of ‘traditional’ companies with respect to the maker movement and open design and manufacturing.

As mentioned above, in the framework of this study we considered as ‘traditional’ those companies that appear less connected with innovative technologies and models, and that do not adopt an ‘open’ approach in their own models, processes or products. Although the number of traditional companies reached out has been relatively small (about 15 in the four European countries), their views on the open paradigm helped us to outline a first picture around the main perceptions that characterize the relationship between the open paradigm and mainstream manufacturing businesses.

Traditional companies do not constitute a homogeneous group. As in the case of innovative businesses, we can describe a continuum that spans from enterprises that are unaware of the maker movement and of the open paradigm, to companies that, although aware, are not interested in finding strategic synergies.

The companies who know the open paradigm but choose not to apply it are particularly interesting in this research, since they allow us to explore the possible barriers and resistances towards this approach. Interviews have shown that traditional companies tend to prefer a concept of closed and incremental innovation, in which the solution to new needs and challenges has to be found within the company itself, or through outsourcing, provided that the final output remains protected. Although these companies are aware of the maker philosophy, they feel that opening up a part of the company’s information could harm their competitiveness and reliability.

Traditional companies targeted by the research do not generally envision the potential of virtuous combinations between an open approach and business strategies, and the hypothesis is basically perceived as unrealistic. Moreover, openness is often associated to free access to information, therefore showing a general confusion about what openness in business models could actually mean and how it would look like. Instead, the interest mainly revolves around the Industry 4.0 topic and the dimension of smart manufacturing rooted in it, as this is frequently perceived as a technological-driven innovation that may contribute to increase competitiveness in a context of globalized competition. Against this landscape, we can assume that a stronger convergence of traditional enterprises towards open making approaches could be achieved if the following aspects were stimulated:

- Openness towards digital-driven change;
- Openness towards a more horizontal internal organization and the application of collaborative methods within the core team;
- Orientation to design and User Experience.
Conclusion

The OD&M exploratory study focused essentially on three main dimensions: a) the key values and principles of the maker movement; b) the learning contexts where makers acquire significant skills and competences; c) the views and perceptions of both Higher Education institutions and businesses around the maker movement and, by extension, around open design and manufacturing.

The research was implemented in four European countries, namely United Kingdom, Italy, Spain and Poland, where the level of diffusion and maturation of the maker movement seem to attest on different stages, from the more emergent case of Poland to the well developed and vibrant making environment of the UK. Coherently, the potential for innovation rooted in this movement seems to be perceived in a number of different ways, and translated into different approaches within both the education and business worlds.

Although the limited scale and scope of this research requires us to be cautious when making any generalization, we can nonetheless affirm that, to date, the maker movement seems to have primarily affected the educational systems, while impacts on businesses appear less evident and systematic at this stage.

Moving at different paces and benefitting from different levels of (institutional) support in the four countries, schools and universities are starting to explore the possible synergies with the making culture and its movement. This is evident in the growing number of makerspaces, fablabs and innovative labs created inside schools and universities, and also in the effort to adapt curricula, methods and profiles according to fast changing needs and scenarios. With different rhythms, the Higher education offer of the targeted countries is progressively experiencing the introduction of advanced manufacturing and digital manufacturing-related contents, mainly with the intention to strengthen hard skills and competences within a 4.0 industry paradigm, and under a renewed political focus on STEM education. This transformation seems to affect not only engineering and technical faculties, but also design and arts ones and, to some extents, social sciences and economics ones.

Further, as our exploratory survey shows, universities are playing a role primarily in the acquisition of technical/technological and research skills and competences, while its relevance in developing soft skills seem to be less strong. Nonetheless, even if through different approaches and to different extents in the countries targeted, the maker movement is increasingly contributing to boost teaching and learning processes around multi-disciplinarity and collaborative features, adding new methods and approaches to the Universities’ pot. Strategic partnerships, extracurricular activities and dedicated projects are more and more leveraged not only to explore new connections and interactions between humans and technologies, but also to draw new models to steer and govern innovation across a plethora of actors.

Importantly, these initiatives often have a pilot or experimental nature, and may not be fully embedded within curricula and accreditation systems. Instead, when it comes to promoting entrepreneurship in the field of making manufacturing,
the role played by Higher education appears to be less pro-active, which may be due both to the fragmented capacity of the maker movement to affect the world of businesses in the different countries, and to the still tentative framings of business models in making manufacturing. Indeed, there seem to be few cases of courses and teaching processes that try to foster entrepreneurial mindsets and approaches, and generally these are not explicitly aimed at creating a new generation of ‘open’ manufacturing entrepreneurs and designers.

When shifting to the relation between the maker movement and businesses in the four countries targeted, this appears to be fragmented. Except for the UK, where open design and manufacturing is already supported by an enabling ecosystem engaging makerspaces, start-ups, large corporations, incubators, co-working spaces and public institutions, the other countries are lagging behind, still searching for viable paths to boost maker manufacturing at scale. The openness-driven approach of the maker movement still struggles to prompt business model innovation and, often, it tends to remain the domain of start-ups. Contaminations between traditional manufacturing and the making culture are often accidents, given that they generally lack both the awareness and supporting system that would be needed to elevate them as drivers of an effective relaunch of the manufacturing sector. Even in the case of pioneering companies, concrete applications of the open approach take the form of experimental projects, and struggle to crystallize into new business lines.

After all, our exploratory study outlined that open design and manufacturing is actually at the beginning of its own journey, and that a number of complex challenges - institutional, cultural, technological and of capacity-building - need to be tackled in order to scale it up at meaningful levels. Nonetheless, the study also highlighted that open design and manufacturing is much more than a claim; even if still few and small in scale, our research has found several examples of businesses that operate around this new paradigm, reformulating production and consumption modes around increased needs of social and environmental sustainability, by means of collective experimentation and co-creation.

By summarizing the results of the research, a triple gap emerges in the relationship between universities, maker world, and traditional enterprises:
1 - a knowledge gap regarding the open design and manufacturing features and potentials for innovation, evident both within educational and business domains;
2 - an awareness gap about the mutual benefits that may stem from unedited alliance between the maker movement, the education domain and the world of business;
3 - a connection gap between these actors.

In the first chapter, makerspaces emerge as places where meaningful skills, competences and knowledge are acquired in relation to the open design and manufacturing world. Such skills and competences are developed through training courses and workshops, but also through practice with materials and machines. On the other hand, makerspaces unleash new relationships and connections between people and scale them up at the level of the community, giving life to collective and collaborative learning processes featured by sharing,
peer to peer exchange and openness. Often, maker communities are strongly informed by social values and have socially-oriented objectives or missions, being committed to the research of more sustainable production and consumption models. Increasingly, especially in the UK and to some extents in Italy and Spain, makerspaces also operate as platforms for open innovation, establishing strategic partnerships with existing businesses, or supporting the development of new ones.

However, the potential for individual and collective capacity-building shown by makerspaces often remains closed in silos, lacking a clear, strategic positioning of makerspaces as ‘hubs’ connecting education institutions, research centres, and businesses. As a consequence, a recognition system is still missing that could allow individuals - be they makers in their different specificities, students, entrepreneurs, researchers and citizens - to capitalize on their own contribution and activities within such spaces, and make them portable across life and working domains.

Within this framework, the OD&M exploratory research aimed to shed light on a yet untapped opportunity: that of creating a new teaching and learning model that, by deploying across educational institutions, makerspaces and businesses, could effectively attract and serve a plethora of different actors - makers, young students, researchers, entrepreneurs, citizens - and give birth to dynamic, multidisciplinary and multi-sectoral collectives able to collaborate on common innovation processes in design and manufacturing, under an overall goal of social innovation.

Building on project-situated approaches, learning proximity, peer to peer collaboration, and on new combinations between frontal teaching, mentorship and tutorship, such model could make the most of all the strengths of these different learning contexts to boost the acquisition of both hard and soft skills, and achieve continuity across disciplines and meanings. Moreover, a community-based assessment system could complement the model, providing all the members - independently from their entry point and from any previous professional or training experiences - with the valuable opportunity to see their knowledge and skills recognised and therefore to capitalize on the activities developed within and across the different learning contexts, building curricula and portfolios incrementally.

As we have repeatedly seen in the report, open design and manufacturing is an emerging concept that essentially needs increased awareness, recognition and capacity building, as well as a higher degree of institutional support and investment to grow and scale to a significant level.

Within this framework, Higher Education offers the opportunity to trigger a massive change of pace, not only serving the needs of open manufacturing companies, but also reorienting the whole educational chain accordingly. By fostering research on the topic, working on the anticipation of job demands in this new landscape, and shaping learning outcomes into codes and meanings that can be widely understood across a plethora of stakeholders, Higher education could play a pivotal role in this open manufacturing revolution.

Doubtless, the maker movement and its own weaknesses and challenges warn us that such a revolution cannot be driven unilaterally: to make it sustainable and viable, we need to acknowledge that open design and manufacturing is mainly about ecosystems of actors, and that an enabling environment pro-actively involving all these actors in a true, open movement of innovation, is indeed the starting point.


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