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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.
Methodology

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 business, 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 polilation 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.
1.2 - Values and principles of the Maker Movement

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.
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.

See: http://www.mise.gov.it/index.php/it/industria40

See: http://www.agid.gov.it/agenda-digitale/agenda-digitale-italiana
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 Council⁶, and the Maker Library Network project⁷, which connected designers and makers around the world to facilitate knowledge and skill exchange amongst professionals in this field.

⁶ See: http://creativeeconomy.britishcouncil.org/projects/hello-shenzhen/
⁷ 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.
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></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.

Important 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>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>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
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.

| Learned through education at university |  
|----------------------------------------|---|
| Technical/technological skills (use of tools, machine, digital skills) | 17,3 |
| Problem solving | 13,6 |
| Research skills | 25,5 |
| Collaborative making skills | 15,6 |
| Entrepreneurship | 8,2 |
| Leadership | 6,8 |
| Communication and networking | 12,9 |
| TOTAL | 100,0 |

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.

<table>
<thead>
<tr>
<th>Learned through planned activities, such as training/courses in the makerspaces/other organization; in-company training</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>
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<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Communication and networking</td>
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<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Chart 4 - Skills, abilities and non-formal learning (percentages)

Source: own elaboration
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.

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 DIY 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.

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.

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.

![Chart 5 - Skills, abilities and informal learning (percentages)](chart)

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 Playwood 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)
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 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.

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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.
3.2 - Traditional enterprises and open design and manufacturing

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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ANNEX: Country Report

I. OD&M Country Report, UNITED KINGDOM

By Matt Malpass, Chris Follows, Paul Haywood, Tessa Read, Prof. Adam Thorpe, Chloe Griffith, Pras Gunasekera | University of the Arts London
There are now over 200 makerspaces across the UK, with nearly every city in the UK having at least one makerspace.

The grounding principle of these spaces is people coming together to create, fix and modify objects and systems. In the UK, Open Design & Manufacturing (OD&M) is supported within the maker movement and is generating much interest among industry, educators, funding bodies, third-sector agents, cultural institutions and government bodies alike. This interest is evident in the proliferation of support in terms of funding, strategic projects and research both nationally and internationally.

Makerspaces are open-access workshops that facilitate practices ranging from traditional manufacture and fabrication through to digital manufacture and production. They host a range of tools and equipment including 3D printers, laser cutters and CNC routers, sewing machines, potter’s wheels and digital looms, physical computing facilities, electronics and robotics, as well as traditional hand-tools and bench mounted equipment. Increasingly, practices in these spaces explore specific thematic areas in design and making. They offer a site of inquiry peripheral to what might be considered traditional or orthodox design and making practices. This is specifically exemplified in green and bio-design spaces.

These spaces house wet labs focused on aquaponics and hydroponics, developed in a context of urban agriculture and bio-design. Such spaces are equipped with the specialist equipment required for growing and designing in biological contexts. Another thematic development is the maker space emerging as an active site for social innovation and community development in local geographic contexts through which complex matters of concern facing local communities are addressed. Other’s thematic focus might focus on Internet of Things technologies, while others focus on business incubation. The non-regulated nature of makerspaces and the activity that takes place within the communities affords a dynamic, agile, activist and disruptive characteristic to the movement.

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8- See Nesta Open Data Set of UK Makerspaces: [http://www.nesta.org.uk/blog/top-findings-open-dataset-uk-makerspaces](http://www.nesta.org.uk/blog/top-findings-open-dataset-uk-makerspaces). There are now 65 hackspaces, 19 FabLabs and 326 Men’s Sheds across the UK, and the number of new workshops opening has increased year on year (Sleigh, Stewart, & Stokes, 2015).

Principles

A common principle identified in this study is **prosumption**. This is specifically evidenced in the use of **prosumer tools** and technologies and the **collaborative consumption** of tools used in the execution of projects. Prosumer tools can be defined as tools with self-fabrication capabilities, where the maker both consumes, and produces media in the creative act; this is typified by 3D printing and its associated practices. These tools are used in contexts of learning, enterprise and socialisation. Projects are often conducted within an ethos of collaborative working. Co-working, time-banking and bartering are common, where the network of makers and members of maker communities offer time, resource and expertise as currency in exchange for access to the space, use of facilities and services. Knowledge exchange is a salient principle in makerspace culture. Makers in the UK OD&M context are united by a shared belief in the importance of working with their hands through forms of tool-based creativity and haptic intelligence.

Engaging actively with technology is a common principle. Importantly, makers aim to develop competencies in tool based creativity in both themselves as the individual maker or in others by establishing communities of interest and, by extension, communities of practice through peer-to-peer proximate learning where skills are shared and developed collegially.

A key principle is community; communities of practice supporting the future generation of makers. The provision of tools, space and opportunities. The provision of a safe space where it is ok to fail, where to fail is part of the process and the space affords the freedom to have a go.

(Claire Tymon, Director Place Shakers, The National Festival of Making)

Some makers are motivated by an interest in exploring the possibilities that are present from having access to the prototyping technology available. They focus on questions like ‘is it possible to make? Can this machine be (mis)used to innovate? What kind of materials is it possible to machine?’ Others are driven by an external interest such as ‘can I make a prototype that enables me to try out new recycling strategies for a typical home? What if you could make almost anything from plastic waste?’ ‘Can I develop a system to grow salad using fish excrement?’ or how might distributed manufacture and co-design address a council’s housing crisis?

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10 This is informed and supported by the findings of the Royal Society of Arts Report by Dellot (2015) *Ours to Master How makerspaces can help us master technology for a more human end*.

Makers in the UK can be categorised on a spectrum from the hobbyist enthusiast acting in spaces where tinkering and experimentation characterises them. Those who use the space as a site of learning in formal contexts related to education programmes that they might be enrolled on or as activist learners, where the focus is self-directed and driven by self-actualisation.

There are also makers and spaces with entrepreneurial intentions who specifically focus on the incubation of start-up ideas in an entrepreneurial context. Here makerspaces support members in completing challenging projects or developing their own business with the aim to incubate businesses, help makers earn a living, and offer career pathways in making. It is common for businesses or professional makers to use the space as a site to run a business.

Makerspaces also function to help people turn member's ideas into marketable products and in doing so establish viable maker businesses. In most cases, entrepreneurs will use tools to rapidly create prototypes of products and services that can be made in bulk elsewhere. Examples of businesses using makerspaces in this way include producers of surgical equipment\(^\text{12}\), Internet of Things technologies, computing products and homeware products. There are also spaces that specifically facilitate and support OD&M companies as in the example of [Makerversity](https://makerversity.com).

Within the UK there are spaces that exist as a context for business acceleration, for example the [Central Research Laboratory](https://www.crl.com). Here start-ups are offered business advice, facilities and funding to grow business ideas. The densest population of OD&M businesses in the UK are situated within the [Maker Mile](https://www.makermile.com) in London. In this one specific context [Machines Room](https://machinesroom.co.uk) operates as a makerspace with a social impact focus and has developed as a Fab Lab with a focus on incubation. The space has successfully incubated and worked with a number of art and technology start-ups and projects including [Technology Will Save Us](http://www.twscalifornia.com), [OpenDesk](http://opendesk.org), and [SAM Labs](http://www.samlabs.com). It continues this support the industry through 'makers in residence programmes'. Current residents here include [Kniterate](http://kniterate.co.uk), [Disrupt Disability](http://disruptdisability.co.uk) and [Ply Set](http://plyset.co.uk). This function to incubate and develop businesses is supported through networking activities and events\(^\text{13}\).

Networking, through activities such as meetups, jams and hackathons is recognised as one of the most salient functions of the community\(^\text{14}\).
Maker’s values are often orientated towards a desire for meaning. Here enterprising individuals are interested in **self-production**. Their motivation may be commercial intent or situated within a broader ideal of self-actualisation. **Positive social impact** is salient, as is openness and accessibility through **collaboration, sharing** and **democracy**.

Where enterprise (in commercial terms) is the motivating factor, the maker movement is a beneficiary since this entrepreneurial intent is often married with principles of collaboration, sharing and democracy in creative contexts. Social enterprise is therefore salient within the movement. In the Enterprise Nation Maker Survey (2016), 53% of respondents said they left their job to start a business as ‘they wanted to be more creative’ and 33% gave up a well-paid job to start a business based on doing what they most enjoyed – making! This type of entrepreneurialism is typical within the movement.

This increase in creative start-ups is the foundation on which the maker movement is based – and looks set to continue, with 96% of respondents seeing ‘making’ as a growing trend.

While enterprising individuals might be using makerspaces to incubate ideas in the creative culture that the spaces afford, equally the spaces serve as a site for retraining and lifelong learning in alternative educational contexts to that of school, college, further or higher education. This is achieved through skill based non-accredited training programmes offered within the spaces. These are delivered by other members of the space. Proximate learning through peer engagement is also important here, as is the plurality of peer engagement, where makers learn through interaction with the collective expertise and competencies occupying the maker communities. Here, self-fulfilment is the main motivation as described by the Royal Society of Arts report Ours to Master:

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**To experiment and to learn are the most salient motivations identified from the survey of UK makers**
The therapeutic effects of making have been well documented. Multiple studies show that the act of creating things can stem cognitive decline and help people control their emotions. But the making activity that occurs within makerspaces may also imbue people with a deeper sense of meaning and a feeling of ‘being in control’ that is elusive within their day to day lives (Dellot 2015: 6)

While business development and entrepreneurialism are typical aims, the profile of makerspace members includes people from all walks of life and experiences; college leavers, those who might have changed careers, members that have been made unemployed and are using the space to reorient their career, or as a means to occupy time in a collegial environment. In some cases, makerspace members find employment as a direct result of the skills they have picked up on site. This plurality is a defining feature of the maker culture and those who participate in it. Embracing the plurality of experience and expertise through socialisation is a key value within the UK profile.

Making is defined by the communities of practice that situate the maker. Different spaces take on different characters (Daniel Charny)
Who are the makers?

Making is a global social movement creating new spaces for learning, innovation, research and self-actualisation (Walter-Hermann 2013; Hatch 2013). These spaces are on the rise both in the UK and internationally and there is much plurality among makers in terms of values, motivations, competency levels and practices engendered in the maker culture.

This section aims to personify the UK maker in the face of the plurality that exists within the culture. The following is developed with reference to the PSFK The Makers Manual (PSFK Labs 2014), Nesta’s Open Data Set, UAL: Central Saint Martins Product Ceramic and Industrial Design Programme’s work on the Future of Design Education (Malpass and Rhodes 2015) and from interviews and survey data collected as part of this project.

While these categories of makers are not gender, age or ethnically or demographically defined, questions should and are being asked in relation to equality in makerspaces and maker culture at large in the UK. Most workshops have no age/access restrictions. The main age group of members is 30s - 50s. And across the sector the gender balance is currently 70-80% male: 18% -30% female.

We propose 14 emergent maker profiles:

- **Agonist**: the agonist looks for, and embraces, plurality in their design/making education; their programme of study is holistic and fluid. They come together in trans-disciplinary teams moving from project to project engaging very different contexts. The agonist causes an action and takes responsibility for their own learning. The process is supported by cross-institutional relationships; HE, third sector and enterprise institutions interact to innovate and create space for proximate learning to occur. The agonist looks to train themselves in managing complexity. A solid skill set in making and tool based creativity affords the ability to move from problem context to problem context effectively, and learning from different problem contexts through situated action in the world.

- **Autonomous student maker**: is typified by the student maker who engages the makerspace culture in order to augment and complement university provision. Often this is through a self-initiated project that will be credit bearing. Students are motivated to participate because projects align with personal interests. The expertise and knowledge transfer through proximate learning enrich the student work, experience and sense of autonomy. The resource and facilities that are provided through the space also complement university provision.

• **DIYer**: these makers come from all walks of life and experience. They have a history of tinkering, building, and crafting. They are typically a hobbyist, enthusiast and making is a personal passion. The maker is curious about the new tools and interested in expanding their repertoire or adding to a familiar skill set.

• **Educator**: Is skilled and knowledgeable in a range of making contexts. They are good communicators and take pride in the development of others. They are particularly interested in demonstration and signpost resources that can inform project and makers development.

• **Entrepreneur**: is adept at picking up industry trends and using those insights to inform things they make, all with an eye towards maximising the bottom line. The entrepreneur is adept at looking for workarounds to get you access to the funding and facilities needed to create a sustainable business, not just a product.

• **Extracurricular student maker**: these are students enrolled on courses but who work on collaborative projects that are initiated or facilitated by the university. In this context projects are often collaborative and are open to students from across a Higher Education Institution (HEI). These projects are often non-accredited but are conceived to contribute to the student experience through collaborative working and exchange. They might also align with HEI institutional strategy e.g. outreach. Students are motivated to participate because projects align with their personal interests.

• **Inspired co-worker**: is inspired by the maker culture. They primarily use the makerspace as a co-working base. Their practice might not focus specifically on making, but the environment and interaction with users fosters creativity. These interactions inspire and provide a site for networking and business development in the proximity of makers. Knowledge transfer is reciprocal and where making skills might not be passed on, enterprise knowhow is.

• **Pro-maker**: has developed competent making skills and openly embraces emerging technologies for their ability to add scale and efficiency to the process. These makers are equally comfortable operating a table saw or writing a line of code, and are constantly expanding upon the available tools at their disposal. They have the ability to hack tools and demonstrate complete technical understanding. They know that experimentation and multiple failures are an essential part of creating anything worthwhile. This maker typically has experience working professionally in a production context.

• **Self-Learner**: learns through principles of effectuation. Watching how-to videos and swapping tips through online forums. Confident and proactive in the application of new skills and engaged in hands on educational setting, this maker finds value in craftsmanship and is compelled to understand the emerging tools and technological trends.
• **Shift-surfer**: the shift-surfer is restless and agile. Experimentation and networking are key as the sites for learning are distributed across the city. Working with local businesses, factories and maker spaces as independent institutional nodes, the shift surfer efficiently engages these resources in their learning which is applied through a variety of projects and materials. Skills are developed through practice in real world contexts.

• **Socialiser**: one of the key reasons that these makers use the space is to socialise and learn through processes of engagement and socialisation.

• **Strategist**: these are the coordinators and staff who play a strategic role in the development of the space, culture and the programming. Their attention is on a range of projects in enterprise and social regeneration or development contexts. These set the agenda of the spaces. They see the space as a project in its own right and are responsible for the sustainment of the project. They are proactive and entrepreneurial in their character as they are constantly required to obtain property, equipment, funding relationships and partners.

• **Student maker**: these are students enrolled in Higher Education. They are working on taught projects set by university courses. These projects require engagement with makerspaces as part of the learning. Here, briefs are set by the course and the parameters of inquiry are established in relation to learning outcomes that students must achieve within their curriculum. The students are motivated by study but the projects might not directly align with individual interests.

• **Thinkerer**: is focused on self-actualisation. These users use the space to retrain and develop skills. Being part of the maker culture occupies time and contributes to self-fulfilment. These users are typically time rich.
The “open” paradox

While openness and accessibility are among the most salient values and principles identified in this study, there are hierarchies of openness at play within the movement. For founders, managers and funders, the makerspace is a project in itself. In all cases, the makerspace (project) is in a perpetual state of strategic development and here a paradox emerges. While maker culture is open and ‘bottom up’ – in the opinion of some coordinators, the terms and thematic intention of the space comes from an authoritative position, where the ideology and ethos of a space is set from the ‘top down’ with strategic direction and often built around focused thematic interests. Economic sustainability and funding always present a challenge. The ultimate success and sustainability of some makerspaces is determined by how open they are, but there is a perception among makerspace coordinators that if the ambitions of the maker initiative are ‘too open’ in their strategic direction and business models they run the risk of being too diffuse and risk future sustainability. Complete openness in how users engage in these spaces, the types of membership supported can paradoxically limit the success of a space in terms of economic viability and sustainability.

Examples of where this diffusion is addressed include Machines Room who are working to operate an incubation model and, Makerversity primarily functions as a co-working space, Green Lab focuses on food and urban agriculture. These focused thematic provide useful handles for recruiting members (and the income stream that membership offers), directing projects and securing funding. Often therefore the social agenda of the space and movement is emphasised since this provides access to favourable funding opportunities.

Blackhorse Workshop opened in 2014. The original vision was to form a DIY fix it service targeting local unskilled users to come and fix bikes and old furniture. However, it became clear that it was not going to be financially viable to provide such an intensive service without external funding.

Following a number of phases, Blackhorse Workshop now functions as a public space dedicated to making and mending, with a specialism in traditional wood work and metal work. It provides shared tools and machinery, and skills development for those transitioning from education to business. This includes supporting freelance creatives from architecture, product, set design, furniture makers, joiners and carpenters.’

(Harriet Warden, Creative Director Blackhorse Workshop)
There is a growing interest in funding and support from Local Authority and Local Economic Partnerships, for example Blackhorse Workshop as a project received start-up funding of £90,000 from the Mayor’s Outer London Fund initiative launched in 2011. It received a further £80,000 from the London Borough of Waltham Forest and £50,000 from Create London, an arts commissioning body focusing on Boroughs in the vicinity of the Olympic Park. The Making Rooms funded through LEP with £250,000 Arts Council funding in Blackburn Lancashire as part of a community and city regeneration initiative Blackburn is open where space and accommodation was given ret free to house the project. Open access facilities with specific community and social aims tend to receive grant funding or local authority support.

The making rooms in Blackburn is a Fablab+ co-working studio project that will aid in the cultural and economic development of Blackburn. The Making Rooms is a place where creativity, technology and advanced manufacturing come together in a community facility for use by businesses, artists, inventors, students, children and just about everyone else to design and make anything from high-tech products and gadgets to toys, artworks, home decorations and t-shirts. The Making Rooms is an independent Community Interest Company (CiC) which aims to xxxx. The local authority supported the development of the makerspace. The council wanted a Fablab having seen how Fablab Manchester (the UK’s 1st FabLab) in a neighbouring city was operating. The ‘Blackburn is Open’ initiative was also fundamental to its development. The development of the makerspace was part of a regeneration strategy for Blackburn and a 12-point plan for the town centre focused on urban regeneration through environmental design and culturally led initiatives. The development of Making Rooms was built into the regeneration manifesto

(Claire Tymon Director at Placeshakers CIC)
The maker culture in the UK is therefore healthy in both activity and support structures. The UK is engaging internationally through bilateral projects and through research and knowledge exchange consortia.

Private backing and funding streams are equally important. Corporate Social Responsibility budgets from corporate partners help sustain the movement, as do income streams through manufacturing, fabrication and corporate training services.

A case example here is Fab Lab London. The Fab Lab was set up in 2014 with backing from corporate and other organisations including Intel, Tech City, Bathtub-2-Boardroom (a start-up support enterprise backed by the Mercers Company, KPMG & Temple Bright) and RSA - The Great Recovery, a materials re-use initiative. As the Lab developed so has its corporate relationships. Fab Lab London’s relationship with Barclays is an example of the private sector supporting maker initiatives and vice versa. The two institutions have collaborated on a number of initiatives; Barclays Eagle Lab created an incubator space for entrepreneurs in the bank’s former cheque processing centre and Fab Lab London developed a series of meetups and training sessions with Barclays in their space. The importance that the bank places on OD&M is exemplified by how Barclays are now investing in their own makerspaces. Barclays Eagle Labs are now in 12 locations across the UK including Belfast, Liverpool, Cambridge, Notting Hill, Brighton and Jersey. The aim is to support businesses to embrace new and emerging technologies that they say are critical to the success of businesses in the UK.

The rationale for such investment is that these spaces operate as incubators for early stage sole traders and start-ups. They offer important benefits, typically, a shared space can save a sole trader £3k-£15k in equipment costs, with further savings on rent, insurance and storage. These savings have further impacts: by reducing overheads, making spaces can enable sole traders to take on apprentices or assistants. This may help address the current lack of skills transfer and training opportunities within the semi-industrial and micro-manufacturing sectors. (Workshop East with Kirk, & Morgan-Hatch. 2014)

But for others the challenge of working with corporate partners remains and they therefore operate more effectively in social innovation and community contexts:

“Blackhorse has not had much success working with corporates, and partnerships mainly centre around community, commercial and the housing sector. Blackhorse is involved in Create London, the arts charity, and they have been part of the Walthamstow Arts School which focuses on the revival of art schools and traditional skills taught in schools in the 1970s. Blackhorse has run skills training around traditional wood and metal work. They have also worked with local partners including William Morris Ward (part of the Big Local initiative - a series of people who live in the ward who decide what should happen to local funding) who commissioned a holiday club’.

(Harriet Warden, Creative Director, Blackhorse Workshop)
Projects are developed with entrepreneurial intention but often in contexts of social and cultural regeneration. Social Enterprise and Community Interest Companies are common business models in the maker culture. A recurring theme in the UK context is that of social impact and regeneration. This is a key thematic interest with makerspaces as they increasingly function as a site of social innovation.

An open innovation agenda (Chesbrough, 2003) seeks to insert makerspace creativity into global manufacturing circuits. Traditionally, new business development took place within the firm boundaries. However open innovation recognises that large amounts of knowledge exist outside organisations and as people move, they take their knowledge with them this resulting in knowledge flows. This flow and interaction governed by open and collegial working practice; cross project, company and sector can be found in the working practices that exist in makerspaces and the start-up communities that are often resident. Others see in makerspaces an infrastructure for a commons-based, sustainable and redistributed manufacturing economy as represented in the Fab City initiative and explored through the Engineering and Physical Sciences Research Council funded project Future Makespaces in Redistributed Manufacturing.

Makerspaces are therefore a site of engagement with issues of profound social significance, and offer an example of innovation democracy in action (Smith 2017).

In terms of values and motivations, many OD&M actors look out to their local community, or aim to tackle specific local issues, such as developing a manufacturing economy, addressing unemployment, developing urban food production, providing an alternative to school–based education, or challenging local complex challenges including overcrowded living.

There is a growing interest in what we introduce as citizen centred innovation within the UK OD&M context.

Designers and makers need to come together in the face of changing design paradigms where local making and production in the borough will add social and economic value to the borough locally.

(Nat Hunter, Strategic Director, Machine rooms)
While these projects are ambitious, their impact might achieve varied success.

“The maker movement incorporates the triple bottom line. It comes from an ethos of sustainability in terms that includes social sustainability. However, while this is the intention, it hasn’t quite developed the foothold and scalability that aligns with the social intention”

(Daniel Charny, Professor of Design, Kingston University and Director, From Now On and Fixperts)

However, the capabilities and perspective that are developed through OD&M projects – collegial, collaborative, social working, open innovation, challenge based working, situated problems, co-design, effectuated design and innovation processes – generate awareness of social implications, and can be carried through to other areas of social life and attain wider significance for social development.

Therefore, the makerspace and its design culture facilitates participation, openness and community, in ways that might appear absent in conventional innovation and even education systems. They are therefore very relevant for innovation democracy, self-actualisation and community resilience.

A striking example of social innovation through makerspaces ins in the case of Fab Lab Nerve Centre in Derry and Farset Labs in Belfast Northern Ireland. These were funded by the European Union Peace Programme with 1.37 million, of which capital costs were 35,000 euro. The labs were conceived to contribute to reconciliation and peace building by giving marginalised groups in Northern Ireland access to the designing and making tools to explore and develop entrepreneurial skills. The success of this initiative is still to be evaluated.
The maker network in the UK is connected internationally. There is evidence of an understanding of the global movement from within the UK context, both locally and nationally. Recent work carried out by the British Council’s Hello Shenzhen project establishes a bilateral residency exchange programme connecting makers in the UK and China.

Nesta also commissioned the Living Research report which documents the developing maker movement in China and the Arts and Humanities Research Council / Newton Funded research project China’s Creative Communities: Making Value and the Value(s) of Making (Rossi, Marshall and Julier, 2016) explores the movement, with particular attention paid to policy and private investment focusing specifically on makerspaces as accelerators and incubators for product innovation in the Chinese context. Furthermore, academics including Prof. Daniel Charny have contributed to understanding the movement in the UK and internationally through The Maker Library Network in collaboration with the British Council.

This project connected designers and makers around the world and facilitated knowledge and skill exchange amongst professionals and encouraged public engagement with making (Bates 2017). International exhibitions celebrating examples of practice from the UK and beyond include The Power of Making at the Victoria and Albert Museum (2011). There is ongoing support from the Crafts Council (UK) aligning with its Make:Shift:Do initiative in partnership with the Victoria and Albert Museum and Institute of Making at University College London. Events take place across the UK at makerspaces, Fablabs, museums, libraries, galleries, and universities and include an internationally diverse range of speakers and initiatives. The maker culture in the UK is therefore healthy in terms of outward looking engagement with international parties through bilateral projects and through research and knowledge exchange consortia as exemplified in this consortium and the projects cited above.

See: http://creativeconomy.britishcouncil.org/projects/hello-shenzhen/
See: http://creativeconomy.britishcouncil.org/projects/living-research-making-china/
See: The Institute of Making at UCL is contributing to the discourse around making in the UK through its Open Workshop Network, Maker Assembly.
One of the key requirements for makers and OD&M enterprises is access to tools, equipment and space. The most popular tools used in maker spaces surveyed are:

- Bench mounted tools
- Digital fabrication including 3D printing and Laser cutting
- Electronics
- Fabric processing
- Vinyl cutting
- General hand tools
- Metalwork
- Plastics
- Woodwork – including CNC Routing

In addition to manual skills and handcraft, the spaces offer facilities and training in digital contexts including:

- Arduino
- Auto Desk Fusion 360
- Cura
- Computing
- Raspberry Pi

As mentioned above, these tools are prosumer tools. Prosumer tools can be described as tools that both consume and produce with self-fabrication capabilities, often these have a digital orientation. Digital fabrication technologies are often supported by open source software. There is also strong evidence of DIY, customisation and cultures of hacking of the tools within the maker movement. The ability to hack, or customise these tools demonstrates increasingly sophisticated levels of competency and understanding of the tools and the user’s agency in application and processes that are used in the maker spaces.

Analogies can be made to the professional craftsman those who might traditionally make their own tools. This practice demonstrates command over process and production. All tools requiring messy space, health and safety guidelines and specialist training are managed within the space by coordinators and trained members. Members are trained through varying levels of induction and formal classes. These are not regulated in the same way that training in the HEI context is where students will be put through various levels of induction in a course and often assessed on how effectively they use equipment through assessment of projects or skill based exercises.
A strong ethos of **collaborative consumption** exists within the OD&M context. Tools are shared openly within the community of designers and makers. There is a principle of facilitating distributed manufacture across the Fab Lab network within this network spaces operate again on open access and open source principles.

> **Blackhorse workshops provide shared tools and machinery, and skills development for those transitioning from education to business. This includes supporting freelance creatives from architecture, product, set design, furniture makers, joiners and carpenters. Through this new focus the space has attracted a number of design based makers who want to develop craft within their product practice**

(Harriet Warden, Creative Director Blackhorse Workshop)

**Learning to learn is paramount in the pedagogy of a makerspace.** In this sense, the great majority of learning is project-based with relevant skills, methods and information being explored in relation to an aim. The learner is required to negotiate their own journey and these journeys are often ‘hyper-linked’ where online resources – instructional videos and forum – form the resource to infrastructure a project.

> **Much of the learning comes from peer-to-peer exchange and support. The workshop manager also has 40 years experience in tool engineering and shares a lot of their expertise. Blackhorse are also a member of the Owl network - a network of makerspaces in London who meet once a quarter. The network provides an opportunity to find out from fellow makers how to make things work and to address issues focussed on best practice and concerns around health and safety. Currently there is no regulation in this sector which remains challenging. With no precedence for this work, there is a learning by doing approach’**

(Harriet Warden, Creative Director Blackhorse Workshop)
The spaces are non-regulated in character and offer a site for exchange, fabrication and knowledge creation. The type of learning that takes place in the maker context is by its nature non-formal and identified through a general shift from a ‘sit back and be told’ culture towards a ‘making and doing’ culture (Gauntlett 201:8). Learning through making serves multiple functions in learning. It is used to experiment, to prototype, to prove, to materialise, to manufacture, and to embody learning. It’s about learning skills of the hand, the eye, the technique, the ritual, and of judgment. Judgement is honed through reflection on personal engagement but strategies for reflection and recognition of learning are what the HEI experience can offer non-formal learning approaches within the maker culture.

The role of proximity between researchers, students and professionals in art, technology and entrepreneurship is an important feature and motivation for learning. Here proximate learning exchange and transfer are key. Makerspaces function as a learning space that enables participation and the cross-pollination of ideas and procedures - again not too dissimilar to a studio culture that might be found in UK Higher Education art and design courses. However, increasing pressures on resources and space in universities is having an adverse effect on studio culture and the peer learning and socialisation that takes place within studio based learning increasing pressures on resources and space in universities is having an adverse effect on studio culture and the peer learning and socialization that takes place within studio based learning.

In the makerspace context, users all bring different skills to the table - this is something acutely distinct from a HE courses in art and design where recruitment processes level the diversity of a cohort and standardise the skills and competencies that come into the course, to an extent. The plurality of skill and profiles in the makerspace is a distinguishing feature. Also, there is not a complex, formal, test-based certification system, but rather apprenticeships and learning by doing. Non-dangerous machines can be used after inductions and in some cases online tutorials. Users just show up and cooperatively share machine time with the other members of the community, meaning that there is time to talk to other users, to learn by trial and error, to inspire each other, exchange ideas and experiences. This gives the members freedom to learn based on their own interests and curiosity, and to be inspired by others who may be professionals from a completely different field.

By using high-tech design and manufacturing tools (3D printing, CNC milling, embedded microcontrollers etc.) the makerspaces provide users not only with basic construction equipment, but enable them to meet high design standards with their fabrications. In doing this, sketching, prototyping and idea generating is not limited to the format of the traditional academic (or design) workshop where sketches and post-it notes compete for attention. Instead, users are able to fabricate functioning prototypes, artefacts and installations to be explored and examined in a diversity of use situations and contexts. This challenges dogmatic design process models.
In some respects, this process is more akin to agile prototyping and project management methods developed in software and web 2.0 rather than the divergent and convergent design processes typical in HE 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.

Most importantly, as a site for learning, makerspaces are social hubs (Dyvik 2013). They connect people and ideas. This environment functions the accessibility, openness and freedom to try out new ideas and brings the best out of the learner. This atmosphere becomes contagious within the making culture and people willingly share ideas, techniques and knowledge with each other.

A user who comes into a makerspace with one specific goal might end up going home with a lot of unexpected inspiration and new collaboration partners. Learning is therefore action-centred but the self is always framed as a site for learning. This is common in both formal and non-formal contexts.

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Making is embraced as the tangible representation of the relationship between imagination and skill. Making is a way of understanding the world. Making is an ontology - our relationship to what we know and to the generation of knowledge. It is orientated towards embodied and tacit knowledge. Everyone needs to have the right to make but having access to making isn’t enough. There is need for reflection on capabilities’

“Blackhorse also host show and tell feedback sessions where people have the opportunity to talk about their product. Issues discussed include: how to fund a product using Kickstarter; what products are successful and how much to charge for jobs. This is a good way to get people to connect”

(Daniel Charny, Professor of Design, Kingston University and Director, From Now On and Fixperts)

(Harriet Warden, Creative Director, Blackhorse Workshop)
The space for failure is also very important. Unlike many traditional knowledge institutes, failure is welcome in the maker context as long as you make sure you and others learn from it (Dyvik 2013:153).

“
You learn through perseverance, you don’t start as a good maker – or start with the ability to see solutions. Failure is a key part of learning and making is a magic way to learn that failure is always there and part of this process.

(James Tooze, Royal College of Art)
”

In this way, it is not only by providing technical equipment and skills - or being a hub transmitting ‘how-to’ knowledge - that the makerspace as a learning environment has unique advantages. It is rather through the creation of a site of exchange enabling face-to-face interaction and what Ingold (2010) describes as creative entanglements with materials; or rather entanglements and manipulations with hybrid associations of technologies, materials, bodies and minds. In this way, the makerspace as a site for learning offers a space for material experimentation and engagements that exceed the emphasis on text and visual representation that normally forms the pivot of academic development in creative education.
1.2 - Makers in the UK: skills, competences and learning contexts

Formal learning

This section explores the where and what questions: where does learning take place and what learning and teaching strategies are employed in a formal learning context? Formal learning takes place in an organised and structured environment, specifically dedicated to learning, and typically leads to the award of a qualification usually in the form of a certificate or a diploma. This includes the systems of general education, initial vocational training and higher education.

In the UK, formal design and making education is delivered primarily through the Higher Education university system and specifically through Art and Design courses. Art and Design curriculum is part of the UK national curriculum at GCSE and A-Level level. Focused programmes also exist as BTEC professional qualifications. The political context in the UK is affecting Art and Design curriculum as there is an increased governmental focus on Science Technology Engineering and Maths (STEM) subjects. As a result, the uptake of creative subjects at secondary school and consequently Further and Higher Education is being challenged. The number of students entering this type of educational journey is declining since art and design is not typically considered a STEM subject within the UK system.

A Foundation Diploma in Art and Design offers students a route into undergraduate study. Here students typically explore a broad range of making and creative subjects and practices before going on to undertake a Higher Education course.

Higher Education courses that focus on making and OD&M are typically in the 3D design subject area. This is exemplified by 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 and Design and Innovation. Digital manufacture is also explored in Computer Aided Design courses and physical computing and digital manufacture is explored in Interaction Design programmes. Our research has also shown that open maker/fabrication/digital practice is practiced across many different arts disciplines arts, performance, fashion.

To date there are no UK courses at undergraduate level that solely focus on OD&M. Such content will be introduced and delivered through curriculum within the course types listed above.

While there might not be dedicated courses, there are dedicated initiatives found throughout the UK HE context. These are within universities that foster making culture and training through extracurricular or elective modes. These are delivered as projects within institutions, as communities of practice and often have access to physical spaces that facilitate the making.

For example, as mentioned previously, The Institute of Making at University College London is a multidisciplinary research club for students and staff interested in the material world. Its mission is to provide all makers with a creative home in which to innovate, contemplate and understand all aspects of materials and an inspiring place to explore their relationship to making.

The Shed at the University of Kent’s School of Computing is a stand-alone open access workshop established to provide space for students to work on practical projects. Its resources include CAD, CAM, turning, 3D printing, electronic PCB design, laser cutting and mould making. Students and staff use The Shed not only to build physical devices within taught modules, such as the Internet of Things, but also to support and develop their own personal interests and hobbies.
The Digital Maker Collective at the University of the Arts London is an open group of University of the Arts London staff, students and alumni who share common goals of exploring digital & emerging technologies in the context of arts, education, society and the creative industries. The Collective meets regularly through interdisciplinary interest-led group meet-ups, gatherings, activities and events in collaboration with the arts/tech sector and industries. Recent activity has been carried out with the Tate Exchange where the Collective explored related connections across digital projects, concepts and technologies through creativity, digital experiments, performances, interventions, and conversation and new work and ideas were developed through informal student-led critiques, debate and reflection on-site and online.

These initiatives share a character of open and distributed learning. These cultures in the HE context facilitate collaboration and interaction specifically through making - between staff, students and external actors. This affords a culture of proximate learning and staff from across various levels and competencies come together in a community of interest.

While perhaps non-accredited, these initiatives exist within the regulated HE sector and will often align with the strategic aims of the institution and feed into student experience and the university culture. These are measures that are increasingly important in contributing to how UK institutions are monitored and quality assured.

Outreach is a salient value within maker culture especially in the HE context. Again because of the current political climate in the UK and the move to STEM subjects, creative universities are working harder than ever to communicate the cultural and economic value of an arts education. Outreach activities are facilitated through makerspace and collectives. University fab labs and public programming are used to support university outreach programmes and act as a site for learning for those students engaging in outreach activities.

For example the resources within the Fab Lab Plymouth, at Plymouth College of Art, are utilised by students across their range of study programmes – including undergraduate and postgraduate students, pre-degree (Extended Diplomas, Foundation Diploma), and importantly arts clubs that engage students from age 9-16 in Saturday and after school clubs. Additionally, Fab Lab Plymouth is opened up to local businesses and members of the public each week during certain times, therefore acting as a site for proximate learning.
The Invention Rooms at Imperial College London is an initiative funded to work with students from 5 locally identified Widening Participation (WP) schools with the initial intake being one hundred 14 - 18 year olds over the course of a year in groups of 20. Each group will have a total of 14 contact days within the space which is split into 2 days as an introduction to the space then 1 evening each week (which is divided into the first half as skill development in a specific area and the second half to focus on the students’ self-directed project to embed skills) with a final day for student presentations. 1 session will be used to focus on ‘soft’ skills such as presentation skills and material costings with a business focus. Students from the 5 WP schools can self-apply to the initiative through an online application process. Student skill development is based on the use of a ‘passport’ i.e. once a skill is accrued they have the freedom to employ it independently. The sessions are led by a postgraduate ‘lead’ and supported by subject specific undergraduate mentors (around 2/3 per cohort of 20). Within the space there is 1 current staff on-site plus an outreach team made up of 1 technician and 1 lab assistant. The first cohort of 14 -18 year olds will start in September 2017 with the aim to start a programme for 11 -14 year olds in January 2018.

The University of the Arts London has ongoing collaborations with Fab Lab London, Blackhorse Workshop and Tate Exchange as part of strategic and outreach initiatives.

“Blackhorse Workshop has also worked with local schools and has collaborated with UAL on a widening participation project ‘Design Untitled’ - housing students in the workshop space with guidance from the on-site technician. They have also been involved in some research projects organised through Kingston University. The space is often visited by people who are interested in understanding more about how the space is run, and they have strong links with the Crafts College in Stratford who refer students, though there exists no formal link. Through the newly built education space, the plan is to focus more on working in the community, schools and groups.

(Harriet Warden, Creative Director, Blackhorse Workshop)
There are challenges in developing and sustaining these relationships however. A lack of funding and costs can inhibit openness and the opportunities that learning through the spaces offer:

"It was envisioned that through the development of UALs in-house maker community, the Digital Maker Collective would offer an opportunity to build relationships with other makerspaces. Although this was not the case, makerspace were commissioned to run staff training & away days for college staff & students, but it has generally been harder to build sustainable relationships. It is questionable whether this disconnect, which was not expected, is symptomatic of relationships being funding led. Put simply, with limited funding it is questionable whether collaboration will happen. Since the Digital Maker Collective is funding poor it makes it harder to form sustainable relationships. A further hindrance to student engagement is that students can’t afford the new prices set by fab labs to access their spaces. On a positive note however, the collective has been successful in building engagement with more community level organisations such as South London Raspberry Jam - a community network of parents & children. The relationship is built on mutually beneficial exchange of shared interests, experience and resource"

(Harriet Warden, Creative Director, Blackhorse Workshop)

Other initiatives are emerging in the UK that advocate and train university students, teachers and school children in making and its potential. One of the most pioneering examples is Fixperts who work in HE and school contexts. This initiative has developed a technical STEM qualification to introduce creative problem solving. Values are articulated through making lesson plans and club type workshops that combine imagination and skill, and are framed in creative and critical thinking. This range of programmes is developed to suit both primary and secondary schools, from hour-long workshops to term-long projects. A Fixperts project offers students the opportunity to engage with problems taken from the world around them and work in teams to research and develop solutions, sketch out ideas, model prototypes, and make a final product. The process develops a host of valuable transferable life skills such as empathy, creative problem solving, collaboration and communication.
From an analysis of the survey, interviews with academics and observations of learning and teaching, we propose six salient categories of learning methods within the OD&M context.

**Learning to learn:** Students are explicitly positioned as active participants in their learning. Staff will rarely provide answers to questions; instead students are guided to reframe questions and leverage a distributed network of actors to define and execute projects. Thereby, the students’ knowledge and critical skills are extended through project-based and self-initiated research.

**Learning through doing:** Teaching strategy has evolved through a clear commitment to ‘learning through doing.’ In this sense, the great majority of teaching is project-based with relevant skills, methods and information being explored in relation to a specific aim.
Collaboration: Makers have always collaborated, whether to realise projects beyond their own capacity or skillset, to explore new avenues of enquiry, to extend their creative knowledge, or more generally in working closely with their clients and customers. Therefore, collaborative and entrepreneurial learning is encouraged and this is taught within the HEI context.

Distributed learning and signposting: Makers learn across the city and its distributed resources, here signposting and directing the learner to relevant resource is key.

Online learning resources: In both formal and non-formal contexts, online learning is important for personal development and as a site for knowledge exchange. Within the HE context, virtual learning environments act as a site for communication, a file repository and for information dissemination. Resources such as Lynda.com are accessed through institutional subscriptions and provide access to a range of training programmes to develop skills in design, business, coding and more. In non-formal contexts, a more effectuated model is adopted where sites such as Instructables, YouTube, maker forums, iItunes University and Massive Open Online Courses (MOOCs), for example the Auto Design University, are used to develop skill.

Problem posing - learning through situated projects: The use of situated ‘live’ projects are a common teaching method especially in the formal context. Briefs are formulated around specific problem contexts and with structured making and design processes as part of the curriculum. There are also clearly defined deliverables and learning outcomes set at the relevant educational level. Case examples where OD&M has been introduced into the HEI context include the MA Industrial Design at UAL, Central Saint Martins collaboration with the Public Collaboration Lab (2017) that explored the function of makerspaces and co-design through parametric design tools to address the local challenge of overcrowded living in the London Borough of Camden. Also, the RCA collaboration with Formlabs in their Bench-top Factory project which explored desktop 3D printing the Design Products Exploring Emergent Futures (EEF) platform. The project involved students creating their own mini-factories following the manufacturing process from concept to product and, in doing so, developing small-scale systems capable of making a diverse range of products. The MA students were offered the invaluable opportunity to experiment with cutting-edge technology, exploring real-world and future-focused applications of 3D printing and, in the process, honing new skills.
Many co-making spaces provide a platform for education and skills training where skilled makers teach or mentor part-time and form a core group of third sector educators. An example of how HEI art and design schools are starting to explore in-house makerspaces is in the development of the CCWs new Collaboration/Maker spaces is a formal learning and teaching experiment which will test how collaborative maker culture and shared makerspaces can support new cross-disciplinary practices across the colleges. Many of those affiliated with the co-making spaces audited were teaching in some capacity - paid and/or unpaid in adult education and with specific communities, providing training in areas not covered by the mainstream curriculum.

Open access co-making spaces often operate as ‘libraries’ by providing skills training and becoming a social amenity. Most co-making spaces, whether employing paid staff or not, rely on experienced makers and managers in developing their education and training programmes. They can provide access to skills that are important in construction, design and technology. These skills may support professional development, social integration and general wellbeing.

Considering the diverse profile of makers, they are a potential target for academic OD&M training courses and there is the opportunity to diversify the portfolio and offer life-long learning and self-actualisation opportunities to those beyond typical HE students. However, these ambitions are always constrained by the fee structures in place at universities but there is scope for course development with commercial backing or nomadic courses that are managed through the HEI, yet work with the maker culture that might exist within any given locality – a potential franchise model that facilitates the non-formal learning characterised later. It is important to strengthen the university offer so it becomes more attractive to makers. The open and collaborative nature of the movement, which is not so easily facilitated in a structured educational infrastructure, needs to be embraced.
Non-formal learning

Non-formal learning takes place through planned activities (in terms of learning objectives, learning time) where some form of learning support is present e.g. student-teacher relationships. It may cover programmes to impart work skills, adult literacy and basic education for early school leavers. Very common cases of non-formal learning include in-company training through which companies update and improve the skills of their workers such as ICT skills, structured online learning e.g. by making use of open educational resources, and courses organised by civil society organisations for their members, their target group or the general public.

Makerspaces in the UK function as an experimental facility for research, innovation and learning by providing a space that affords close proximity between users, producers, technologies and materials. Therefore, the maker profile is made up of people who are first and foremost curious. Members learn through and innovate in the space. UK makers engage with open design to learn and close to 70 percent of makerspaces offer classes to users, while just over 60 percent have their own school programmes. There are introductions to 3D printing, boot-camps for Arduino, masterclasses in throwing clay and even classes in so-called ‘mind hacking’ (Sleigh, Stewart, & Stokes 2015:5).

<table>
<thead>
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<th>YES</th>
<th>NO</th>
<th>I DON'T KNOW / PRACTICE THIS</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>IoT (Proprietary RFID, NFC Sensory etc.)</td>
<td>10.53%</td>
<td>52.63%</td>
<td>36.84%</td>
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<tr>
<td>IoT OSH Open Source Hardware (Arduino etc.)</td>
<td>50.00%</td>
<td>36.36%</td>
<td>13.64%</td>
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<tr>
<td>Digital Manufacturing (3D Printing, Lasercutting, CNC etc.)</td>
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<tr>
<td>3D computer graphic design (CAD, CAM) with proprietary or open source software (Sketchup, Solidworks etc.)</td>
<td>52.30%</td>
<td>33.33%</td>
<td>14.29%</td>
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<tr>
<td>Digital modeling (with scanners etc.)</td>
<td>38.10%</td>
<td>42.86%</td>
<td>19.05%</td>
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<tr>
<td>Crowdsourcing (co-design, crowdsourcing, contest etc.)</td>
<td>30.00%</td>
<td>90.00%</td>
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</table>

Table 2: UK OD&M Maker Survey Response: Learning through makerspace training activities
Knowledge, skills, competences learned at the training sessions in makerspaces, companies and in other organisations

Our survey of makers and coordinators indicates that knowledge, skills and competencies learned within the maker culture focus on:

- 3D printing and machine training
- 3D scanning
- CNC machining
- CNC milling
- CNC production and machine training
- CNC routing
- Computer Aided Design (CAD)
- Creative coding and physical computing
- Design for CNC
- Fundraising
- Fused Deposition Modelling
- Laser processes and training: Laser cutting; Laser engraving
- Robotics
- Vinyl cutting
- Woodwork, metalwork and assembly

“A good measure of understanding and skill is the ability to hack. This shows competence.”

(James Tooze, Senior Tutor Design Products Royal College of Art)
Attributes that are present and developed within the culture include:

- **Agility**: The ability to embrace rapid change and retain an open mind.
- **Effectuation**: The way of thinking that serves entrepreneurs in the processes of opportunity identification and new venture creation. Effectuation includes a set of decision-making principles expert entrepreneurs are observed to employ in situations of uncertainty. Situations of uncertainty are situations in which the future is unpredictable, goals are not clearly known and there is no independent environment that serves as the ultimate selection mechanism.
- **Enterprise**: The mind-set that takes measured risks and perceives and creates opportunities, as well as the resourcefulness to pursue these opportunities in an ethical and sustainable way.
- **Resilience**: The willingness to adapt and remain motivated, overcome obstacles, and deal with ambiguity, uncertainty, and rejection.
- **Collaboration**: The understanding and working with the collective skillset of yourself and others.

Technical operational skills are introduced through training programmes, courses and through demonstration. These courses are as diverse as the spaces and the makers in them. Skills and competencies are known through the community of practice and the community offers a measure of quality. Spaces with a digital manufacture orientation will run sessions on design for CNC, design for laser cutting through introductory sessions in vector CAD programmes. CAD software packages such as SolidWorks and AutoDesk Fusion 360 will be introduced through training sessions pitched at the complete amateur though to more sophisticated user. Makerspaces will also run training and education programmes.

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23 Such courses include: Learn Components and Moving Parts in Fusion 360; Arduino Controlled Automaton: Intro to Making - Level 2B; Opendesk Chair: Intro to Making – Level 1, 2 and 3

24 See for example: Makerversity DIY http://www.makerversitydiy.com/lessons/
1.3 - Open design and manufacturing: the point of view of enterprises

Innovative manufacturers

An open innovation agenda seeks to insert makerspace creativity into global manufacturing circuits. The movement is seen as somewhat disruptive in terms of a design paradigm as it challenges conventional modes of production and consumption, and new design cultures and businesses are emerging from the movement. There are a range of innovators in the British context that exemplify this entrepreneurial point of view. Examples include:

**Opendesk**: Opendesk offers a local platform for global making. The platform has a global network of makers and a collection of furniture by a range of designers. Because that furniture is designed for digital fabrication, it can be downloaded as a digital file and made locally — on demand, anywhere in the world. The company term this “Open Making”, where designers get a global distribution channel, Makers get profitable jobs and new customers and the customer get designer products without the designer price tag, a more social, eco-friendly alternative to mass-production and an affordable way to buy custom made products. Following crowd funding in July 2014, Opendesk is part-owned by members of the community, including designers, makers, customers and private investors. Key partners include AtFAB, Colektivo, Impact Hub, Machine Made, Matter Machine, ShopBot, SketchUp; as well as many of the designers and makers on the site. Opendesk has also been backed by a SMART Development of Prototype grant from Innovate UK and by Telefónica’s Wayra accelerator programme. The team also owns and operates the digital fabrication directory FabHub. Three of the founding team were also co-founders of the WikiHouse open source construction set. Through encountering CNC manufacture and realising that sending design files would enable local manufacture the original premise of Opendesk was formed.

The business developed through approaching companies directly but recent links with Greenpeace and Google have lifted the visibility of the company. They are clear in that they are not a design studio but a platform/market place for workspace furniture.

Initially, although they never publicised it hugely, the Opendesk platform was open to the public who submitted ideas with no design restrictions which were to be crowd ‘favourited’, but this led to a large and varying amount of designs being submitted.

Initial products were purely bespoke designs for clients but the platform has developed to be more ‘curated’ in terms of a specific product range, as well as to elevate the customer experience. The platform connects customers to makers, designers have no interaction with either the makers or customers.
Opendesk operates on a blended income stream from funding and from product sales. It has a core staff of 26 (with 3 being part-time, 1 remote worker in Vancouver developing their global maker network and 1 freelance service designer).

Given that Opendesk operates to a ‘workspace furniture on demand’ philosophy and that there is demand from customers to purchase designs, the need to source reliable local makers is key and has presented issues in insuring consistent quality globally. The local manufacturers set the pricing for the products (which at times can be inflated) with 30% going to Opendesk and 8% to the designer.

Opendesk are developing their parameters as what is ‘open’ and what is ‘protected’ as they have encountered issues around IP and copyright, not related to their design drawings (as these are open) but to their website platform content which has been replicated on other commercial sites. Whilst the company is open to sharing, there are commercial and product cost implications that have to be considered.

Opendesk includes themselves in the OD&M paradigm as digital fabrication is directly linked to the companies USP. Whilst accessing the maker community helps to support the development of the business, Opendesk want to develop the practical and sustainable elements to local manufacture.
**SAM Labs**: Founded in 2014 by Joachim Horn who, after studying mechanical engineering at Imperial College London, wanted to explore how to share the skills learnt through HE and make them more accessible to everyone. Through exploring how electrical components can be simplified, the development of a visual language and the ‘blocks’ came into fruition. SAM Labs was initially funded through a Kickstarter campaign in which the target of £50K was superseded, raising £120K for prototyping tools based around the Internet of Things. Once launched, the education sector and children were found to be the majority users of the kits, so SAM Labs focused on empowering children within STEM (science, technology, engineering and mathematics) fields, working with the Science Museum to develop hardware as well as teaching and learning methods for education.

SAM Labs developed a strategic focus on making learning coding and programming skills fun and engaging through creativity. SAM Labs work with selected retail partners (John Lewis in the UK and Barnes and Noble in the US) with sales of the kits being their primary revenue stream. Current projects include working with the city of Helsinki, who are world leaders in phenomenon and thematic based learning in schools, to develop a framework to enable these concepts with technology. SAM Labs is the tech provider and the project is partnered with Microsoft and Intel. SAM Labs has a current core staff of 30 who undertake all work in house (including graphic, UX, programming, and sales and marketing) to provide a coherent vision and have complete ownership to create a holistic package of software and hardware, which they can then take to market.

SAM Labs include themselves in the OD&M paradigm as they are leveraging the concepts that are key to the maker movement; building, creating, being creative – a constructivist mindset and hope to make these maker concepts more ‘mainstream’. They also aim to break the idea of programming being something you need in-depth knowledge of, and are making it more accessible by having minimal barriers to entry and focusing on the notion of play.
Bare Conductive: Was born out of a student project that gained public interest through the press, rather than coming into conception through wanting to fulfill a specific problem. Initially funded through the Innovate UK and the Technology Strategy Board (£100,000) the company has attracted private investment and launched products through Kickstarter. Bare Conductive’s core business is their conductive paint line. The company currently has 6 additional full-time staff with an aim to grow to 29 core staff. Bare Conductive include themselves in the OD&M paradigm as their existence is a symbiotic one with the OD&M community. Whilst they have to look at ways to protect their main product and its technology, as it is their core business (and their touch board had been copied resulting in a decision not to open source other hardware elements), their approach and attitude towards other aspects of OD&M remains collaborative. Bare Conductive operates within an entrepreneurial setting where turnaround time from idea to implementation can be quick. As the organization grew, Google’s OKR’s organizational structure was employed to set clear objectives that translate to manageable results. The ability of being part of the OD&M paradigm enables them to create unique products taking input from multiple sectors (market, production etc.).
Gravity Sketch: Gravity Sketch is a 3D design software which uses future technologies to push how human interactions happen through digital media. Touchscreens, VR and AR are used, as opposed to a mouse, to facilitate 3D interactions and tool sets. Gravity Sketch came about when looking at the 3D authoring space and how the majority of tools are based on engineering needs, not necessarily what the designer is trying to achieve. It allows the user to always work around what the final output will be and what a machine allows you to do. The company are disruptive in the sense that they challenge the current trajectory of the maker movement based on simple CAD tools based on engineering needs.

The founders of the company graduated with a project that was kind of a prototype and, based on that prototype, were offered a place in the incubator at the RCA. The team started to build a company around the project and found early on that the immersive technologies took a little bit longer to reach mass adoption. They built an iPad version and made sure that they constructed it in such a way that it could scale into the VR version.

Gravity Sketch feel that human input needed to be absolutely paramount to the digital space, and they began to play with different ideas. Their idea is to have a very simple set of rules, and based on those simple set of rules allow the user to exponentially grow their imagination.

There’s only one other point that would be pertinent to it - the idea of being language agnostic to allow a variety of skillsets to have access to these tools. Some of the best CAD tools are still not translated to all the different languages that industries need, and so often what happens is someone will just learn English to make sure they can navigate through those CAD tools.

The company are sharing tools for free. Democratisation of the technology is the core focus, ‘how do we make this easier for people to engage with and access?’. The long-term vision is to offer something like a Google Drive for 3D where everything exists in one centralised place that users can pull out from any device that provides both ease of use and a democratic platform.

“If you make a tool that’s super easy to use, superfast and shortens the product cycle, and on top of that allows you to have free creativity, then maybe this could be a good example of how you can generate economic change through democratic tools. It’s a very long shot for us, we’re a small company but it’s some of the bigger vision that we see.”

(James Tooze, Senior Tutor Design Products Royal College of Art)
Raspberry Pi Foundation: Raspberry Pi was conceived when the founders, who were mostly academics or from manufacturing, came together after they saw a problem in the education system. They identified that the numbers of people applying to university at Cambridge to study Computer Science were dropping. Not only that, the quality and the level of skill that applicants had when applying was also decreasing, and they wanted to fix the problem by trying to provide something that would allow potential students to upskill before they started the course. They started to look at a way to build a device that they could give applicants so they could learn some skills before they started. Then they decided to take it further back and actually move it down the chain, they wanted to improve the experience for children in education rather than just university applicants.

The intention is to democratise computing by making computers as cheap and possible. The open design is accessible and encourages people to tinker, hack and dive into the bare metal, understanding the basics and what’s going on underneath. A computer isn’t just a black box, it is a circuit board with components and it is an operating system and it is a stack and it is all of those bits and there’s so much to learn, but in order to do this you need to start somewhere. The company want people to unravel the layers and start learning about programming, start learning about operating systems, start learning about electronics to dig deeper and deeper and start learning to understand what computer they are using.

Essentially this company and its product encourages prosumption where the user is a creator and consumer. Development boards like the Raspberry Pi existed before but they would cost hundreds of thousands of pounds for about the same spec as a Raspberry Pi. These development boards were made for engineers who wanted to build stuff on it or to run servers etc. - they had a bespoke use. Raspberry Pi has opened this up as it is essentially a mobile phone chip.

As a foundation Raspberry Pi would like to see things like digital making with technology become more normal and broadly adopted across a wider spectrum of people around the world, not just middle-class families in certain areas of England but to democratise it and see it in rural areas, used by disadvantaged children, adults upskilling or reskilling or unskilled adults becoming more digitally competent or even just becoming digitally literate and learning through the resources and programmes.
**Digital Forming:** Digital Forming believes that digital manufacturing technologies, including 3D printing, can enable a better society: Democratizing manufacturing so smaller, localized centers can take off. Enabling independent designers to realize engaging products for consumers. Providing consumers with bespoke products and even custom made medical prosthetics. The Digital Forming Platform is a Software as a Service (SaaS) solution that includes modular options to enable co-creation between the designer and the consumer. The co-authoring dialogue begins with DIGITALFORMING STUDIO. Product designers can import and manipulate geometries using sophisticated modifiers that set up the design templates and boundaries. The geometries are each linked to the materials and manufacturers needed to realize them using an integrated digital supply chain management system. Once your template has been created, it can be uploaded into the platform where the co-authoring process continues.

**Projects by IF:** More and more of the world is connecting to the internet. The things we own, the places we live, the organisations we work for, they all generate and share data about us. We don’t have much control over that at all. Projects by IF Founded by Sarah Gold state that it doesn’t have to be that way. At IF, they make digital services that empower people. They want to develop consent models that mean something and see digital rights become a mainstream issue. The company position themselves as an agile team of designers and developers. Every project involves ‘thinking by making’ – building prototypes to understand problems and approaches. They work as a design consultancy, collaborating with clients to build better products, they have we have a not-for-profit research arm, taking on wider briefs and publishing in the open. If is founded on principles that relate to the digital commons and engage issues of data privacy. They operate from a space within Makerversity around accountability, digital rights, machine learning and privacy. We work as a consultancy, collaborating with clients to build more empowering products, and as a research team, exploring the bleeding edge of trust and design.

Common traits shared between these enterprises is their foundation from education projects. Sam Labs, Projects by If, Gravity Sketch and Bare conductive all started out as projects developed from the educational contexts. They have all been incubated within a maker culture, be it in HE incubators, makerspaces or community makerspaces. They all offer product as platform (with the exception of IF) in this the products and services offer are situated within a broader system supported by social networks where users can share ideas, and contribute to ongoing product development. Here an open innovation model is common.
Knowledge and skills in demand within the UK OD&M context

Companies in the OD&M context focus on agility and resilience and collaborative approaches to working within their teams. They expect:

- Digital literacy
- Good listening skills
- Elements of resilience and the ability to operate in an entrepreneurial setting where turnaround time can be quick from idea to implementation.
- The ability to set clear goals that are actionable.
- There is a need to organise tasks that seem nebulous.
- The ability to set and manage goals to manageable levels.
- Communication with the team to understand whether goals are set with the team’s goals. Continual open conversation with the team to understand parameters.
- Holistic understanding of the team and the capabilities within the team and their needs/requirements in order to meet collectively set/facilitated/curated goals.

Enterprise operating within the OD&M context are looking for:

- The ability to collaborate is valued as the most salient attributes both by enterprises but this is also the perception of makers surveyed in this research\(^2\).  
- Communication\(^2\) with the team to understand whether goals align team goals. Continual open conversation with the team to understand parameters.
- Digital literacy
- Elements of resilience and the ability to operate in an entrepreneurial setting where turnaround time can be quick from idea to implementation.
- Good listening skills
- Holistic understanding of the team and the capabilities within the team and their needs/requirements in order to meet collectively set/facilitated/curated goals.
- Prototyping abilities: Many enterprises interviewed who operate at the high-tech/industrial end see making in OD&M contexts as essential to their research and development process, before outsourcing mass product on of their products.
- The ability to manage competing complex demands. There is a need to organise tasks that seem nebulous.
- The ability to set and manage goals to manageable levels.
- The ability to set clear goals that are actionable.

\(^2\) 21% of respondents rated collaboration as most important competency.

\(^2\) 17% of respondents rated communication as most important competency.
Platforms for experimentation: Maker spaces contain potential for informing the role of universities as not only knowledge producers but as agents offering platforms for experimentation, exploration and re-imagination in relation to real-world technological, social, cultural and material futures through an open and distributed model of provision. Here the university might become a node within the maker culture. This is of benefit, as the collaborative approach is in contrast to the hierarchical and meritocratic structure of academia. Makerspaces make it possible to engage in dialogues across social spheres and disciplinary boundaries in a more agile way than formally structured HE courses might allow. This provokes thought as to what a distributed model of provision might look like.

Open distributed learning: The HE institution working with Fab Lab and maker space networks diversifies its typical cohort. This benefits university outreach initiatives, provides greater opportunities for access to HE aligned education programmes for learners who might not have considered or been interested in formal education. Addressing diversity issues in making and the UK’s creative economy is a nationwide challenge.

For HE student’s the engagement with OD&M culture enriches the student experience, networking opportunities and offers a platform of transition from education into professional practice.

New modes of engagement and the delivery of educational qualifications to support flexibility in HEI operations and present the institution with a widening demographic should be considered. These might include temporary programmes that pop up in collaboration, with makerspace, community or industry in address to a specific thematic problem areas.

Recognition and accreditation of experiential practice through mechanisms of capture and reflections on practice. A huge amount of informal learning occurs in makerspaces. Significant experiential knowledge is present and transferred on a day-to-day basis through social practices of making. In contrast to ‘normal’ design exercises in education, the cases from Maker Culture also blur - intentionally - the distinction between novice users and highly skilled experts.

These approaches both enable students and experts to be treated as equals in mutually inspirational processes where everyone are co-designers. In doing this the build-up and transfer of personal experiential knowledge becomes a key concern. There is an opportunity - informed by the knowhow from within HE to develop mechanisms for capturing and accrediting learning within formal models of validation. This will allow members to credit learning should wish to for example through an open access diploma. This provides opportunities for work based learning/ training for those participating in projects and interacting within the OD&M context.
Innovation pipelines and progression routes. Users of makerspaces tend to be start-ups, recent graduates or those whose business circumstances have changed. Many spaces provide equipment that cannot be found or afforded outside education or employment. The spaces are used particularly by recent graduates who have little access to specialist equipment elsewhere in the city. The emphasis on experimentation development and prototyping abilities in OD&M contexts offer opportunities for the research and development process within enterprise. The makerspace as an innovation lab provides a context for developing product and service before outsourcing mass production.

A knowledge alliance progression route might foster innovation through 2 scenarios:
• Education – Students begin projects in the HE context.
• Makerspace acts as a transitionary space where residency and the environment function as an incubator. A project is developed beyond the HE context in the maker space.
• Makerspace with industry collaboration acts as an accelerator (moving project to market through bilateral activity)
• Enterprise developed (scale)
• HE and makerspaces support and accredit learning through a project (industry sponsor)
• The project is incubated in makerspace with industry support (mentoring or investment)
• Industrial partner benefits from insight developed through the project; any viable enterprise outcome; staff with appropriate skill set.

Input from industry stakeholders and collaborators within a project can also be accredited through a framework to capture experiential knowledge competencies and capabilities can be used to assess learning in a context of work. This recognises the pluralism within this context where users are all on the same project but are getting different things from it.

Considerations for the training program:
• Technical training is present in Industry, HEI and maker spaces. However, development IoT proprietary teaching and digital skills, structured curriculum around CoDesign and crowd sourcing presents an opportunity in all contexts according to survey responses.
• Considering the plurality of interests and thematic challenge based project are perhaps the most applicable form of delivery. Content will always be contextually specific.
• Softer skill sets in communication, resilience, collaboration, effectuation, should be considered in a training programme. The social function of the movement and culture is emphasised in all data: openness, collaborative, sharing, empathy are recurring concepts.
• How do we define Open?
• The is a need for a recognition framework, that recognises skill and attributes developed in through learning in the open context. How do we validate a distributed model of education where proximate learning in OD&M culture?
• Citizen Centred Innovation is of thematic interest to the UK context.
ANNEX: Country Report

II. OD&M Country Report, SPAIN

By Rodrigo Martínez, Aiur Retegi, Itziar González Zuazo, Marcelo Leslabay and Rebeca Cortázor | University of Deusto
According to ‘The Maker Movement Manifesto’\textsuperscript{27}, a maker is anyone who can develop and create new products, bringing positive changes to society and obtaining an economic benefit out of this activity.

In Spain, the maker movement is characterized by an increasing number of people who share the following features:

- An interest in \textit{making their own products} (Do It Yourself - DIY) and in \textit{collaboration} with other people (Do It With Others - DIWO);
- Use of \textit{digital desktop tools} to create new products or objects, replicate elements and develop prototypes (3D printers, CNC milling machines, laser cutting machines, etc.);
- Culture to share their designs on the web and collaborate within online communities, so that anyone can access the information and create products using the corresponding manuals and existing facilities;
- Use of standard design files that allow anyone to send designs to manufacturing services and produce them at scale.

In relation to the OD&M paradigm, the maker movement and its representatives are usually considered as agents who are able to change society’s perception about the benefits of open models, even though the ‘open’ concept still appears to be much focussed on the technological dimension, and the adoption of a broader open paradigm does not seem to be an assimilated concept.

Experts agree that the most significant competence in the maker profile is self-learning, even though academic knowledge in domains such as physics, electronics, programming and manufacturing knowledge are common. Likewise, manual skills in the use of working tools are also relevant. These skills are combined with competencies such as \textit{curiosity, entrepreneurship and tolerance towards error}.

In accordance with the model proposed by Min Basadur, maker profiles are oriented to the ‘gut’ vision of problems. According to this model, divided into 4 profiles (1. Idea, 2. Concept, 3. Development, 4. Prototype), Marc Segarra argues that in his students, he has been able to detect that profiles 1-4 (Idea-Prototyping), are interestingly an exception, highly linked to the maker collective. As an example, he argues that a maker begins his ideation and prototyping process as a game dynamics, which soon becomes a serious game (e.g. James Dyson: a person who gets to make 500 prototypes of his famous vacuum cleaner).

\textsuperscript{27}The Maker Movement Manifesto is part of the book “(Casi) Todo por Hacer. Una mirada social y educativa sobre los Fab Labs y el movimiento maker” edited by Fundación Orange (García S.C, 2016).
As a maker, I look for ingenious solutions with everyday and easy to reproduce materials. I would define myself as a person with ideas that is not limited to having them.

One of the most recurrent aspects related to the maker profile discussion is its weak focus on the business world. In Spain, society in general, and creative initiatives in particular, frequently focus on the concept of legal protection of ideas and work, which constraints the growth of the ‘open movement’; an idea that reinforces the limited penetration of the open paradigm. In the interviews we conducted, the following opinion was collected:

In Spain, therefore, we are witnessing the consolidation of a new generation of self-employed entrepreneurs who design and produce from craftsmanship, but also from high technology. They produce small batches, or unique pieces on special request, characterized by a high degree of customization. In this way, they take advantage of the control of all phases of the process and maintain a direct and personal relationship with the final user, something hard or almost unrealistic for the traditional industry.
When questioned about competencies, resources and values that makers bring to their companies or working environments, the relevance of intangible aspects is frequently highlighted, beyond the specific technical knowledge about design and manufacturing fields. In this sense, the most repeated values are linked to the creative process and innovation (Table 1 shows values mentioned by the makers collective).

While the economic crisis has indeed contributed to boost, accelerate and support the rise of the open paradigm, it cannot be considered as the unique factor. There are indeed other crucial drivers, such as the availability of new production technologies and the possibility of sharing experiences and knowledge through the internet, which have in turn fostered new approaches to entrepreneurship informed by the DIY logic and the maker movement.

In Figure 1, we can see that among the values surveyed in connection with the maker movement in Spain, collaboration (87.2%), openness and accessibility (80.9%), and social impact (72.3%) stand out. On the other hand, the vision of the maker movement as a facilitator of new business models is not considered as particularly relevant by the maker community (2.1%).

Table 1. Competences and values provided by makers

<table>
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<tr>
<th>Creativity/ Technical Knowledge / Digital and Manual Fabrication Technology / Open Thinking / Collaborative practices / Innovation / Critical Thinking / Social Sensel / Prototyping / Change in the innovation process / Ethics/ Value Proposition / Rapid Solutions / Economic Solutions / Contact Network/ Multidisciplinarity / Fun</th>
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Figure 1. Values related to the maker movement. Source: own elaboration.
Survey sample size: 47 surveyed.
Organization and structure of makerspaces in Spain

Technological progress - from personal computer to personal manufacturing - has followed a logical progress, taking as reference platforms and spaces such as FabLabs, Makerspaces and other digital manufacturing laboratories. This fact explains the impact and expansion of accessible technologies. This is the cultural framework of a new model in which open design and manufacturing is making its way. Besides, the Open paradigm is understood as the next step in a chain developed by the ‘Do It Yourself’, ‘Do It With Others’ and the Maker culture, which encourages a model of social construction in which people can feel engaged.

The maker movement makes no sense in Spain without mentioning the creation of its own physical spaces: Fab Labs and Makerspaces.

“In the first stage (2010-2011), spaces with a markedly institutional character are set up, linked to private institutions or universities; from 2011 to 2013, Fab Labs and makerspaces are set up and offer associative or collective models in search of financial sustainability, such as Makerspace Madrid or MADE BCN Makerspace; from 2013 onwards, these types of spaces begin to multiply, both linked to regional initiatives or dependent on municipal institutions, as well as to technical schools or technology centers.

In 2017, makerspaces are more than 40 throughout Spain (Figure 2); most of them are relatively young, so they devote most of their time and effort to identify and build models able to ensure long-term sustainability.

The main targets of the space are entrepreneurs and professionals who want to innovate, from the generation of new ideas to the materialization of new business initiatives, as well as young people and citizens in general, training them and creating an innovative culture for local development, which will increase employability and social cohesion.

Figure 2. Map of FAB LAB, Makerspace and Hackerspace in Spain. Source: Experimenta.
In Spain, there is no clear thematic link to Makerspaces; in other words, Fab Labs, Makerspaces and Hackerspaces do not seem to focus on specific topics or objectives. Even when funds for these spaces come from private entities - such as Fab Lab Leon, funded entirely by a foundation belonging to the company Telice, in the railway industry- activities are not devoted to specific thematic areas.

However, there is a clear link between Fab Labs and educational institutions such as schools and Faculties, linked primarily to engineering and technical domains. Thus, projects that are developed in makerspaces are connected, in some cases, to the area of specialization of the institution: product design, information and communication technologies, electronics.

This point is also reflected in the work sectors targeted by our survey (Figure 3), where 76.6% of the makers mention the educational field as a sector of employment. In terms of industrial sectors, electricity and electronics (44.7%), ICT (42.6%) and wood and furniture sectors (34%) stand out.

Makerspaces in Spain have successfully expanded are around the two most important cities of the country: Madrid and Barcelona. Besides, the regions of Euskadi and the Valencian Community show a relevant number of spaces, in line with the industrial importance of these regions.

The case of Barcelona, that hosts the first Fab Lab created in Spain, is particularly interesting for its Fab City project: an example of city transformation into a productive model, with empowered citizens as leader, that allow to turn cities into local productive places, locally connected. Currently, Barcelona and its metropolitan area host about 25% of the Fab Labs, Makerspaces and Hackerspaces in the country, and the city has become a strategic hub for the maker movement and the OD&M paradigm.

![Figure 3. Sectors of action of the maker collective. Source: own elaboration. Survey sample size: 47 surveyed.](image-url)
The publication ‘(Casi) todo por hacer, Una mirada social y educativa sobre los Fab Labs y el movimiento maker’ by César García (Cofounder of Makerspace Madrid and president of CREFAB - Spanish Network of Creation and Digital Fabrication), one of the leading figures in promoting the maker movement and the OD&M paradigm in Spain, proposes the following Maker Movement Manifesto:

- **AMAKING**: Making is fundamental to what it means to be human beings. We must make, create and express ourselves to feel fulfilled. There is something especially unique about physical things. These things are like small parts of ourselves and embody portions of our souls.
- **SHARING**: Sharing what you’ve made and what you know about making with others is the means by which a maker gets a sense of wholeness.
- **PLAYING**: Play and experiment with what you’re making. You will be surprised, excited and proud of what you discover.
- **EQUIP YOURSELF**: You must have access to the right tools for the project to which you are working. Invest and get access locally to the tools needed to make the things you want. Making tools have never been so cheaper, simpler or more powerful than nowadays.
- **SUPPORT**: This is a movement and therefore it requires emotional, intellectual, financial, political and institutional support. We are the best hope for improving the world and we are responsible for creating a better future.
- **CHANGE**: Embrace the change that will occur naturally as you walk your way as a maker. Since making is fundamental to the human being, you will become a more complete version of yourself.
- **LEARNING**: You must learn to make. You should always try to learn more about what to do. You may become a skilled craftsman or a master, and you will still learn, you will want to learn and push yourself to learn about new techniques, materials and processes. Building your way to lifelong learning ensures a rich and comforting life in making, which will allow you to share it with others.
- **GIVING / OFFERING**: There are few things as generous and satisfying as giving something you have made. Making puts a small part of you on the product. Gifting this product to someone is like giving a small part of yourself. These kind of things are often our most valuable possessions.
Our survey reveals that the educational background in the maker community is very diverse (Table 2); however, 67% of them report university level studies.

It is noteworthy that there are three studies specifically related to the maker collective: ‘Advanced Fabrication Techniques’, ‘Fab Academy’ and ‘Arts and New Technologies’.

Despite the aforementioned remark, programmes and courses are gradually starting to be offered with a specific connection to the maker world, such as the initiative of the University of Cantabria, in association with the Fab Lab Santander; they are launching a Master in Rapid Prototyping and Digital Fabrication (MasterFAB) that tries to bring the open philosophy to anyone interested in technology. The Master is structured and organized into modules: there are four specialization courses that can be combined two by two, leading to an expert diploma (Expert in Digital Fabrication or Expert in Rapid Prototyping) or to the degree of Master in Digital Fabrication and Rapid Prototyping, if all four are completed.

This is a rare example within the Spanish university offer, since most universities only offer short courses or summer courses related to the maker culture, including training in digital fabrication within universities that have their own makerspace or fablab, as in the case of the University of Deusto or the University of Extremadura.

However, the educational offer is essentially beyond university institutions. Over time, educational options related to digital manufacturing have expanded. This proliferation is mainly due to the lowering cost of technology and the increasing demand of professionals in the fields of science, technology, engineering and mathematics (STEM). In this context, Fab Labs and Makerspaces are used as informal peer-to-peer learning spaces. It is very common to find training courses for learning to use equipment, mostly in those spaces that do not have fully dedicated staff.

Table 2. Studies reported by makers in our survey.

Industrial Design / Product Design / IE Executive MBA / Social Studies about Science and Technology / Fine Arts / Fab Academy / Science Marketing / Master on Branding / Business Administration / Computing / 3D Animation and Digital Post-production / Marketing / Architecture / Arts and New Technologies / Prevention of Labour Risks / Scientific and Innovation Culture / Communication Digital Projects / Psychology

María Elena García Ruíz (University of Cantabria) supports this organization as follows:

“The reason behind this distribution, by means of specialization courses or expert diplomas, is based on that we have met many makers with knowledge and technical skills that could be interested in accrediting their training, but they are not accepted at master level studies, as they do not have the access qualification (bachelor degree or similar”
Among the available offer, some examples are:

- **Aulab - LABoral** (Laboral, Center of Art and Industrial Production) has been working during the last years in order to offer Fab Lab services as a didactic resource for schools.
- **Xtrene Makespace Almendralejo**. The non-profit association Xtrene has carried out several digital fabrication workshops, focused on young people, in their premises in Almendralejo (Extremadura). Their aim is to disseminate new technologies related to digital fabrication and electronics across different groups in the region. They have worked with young people, unemployed and elderlies, to try to bridge the digital divide.

In relation to the knowledge and skills of the maker world, they usually come out inherently in other training programs, which may have similar interests. This is the case of degrees related to industrial design or product design, both at undergraduate and graduate levels. Without offering 100% specific subjects connected to the maker culture, the latter is delivered in compulsory subjects in those study programmes, such as: Arduino, 3D design and printing or prototype fabrication.

With relation to the acquisition and transmission of competences, different teaching methods have been identified. In the well-known **ELISAVA design school** there are hours dedicated to mentorship, in which a specialized instructor stays at the laboratory and students can approach him/her to get guidance on their own projects. This role is crucial, as it helps to overcome small obstacles that often prevent students from achieving progress in their learning path.

Additionally, fostering entrepreneurship and innovation is paramount. It is quite usual that during sessions and specific subjects on these competences, contact with the maker movement is considered as a valuable resource. In this way, from the methodological or creative education, the role of the instructor should be that of a facilitator and connector with the maker movement.
However, our exploratory survey addressed to makers reveals that formal training activities are not effective in fostering the key competences of the maker profile (Table 3). These kind of activities mainly foster research skills (27.7% of respondents report that they acquired this competence through formal education), while entrepreneurship and cooperation are scarcely encouraged (12.8%). Likewise, neither are the technical skills typical of the OD&M paradigm gained through formal training, since only 12.8% of the respondents claim to have obtained this competence through formal training.

<table>
<thead>
<tr>
<th>Knowledge obtained during secondary school education or during studies at the universit</th>
<th>Nº Answer</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical / Technological Skills</td>
<td>6</td>
<td>12.8</td>
</tr>
<tr>
<td>Problem solving</td>
<td>7</td>
<td>14.9</td>
</tr>
<tr>
<td>Research skills</td>
<td>13</td>
<td>27.7</td>
</tr>
<tr>
<td>Cooperation skills</td>
<td>6</td>
<td>12.8</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>6</td>
<td>12.8</td>
</tr>
<tr>
<td>Leadership</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>Communication and networking</td>
<td>7</td>
<td>14.9</td>
</tr>
</tbody>
</table>

Table 3. Competences obtained during the formal learning. Survey sample size: 47 surveyed.

Formal education - especially at university level - should be oriented to practical work in spaces such as Fab Labs or Makerspaces, through projects and challenges that encourage students, and thus avoiding an excessive theoretical approach that can demotivate the learners. For example, in the aforementioned MasterFAB, much of the student workload corresponds to a laboratory of development and prototyping, in which students can use the resources existing within Fab Lab Santander to develop their projects autonomously and with the support of an expert instructor if necessary, but encouraging the search for solutions in an individual way or in cooperation with peers.
Non-formal learning

One of the fields in which digital fabrication is presently implemented in a cross-curricular way is throughout primary and secondary education. Tomás Díez Ladera holds the following viewpoint on the influence of digital fabrication in the current educational field:

“Our influence in schools is terrific, we are moving from a model where a computer lab was set apart and not used to teaching different subjects, to a more holistic view of education, using new ways where children adopt everything digital as something much more intuitive. There are plans in Catalonia, in Europe, in the United States, in India where the use of Fab Labs is being introduced in schools; for example, learning geometry through 3D printing leads to much more meaningful learning.”

Similarly, the usual activities of the maker culture are integrated into university courses in the form of workshops, projects in subjects and/or cross-cutting projects (project-based learning courses, bachelor, master thesis), in which the way of learning is generally different from the traditional one (which generally follows a number of linear and pre-defined steps). These activities, typically considered as non-formal, are highly practical and context-dependant: learning is based on the specific traits of each student and the particular project, and from there, the required knowledge is introduced with the personalized help of the instructor.

On the other hand, another type of non-strictly formal education (in the sense that it is flexible and does not adhere to closed curricula) is the group training aimed at acquiring technical skills related to the typical maker tools: the Fab Lab training courses. This type of training, informed by ‘lab-based practices’, allows students to become familiar with digital fabrication technologies, so they can use them safely and effectively. These kind of activities are common in Fab Labs such as Deusto’s, which implements a series of gradual training workshops during the university studies, so that Industrial Design students can gradually acquire skills and make use of different technologies in their projects. The focus of these training activities is eminently practical and highly technology-oriented, but they also allow to get an accurate view of existing technologies and the possible use that designers can make of them. In this type of training, the following teaching-learning methodologies can be found:

- Theory about technology, equipment/tool and type of design/software to use;
- Supervised practical work, in which knowledge acquired throughout the design-fabrication phase is identified.

Non-formal learning concerns learning that takes place through planned activities (in terms of learning objectives, learning time) where some form of learning support is present (e.g. student-teacher relationships). It may cover programmes to impart work-skills, adult literacy and basic education for early school leavers. Very common cases of non-formal learning include in-company training, through which companies update and improve the skills of their workers such as ICT skills, structured online learning (e.g. by making use of open educational resources), and courses organised by civil society organisations for their members, their target group or the general public.
When using this type of teaching method (non-formal learning), some critical points are clearly identified, which are repeated in a general way. Prominent among them are:

- Lack of previous technical knowledge in engineering or technical disciplinary domains; for this reason, the first phase of the training may get longer, requiring technicians at Fab Labs to be very present and near to the learners;
- Lack of understanding of the fabrication process and impatience from learners. There is a perception about activities in a makerspace, such as rapid prototyping, which require adequate time for preparation and fabrication, that participants in these training workshops are often not aware of;
- A sense of lack of time, as students consider that the assimilated concepts are not enough to undertake activities on their own. This is an aspect that undoubtedly clashes with the entrepreneurial view of the makers collective.

Through non-formal learning, makers claim (Table 4) to have developed the ability to do networking (27.7%) and to a lesser extent, leadership and specific technological skills (17%).

As for the type of technical knowledge and technological skills gained (Table 5), practically a third of the knowledge and skill about a specific technique or technology is learned through these processes, in particular knowledge about digital fabrication and 3D graphic design (25.5%).

<table>
<thead>
<tr>
<th>Knowledge obtained through non-formal learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>N° Answer</td>
</tr>
<tr>
<td>Technical / Technological Skills</td>
</tr>
<tr>
<td>Problem solving</td>
</tr>
<tr>
<td>Research skills</td>
</tr>
<tr>
<td>Cooperation skills</td>
</tr>
<tr>
<td>Entrepreneurship</td>
</tr>
<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Communication and networking</td>
</tr>
</tbody>
</table>

Table 4. Competences obtained through non-formal learning. Survey sample size: 47 surveyed.

<table>
<thead>
<tr>
<th>Technical knowledge and skills gained within non-formal learning environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>N° Answer</td>
</tr>
<tr>
<td>IoT</td>
</tr>
<tr>
<td>IoT OSH</td>
</tr>
<tr>
<td>Digital Fabrication</td>
</tr>
<tr>
<td>3D Graphic Design</td>
</tr>
<tr>
<td>Digital Modeling - Scaling</td>
</tr>
<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Crowdsourcing</td>
</tr>
</tbody>
</table>

Table 5. Technical knowledge and skills gained through non-formal learning. Survey sample size: 47 surveyed.
Informal learning

Learning resulting from daily activity related to work, family or leisure seems to be key across the maker movement. It is usual that during trainings offered by makerspaces, a specific workshop takes another direction than that planned, and participants orient their attention to other tools or knowledge. Nuria Robles, Manager at Fab Lab León defends the ability to self-learn through curiosity.

This fact is also observed in our survey, which highlights (Table 6) how the maker collective acquires most of their skills through informal learning across daily activity. For example, cooperation (59.6%) or entrepreneurship (53.2%), that are perceived as crucial skills within the community, are acquired mainly via informal practices.

<table>
<thead>
<tr>
<th>Knowledge obtained through informal learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nº Answer</td>
</tr>
<tr>
<td>Technical / Technological Skills</td>
</tr>
<tr>
<td>Problem solving</td>
</tr>
<tr>
<td>Research skills</td>
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<tr>
<td>Cooperation skills</td>
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<td>Entrepreneurship</td>
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<tr>
<td>Leadership</td>
</tr>
<tr>
<td>Communication and networking</td>
</tr>
</tbody>
</table>

Table 6. Competences obtained through informal learning.
Survey sample size: 47 surveyed.
The main sources of informal learning distinguished in our study are: individual experimentation and interactions among the members of the community.

Experimental individual research is part of the maker’s curiosity main feature and of the evolution of projects towards divergent directions, which bring participants to explore new boundaries. Makers are eager to explore new ways of solving problems by means of existing technologies and experimentation, rather than by theoretical means. Mistakes and failures are integral part of the learning process, and often valued as crucial factors to succeed. Makers philosophy is based on learning by doing. This allows them to gain new insights that they share with the community. It is usual for makers to have some technical background.

On the other hand, the interaction with the community is part of the open character of makers, and this interaction gives meaning to the maker movement and to its connection with OD&M. We cannot forget that the maker movement is based on learning as a shared process: beyond the spaces themselves and their machineries, makerspaces facilitate informal learning among peers. In this way we can distinguish different activities within the interaction process:

- Meetings for updates and information sharing are a common activity;
- Digital information sharing is also a way to access collective knowledge. From the community, many examples of applications can be found, which promote inductive learning. For example, one of the makerspaces has uploaded some open code in thingiverse and they are part of the fablab community. Although contact has been made through makerspaces, no collaborative project has been carried out yet. Their own website is not updated, and this is seen as a major issue by the coordinator in order to make contact with other fab labs (possibly because this would mean they are not active enough).

- Peer-to-peer learning is done via face-to-face meetings with other members of the community. Networking is managed via makers present in the meeting areas, such as laboratories and via mobile groups (i.e. Telegram) by asking for the contact with the required knowledge.

FabLabs and makerspaces serve as informal learning spaces between peers. It is very common to find training courses for the use of equipment in those spaces that do not have dedicated staff. In addition, many of these spaces operate through working groups in which a common topic is set and everyone participates to the creation and learning process.

In those makerspaces linked to universities, their background, related with programming and design, has been useful. Makers who access the makerspace are very different from one another, and each of them can expand the existing boundaries of knowledge. For example, a group of artists might lack some technical resources, but others who lean towards the technical side, may benefit from the creativity related with the poetics of the artistic application, as a new trigger for learning. Another know-how that would be desirable is how to translate projects into business initiatives. Last but not least, interpersonal skills are promoted as a result of teamworking and the need to make oral presentations in order to explain proposals which will have to be funded with all stakeholders’ agreement.
The companies targeted by our research show a number of different business models (Table 7). Thus, the identification of an OD&M's archetype is indeed complex. In this sense, our interviewees are usually involved in distinct activities, but generally related through the use of specific tools that stem from open design and manufacturing (e.g. a business based on changing traditional manufacturing that now uses means belonging to OD&M).

One of the most common business model is based on ‘institutional mentoring’ (local or regional institutions which not only provide funds, but also other services such as training and networking). Typically, two or more partners work on a common idea, applying for funds within programmes for business development, subsequently getting the resources needed to kick off their project. In addition, the open companies interviewed, generally, do not exceed ten employees.

<table>
<thead>
<tr>
<th>Enterprise Name</th>
<th>Core Business</th>
<th>Open part</th>
<th>Non-open part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirikilabs</td>
<td>Consulting</td>
<td>Design models / Technologies</td>
<td>Final products</td>
</tr>
<tr>
<td>The Open Shoes</td>
<td>Physical product</td>
<td>Shoe’s Midsole</td>
<td>Ergonomic studies</td>
</tr>
<tr>
<td>Oskook</td>
<td>Physical product</td>
<td>Design models</td>
<td>Hardware specs.</td>
</tr>
<tr>
<td>Everis</td>
<td>Consulting</td>
<td>Innovation process</td>
<td>Final products</td>
</tr>
<tr>
<td>Cloaq</td>
<td>Physical / Digital product</td>
<td>Programming code</td>
<td>Final products (i.e. robots)</td>
</tr>
<tr>
<td>B-Cook</td>
<td>Physical product</td>
<td>Design models</td>
<td>Hardware specs.</td>
</tr>
<tr>
<td>SICNOVA Group</td>
<td>Physical product</td>
<td>Model parts</td>
<td>Technologies</td>
</tr>
<tr>
<td>Arquimoña</td>
<td>Consulting</td>
<td>Technologies</td>
<td>Final products</td>
</tr>
<tr>
<td>Geko Navsa</td>
<td>Digital product</td>
<td>Programming code</td>
<td>Hardware specs.</td>
</tr>
</tbody>
</table>

Table 7: Interviewed companies details
Other models we analyzed, which come from larger companies, are based on collaboration and service delivery. For instance, a disruptive innovation consultancy gets in touch with entrepreneurs and young talents who seek to develop an idea. As Marc Segarra, expert in entrepreneurship, underlines, this type of model solves one of the problems of the maker collective:

> Experience says that makers must learn to be makers in earnings, to become professionalized. They do not have a business orientation or an orientation towards the use and exploitation of their skills and competences.

Another aspect that should be highlighted is that ‘open’ business models are often subject to evolution. They are open models ready to change, as they are defined as agile and in line with needs that evolve fastly. For example, models evolve according to improvements in the decision-making process. This evolution is usually connected to the increasing professionalization of the services provided.

Also related to the business model, in this case with the business value proposition, how the ‘open’ concept is used in a strategic way is clearly seen, for example, through the use of a specific open technology.

The background of people in charge of the consulted open companies is noteworthy. Typically, the company’s business is not related to the area of expertise of its managers, but rather from interests or hobbies that become business. This is the case in The Open Shoes, where Javier Bustamante, its founder and a journalist by trade, started in the healthy footwear business from a need and self interest, transiting from importing and selling this type of product, to designing an adaptive midsole to ailments and the foot type of each customer.

Another feature of the companies that are considered open or operating within the OD&M paradigm is their frequent nature of consultancy service providers. This is the case of Arquimaña, an architectural studio transformed into a digital fabrication workshop, which, in addition to having professional machinery, advises its clients about their designs, prototypes and models in small batches through self-production. On the same line, The Open Shoes not only provides users with the possibility of adapting their footwear, but it also offers a specific service to shoes manufacturers: the service of embedding these designs in their products; that is to say, the business again is focused on service provision.

There is also another type of company that can be included within the open paradigm, dedicated to disruptive innovation, whose aim is to incubate and offer support to innovative ideas under the Industry 4.0 trend (Smart Industry). This is the case of the Everis consultancy and the Cloqq initiative.
In summary, we can distinguish the following types of businesses in relation to the OD&M paradigm:

- Businesses that are fully aware of the current digital transformation trends;
- Businesses that arise from a process of forced restructuring by the market or the economy;
- Businesses that arise from personal initiatives related to needs and/or hobbies.

Despite the differences observed, open companies tend to rely on horizontal business structures, where the experience and vision of each component of the team is strongly valued and embedded.

An interesting finding related to the origin of the open culture was the—somehow—automatic response: ‘We come from the open world’. Inquiring and delving into this type of claims, there are several cases where people now working in such companies, had previously been developing ICT products based on open source software. In this way, we conclude that the open concept is attributed to a personal philosophy scaled up to the level of the company. However, it is difficult for companies to clearly explain how they are actually ‘open’. This could be due to the confusion that the open concept tends to generate across companies, as it is often associated to ‘free access’. On the other hand, acceptance of this paradigm as a philosophy and not as part of the business (companies adhere to this movement by conviction and not seeking profit) highlights this difficulty.

This means that the type of companies with which makers collaborate are, by their philosophy, companies that are also willing to collaborate with makers. As a consequence, traditional companies become subcontractors or isolated service providers.

As for the types of staff profiles, as well as in terms of educational level, most of the staff in these open companies is aligned to the maker profile: eager to learn, seeking knowledge, and holding certain skills. Companies admit that the technical know-how is interesting; in fact the average education is at university level, although they also claim that the educational level is not the most important issue, but rather their attitude to seek knowledge and their inner capacity to develop projects. Iñaki Muñoz, founding partner of Oskook, defines his staff as it follows:

“We are not eager to accumulate diplomas. We do not care about degrees. What matters is attitude”

However, companies agree that staff must be able to adapt and learn within the business structure. The learning process is done internally, and although it is important for companies, they understand that it is something that employees can do on their own. Thus, companies are concerned with attracting talent, sometimes questioning the need to organize training actions within the company, and even implement training courses to help them acquire specific knowledge and skills.
Among the strengths that the Open paradigm offers, we have identified the following:

- There is a drop in the barrier to development. Now development does not depend exclusively on the resources of companies.
- There is openness towards disruptive innovation. This paradigm entails a constant look towards innovation.
- There is a possibility of greater business development. In terms of business philosophy, this paradigm offers accessible solutions.
- There is no fear of failure. Together with constant innovation, iteration as a key to success is something that is common in this type of business - it is usual for these companies to be working on their second or third business idea.
- It enhances the creative attitude of staff. Employees’ capabilities are now valued in terms of flexibility and adaptability to change, not to the management of specific tools or methods.

On the other hand, we can assume that this kind of companies still have to pay attention to some factors that may harm their development:

- Training makers in specific tools is necessary. These profiles are selected beyond specific knowledge, but are expected to be able to easily manage certain technical skills.
- The maker movement is hobby-related. It is necessary to promote the idea that the maker profile can be scaled up to a professional activity, well-recognized and paid.
- For the maker collective is hard to take the leap to different business models. Greater approach and knowledge of the business world is needed. From the very first moment, it would be interesting to think from a business point of view.

It is true that in Arduino’s network, there are a number of vendors that get a part of the cost, which makes the boards more expensive, but it is also true that these people are responsible for having a stock close to users, for providing local support by means for workshops and talks, for importing boards from places I will never visit after having flirted with the bureaucracy of impossible countries.

Making open things implies a risk, mostly not getting acknowledge of the effort that is invested to get things going.

Several attitudes have been identified in relation to the concept of ‘open company’. On the one hand, companies like Cloqq, The Open Shoes or Oskook affirm that operating within an open philosophy makes them stand out in the market, even though they are aware that this openness cannot be complete, as they have to deal with the economic viability and sustainability of their initiatives. From a more optimistic point of view, the movement is understood as an opportunity to take a stand against multinational corporations, understanding that the core of these companies must precisely lie in the creative capacity and as source of proposals, and not so much in the exploitation of unique solutions.

However, companies that are included in the open paradigm claim that this type of initiatives should have a better response by consumers, as well as by makers who use existing open solutions. David Cuartielles, co-founder of Arduino, contributes to the debate with the following reflection:

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Traditional manufacturing enterprises

The profile of the companies contacted is similar in terms of organizational structure, number of employees and hierarchical structure. The typical employee holds a higher education degree and usually collaborates with expert consultants of varied typology and experience. In this structures, we frequently find a board of directors, together with the roles of financial director, sales director, director of operations and director of commercial services. These structures have a clear organized hierarchy which allows them to be reliable in the decision making process.

These companies understand innovation in a closed and incremental way (the solution is always inside), and they are currently taking the first steps towards a more open and disruptive innovation process. Their perception of the maker movement could be summarized as follows:

"This is a movement that demonstrates day by day that knowledge is accessible and global, that can be shared and enriched by the community, and that is possible to produce locally by means of digital fabrication technologies."

Through the interviews, we conclude that there is a deep understanding of the maker movement, and empathy is even felt towards its features. Interestingly, many traditional companies define themselves as companies informed by the maker philosophy, based on: ‘think, innovate and do things ourselves first. On the other hand, Open Design & Manufacturing is perceived as a driver for stimulating diversity and attractiveness of the offer vis-à-vis the final consumer.

However, there is strong reluctance by traditional companies to collaborate with makers included within the ‘open’ spectrum. Thus, the main focus of the debate is on the opening of developed products and the low competitiveness that this would entail. This point of view was evident in the event ‘OpenMaker is born’, a community-based project that aims at stimulating strategic partnerships between makers and manufacturers under the open paradigm. We highlight the following reflection stimulated by the event:

"One of the main concerns that raised from an intense debate was the ownership, rights and licensing of the resulting products. A workshop tackling all these concerns is needed and will be carried out in the near future."

Again, in relation to the OD&M paradigm, there is some resistance and negative connotations that do not exist when we speak of the maker movement:

"I think it has positive things because it can give you access to people or ideas that you could never even imagine and at the same time, it can be used for good in developing countries. However, I think it can also be a danger, if misused. I would have to think a little more closely about this possibility of working in the open design and manufacturing paradigm."

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In spite of this, the Open concept is understood as a possibility to improve the social impact of companies. In all cases, the opening of their business would mean a greater openness among its target audience, and the improvement of communication and distribution processes; however, the distance generally perceived between the terms ‘open’ and ‘business’, at the moment places the open paradigm as utopia for most of these companies.

Regarding the needs and required profiles, we highlight the need to integrate design-driven profiles in their structures; these profiles are also expected to have a wide diversification. In addition, these types of companies are focused on aspects such as quality and continuous improvement. Marga Valiente, communication director at Enganches Aragón, talks about the demand of profiles of her organization:

“Continuous improvement in the design and development of new products requires that we strengthen the specialized staff to meet all the needs and demands of quality and new products that the market demands.”

It is therefore likely that traditional companies are not directly demanding maker profiles or employees who explicitly have competencies and abilities connected to the OD&M paradigm, even if they could be interesting profiles.

Traditional structures confirm that they get advice through different external agents. In all the analyzed cases, companies are open to outsourcing services, including creative design and consulting services. Although we cannot directly talk about subcontracting maker talent, we observed that part of the contracted services deal with the kind of knowledge, skills and values of this movement. In relation to an understanding of the maker collective, it is worth noting that when a company is not able to identify such profile, they rely on other organizations they know directly, such as universities or research centers.

Regarding their innovation policies and strategies, we noticed that in each case there is an innovation plan in progress, which nevertheless shows aspects linked to short-term innovation. We find especially remarkable the case of Lagun ARO, an insurance company that considers its future as follows:

“We have established a committee of innovation and we are shaping the future of the company in terms of digital transformation, based on three axis (people, technology and new business models).”

Although the traditional companies consulted are interested in the maker movement, through the observation of events, we have also noticed that their main interest is on the Industry 4.0 (Smart Industry) topic. The meeting ‘R&D Ecosystem in Linares for Industry 4.0’ is a great example of how traditional companies, based in a region devastated by the economic crisis and the disappearance of industry, now focus on this paradigm, as an opportunity for relaunching their businesses. Thus, it is interesting to notice the union of the different agents that can promote this change: University, industry (including technology centers) and public institutions (such as the municipality or the commerce chamber).
In the following paragraph, the reasons for the industrial transformation of the region are reported:

“Linares has already become a relevant focus in R&D, since we have an innovative space, the Scientific and Technological Campus, which welcomes a number of important players at the forefront in terms of Industry 4.0, such as the academia with the University of Jaén and the Higher Polytechnic, the Cetemet technological center, public bodies such as the Chamber of Commerce and, of course, a network of technological businesses, made up of new companies trained to work on additive manufacturing, digitized, robotic or virtual reality projects.

Another indicator that allows us to assume the existence of interest of traditional companies towards the maker movement is their approach towards FabLabs and Makerspaces. The Deusto FabLab gets weekly visits from different groups, among which makers and traditional companies stand out. Thanks to these visits, it is common for companies to question: How can they be part of all this? How can they benefit from FabLab resources? How can they get training in the use of specific equipment and machines?

On the other hand, we can point to some initiatives, activities and projects - usually in the shape of challenges - that are being carried out by the traditional companies consulted, in relation to the maker movement and the Open Design & Manufacturing paradigm:

- Elaboration of mold prototypes that allow to fine tune the final design and save substantially on final product manufacturing (e.g. in the metal extrusion industry).
- Elaboration of prototypes for events and trade fairs, whose purpose is only to show advances of catalog, without a functional objective.
- Implementation of conceptual projects aimed at long-term business change, supported by digital manufacturing technologies (e.g. an insurance company that is interested in the development of control devices manufactured through digital manufacturing).
- Activities in collaboration with universities in relation to the open philosophy (for example, a company producing and distributing raw products, which aims to move to the manufacturing of final products through a collaborative philosophy, leaving design in the hands of the user - similar to Opendesk).
- Creation of rapid prototyping departments.
- Allocation of spaces and resources for the implementation of collaborative work dynamics, freely accessible and that allows the company to approach the end user.
Associated with the maker movement and the Open Design and Manufacturing movement, the following needs stand out in order to improve the competitiveness of traditional organizations:

- Improving the agility of traditional enterprises;
- Promoting a cultural change towards digitization;
- Prompting business models towards new trends, such as the collaborative economy, the emergence of new types of customers and the use of different technologies;
- Understanding their business from the consumer experience (Customer Journey);
- Taking care of any item or service with a design component;
- Being ready for the emergence of new technological elements;
- Understanding the different roles that an organization can play within the value chain;
- Participating to and promoting initiatives that stimulate the diversity and attractiveness of the offer to the final consumer.

Finally, as shown throughout this section, we can say that the factors that prevent from the adoption of the OD&M paradigm in traditional enterprises are mainly related to:

- The youth of the processes of disruptive innovation;
- The inflexibility of organizations;
- The perception of the maker movement as a service;
- The fear of adopting an open philosophy in terms of business
Conclusion

In Spain, the maker movement has grown exponentially during the past recent years. There is good understanding and acceptance from the industry, and its origins are linked to the practice of DIY - Do It Yourself. Among the values of the movement, self-learning and collaborative culture must be emphasized, beyond technical skills or knowledge about specific technologies. Although the maker movement is an acknowledged term, the Open Design & Manufacturing paradigm does not enjoy the same condition, as it is not commonly used in Spain, yet.

In the country, we can find a wide range of makerspaces. The Fab Lab network has grown exponentially since 2013, especially in the main cities of the country - Madrid and Barcelona - and in its most industrialized areas - the Basque Country and the Comunidad Valenciana. In these spaces, there is no specialization in an extended way; that is, there are makerspaces that address varied topics in which all types of profiles and interests converge. However, it should be noted that in cases where the Fab Lab or Makerspaces is established thanks to private initiative, these spaces may have a greater link with their founding partner. This happens especially in those universities and faculties that include a Fab Lab inside their facilities (being linked to areas like industrial design, architecture or telecommunications).

The provision of training (formal learning) is scarce and is not reflected by the profusion of maker activities over the last years. Thus, the values of the maker culture are essentially learned within non-formal or informal learning processes, carried out by different agents (universities, makerspaces, public bodies, etc). It is worth noting that there are innovative programs such as MasterFAb (University of Cantabria), which precisely intends to bring the open philosophy to young students. On the other hand, collaborations among institutions in the framework of joint training proposals are common. Therefore, in Spain the values and skills of the maker movement do not come from accredited education.

Although the academic offer of HEIs is scarce, this does not happen with the offer of specific training courses in makerspaces, sometimes in collaboration with other entities. In this way, numerous collaborations have also been detected between universities and makerspaces, although non-formal oriented. It is clear, from our survey, that the abilities and values of the maker movement are largely gained through informal learning processes, highlighting the acquisition of specific knowledge - on tools or technical processes - through micro-training. We can say that, to great extents, makers acquire their skills and competences through daily work.
Companies considered within the OD&M paradigm come from different settings, from the restructuring of traditional business due to economic reasons, to those based on the identification of personal needs or the transformation of a hobby into a business. These companies share a flexible organizational structure that has been adapted over years. Although the profile of the employees of this type of company is at university level, their managers affirm that the desired profiles should have an entrepreneurial spirit and a high capacity of self-learning. Additionally, specific technical knowledge (e.g. coding skills or additive manufacturing experience) is highly desirable. This know-how can be acquired by means of internal training processes. Among the strengths of the open companies, we find the loss of fear to business failure, as well as a drop in barriers towards innovation - now faster and more disruptive-. On the other hand, the maker community must improve its professionalization.

Traditional companies, in relation to the OD&M paradigm, show great interest, as well as distrust for its openness. These companies understand that an open philosophy can help improve their agility and adaptation to the market, as well as being a gateway to new ideas and solutions through collaborative dynamics. The Open concept is understood as a possibility to improve the social impact of companies. However, the competitiveness in terms of business is indeed questioned. It is remarkable the number of initiatives that traditional companies are carrying out, linked to the maker movement and the OD&M paradigm. These initiatives range from the proposal of projects or conceptual challenges using techniques and technologies of the OD&M, to the creation of rapid prototyping departments, which are already working with additive manufacturing. This type of action is carried out, on occasion, with universities and research centers, which are in turn perceived as bridges towards the maker movement. It is necessary to emphasize the acceptance of the maker’s movement against the lack of acknowledgment of the Open Design & Manufacturing paradigm. Traditional companies are used to outsource specific services, such as technical and consulting services. In this sense, the maker movement is understood by these agents as a service that may be required at any moment of the production process. This vision, together with the youth of the processes of disruptive innovation and the inflexibility of organizations, are the factors that mainly hamper the adoption of the OD&M paradigm.
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ANNEX: Country Report

III. OD&M Country Report, POLAND

By Ewelina Widerska, Joanna Kurowska-Pysz, Maciej Witkowski, Paweł Buchwald
| University of Dabrowa-Gornicza
1.1 - Values and principles of the maker movement in Poland

The key values and principles of the maker movement in Poland should be considered in light of its early stage of development in the country. Our respondents consistently agreed that the maker movement in Poland is a new phenomenon and, despite its potential, it is not yet very popular.

The most active makerspaces and making centers in Poland are concentrated in industrial centers, that is, in: Warsaw, the Upper Silesia agglomeration, the Tri-City (of Gdańsk, Gdynia and Sopot), Łódź, Kraków and Poznań.

Despite official information existing on about 50 locations of this type in the country, only half of them can be considered as fully active (Belica 2017). Only 13 makerspaces are currently registered on the Fablabs.io directory; nonetheless, as shown by the observation of makerspaces’ events realized by our study, we can assume that there is a much larger number of organizations across Poland involved in the making culture. These organizations generally operate as foundations, associations, social cooperatives or (student) academic/scientific circles, and are therefore very different from each other.

The involvement of Polish makerspaces in the global maker movement is relatively weak. Polish organizations that perceive themselves as part of the maker movement rarely have direct contacts with counterparts from other countries, mainly because they do not believe that such contact is needed. They mainly look at their activities as local ones, and therefore work with relatively narrow groups of makers (that they often already know) and partner organizations (local enterprises or local government organizations, mainly). To date, there has not been even one Maker Faire officially endorsed by the Maker Magazine. The coordinator of the Warsaw FabLab, which operates at the Copernicus Science Center (one of the most active centers of the movement in Poland), presents the problem in the following way:

“Poland is an empty space on the map of the global maker movement. I have seen this very clearly for many years. In my opinion, in Poland a connection with the global world practically does not exist. There are some random cases or individual cases, and I do not know completely where this problem comes from because I know a lot of people from other European countries who participate to the global movement intensively.”

(Wojciech Karcz, Copernicus Science Center)
During the interviews, people who identified themselves as leaders of the movement made very little reference to its own global character; they usually think that, in their case, it is difficult to say that they belong to a global social movement. Besides leaders, makers as well are often not aware of the global nature of the movement. Their involvement in manufacturing activities is usually described as temporary, while their knowledge of the values of the international maker movement and its social-political goals is limited. According to our study, most of makerspaces’ coordinators tend to perceive themselves as local animators of groups of people who are interested in developing technical knowledge and in applying it concretely. Makers stress that their activities are often improvised and continuously adapted to changing conditions. From their direct experience with the maker movement in Poland, it is not possible to compare the latter with the scale of the same phenomenon observed in the Western Europe. At the same time, we can see that Polish makers are nevertheless fascinated by the overall narrative and storytelling developed within the global movement (especially the ideas of openness and innovativeness, as understood in a wide sense).

Importantly, the Polish language lacks expressions which allow to fully encompass and describe the nature of this movement, its vision, and its typical activities. In order to describe what the maker movement actually is, there is tendency to use English terms that often do not have equivalent meanings in Polish. For a Polish person who is not particularly aware of the maker movement, such terms are hard to be understood, and this actually creates barriers to the further development of the movement across the country. In the course of ordinary, every day conversations, many members of Polish fablabs and makerspaces adopt Polish terms that do not fully transfer the meanings of the English terminology. For example, in Poland, few people understand the differences between makerspaces, FabLabs and hackerspaces. For the purpose of this report, all laboratories which are identified with the maker movement are defined as maker movement centers.

Maker communities usually define themselves as groups of highly qualified and talented ‘outsiders from normal society’ who enjoy only their own company. That is why the representatives of Polish makerspaces insist that advanced social skills, which make it possible to create an integrated micro-community, are so significant for the further development of the maker movement in the country.

Marketing competences enable their creators to adjust their works to social needs. Marketing is perceived as a mechanism that ‘rationalizes’ makers’ otherwise spontaneous actions. Understanding the needs of other people appears as the most appreciated skill.

The makers’ environment is perceived by representatives of companies as hermetic. Sometimes it happens that, despite the generally declared adherence to the value of ‘openness’, a person who wants to join the movement may be rejected or ignored by others. One of the entrepreneurs who sympathizes with the movement said:
The most active centers of the maker movement try to integrate the environment (provide makers with the opportunity to share experiences and support each other) and their striving for this integration is perceived as the crucial value. Especially Fablab Łódź and the Fablab at the Copernicus Science Center make attempts to fulfill this mission. The center in Łódź organizes events that gather representatives of other makerspaces, representatives of the academic environment, sympathizers and professional makers. These events may differ in terms of topics and formats; for example, the event ‘Makers’ Night’, observed by our research, is specifically devoted to networking. The FabLab of the Copernicus Science Center organizes a cyclical integration event called Hackathon. Participants to such happenings usually define this maker movement internal cooperation as ‘casual relationships’ or ‘searching for future cooperation partners’.

Generally, the representatives of the maker movement centers define their role as that of providing makers with non-commercial access to equipment, so that makers can ‘come here and make something’. This is considered as a general assumption which, in practice, takes a number of different forms. For example, the coordinators of PutLab in Poznań (at the Poznań University of Technology), which is the only Fablab in Poland created by students, describes how this space was created:

"The founder is a social activist, he wanted to create a place where (student) scientific circles would be able to work, because not all circles have their own laboratories, or the opportunity to implement projects, and we also provided a great amount of funding in order to give them the chance to implement these projects. So, the creation of this space was a natural step forward. Two years ago, we opened the first PutLab, a room where it was possible to do everything with the tools provided: hammers, screwdrivers, drills, a 30-year old lathe."

(Przemysław Zakrzewski, Centrum Wytwarzania Oprogramowania ABB)

Among the maker movement centers investigated by our research, it is possible to highlight three main types of activities:
• Educational: concentrating on the broadly understood popularization of knowledge (most frequently technical knowledge);
• Inventive: focusing on constructing innovative prototypes of devices and products;
• Revitalizing and cultural: concentrating on the reconstruction and digital archiving of traditional productive techniques, sometimes defined as ethnographical intervention activities.
In the majority of cases, the activities within the movement started less than five years ago (in practice these organizations have usually been functioning for 2-3 years). Existing maker movement centers usually change the formula of their activities, and are constantly searching for sound and viable business models. Some of them, de facto, have not started their own activities yet.

In recent years, the essential input for the development of the maker movement in Poland came from the European Union and the Structural Funds, with dedicated grants for urban revitalizing projects implemented usually in post-industrial districts. In such locations, there is great availability of spaces from former industrial halls and workshops. Municipal authorities – directly responsible for carrying out projects aimed at revitalizing urban spaces - have started to acknowledge the value of makerspaces as alternative places for the activation of local communities.

At the same time, a strong interest in the potential of the maker movement contributed to the development of this phenomenon. However, according to the leaders of the movement, the further integration between different fablabs and other maker groups in order to create a true network of cooperation is vital. Working out efficient operations is also needed. Action strategies are still weakly conceptualized. In many cases, activists are still looking for the best formula for these organizations to work effectively.

The main guiding principle is the widely used (but variously understood) concept of ‘openness’. The PutLab representatives present this principle in the following way:

“We try to create an open atmosphere that fosters conversations because people do not always take it for granted that it is possible to ask about everything, to get to know something, etc. We never refuse this help when needed.”

(Olga Andrzejewska, PutLab Poznań)

The principle of openness is understood differently in the Silesia FabLab:

“If someone wants to develop specific competences, that’s fine for us. That person is exactly our customer, and we want to give to that person the time, resources, space, etc. This means maintaining an attitude of openness.”

(Bogusław Kamiński, Fablab Silesia)
The coordinator of the Września FabLab describes ‘openness’ in a slightly different way:

“
We run a laboratory open to everybody, although not necessarily for free, and our goal is connected with spreading the idea of being inventive and creative using modern technologies, for example, 3D printing, or laser plotters

(Bartosz Kubisiak, Września FabLab)

”

The key feature of social interactions within makerspaces is to maintain egalitarian relationships among members. In particular, all members must have equal rights regardless of differences in formal education. That applies both to access to equipment as well as to how people communicate with each other. Furthermore, community members are expected to take full responsibility when using tools and to take care of their conditions, as well as maintain order in the space. These principles are particularly highlighted in maker centers accessed by young people (according to the survey addressed to Polish makers, the average age is about 29 years old, and the standard deviation is 8 years).

Representatives of almost all makerspaces covered by the research strongly express their non-political nature and the lack of any relationship with broad ideologies. Inside the movement, originality and innovativeness that stem from hard and persistent work are much valued. According to representatives of the maker movement, the key value of their organizations is the rule of ‘sharing’, which differentiates the maker movement from the mercantile values of the business world.
According to the representatives of academic institutions involved in the research, there are three fundamental factors that limit the creation of an educational offer based on the maker culture.

First, the maker movement in Poland (and, by extension, the OD&M paradigm) is not yet very popular, and it lacks any institutional support. Hence, it is not sufficiently mature to constitute a direct target for the Higher education system. Representatives of universities which provide education in the fields of computer studies, art or polytechnic assume that in Poland the demand for these types of study fields for this purpose is low.

Secondly, for educational paths dedicated to those taking part in the maker movement or companies in the ODM sector to make sense, those paths should be based on cooperating with such organizations. However, educational institutions interested in this kind of cooperation generally have to face high bureaucratic requirements and burdens. The vast majority of HEIs in Poland are financed from public funds, and in order to limit the risk of misuse of public funds, there are strict rules over funding reporting procedures. For example, the purchase of expensive equipment requires detailed documentation about its use. Usually, such equipment is bought for a specific person (a researcher) to achieve a particular aim, or for a specific group of students. Therefore, it is difficult to meet these strict requirements if we consider the extent to which fablabs are informed by openness and equality. In most fablabs, the shared rule is that all equipment is available to all participants. Instead, according to the strict framework of educational institutions, such equipment should be used only by certain persons and for pre-defined purposes. It is not permitted for equipment bought with public funds to be used by private companies. Therefore, the preference is for an informal cooperation between higher education and makerspaces.

Lastly, university lecturers encourage their students to make use of makerspaces so that they can be better prepared for their lectures. But this does not represent a satisfactory solution for maker centers, since they still have the problem of finding resources to ensure their functioning and development. Creating new degree courses requires considerable documentation, and accreditation from the national government. Thus, in a short period of time, it is not possible to adapt to the new and niche trend of the maker movement or to consider the OD&M sector as a ground of development.
Nonetheless, there are a number of university initiatives which provide qualifications that are coherent with the maker culture. For example, at the Łódź University of Technology, there are two-semester post-graduate studies in the field of industrial design. Graduates obtain a sound preparation in running their own activity in the industrial design sector. Competences acquired include: knowledge of modern design trends, drawing techniques, digital prototyping techniques, marketing skills and high interpersonal abilities. However, these studies are not aimed specifically at maker movement participants and they do not prepare students to operate under an open paradigm.

During these studies, the project-based methodology (a type of learning which involves students in the creation of new products from scratch) and tutoring methodology (an individual piece of student’s work, but closely overseen by an experienced researcher) are commonly applied. Students are encouraged to take advantage of maker centers, where it is possible to benefit from ‘learning by doing’ which in these spaces often happens via ‘prototyping’, rather than during formal academic classes.

According to Professor Anna Miarka (Department of Interior Design and Industrial Design at Łódź Academy of Fine Arts), the post-graduate studies in product design at this University focus on the ability to identify a need which can be met by a particular product. Students obtain a Degree in Designer of Industrial Models (generally designed become products for mass markets) or the Degree of Designer of Industrial Design. During their studies, students are required to conceptualize and complete their own projects related to new, innovative products.

According to Miarka, the engagement with the maker movement is an excellent supplement to this type of studies. This kind of cooperation gives students the chance to gain practical experience in carrying out a complete project independently. Student-makers create products in Fablabs and eventually implement them for sale. These are generally small series. However, some graduates, such as designers of industrial models, find jobs in the industry and their products are then manufactured in large numbers. Although Fablab Lodz is not the official partner or co-producer of the studies, it plays an important role in the educational process. Miarka describes the process in the following way:

“\nIn our faculty, we work very hard to understand what is going on in the real world. When it comes to technologies, manufacturing techniques, and prototype techniques such as those used in FabLabs, it is normal that we talk about this with our students. Our students start their work from practical activities. In our faculty, we do not theorize. Our students should know how a sheet of paper must be folded and they get acquainted with that by folding themselves this piece of paper. Next, they take scissors and cut it, and next they use the laser plotter and try to do it by means of these devices and tools, commonly available

(Anna Miarka, Łódź Academy of Fine Arts)
During the focus groups held in PutLab Poznań, students involved in the maker movement stressed that taking advantage of makerspaces is a much more creative form of learning than lessons attended in traditional labs at the University. They affirmed that the necessity to complete formally the specified number of practical classes included in compulsory academic curricula has a negative effect on their creativity. Academic courses force students to study rigid procedures that give no opportunity to experiment freely for pure cognitive pleasure. Students also complain that formal education lacks a practical dimension:

“...
We can theoretically learn about, for example, 2000 methods of, let’s say, cutting by CNC, or something, but a student who is able to describe in theory all those methods has never seen them in reality. He has not been close to them, he has not touched anything. Only in the third semester students see an engine or an electric generator, although theoretically after completing those studies, they have to deal with electricity production. In fact we are studying theoretical bases, but we completely do not know how things works in practice...
”

(Focus group, PutLab Poznań)

Table 1: Competences obtained during formal learning (N=59; multiple choice question)

<table>
<thead>
<tr>
<th>Knowledge obtained during secondary school education or during studies at the university</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical / technological competences (using tools, machines, digital skills)</td>
<td>20</td>
<td>33.9</td>
</tr>
<tr>
<td>Problem solving</td>
<td>6</td>
<td>10.17</td>
</tr>
<tr>
<td>Research skills</td>
<td>25</td>
<td>42.37</td>
</tr>
<tr>
<td>Cooperation skills</td>
<td>14</td>
<td>23.73</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>6</td>
<td>10.17</td>
</tr>
<tr>
<td>Leadership</td>
<td>3</td>
<td>5.08</td>
</tr>
<tr>
<td>Communication and networking</td>
<td>9</td>
<td>15.25</td>
</tr>
</tbody>
</table>

Source: own elaboration

1.2 - Makers in Poland: skills, competences and learning contexts
The quote above shows a lack of satisfaction both about the nature of the learning process and the effectiveness of such learning in relation to gaining technical skills during university study. The results of the survey addressed to a group of 59 makers (table 1) nevertheless show that almost 34% respondents gained technical skills thanks to formal education. However, students who took part in the research (including students studying at technical universities) emphasize the significant role played by secondary schools in providing technical skills, especially for those with a technical profile. In their opinion, that form of education is highly valued in the maker environment. One of the most valuable competence is the practical ability to build electronic modules and circuits.

From the perspective of experienced makers, the creation of a separate educational path for someone to take part in the maker movement is not advisable. However, real world competences, for example, manual or technical competences, are necessary in order to function effectively within the framework of advanced technologies in maker movement centers. It is possible to gain those competences during the majority of polytechnic study fields or in vocational technical secondary schools. Apart from these individual technical competences, the ability to move freely among various systems of specialized knowledge is considered crucial. It is very useful to connect design skills with programming skills, marketing skills or knowledge of psychology.
The informal principle of almost all Polish maker movement centers is that they take full advantage of the technical trainings organized by companies who manufacture tools and workshop equipment. These firms give workshops and carry out promotional activities in FabLabs and makerspaces. The most popular activity is connected with trainings on 3D printing. Putlab’s representatives in Poznań present this mechanism in the following way:

“We have just been given two printers by this company; they support us on a regular basis. They, of course, make available materials for these printers, or a suitable workdesk, etc., but they also organize trainings for us, and recently, they visited us with a whole set of printers and they showed us the newest model of the Zortrax M300, they showed us the Maker Bot, the big one, with the printer head which is able to print on metal. They showed us a printer; this is the newest, it is probably SlasH ISA, it is also a Polish printer which prints using the method of powder sintering and they showed us also a printer which prints applying photo-resin, so such complex trainings and workshops on 3D printing were delivered by them.”

(Olga Andrzejewska, PutLab Poznań)

Internal openness directed to sharing knowledge with the other members of the community is the most frequently declared value. Most makerspaces organize periodical internal trainings as well as regular trainings joined with sharing knowledge of various scientific disciplines:

“It is possible to participate in trainings on everything, you know, there are 60 scientific circles, but the circles do different things, some for example, deliver presentations, visit schools and give shows. I know they do not offer trainings, but it is possible to go to them and learn nothing at all from them. There are circles that only provide trainings and some lectures, they come in the working week, some people from industry or for example, managers and their team, and there are trainings for students.”

(Olga Andrzejewska, PutLab Poznań)
Trainings do not focus exclusively on technical skills (although these are the most popular) but they also provide soft skills, mainly focused on communication and team working. A common solution is for members of the community to invite people they know well and that are expert in coaching, psychology-based training or group-based training. In this way, amateur integrating workshops take place either at the headquarters of the maker space or elsewhere. Such trainings are often free. In this way, the organizers of such workshops frequently research material to be used in the framework of their Master’s degree thesis.

<table>
<thead>
<tr>
<th>Grading scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total</th>
<th>Number of indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical &amp; technological skills</td>
<td>31</td>
<td>12</td>
<td>8</td>
<td>79</td>
<td>51</td>
</tr>
<tr>
<td>Files and data concerning the existing projects</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>49</td>
<td>25</td>
</tr>
<tr>
<td>Information on the development of new projects</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>46</td>
<td>20</td>
</tr>
<tr>
<td>Areas and tools to implement projects</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>51</td>
<td>23</td>
</tr>
<tr>
<td>Relations with companies and organizations</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>28</td>
<td>13</td>
</tr>
<tr>
<td>Benefits from the exchange of opinions and a debate on crucial social/economic/environmental issues</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>Knowledge on possibilities of business and professional development</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Relationships with the global movement of manufacturers</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>Knowledge on opportunities of co-manufacturing (products/systems/processes) with other manufacturers</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>26</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 2: Question 13: What do you share with other makers most frequently?
Source: own elaboration
Polish makers are strongly convinced that the social element plays a key role in the development of the movement across the country. Hence, apart from purely technical competences, a maker’s skill profile includes certain interpersonal qualifications: communications skill, working in a group, empathy. In a community of makers, it is expected that members will accept open relationships, will be open to share knowledge and to interdisciplinary cooperation for implementing projects, and will be ready to learn. Such expectations usually collide with situations where the maker community consists of people who possess a scientific education or they lack formal education in the area connected with functioning within this group. Makers are also convinced that many people choose technical studies because of their low level of competence in interpersonal skills. A large group of makers is constituted by software developers, who use their own specific language. According to our research, many developers do not have enough pedagogical skills that let them share their particular knowledge with others. These people stressed that, during trainings organized within makerspaces, many projects were difficult to implement due to communication problems.

Research on the basis of the survey conducted on the sample of 59 makers from Poland might suggest that learning during trainings organized in maker movement centers do not play a crucial role. As shown by the table below, the most frequently acquired skills are: team work (20% of makers) and technical knowledge connected with machines and equipment (19%). In general, the results show that non-formal learning plays the less relevant role in makers’ learning. When it comes to the most useful skills in the maker movement, the largest role is played by informal learning (see: table 4).

| Knowledge obtained during planned activities i.e. trainings/courses in the makerspace/fablab or other organization of this type as well as company internal trainings |
|---|---|
| **Number** | **%** |
| Technical / technological competences (using tools, machines, digital skills) | 11 | 18,64 |
| Problem solving | 8 | 13,56 |
| Research skills | 5 | 8,47 |
| Cooperation skills | 12 | 20,34 |
| Entrepreneurship | 8 | 13,56 |
| Leadership | 9 | 15,25 |
| Communication and creating the cooperation networking | 9 | 15,25 |

Table 3: Competences obtained during formal learning (N=59; multiple choice question)
Source: own elaboration
Informal learning

According to the makers targeted by our research, the basic competence which makes it possible for a person to feel like a maker and, at the same time, to participate actively to the community is the possession of certain informal skills. The set of these informal skills is described by means of slang language as having a certain “talent” – that is to possess some kind of innovative technical thinking combined with a strong belief that solving technical problems is always possible. Makers investigated were convinced that this is based on acquiring at early childhood a form of thinking which is later considered as the most valuable asset in the community. Focus groups showed that, for makers, this skill is the most important one. They think that the ability to master machines, devices and advanced programmes have relatively little value without creativity. They also highlight that the key significance for the development of this kind of skill is how children are brought up by their families or receive some significant influence from their peers. It is considered that the following two types of contexts provide an opportunity for these competences to be developed:

- A stimulating family environment, where technical knowledge and inspiration come intentionally from parents (sometimes from grandparents). In such families, leisure time is spent together with family members on DIY activities, mending, fixing and solving various technical problems.

- A family environment which actively puts significant limits on what children are allowed to do. The frustration of not meeting the need for such activity then motivates that child to carry out creative activities and develop the associated creative thinking skills. In such an environment, a child thinks up technical solutions which will meet that need (see more: Strelau 1983; 1998).

Putlab representatives from Poznań think that non-formal, spontaneous, hobbyist learning is the only one that is provided in their fablab. The basic method of acquiring knowledge is based on learning by ‘trial and error’:

“...You can attend lectures, you can attend classes, you can do calculations in your notebook, but if you have not entered this uncontrolled environment, meaning the workshop, and you have not done something alone, you cannot say that you can do something. We know how painful it is for people to create their project, etc., but the amount of pain is not important – what’s important is that they learn something. We do not assume that they are experts in this field. They have the tools they need, and they have to learn

( Olga Andrzejewska, PutLab Poznań)
Working for fun is indicated as a driver for attaining a high level of innovativeness:

“In our experience, if engineers start playing around with artistic activities or sculptures, then, in a natural way, sooner or later, they will join these competences together and something amazing will come out from the mix."

(Wojciech Karcz, Fablab przy Centrum Nauki Koonmik)

It is worth emphasizing that creative skills are the most appreciated abilities in maker communities. Respect and group acceptance are closely related to the demonstration of skills in terms of being creative. At the same time, these values play a crucial role in terms of self-identity:

“This is the feature of the brain that I have just mentioned, a kind of curiosity, a striving to improve. It is very valuable because it reflects the process of adaptation that a person experiences when approaching to something new, such as a new job. It is a kind of training. It is possible to force knowledge into somebody's head using a hammer, but if you are genuinely interested in something, you simply absorb the required knowledge. You don’t need a high IQ, just curiosity"

(Focus group; Fablab Łodzi)

As shown in psychological research, the development of creative skills depends only partially on training; on the other hand, very significant factors are genetic factors, as well as the way in which a child is brought up (Sternberg 2011; Martindale 1999: 137-152). Therefore, in the case of makers who place such a great value on creative abilities, it is possible to say that the rarity of this factor (such creative abilities) increases the likelihood of the maker movement itself tending towards a type of social exclusivity.

### Table 3: Competences obtained during the informal learning (N=59; multiple choice question)

<table>
<thead>
<tr>
<th>Knowledge obtained during everyday activities connected with work, family and leisure time</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical / technological competences (using tools, machines, digital skills)</td>
<td>25</td>
<td>42.37</td>
</tr>
<tr>
<td>Problem solving</td>
<td>39</td>
<td>66.10</td>
</tr>
<tr>
<td>Research skills</td>
<td>24</td>
<td>40.68</td>
</tr>
<tr>
<td>Cooperation skills</td>
<td>29</td>
<td>49.15</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>32</td>
<td>54.24</td>
</tr>
<tr>
<td>Leadership</td>
<td>25</td>
<td>42.37</td>
</tr>
<tr>
<td>Communication and creating the cooperation networking</td>
<td>24</td>
<td>40.68</td>
</tr>
</tbody>
</table>

Source: own elaboration
1.3 - Open design and manufacturing: the point of view of enterprises

Innovative manufacturers

The companies targeted in the Polish context exhibit a mixture of business models. However, we can distinguish the following types of business in relation to the OD&M paradigm:

- Businesses aware of the current digital transformation trend;
- Businesses that arise from personal initiatives related to needs and/or hobbies;
- Business model based on institutional mentoring: typically, two or more partners work on a shared idea, applying for funds on programmes for business development, subsequently getting the resources needed to incubate their project.

Grafis Projekt specializes in designing visual identification for brands and companies, in designing the environment in which the latter function, and in building integrated strategies which help to create, develop and manage the image of brands. The team of designers include experienced designers and consultants in visual communications, art, industrial design, IT, marketing and brand management. They mainly work in the areas of corporate design, design & equipment, digital solutions, brand consulting.

The sole proprietor company run by Tomasz Roszewski designs machines and equipment. He also creates simple drivers as well as complex measuring instruments, instruments for diagnosing batteries in short-range missiles, and transportation pallets made of corrugated cardboard. An important part of his activity is related to R&D.

The mission of the Printor company is to be the electronic manufacturing company of choice and a partner in innovation through constant development of competences and a customized approach to each client. Currently, Printor offers complex Electronic Manufacturing Services (EMS): PCB manufacturing, SMT and THT assembly of electronic components, final launching, product testing and wire processing.

The Centre for Travel Education is an enterprise in the area of travel education which is dedicated to communicating knowledge about energy. The Centre will in the future have an astronomical observatory and experimental laboratory. This enterprise has been designed in cooperation with FabLab Lodz and makes use of the most recent technological developments in digital prototyping of the equipment for such a centre.

At Zamek Cieszyn, they are convinced that digital design is an effective tool for increasing the competitiveness of businesses, institutions, towns, cities and regions. The design workshops to which they invite experienced design experts from Europe and the United States enjoy international acclaim. They encourage local businesses to take part to meetings of the Enterprise Club, and members of local government and the media, designers and entrepreneurs from Poland to take advantage of their practical courses, consultations and the location itself, which is an attractive tourist destination.
On the basis of the research carried out, it is possible to conclude that in Poland, it is difficult to identify enterprises which are clearly functioning under the OD&M paradigm. Most of them limit their activities to the episodic usage of open software or to basic cooperation with the maker movement. In addition, these companies are often small in size.

From their perspective, cooperation with fablabs and makerspaces mainly occur for promotional purposes: there is a conviction that, among today’s makers, they can find future employers or contractors. Many representatives of companies are personally involved in the maker movement. Relationships are made on the basis of informal relations and interest communities.

Most companies emphasize a number of difficulties related to the development of an open manufacturing movement. On the basis of interviews conducted, it is possible to say that, although the ideas of the open manufacturing movement are trendy and popular, the involvement of entrepreneurs is really very limited. Entrepreneurs stated that the key reason for their involvement in maker movement activities is rather a form of positive self promotion. Activities of this type are regarded as prestigious and valuable in terms of positioning and branding. When we tried to gain more information on any real-world venture of this type, it appeared that no particularly relevant projects and activities have been created. A connection with the open manufacturing and design paradigm provides a company with certain prestige, and makes that company innovative and modern in the eyes of external society. However, no real action is taken to match declarations of interest in OD&M. Even in the opinion of strong followers of the idea of open manufacturing, shifting this idea to an effective business model is difficult to be achieved in current conditions.

1.3 - Open design and manufacturing: the point of view of enterprises

“I think that there is such a trend, somewhere, a belief in this, that somewhere in the world it is possible to function consciously in such a way. It seems to me that, for sure, this conviction applies to a very small social group, but I think this is not only in Poland, but also generally in the world.”

(Bogusław Kamiński, GreenGo)

During interviews, we saw many times that people understand differently what is meant by open manufacturing movement. This approach is not connected with any broadly understood social ideology, but rather with short-term tactics to make it possible to increase economic effectiveness or improve a company’s image. In this sector, companies are often small organizations with a relaxed, egalitarian structure, and they focus on carrying out projects:

“At different periods of time, it looked differently, because if we concentrated on design projects, we were employing designers. We did not try to organize a big team. At the moment, the educational activities we are implementing rely on a small team. We only involve experts on rare occasions. There is an assembly bricklayer-technical team which consists of four people.”

(Tomasz Tomczyk, Tomto)
I am a designer, and at the beginning the company mainly dealt with marketing activities. Later it shifted to things connected to designs, in the sense that we were designing devices, the web-presence of a producer of paints, and we were running projects up to the moment of their installation. This was one department, the second one was dealing with designing, but mainly they were focused on the management of projects connected with image-building, which means printers, media and things like this. Actually, for the last three years we have been mainly dealing with industrial design, we try to create projects which popularize design as an element of the economy, as the element that should be a driving force. We cooperate with municipal authorities; we organize an industrial design competition which has been converted to an educational action. The subject of this competition for the last three years is the issue of sustainable design.

(Jacek Graś, Grafis Projekt)

For ventures of social marketing, the possibility of taking advantage of structural funds and other grants means that some companies changed their activities: this often means moving from a less profitable commercial business to educational and pro-social activities. Besides local government organizations, commercial enterprises are the largest beneficiaries of EU funds. Micro, small and medium-sized enterprises have access to the widest range of support. Above all, funding is available for them from the Regional Programs of particular provinces, but also from the Intelligent Development Program and the Eastern Poland program. This funding is available for R&D projects, research infrastructure and for introducing innovations. These programs can be used to finance many innovative applied solutions in the framework of OD&M.

We are dealing with projects and education. We are creating projects, in the sense, that we are creating projects which popularize educational projects. They are educational tools, software packages that help to understand the problems of the environment, natural environmental protection, actually it is about increasing awareness, because this is what we care about mostly. We have given up promotional actions a bit. I was working in the first advertising agency that was established and I know that, after few years, it was not successful, that is why I was happy to return to a form of industrial design which is largely related to the concept of recycling.

(Lubomira Trojan, Zamek Cieszyn)
Grants devoted to the development of innovation activities in the sector are easy to access, and some companies representatives’ approach to this kind of activities is disrespectful (from the perspective of extreme supporters of economic liberalism, interference of this type may be considered as harmful), and their ambition is to work out a model of functioning in a completely free market.

The free market Printor Company defined its business model as the production of ready-made electronic subassemblies or even a ready-made device depending on a particular customer’s needs. Their customers are companies that order a ready-made subassembly component, which means an assembled PCB plate (sometimes programmed). However, this basic type of production is not treated as Open Source because a confidentiality agreement is signed with every client. Despite this, the company chairman declares proudly that he belongs to the sector of open manufacturing because his company uses the Open Office package and because he has been operating as a maker in the Łódź Fablab for many years. As a result of his personal involvement, his company became a Fablab sponsor and cooperation started on implementing a common project. The main idea for this project is to run a competition for makers entitled: “PCB Creator”. For the purposes of the competition, competitors were selected who had come up with their own concept for (or prototype of) an innovative device. Ten people were selected and they were given training in designing a PCB plate and CNC electronics in order to able to create ready-made concrete devices. The chairman described the sense of this venture in the following way:

"So, from my point of view, this is a cool thing because, on the one hand, it provides some kind of social value, because when a man is involved in some ideas, he must do something, plan, assemble, learn many things, it provides him with experience and entrepreneurship is activated in him, some kind of the willingness to act, it is very valuable according to me, such an experience, especially for a young person who earlier used only a piece of chalk and a blackboard, mostly. Such a pro-social activity is important. The second activity, from the business point of view, is, in my opinion, connected with promotion, and mainly the promotion of the brand. People who come from Fablab, as do several people who work in our company, these are people who work to a higher standard than our average employees.

(Krzysztof Torczyński, Printor)"

Lubomira Trojan of Zamek Cieszyn points out, that in her opinion, there are more and more designers who are supporting open licensing. She thinks that, for many programmers and makers in Poland, their activities are a source of pride and of great personal satisfaction. On the other hand, a considerable number of designers and makers do not agree with this point of view, and expect the copyright in their works to be respected. This means that any company which cooperates with both those for and against open licensing must in practice remain neutral in respect of its ideological stance on this question.
Traditional manufacturers in Poland are looking with interest at the growing popularity of the idea of open creativity. This concept is potentially attractive in terms of their development and in their search for innovations. They are well aware that, given the increase in market competition and the constant chase for innovation, moving towards the open creativity approach may soon become a strategic necessity. At the same time, the representatives targeted by the research pointed out a number of problems related to turning towards an open design and manufacturing paradigm.

• Resources available as open source software are still too modest and do not often meet their needs;
• There is not enough available training (or, more generally, not enough sources of knowledge) to make it possible to gain knowledge of the potential and practical aspects of open design and manufacturing;
• Open design and manufacturing would require them to change constantly and quickly absorb technical knowledge. However, presently they do not feel to have effective channels of communication with the academic world, which is the place that they mostly value in terms of source of innovation;
• Clients expect to receive the project deliverables which they have ordered on the basis of a legal license for their exclusive use only. As a rule, in the world of real business, project deliverables are sold to a client along with an exclusive legal right to use them, and this applies even in cases when, in reality, such an arrangement is not in fact required.

Because the way in which the open design and open manufacturing sectors function is not fully developed (and it is even difficult to state whether it exists at all in Poland), it is hard to indicate any substantial differences in business models compared to traditional manufacturers.

The InfoMet company deals with electrical, tele-technical systems and with industrial automation. They focus on the integration of all these systems and, to some extent, they rely on information technology tools. Everything they do creates one whole in order to form a complete Building Management Systems (BMS). They ensure that everything is implemented and, later, there is the opportunity to provide monitoring, observation of events, some tele-historical analyses, and predictions.

The Centrum Wytwarzania Oprogramowania (Centre for Creating Software) in Łódź produces software drivers which they sell worldwide. Their Research Center plays a crucial role by finding out what areas it is worth moving into. The Research Centre focuses on using the newest available technology at a given moment. They have to understand what new technology is being developed in order to convert a concrete technology into a concrete product. They also add a business idea to this: an idea of cooperation, customers, marketing. On this basis, they construct a whole package, a product that is launched. Today these packages are exclusively software products which provide enterprise level solutions at a company level for systems management, as in the management of extensive energy networks, construction of IOT cloud platforms called Internet Fix, Internet of Things, artificial intelligence.
The companies described above try to supplement, de facto, their standard business model with activities related to the paradigm of open manufacturing or with cooperation with fablabs. However, this additional activity does not turn into a structured business line within their own model. Consequently, it is difficult to highlight essential differences in the scope of the organizational structure or within the approach towards innovation. There is a great variety across the targeted businesses.

Activities within OD&M are perceived as ones which do not bring in any profit or possibly only make a small profit. The sale of licenses provides a much bigger income. Companies’ representatives declare that they do not have time for ‘fun’ and maybe for experimental undertakings that would be interesting, but are less valuable. Obtaining financial means for the organization activities is connected with the sales of exclusive licenses to clients. This kind of solution is presented as the indiscriminate and obvious foundation of the activity. For a very long time, traditional manufacturers have been talking about throughput and the costs they bear in relation to their creative activity. During the research they often tried to discredit the ideas of the open manufacturing by accusing this type of activity as ‘spoiling the market’. When a researcher tried to explain the advantages of OD&M activity, the final counter-argument referred to customers’ expectations of purchasing an exclusive license.

I am not able to change government acts or regulations. Somebody orders some work, and so he wants to have this work for himself. If somebody is a private entity, it is possible to negotiate, or if it is a private company, we might be able to agree to work on the basis of ODM. The argument is that, if something is available to everyone, then it will work out cheaper for our customer. But if the Silesian Bank outsources to me the design of the interior and logotypes, and I sell these to that bank, and later it turns out that PolBank can use the same deliverables, then the Silesian Bank will not want this to happen. They would like to have this work exclusively for themselves.

(Bartłomiej Bulawa, Pracownia architektoniczna)
Concrete examples of functional restrictions related to using open software are also provided. For example, there are references to a company which works on visualizations for corporate usage or product image using a significantly functionally limited equivalent program (available as open source) of Adobe Photoshop, and to a design company using an equivalent of Autocad.

Many traditional entrepreneurs perceive maker communities as those that are coordinated specifically to deal with solving concrete technical problems. They point out significant shortages in terms of skills connected with team work, time management or in the number of people who have leadership abilities. The crucial significance of this is that there is no business model which can be adjusted to the specific nature of how a maker movement center functions.

According to the traditional manufacturers targeted by our study, although makers’ projects are interesting, it seems to be impossible for a serious business cooperation to develop because of the differences in their respective philosophies: one is based on spontaneous creativity aimed at meeting the need of forming a new reality, whereas the other requires methodical work aimed at being economically effective. Maker centers cannot fit into the regime of controlling time and costs which exists in the world of business. In the opinion of traditional manufacturers, no idea yet exists for how a business can cooperate effectively with makers.

Some entrepreneurs indicate a lack of trust among entities that compete on the same market. This limits readiness to share knowledge. It is difficult to share information if people are not confident that this cooperation is pure in nature and that cooperation rules are transparent.

“Now if, for example, we know that these people run similar companies or support other companies and they are connected with these companies formally or have a family connection or in other ways, then it is difficult to enter into cooperation and accept this arrangement because there is a mental barrier. I wonder whether this will not rebound on me, or whether the data will not be used, and somebody will simply submit a better tender offer, and this is a risk.”

(Waldemar Toborek, FriendlyNet)
During the research, it appears that the main model of relation among the maker movement, open design and manufacturing and the academic environment is a non-formal cooperation driven by personal relationships. Mutual cooperation develops best when representatives of enterprises or the academic world are involved with makers. When such people actually work at the same time in two completely different social worlds, then they can: better understand the advantages stemming from open source integrated with businesses, and create links with maker communities which are based on trust and cooperation which is mutually satisfying.

The positive features of cooperation are flexibility and the authentic enthusiasm of activists and professional makers who create this cooperation and, at the same time, who join these different environments. The entrepreneurs that hold relationships with the maker movement emphasize the fact that, in makerspaces, there is an exceptional atmosphere; that there is real commitment to carrying out the required work and that there is a great community spirit. They clearly feel that the environment in maker centers is quite different in terms of fostering creativity compared to even the most egalitarian version of corporate culture in commercial companies. But it is a serious problem to maintain the required continuity in such relationships, especially over a long period of time, and it is also a problem to work out an effective business model for the maker movement centers.

It seems that the main impediment to developing cooperation between open manufacturing, the innovation industry and academic environment is the lack of knowledge about how to introduce effective and attractive models linking all parties. Within these environments, the lack of good practices of economically effective business in the conditions of the free market is experienced. It is true that ambitious projects for tri-partite cooperation are being thought up, but presently, these are only abstract concepts. These projects refer not to obtaining benefits from the sale of innovative material products, but to innovative techniques of promoting brands of electro-technical devices to maker groups and, therefore, to their social environment, which is the academic environment.

Due to difficulties in creating sound open business models, most plans oscillate around solutions for social marketing, as well as directly subsidizing the maker movement centers. In some cases, the great availability of grants and the profitable implementation of these ventures are displacing free market initiatives.
Whilst the business world, which is based on creating innovative and advanced technologies, is developing very rapidly, the academic environment is too highly institutionalized to be adapted to the business environment quickly. It is difficult to change standards quickly, and this hampers adaptation to the needs of businesses.

For universities, the highest priorities are: obtaining accreditations for separate study fields, academic staff promotion, university rankings position, popular study majors’ promotion, and applications for research grants. These are the main factors that result in gaining the financial means required for educational activities. In present conditions, all these elements can be achieved by means of easier and well-tested methods rather than experimenting with cooperation with the maker movement or with the OD&M sector. In Poland, despite popular discourse on the necessity of increasing innovation in the economy on the basis of academic knowledge, there is in fact no general strategy which aims at increasing cooperation between makers, the OD&M sector and the academic environment.
ANNEX: Country Report

IV. OD&M Country Report, ITALY

By Prof. Giuseppe Lotti, Debora Giorgi, Irene Fiesoli, Valentina Stefanini Pennucci
| University of Florence
Angela Lobascio | LAMA Agency
Irene Burroni | Furniture and Furnishing Centre
Defining a ‘maker’ is not an easy task, given the multitude of profiles and characteristics that have been associated with it in the past years, and the diversity of approaches on this subject that characterise different national and local contexts.

In this paragraph, we attempt to identify the predominant attributes given to the ‘maker’ in the Italian context. In order to do so, we will take into consideration two main sources of information and inspiration: the international literature on the subject and, in particular, the results of the Italian ‘Makers inquiry’31 (which represents one of the main empirical sources of information on this topic to date, with specific reference to the Italian context), and the findings from our fieldwork, based on interviews and focus groups with national stakeholders including makers, makerspaces coordinators, academics and experts from different disciplinary domains and sectors, as well as on a survey addressed to makers.

Among the existing international definitions, we may refer to the following one given by Chris Anderson (2012): a maker is anyone who uses digital tools and a computer in order to develop projects and prototype them autonomously. Beyond this, an additional feature that characterises the maker is the propensity to share his/her projects online, and to cooperate with others within a broader ‘maker community’. According to Anderson (2013), the digitisation of the DIY approach rooted in the maker movement will drive the next industrial revolution by ‘treating atoms like bits using the powerful tools of the software and information industries to revolutionise the way we make tangible objects’ (Anderson, 2013).

Looking at the Italian context, our interviews showed that, rather than responding to a single definition, makers tend to be associated with a number of different profiles: among these, the digital hobbyst – who is mainly driven by the passion for experimentation and discovery, the independent designer – who produces its projects through its own brand and autonomous management of all processes, and the Fablab manager – who connects and engages other makers, and who in turn is often an expert maker, stand out (Menichinelli, 2016).
In order to explore the perceptions of the maker movement from the inside, we may report a consideration made by one of the interviewed makers, regarding the values and principles underlying the making activity, and the role of the community.

The main values and principles of the maker movement are ‘collaboration’ and ‘sharing’. Indeed, the maker is happy to share his/her solutions with others. I practice the making so that my work can be replicated by others. This mechanism legitimates the activity of the maker and increases his/her reputation. Being a maker means exactly this: to use things made by others, and then share the results with other people who will use them next. This mechanism strengthens the exchange dimension and generates a sense of gratitude towards the community. We [the makers] don’t think in terms of plagiarism, we don’t fear the fact of not being original. When somebody uses something, he/she has to improve it and give it back to the community, it is a virtuous circle where everyone has ownership of the product or process that he/she has contributed to create.

(Entrepreneur, interview n. 1)
The birth of the maker movement can be seen as linked to a number of interconnected events and processes that increasingly gained ground in Italy: the growth of the open source culture; the discontent with and refusal of the traditional intellectual proprietary system; the availability of new technological solutions which allowed the spread of fast and low cost prototyping (e.g. Arduino, Raspberry Pi); the spread of free and open technical knowledge accessible from the internet through a multitude of tutorials and handbooks; the presence and growth of online communities.

(Entrepreneur, interview n. 1)

A key debated issue within the Italian maker movement concerns the role of makers in the socio-economic system: what is their playing ground? Who do they interact with? Where do they potentially produce an impact? Considered the Italian context, characterised by the strong presence of small and medium manufacturing enterprises, the role of makers has been defined as that to combine new technologies and digital tools in a way that allows to foster the crossbreeding of the traditional and artisanal productive systems, with a significant impact on the local economic model (Schiavo, 2017).

Italy is known worldwide for its excellence in craftsmanship, and artisans are commonly perceived and considered as the guardians of know-how and traditional manufacturing techniques, and therefore as privileged interlocutors vis-à-vis the innovation need of the sector. As pointed out during an interview, this factor may have slowed down the spread of makerspaces in the country and, at the same time, it may have contributed to surround these spaces with unedited features and connotations, which cannot be found elsewhere (Expert, Interview n. 1). According to another interview (Academic, Interview n. 3), makers in Italy seem to act in a counterintuitive, somehow counterproductive way, since they tend to create products without a specific market strategy; this trend has often proven to be harmful, particularly within the furniture and high end sectors.
Recent marketing studies demonstrate that makers’ products have been poorly accepted by the Italian market. This is because in Italy, design products are often surrounded by emotions, both for our long tradition, and for the kind of cultural meanings associated to such products. When these products are improved in terms of functionality and usage, the impact on the market is often poor, because you are not stimulating the core levers of purchasing decisions. Italian design products generate curiosity independently from their functionalities; they capture interest and fascination because of more complex, almost cultural dynamics.

(Academics, interview n. 3)

Doubtless, the current period of ‘technological discontinuity’ is demanding radical new competences and skills. As repeatedly stressed during the interviews with academics realized for this study, Italy presents a number of specific technological know-hows which are distributed across the country, but often not organized into a solid and consistent long-term strategy of growth. This factor, together with a certain degree of resilience and adaptation shown by Italian SMEs, has allowed the country to resist and compete in the contemporary phase of globalization. Nevertheless, a deeper understanding of the potentials rooted in the emerging technologies on the one hand, and of specific situations of Italian enterprises on the other hand, are the starting point for any action willing to ride the wave of the current technological revolution.

According to our study, the combination of new and emerging technologies with the Italian high end handicraft is not always viable, nor it would necessarily lead to better market performances. Especially when it comes to high end products, the introduction of digital technologies across the manufacturing process would paradoxically remove any added value from the product itself, lowering drastically the quality perceived by the final customer. Instead, new technologies would better serve traditional SMEs characterized by mass or serial productions; in this context, the role of makers could be strategic and pivotal, as they could drive the shift towards increased customized and on-demand production, in line with the ongoing trends of the global market. Moreover, the typical districts-based system of the country would represent the privileged playground for makers: if scaled up to the level of districts and integrated systematically within their already existing networks, makers and makerspaces could represent a viable driver for the relaunch of the Italian manufacturing in the international arena.
Fablabs and industrial districts have a key feature in common: they are able to work collaboratively under a network-based approach, creating meaningful synergies and value chains that proactively involve all the key actors of the production process, from research, to design and production, till to post-production.

(Entrepreneur, interview n. 1)

Importantly, our study also highlighted the special relationship that exists, in Italy, between makers and the design world. These two worlds share many elements, as many makers are also designers, and the fusion between their respective competences and skills is more and more giving life to unedited profiles. Based on this consideration, one of the academics interviewed in the research (Academics, interview n. 2) explained the interlinkages between makers and designers by referring to five different ‘making models’:

- ‘Open’ model: it explores the application of open source principles and approaches to the field of design, trying to expand its boundaries through the use of new technologies;
- ‘Craft’ model: it refers to the role of the maker in the innovation of existing craft products and processes, and looks at the new synergies potentially emerging between innovation and tradition;
- ‘Distributed’ model: in this model the maker is the enabler of a new distributed manufacturing paradigm. In the past, the manufacturing process was based in a specific place and location, i.e. the factory. However, thanks to the use of new digital fabrication tools mastered by the makers, today part of the physical production process can be segmented and distributed within and across territories;
- ‘Enterprise’ model: in this 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;
- ‘Social’ model: the one in which makers use these new technologies for social purposes, for example for the creation of new products and services with social impact, or for the design of new solutions for urban regeneration of abandoned and degraded areas.
Makerspaces and fablabs are generally considered the physical places of the maker movement. Despite the tendency, widespread in Italy, to identify any makerspace or laboratory with the term ‘fablab’, this term refers to something very specific that has been defined by the Center for Bits and Atoms at the MIT of Boston. According to the MIT, a Fablab is a space characterised by the following elements:

- Open access to the space;
- Evidence to the Fab Charter (the manifesto of fablabs), which shall be displayed in the space;
- Presence in the space of a certain set of self-production tools and machines;
- Sharing of the processes and learning produced within the fablabs’ network;
- Active participation to the global fablabs’ network.

In concrete terms, the sharing of physical spaces and tools for digital manufacturing is one of the key objectives of all the fablabs. Most fablabs promote training for the use of such tools, and carry out activities to promote digital fabrication and open innovation. Fablabs’ activities are directed at individual users, but also at schools, businesses, and the wider public.

Compared with other European countries, Italy experienced a late rise of the maker movement, and the first fablabs were launched relatively late. Nonetheless, the movement has grown rapidly and nowadays Italy represents the third country in the world in terms of number of fablabs, behind the United States and France. Today, we count 134 Italian fablabs registered on Fablab.io, one of the main online maker community managed by the Fab Foundation at global level.

The massive proliferation of fablabs and the dynamism of the maker movement in Italy has attracted significant attention and curiosity among the observers. One of the positive factors influencing such a trend has been the presence of a number of making-related initiatives, such as WorldWideRome (since 2012) and the European editions of the MakerFaire in Rome since 2013 (Menichinelli and Ranellucci, 2014). Thanks to such events, the general public in Italy, but also institutions and enterprises, discovered the maker movement and the nature of its activities. Moreover, it is worth highlighting that since 2014, specific policy measures and investments from the national government have been launched within the framework of the National Digital Agenda32, with the overall aim of exploring new connections and contaminations between the movement and the national educational system.
Through such measures, many schools have embarked in the creation of internal fablabs and makerspaces, in order to trigger alternative and complementary teaching and learning, especially in creative and scientific disciplines. Besides, specific public measures have been launched in 2016 to support education and training actions for young artisans, with special focus on digital manufacturing competences and skills.

According to a recent research (Manzo and Ramella, 2015) focused on the Italian geography of fablabs, the rise of these spaces in the country has been facilitated by two types of territorial contexts: on the one hand, they emerged in big metropolitan centres such as Milan, Turin, Florence, Rome and Naples; on the other hand, they developed in the regions characterised by the presence of localised industrial districts, typically showing a flexible specialization model, and often labelled with the term ‘Third Italy’ (Pyke, Becattini, Sengenberger, 1990). Looking at the features of makerspaces in the different areas of the country, this study found that those located in the North-West regions tend to show a more pro-market orientation, with a strong propensity to develop commercial projects and prototypes, often in collaboration with companies. On the other hand, makerspaces situated in the South, are more often devoted to training activities for schools, probably also due to the wider availability of public funds for so-called integrated teaching. However, the highest number of makerspaces is actually located in the ‘Third Italy’, where they demonstrate a strong ability to establish ties with the local actors. According to this research, one of the possible explanations for such a high presence of fablabs in the country lays in the fact that these spaces, by promoting an alternative, civic infrastructure for active learning and experimentation, are actually complementing an existing gap in the national public and private education and research system; given that the provision of infrastructures and services related to new digital technologies is relatively weak in Italy, fablabs and similar laboratories provide people with the opportunity to develop skills, grow collaborative networks, and access reputational resources, which can be synergistic and functional to other professional and entrepreneurial activities. On the other hand, the proliferation of makerspaces across Italy may also be interpreted in light of renewed instances of active participation and civic engagement from citizens and young people, who may look at these spaces as new contexts of socialization.
By definition, formal learning is delivered in an organized and structured context (e.g. high school and university), and is purposely designed in terms of objectives, times, resources, and learning outcomes. In addition, formal learning is intentional from the learner’s point of view and usually results in a validation and a recognized certification.

In this paragraph, we will analyse the contribution of formal learning to the creation of a ‘maker profile’ and, in connection to this, we will explore the current relationship between Italian academic institutions and the world of makers, or more broadly the world of advanced manufacturing and digital fabrication. More specifically, using the results of our action-research, we will illustrate how Italian universities have so far engaged with this topic, and what role the formal education system is actually playing in the development and diffusion of a ‘maker profile’ and culture. The main sources adopted for this specific part of the research have consisted in desk research, semi-structured interviews with academics and experts from different disciplinary areas and sectors, and a survey addressed to makers. In particular, through the survey we have investigated the main learning patterns of the makers, and their perceptions about the relevance of different learning contexts – formal, non formal, informal – for the acquisition of valuable skills and competences vis-à-vis their professional careers and lives. The survey targeted 51 makers across Italy; the large majority of them are men (74%), and the professional involvement in making activities slightly surpasses the hobbyist-driven ones (53%). Moreover, in terms of educational levels, the sample is constituted by 45% of makers with secondary education, 37% with a university degree level, and 18% with a postgraduate level. Of course, given the limited number of makers reached by the survey and considered that the latter is based on individual perceptions of makers (who, in turn, may be influenced by a number of personal reasons and individual experiences), the analysis cannot be considered as exhaustive, but rather as an attempt to provide a general overview about the relation between the Italian formal education system (in particular, Higher Education) and the making culture.

In this context, it is also worth mentioning that the maker movement tends to give a precise connotation to the concept of learning. Learning by doing and by making, distributed learning, liquid learning and democratization of learning are fundamental parts of the making culture, and they all contribute to shape the movement as an alternative, mostly unconventional, learning context. On this ground, the unstructured and spontaneous teaching and learning processes that take place within makerspaces may actually clash with the codes and procedures of formal learning, losing their own identity and meanings.
Nonetheless, the contamination between formal learning and the making culture may emerge as a fertile ground to upgrade and develop meaningful training patterns, able to better respond to fast changing needs and demands in the labour market.

According to the survey, the role of formal education is particularly relevant for the acquisition of research skills, which are highly relevant for makers to the extent that the research component informs the vast majority of their making activities. Secondly, formal education seems to play a valuable role in the acquisition of collaborative skills and problem-solving skills; instead, hard skills (mostly related to specific making technologies and techniques) and soft skills related to entrepreneurship, leadership and effective communication see the predominance of both non formal and informal learning as relevant contexts.

In general terms, the Italian academics interviewed for this study pointed out the need to introduce innovative elements in both teaching, learning and research. From their perspective, the engagement with the topics of digital fabrication and open manufacturing may represent an opportunity to foster innovation in the academic field, and strengthen the links between universities and enterprises. The creation of makerspaces and dedicated labs inside Universities has been repeatedly pointed out as a valuable driver for the development of a more market-oriented research, and for the creation of win-win synergies with external actors and stakeholders.

Compared to Italy, foreign universities are often more able to recognise the role of makers and to offer something that is consistent with their needs and expectations. Many schools and universities have introduced laboratory-based courses to facilitate more practical and experiential approaches to learning, while Italian training is often limited to theoretical and vertical teaching. It would be useful to enhance the presence and role of technology labs, integrating them across curricula.

(Entrepreneur, interview n.2)

There is a high need of new intermediary figures able to link research activities carried out at university (generally with a long-term approach) with the practical and productive activities taking place in SMEs (often driven by shorter term approaches). Actually, it would be even more interesting to imagine a physical space where the relationship between businesses and universities can effectively grow and develop. Fablabs and makerspaces are of course ideal candidates for this role, and they could become key enablers of the encounter between these two worlds.

(Entrepreneur, interview n.3)

This space is an area where very fast, streamlined and applied research takes place and where businesses can find an immediate feedback on key innovation issues. At the same time, for the University this place creates a concrete opportunity to see the implementation of its research, making it closer to the needs of the companies and the market.

(Entrepreneur, interview n.4)
According to our research, Italian Universities have engaged with the making culture mainly via three types of initiatives:

- Courses, mainly found within faculties of Design, Engineering and Architecture. Such courses can be either compulsory or optional courses, and can be found both at undergraduate and postgraduate levels.
- Dedicated laboratories and makerspaces physically situated inside Universities.
- Strategic partnerships and projects with external fablabs and makerspaces.

With relation to courses, over the past years a number of options about advanced manufacturing and digital manufacturing emerged among Italian Higher Education Institutions, mainly within Master’s Degrees in Engineering, Design, and Architecture. As examples, we can mention: Makers Approach to Electronic Design (Faculty of Engineering, University of Genoa); Digital Interaction design (Polytechnic University of Turin, University of San Marino); Product Components (Polytechnic University of Turin); Advanced Design (University of Bologna). In addition, there are several examples of postgraduate courses such as Interaction design (European Institute of Design in Rome, Milan and Cagliari), Digital Manufacturing at IUAV in Venice, or the D.re.a.m. Academy (Design and Research in Advanced Manufacturing), created by the Science and Technology Park of Naples (Città della Scienza).

The latter offers a structured program on advanced manufacturing and digital fabrication that cuts across different industries (biomedical, design and fashion, advanced architecture and manufacturing, cultural heritage and museum installations) and technological domains (robotics, advanced manufacturing, digital fabrication, data mining, IoT). Furthermore, 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, while the University of Siena proposes the course of ‘Physical computing’ within its Master Degree in Strategies and Techniques of Communication. Interestingly, both courses are relevant to the extent that they show the effort to infuse social and economic disciplinary domains with making-related contents, going beyond the purely technological dimension. Finally, within the Italian landscape, 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.

Regarding physical spaces inside universities, our research identified two main types of spaces: dedicated laboratories and makerspaces.
With relation to laboratories, the majority of Universities targeted by our study (mainly via desk research and interviews with academics) show the presence of a number of dedicated labs that span across advanced manufacturing, robotics, reverse engineering, interaction design, design for sustainability, 3D modeling and printing, product design, service design. Similarly to courses, these labs can be primarily found out within faculties of Design, Art, Engineering and Architecture, and predictably within technical Universities. Doubtless, the thematic areas covered have several points of connection with the technological dimension of the maker movement; nevertheless, direct connections to the open source topic and to openness as a paradigm underlying production are less evident. Amongst the labs mapped, we can mention the **Advanced Manufacturing Laboratory** of Milan Polytechnic University, which connects the departments of Science and Technology, Mechanical Engineering, Chemical and Material Engineering, Civil and Environmental Engineering. The main goal of this lab is to reach out to public and private companies and to be recognised as a reference point for research and applied technological research on advanced materials. Another example is provided by **DIDAlabs**, a structured system of laboratories promoted by the Faculty of Architecture of the University of Florence. This labs-based system constitutes the scientific and technical support for teaching, research and higher education, as well as the transfer of knowledge in the area of architecture, industrial design and urban planning. At the University of Bologna, it is worth mentioning the **Making Laboratory**, that supports students in the acquisition of specific skills and competences for the design and creation of digitally enabled ‘things’, with the overall aim of shaping ‘digital craft working’ professionals.

The creation of University makerspaces is a relatively recent trend, that particularly characterizes those Universities located in the Centre-North of Italy. **Polifactory**, at the Polytechnic University of Milan, has been conceived and developed by the Department of Design together with the Department of Mechanics and the Department of Electronics, Information and Bioengineering, with the goal of strengthening the contamination among the various design cultures existing within the University. The space is mainly used by professors, researchers, PhD and university students, and it proposes four main areas of activities: research and consulting for companies, corporations and institutions; support and professional growth of young talents; advanced and experimental teaching and learning; cultural dissemination initiatives that explore the relationship between design and new production models. Polifactory’s main objective is to experiment concretely with new digital design and manufacturing processes, developing frontier research on technologies and on production and distribution models that presently characterize the evolution of contemporary products and services.
Fablab Pisa was born in 2012 thanks to the support of the Piaggio Research Centre at the Faculty of Engineering of the University of Pisa, who currently hosts it in its own premise. University and PhD students mainly from medicine and engineering courses attend the fablab, experimenting with innovation projects and prototypes over products and services in close collaboration with businesses. In recent years, Fablab Pisa has also attempted to build a specific training offer for citizens, showing the effort to reach out to audiences outside the University. The University of Siena also hosts its own Fablab since 2015; it provides guidance to external actors willing to experiment with specific machineries within the space, as well as specific trainings for schools, teachers and lifelong learners, also through its own role of Fab Academy’s node.

With relation to strategic partnerships and projects, the Italian landscape shows several initiatives that aimed at creating structured and stable connections between Universities and makerspaces. FAMO (Fablabs, Arts, Makers, Open), promoted by the University of Camerino, Civitanova Marche City, Winitalia and Creativity, promotes a new concept of fablab that provides consultancy, design and R&D services to local enterprises and artisans, based on an innovative public-private partnership that also involves start-ups. Fabspace 2.0 involves the so-called Universities 2.0 from six European countries and aims at creating a collaborative network of universities, fablabs and enterprises in the domain of geo and spatial data. Kids University is an initiative promoted by the University of Verona that aims at fostering creative and inventive-based education among schools, through dedicate workshops and labs for teachers, children and young students. Lastly, in the context of secondary education, it is also worth mentioning: the ‘Fablab at school’ project promoted by the Fondazione Nord Est, that aims at creating a network of fablabs across schools in the North-East regions, in order to complement teaching and learning with concrete collaborations with makers and local enterprises; the ‘Mak-ER’ project is a networking initiative devoted to connect all digital fabrication labs existing within the Emilia-Romagna Region, in order to boost a regional strategy of smart specialization and growth based on new technologies and on the active involvement of young talents; the ITS Maker (Emilia Romagna’s Higher Institute of Mechanics, Mechatronics, Motoristics and Packaging) is the biggest Higher Institute of the country, and it involves more than 50 institutions among Universities, vocational training institutes and schools of the Emilia-Romagna Region.

As our study contributes to highlight, makerspaces and fablabs – be they connected or not to Universities – are able to develop a set of competences and skills that, although not codified, are strongly oriented to innovation-driven research. In this context, they could position themselves as ‘intermediary’ places for fast and ready-to-market research and prototyping, supporting both Universities and enterprises in converging towards concrete and rapid applications of their own activities. In this vision, makerspaces would act as complementary learning contexts that support student in the practical application of knowledge and competences acquired within formal contexts, while working as devices of career orientation and guidance.
Makers and non-formal learning

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

According to our interviews and focus groups with makers, and consistently with the main characteristics of the movement described in the first chapter, makerspaces emerge as the contexts in which most non-formal learning takes place. Indeed, here makers can experiment, research and innovate using machines, technologies and materials, and take part to courses, workshops and collective projects. Thanks to the presence of a multi-disciplinary and varied community of individuals, makerspaces tend to imprint learning and discovery processes with original and often unexpected features, unleashing the serendipitous exchange and contamination of different skills, knowledge, languages and approaches, which throughout these processes constantly evolve and take new forms. The open, horizontal and often unstructured collaboration within makerspaces is also supported and empowered by the use of digital platforms, through which makers can exchange resources and collaborate on common projects.

Makerspaces may build on different vocations and topics, and their connection with the world of businesses varies significantly depending on many factors: the profile of the founders, the availability of dedicated funds, the presence of specific machineries and equipments, the kind of relationship with external actors and stakeholders, among others.

"The mission of our makerspace is to enable the meeting between the emergent prototyping culture and the world of traditional manufacturing enterprises, and we do that through research and consultancy. We organize trainings in our makerspace, but we also provide training to external organizations. We also offer consultancy services for institutions, fablabs and enterprises."

(Makerspace coordinator, interview n.3)

"I define the fablab as a research and development center on physical objects, mainly at the service of small and medium size enterprises. We do not take into consideration large corporations because they already have the power and resources to do that. Italy is mainly built on artisans and small and medium enterprises, so we want to meet them and bring our skills to them"

(Makerspace coordinator, interview n.1)

"The fablab is a way to democratize innovation and make it more accessible, small and medium size enterprises have a strong need of productive and technological flexibility. In our fablab we mainly organize trainings related to the methodologies of collaboration in the digital world; the fablab is an investment in culture and research"

(Makerspace coordinator, interview n.4)
Technical and technological aspects are crucial in the definition of both the maker movement and its typical learning and teaching processes. Nonetheless, they offer a partial description of the makerspace environment, since they are not able to fully encompass and describe the social dimension of making and its deep nature of collective experimentation and discovery process.

Makerspaces are generally built on the presence of communities of practice that engage and experiment with specific topics and projects, working through horizontal and peer to peer approaches and methods. By blending learning to learn, learning through making, and learning through collaboration, makerspaces show alternative, almost unedited patterns of education and training, characterized by a shift from learning outcomes to the learning process itself. Moreover, not only they support members in the acquisition of hard skills, but they seem particularly able to develop a plethora of soft skills such as problem solving, empathy, resilience, team working, planning, entrepreneurship (Bezzi, 2015).

The social dimension of the Italian makerspaces does not only concern their internal practices, but also the kind of relationships that they build with the surrounding environment and the local communities. Genoa provides a concrete example of makerspaces that are actively tackling societal challenges like urban degradation, and that are looking for meaningful integration with the local communities.

Genoa has always been a ‘transit’ city, due to its nature of port city, but nonetheless it lacks a strong productive system. Here the maker phenomenon has become highly social in nature and scope, looking for synergies with the city and local institutions. In Genoa, there are actors such as Talent Garden and MADlab that work a lot on the social context of the city; for instance, MADlab has attempted to revitalize a problematic neighborhood of Genoa. It is interesting to notice that an attitude of “social protest” is, probably, typical of the Italian makerspaces, because these spaces are often places of aggregation for young people. Makerspaces are places where it is possible to work but also debate on societal issues, and in this way they enhance the re-activation of social networks and ties. More generally, makerspaces are able to bridge a typically Italian social gap, creating active and useful spaces for young people.

(Makerspace coordinator, interview n.4)

To sum up, non-formal learning within makerspaces follows two complementary directions: one is 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 the strengthening and development of soft skills, such as the ability to collaborate and work in teams, communicate, solve problems, pursue pre-defined objectives and acquire an entrepreneurial attitude.
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 action-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 and fuzzy connotation to the learning process, which spans across life times and life experiences.

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 the research, we considered as ‘innovative businesses’ those companies that are exploring the integration of new and emerging technologies in their business models, production processes and/or products, eventually embedding - to different extents - the ‘open’ approach inspired by the maker movement.

As we will see further on, most of these companies are deeply informed by the digital world, and are or have been in close contact with the maker community.

Below, we briefly list some of the key characteristics that appear as most recurrent among the innovative entrepreneurial realities involved in the research:

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

With relation to their connection with open design and manufacturing and the maker movement, it is important to notice that each enterprise relates to them in a number of different ways, depending their core business and on whether the founder is a member of the maker movement.

For the sake of this exploratory study, we have divided the targeted enterprises involved in the research into three main groups, according to their core business:

- Research, consulting and educational activities and services;
- Design, development and production of physical objects;
- Design, development and production of technologies.

In the following table, we provide more detail on the three groups, and list the specific companies included.
Companies in this group provide rapid prototyping services to external enterprises and organizations that want to experiment with new products and/or processes. Often, rapid prototyping (and similarly also the educational projects) have the overall objective to connect the physical with the digital world, and to promote the adoption of new technologies within traditional production sectors. Research activities are often meant to support the practical realization of the aforementioned project, but may also take a broader approach and concern the study of the relationship between the physical objects/devices/machines and individuals, or the social and human consequences of such human-machine interactions. Educational activities are usually implemented across schools, universities, enterprises and organizations, often in partnership with fablabs and makerspaces.

<table>
<thead>
<tr>
<th>PHYSICAL OBJECTS</th>
<th>Production of physical objects using new technology and/or DIY methods</th>
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<tbody>
<tr>
<td><strong>Playwood</strong> (Reggio Emilia)</td>
<td>is a modular furniture system that uses 3D print connectors and boards to produce desks, shelves and stools with eco-friendly and recyclable materials, especially for collaborative working space. Connectors and boards can be easily combined together, and the client can choose the material and improve the design of the furniture.</td>
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<tr>
<td><strong>MP Arch</strong> (Florence)</td>
<td>is a design and programming studio with strong focus on rapid prototyping and modeling. IOKitchen, one of its champion project, is a kitchen for people with mobility problems, that helps them to achieve greater autonomy and freedom thanks to a revolving, multifunctional and automated table. The product can be customized according to specific needs.</td>
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<tr>
<td><strong>FABtotum</strong> (Milan)</td>
<td>produces a multipurpose personal fabrication device, designed and made in Italy for a wide range of professional uses: 3D Printing, 3D modeling, cutting or 3D Milling of metals and wood, rapid laser prototyping. The device can be customized according to one or multiple modules and additive and subtractive heads, according to the needs of the client.</td>
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<tr>
<td><strong>Plug and wear</strong> (Florence)</td>
<td>is a company operating in the field of technical textile production, and is characterized by the massive adoption of Internet of Things and robotics, mainly for industrial environments and interior design.</td>
</tr>
<tr>
<td><strong>Blca</strong> (Milan)</td>
<td>produces customized and on-demand mirrors and lamps. They combine the use of technological tools (such as laser cuts and 3D printers) with traditional handmade quality and design.</td>
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<tr>
<th>TECHNOLOGIES</th>
<th>Production of digital products, in particular software technologies connecting existing devices.</th>
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<tr>
<td><strong>Volumio</strong> (Florence)</td>
<td>produces a free and Open Source Linux Distribution designed and fine-tuned for music playback. It runs on a variety of devices, typically small and cheap computers like the Raspberry PI, but also on low power PCs and notebooks. In turn, Volumio’s UI allows an easy and intuitive control of playback sessions.</td>
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**Officine Innesto** (Turin) is a company that deals with design and technology; they connect the physical with the digital world through education, dedicated events and prototyping activities. One of their outstanding projects focuses on experimenting with the use of robotic devices in the context of art, architecture and design. The main goal is to boost the cross-pollination between Italian experience in furniture and interior design with emergent skills in open-source electronics.

**Casa Jasmina** is a pilot project of Arduino cc. started in 2015, which has now become a permanent project carried out by Officine Innesto. The project works in the field of domestic electronic connection, relying heavily on Internet of Things’ technologies. and is characterized by the combination between traditional communication and product design methods with innovative, digital-driven approaches such as the Social Networks Ecosystem Observation and Big Data analysis.

**Nefula** (Florence) is a ‘near future’ design studio that focuses on the adoption of specific design methodologies in the production of desirable scenarios for the future. The company provides research, education, consultancy and transmedia design services to institutions, companies, non-profit organizations and communities, support clients in the identification of new products, and in the organization of supply chains according to principles of participation, control and sustainability.

**Slowid** (Modena) is a collaborative community of designers and artisans that develops design-driven solutions for distributed, local and sustainable manufacturing. They itself as enabling environment for innovation in the textile sector, supporting young talents and operating as local hub for international networking in this sector.

**Lottozero** (Prato) is a dedicated Centre for textile art and culture, equipped with an open lab for textile production, research and experimentation. Lottozero positions itself as enabling environment for innovation in the textile sector, supporting young talents and operating as local hub for international networking in this sector.

**BIca** (Milan) produces customized and on-demand mirrors and lamps. They combine the use of technological tools (such as laser cuts and 3D printers) with traditional handmade quality and design.
When observing the connection of these enterprises with the maker movement and, by extension, with open design and manufacturing, we may refer to a sort of continuum that spans from companies that are fully rooted in an open design and manufacturing approach, to businesses that are curious and attracted by this world, but have not yet experimented with concrete patterns of ‘openness’. In this latter group, most of the enterprises were or still are in contact with makerspaces, for example because they use their machineries and equipments, or because they actively participate to workshops and trainings organized by such spaces. 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; however, when it comes to doing business, they feel that these principles are approaches 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.

Employing a maker may be useful in a company like us, however, he/she should be a person that considers the making activity not as the main objective, but rather as an instrument that generates transformations over people and organizations.

(Entrepreneur, interview n.2)

“Our start-up was born in a fablab; there, we learnt how to master laser cutters and 3D printers, and we also received practical advice and support for the commercialization of our products. Indeed, we enjoyed a lot the collaboration with other people within the fablab, but we are not so active in the overall maker movement.

(Entrepreneur, interview n.3)

Seven years ago our enterprise was much interested in the maker movement; I personally organized a number of workshops across makerspaces. I generally share the open design principles, but in our case they do not work, mainly because of the small size of the enterprise. We participated to two Maker Faires in Rome, there was a lot of fun and enthusiasm, collaborating with makers is very stimulating but in practical terms you don’t see a lot of business going on! We developed some projects in the past but the maker world did not support us, so we started to work with other enterprises, private investors and patents. Personally I do not believe in the importance of the patent, it is important to keep the innovation open, especially for big companies. But for investors, patents are a fundamental element, and our clients as well are interested in them. All in all, patents improve our reputation.

(Entrepreneur, interview n.5)
In relation to ‘pioneer companies’ (i.e. companies that adopt an ‘open’ approach and are consciously linked to the maker world), we can equally find different levels and extents to which open design and manufacturing is applied over business models, production processes and products. Amongst the analysed companies, we found different examples: one allows the maker community to access a shared platform and download files with interior furnishing designs; another one keeps free both the hardware and software components of its product; lastly, there are companies that have founded themselves a makerspace.

Motivations and drivers towards openness highlighted by these enterprises are many. First, open exchange and sharing with the maker community allow to explore and experiment with product and process innovation. In this case, the maker community is often perceived as a valuable source for R&D activities, in particular in light of new market demands. In this respect, one of the interviewed entrepreneurs stated that he does not start a new production line without an early, positive feedback from the maker community. Likewise, another outlined the importance of new applications developed by makers built on existing top products. Openness is an essential element that contributes to shape the external relationships with clients and business partners; increasingly, networks and networked communities are harnessed to boost new collaboration and business projects, access new assets and capacities, and mobilize information in more effective and efficient ways. Lastly, the open approach is also valuable in terms of reputation and identity; in this case, it is often used as a key element of narrative and storytelling that helps to position enterprises in the market, especially vis-à-vis growing societal and environmental sustainability concerns.
It should be noticed that many of the interviewed entrepreneurs underlined the need to rely on sound and consistent ‘openness strategies’ in order to attain economic sustainability, and to effectively strike a balance between the ‘open’ and ‘closed’ parts of their enterprise. For instance, as many interviews pointed out, the recourse to patents for the protection of specific technologies that enable the whole business model is often crucial to ask for and obtain funds from investors; likewise, the selection of business partners - especially when it comes to platform-based business models that share open design products - is a key driver for accountability and reliability.

“In our community, we only accept those enterprises that are able to collaborate with designers; we are not interested in entities which want just to take from the others without giving anything back. So we select reliable professionals and entities for our community. (…) We are not interested in a project which does not allow us to improve the world; we are far from the idea of American start-up totally dedicated to the profit.”

(Entrepreneur, interview n.6)
Skills and competences in innovative enterprises

The most widespread professional profiles among the innovative enterprises targeted by our study are designers across different fields, such as product designers, service designers, interior designers. We also found numerous architects and engineers, as well as ‘computer geeks’ with background education in social sciences and humanities.

Multidisciplinarity is a recurring aspect of these businesses, and often perceived as a key principle that informs both the organizational structure and the approach to design and manufacturing activities. In particular, the contamination between technical and technological skills with social and communication competences is frequently pursued in the composition of working teams, and particularly applied to the analysis of clients and business partners’ needs. On top of that, the majority of the interviewed highlighted the importance of soft skills such as problem solving, entrepreneurial attitude, empathy and team working for the overall management and development of their business.

An interesting quote from one of the interviews concerns the ongoing transformation in the designer profession and its contamination with new skills and competences. An attitude towards multidisciplinary seems to be particularly linked to the need of current professional figures to adapt to a socio-economic-technological reality in continuous evolution. At the same time, multidisciplinarity assumes a key role especially in smaller enterprises, where it is fundamental that all employees are able to communicate and collaborate with one another across their respective competences and areas of expertise.

“Considering my studies, I can define myself as a graphic designer, but in my job I deal with a number of different topics and disciplinary domains such as sociology, transmedia, use of data and communication. My company was born during a “digital and multiform design” course at the university, which was a course about future design practices. For us, design is a tool for stimulating the debate among people, and its final aim is more related to the creation of performances and interactions, rather than industrial or mass production.”

(Entrepreneur, interview n.2)
At present, formal education paths in Italy seem not to fully support the development of practical abilities to use machines and tools needed for digital manufacturing. Due to this gap, the study found that often, it is the makers who act as trainers for professionals that want to introduce 3D printing or the use of lasercut machines in their work. The fablab becomes a key-space for this learning process, as demonstrated by the fact that almost all the representatives of enterprises interviewed declared that they had learnt and practiced the use of such machines in the fablabs. In this context, again a key role is played by those professionals that have some background and general understanding of both communication and technology, because they represent a sort of ‘bridge’ between the technological sector of the enterprises and the external context, and can help the different worlds communicate and cooperate with one another.

“The idea was to self-produce something in the fablab. Thanks to the people who work here (in the fablab) we learnt how to use a lasercutter, but also a 3D printer. It was easy to learn how to master these machines, we needed to learn how to obtain, through these machines, specific effects on our product. We learnt to use the new software of these machines and the software we already used in connection with the new machines. We learnt on the field how we communicate our product, the 3D modeling; during the courses at the university (of Architecture) we did not acquire these skills, they were not judged important some years ago.”

(Entrepeneur, interview n.8)

“I have a Degree in Communication, I learnt on the field how to use a 3D printer and now I am in charge of technical assistance for the enterprise”

(Entrepeneur, interview n.7)

“I studied Communication, then I attended at workshop on Arduino, and I continue learning on the job. Now I am able to manage people who deal with technology but I do not make computer programming”

(Entrepeneur, interview n.7)
With relation to the demand of skills and competences shown by innovative manufacturing businesses, our exploratory study highlighted a very diversified situation, where companies require different skills according to their core business, the stage of development, and the near future perspectives.

There are two main challenges that companies, which are engaging at different levels with the open approach, seem to face. The first challenge concerns the relationship between these enterprises and other more traditional enterprises and professionals with whom they collaborate or do business. When it comes to their approach to design, for instance, ODM enterprises underlined that their emphasis on the flexible, cross-cutting and speculative approach of design thinking tends to be poorly understood and acknowledged in the Italian context, possibly because of a primacy of interior and product design over service design. Similarly, the connection between the ODM enterprises and artisans seems to be difficult because of their respective approaches to both the market and business partnerships, but also because of cultural barriers and differences in languages. Another challenge emerge when the ODM enterprise is supported or participated by large corporations. In this case, the ODM enterprise finds itself in the need to manage this relationship in a way that is able to preserve its own identity, which in turn means keeping a real and substantial degree of openness and fostering the virtuous cycle of innovation, reputation, networking, and availability of skills.
Traditional enterprises

In the framework of this study, we consider as ‘traditional’ those companies that appear less connected with innovative and emergent technologies, and that do not adopt an ‘open’ approach in relation to their own processes and products. As in the case of ‘innovative manufacturing businesses’, traditional companies do not constitute a homogeneous group; we can therefore describe a continuum that spans from enterprises that are unaware of the maker movement and the open paradigm, to companies that, although aware, are not interested in finding relevant synergies. Within this specific strand of the study, we involved 5 Italian companies that mainly work in the field of interior goods and furniture, producing 5 different typologies of products.

Since 2008, the furniture and furnishing sector in Italy has been experiencing a profound crisis, which in some cases has lead to significant breakdowns in turnovers and, consequently, to serious reductions in size and scale of the enterprises all along the supply chain. Since then, business model innovation and value chain reorganization have increasingly become urgent concerns, and turned into grounds of incremental experimentations which in many cases are leading to the identification and crystallization of new approaches to the markets and new sets of product.

Against this background, the companies involved have been:

- **Corte Zari** (Siena): Started as producer of iron beds, over the past 10 years, this company has gradually become a point of reference for international interior design studios and architects that are supplied with offers and proposals of interiors’ concepts with all typologies of products, from beds to living rooms. The approach to market of the company has completely changed over the past years, and also the strategy for approaching a new target instead of focusing on traditional showrooms and sales point for the large public is now turning to be the right choice for facing a highly competitive market.

- **Marioni** (Florence): similarly to the case of Corte Zari, Marioni has maintained the manufacturing of ceramic lamps as its own core business, but it has progressively extended the range of its production to a home collection proposal of unique taste on a market where differentiation is not easy to be done. Furthermore, between 2013 and 2014, the company has kicked off a sort of internal revolution: believing that traditional stores will completely disappear in some years, the company has started to focus on the coordination of networks of producers of high quality products in Tuscany, relying heavily on e-commerce strategies. Marioni thinks that the potential of web marketing is really high in terms not just of sales, but appreciation of the brands (even the no brands can become brands – opportunity) and of getting information on products (new products, before production starts, should be verified with a specific campaign online in order to understand the level of appreciation by the consumer: this reduces failure risk and linked costs). Finally if you approach the online market the right way you may enter new markets even without addressing your attention to them, at zero cost.
• **Morelli**: Morelli is another example of company that mostly focuses its efforts on the organisation and management of a distributed network of manufacturing companies. Its network ‘Fabbrica Diffusa – Apuana Corporate’ currently gathers more than 15 companies that share a common strategy of market access: the economic crisis in 2008-2012 was so strong that most of them had to reduce their production and in some cases close factories. Presently, they work on demand with customized products by keeping relationships with architects that are interested in marble objects, accessories and finishing-construction materials. The group is working significantly with innovative tools and technologies, both for prototyping/design phases and for supplying architects with complementary services (3D configurator for designing their own products and supplying the demand on time).

• **Segis** (Siena): Segis is a small company which in the past 2 years started recovering sales shares on the market: the contract-hospitality market is particularly tough, logics are complex and the addressed markets – US, Canada, EU – were highly affected by the crisis. Considering the specificity of these markets, the company decided to focus on quality (much more related to after sales assistance than to the products itself) and differentiation (most of the big players that are international competitors for Segis are not flexible in terms of production and connected service, due to their size: Segis turned this into a plus). 3 years ago Segis also started exploring the online market with external web marketing competences for the definition of the company’s placement.

• **Richard Ginori** (Florence): The case of Richard Ginori is peculiar amongst the 5: the company has undergone a thunderstorm lasted 10 years with several changings of property up to 2013, when it was redefined completely and acquired by Gucci. The company is medium sized in dimension but organised as a big company. The business model has been completely redesigned and the company is actually looking at the adoption of innovative technologies for better communicating to both clients and interiors designers the long tradition that lays behind this company and its production. The company is further investing in supporting commercial agents and intermediaries in better displaying the complete offer provided by the company using also Augmented Reality tools.

From the interviews with these companies, it seems that none of them is actually aware of the maker movement, but in some cases they are aware of what open design and open manufacturing paradigm means. In general, it emerged that all of them could be approached by makers because the competences that they mostly frequently require are related to prototyping tools and technologies, KETs in general and IoT tools going from applied technologies to web marketing and multimedia. In the group of 5, the concept of Diffused Factory developed by Morelli has indeed several points of connection with an open paradigm.
Additional competences and skills required by the 5 companies in order to answer their market challenges are mostly related to: multimedia, web marketing, social media marketing, 3D printing/additive manufacturing, fast prototyping techniques, KETs, applied technologies and IoT, nanotechnologies and innovative materials, Virtual Reality and Augmented Reality. They are actually working with established professionals, known by the company for ages, which in some cases have adapted their competences to new fields of intervention. All of them, except for Richard Ginori which has internalised some of the needed competences – product design and communication –, mainly work with external competences also in relation to design.

Among the 5 interviewed companies there is a high focus on innovation, as well as a strong awareness of their own innovation needs. Open design and manufacturing is known (for some of its aspects) by most of them (4 of 5), but there seem to be poor knowledge or at least significant confusion in relation to what the makers movement is, which capacities makers have, and which skills and competences they may provide. Only 1 company out of 5 has previous experiences of collaboration with makers, specifically in the area of 3D printing for prototyping.

All the interviewed companies reported they need of renewing their production and offer on the market in a faster and more flexible way, coherently with the new trends in demand. The need for fast adaptation, flexibility and improved positioning in the market is common to all of them. Competences and skills that would support traditional manufacturers in this path are available but not easily recognisable for them, who have always been much more focussed on product quality rather than on the quality, efficiency, and speed of the service. This is indeed the biggest change for all of them: turning into companies able to produce not only good products, but rather to provide a full product-correlated services offer.

Deep knowledge of the job supply and available skills and profiles is important but lacking, at the moment, within these companies: most of them claimed that they are not used enough to explore the complex panorama of competences offered by the market, and that they often tend to rely, because of lack of time and capacities, on their usual consultants.

Among the companies there is a widespread idea that open design and open manufacturing approaches are actually not safe and efficient. Also considering what makers can offer to traditional companies, all of them, apart from acknowledging their own information gaps, believe that makers are not well structured and generally are too new to the manufacturing world, lacking the necessary level of professionality to be involved in companies. According to them, makers need first of all to be trained to become experts and be able to give a concrete contribution to the traditional manufacturers’ activity on the market.
Conclusion

Against the yet untapped opportunity to build a sound and virtuous relationship between the key actors of the Alliance – Universities, makers and enterprises – the creation of a specific ‘catalyst’ profile seems to appear as a valuable direction for the further development of the OD&M project. The main gap highlighted by this study is in fact a cultural gap, that prevent these actors from overcoming their own resistances towards open and horizontal dialogue with their respective ‘unlikely’ allies. This catalyst profile would play a pivotal role in defining collaborative projects where Universities, makers and enterprises can make the most of their strengths, in a win-win logic. In this context, such a profile would host the actors, creating the bridges needed to turn the Alliance into a vibrant environment of collaboration. As repeatedly stressed during both interviews and focus-groups, none of these actors seem able to drive this transition unilaterally; therefore a ‘neutral’ figure is needed together with systemic actions of education and awareness-raising targeting all these actors within a new entrepreneurial culture.

The catalyst profile should be grounded in strong relational capacities, and on strategic competences able to channel investments and individual efforts meaningfully and towards concrete outputs and outcomes. Acting as ‘knowledge intermediary’, this profile should be devoted to the identification of knowledge and skills gaps, facilitating new matchings and multi-disciplinary collaborations; indeed, it should also present strong capacities in understanding potentials and needs of the various actors involved. According to our study, the catalyst profile could also be framed in terms of ‘systems designer’, therefore insisting on the strong combination between design-driven skills and competences with sound research, analysis and strategic development ones.
On this basis, we can expect that rather than a maker, this profile particularly builds on a number of soft skills where the capacity of systemic vision emerges as the predominant ones. Amongst them:

- Empathy, interaction and communication skills;
- Analytical capacities;
- Openness towards learning to learn;
- Problem-solving;
- Capacity of scenario building;
- Capacity to prioritize needs and problems;
- Capacity to identify specific domains of knowledge;
- Sound knowledge of ongoing social-technological trends;
- Knowledge of patents system.

Coherently, the following disciplinary domains could actively contribute to the creation of this profile, namely:

- Communication, with special reference to innovation-related communication;
- Management Science and Engineering, provided that more visionary approaches to innovation and to the innovation management are pursued;
- Design, particularly in its own capacity to drive new trends and anticipate the market demand.

Within the Alliance triangle, Universities would position themselves as pivotal actors able to prepare this figure, creating the ground needed to combine and connect complex knowledge within a codified and recognizable training pattern. In turn, the systemic adoption of project-based teaching and learning, open innovation calls, distributed learning and team working developed in close collaboration with both makers and enterprises, could represent a valuable complement to the training offer, while serving the progressive construction of networks and communities where this new figure would find its natural field of action.
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