“Higher education in the making: reinvigorating learning institutions throughout cross-academic collaborations”

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EXECUTIVE SUMMARY

The aim of this white paper is twofold: **recapping the main learnings and experiences delivered in the OD&M project during the last 3 years, as well as presenting a different set of guidelines that can help bridging maker culture with Higher Educational Institutions (HEIs) at European level.**

To this extent, the paper presents a 7 point-structure starting with a brief introduction of how the project was originally conceived, second point builds up on the findings of a previous report delivered into the project, third section presents the OD&M approach, the different nodes that have been involved, as well as the particularities of the training prototype and the digital platform that has supported the development of the project. The fourth point recap the main research methods delivered, the fifth one sums up the main project learnings, number six provide a set of policy recommendations and the last points provides some concluding remarks,reflections and the bibliography used.

During this period of time 4 nodes (Italy, Poland, Spain and UK) have been piloting a training prototype that has been based on the results of the exploratory study (Martelloni et al., 2017) implemented by the Alliance over 2017. This report aimed to achieve a deep understanding of the types of collaborations that universities, maker communities and companies across Europe and China are currently developing around the making culture and, by extension, using open design and manufacturing. The results of this study have been used to design training prototypes where effective collaboration between these agents has been carried out, taking into account the cultural and socioeconomic particularities of the 4 different nodes.

The main rationale that supported experimentation among the actors of the OD&M triangle is that **maker movement is a revolutionary force for experiential education, but this cannot underplay the need of establishing alliances and collaborations between different stakeholders to make it sustainable and viable**. Open design and manufacturing are paradigms mainly supported by ecosystems of actors that need to be engaged and supported, and this is the first step to establish and open innovation ecosystem oriented to education and supported by digital platforms.

After developing the second phase of the project where 4 training prototypes were delivered in the four nodes and putting an end to the trip that was initiated at Florence in January 2017, a final set of recommendations are collected and presented at the end of this document.

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These are the following:

- **To extend funding for students mobility actions**
- **To provide the right incentives for establishing collaborations between stakeholders and HEIs**
- **To allocate adequate resources for the institunioalization of makerspaces**
- **To foster individualized learning paths throughout participatory processes, group dynamics and teamwork**
- **To promote new ways of formal recognition of skills and knowledge gathered throughout non-formal and informal learnings**
- **To promote diversity, equity, inclusivity and responsibility through maker culture**

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GLOSSARY

AI: Artificial Intelligence.
CEOE: Confederacion Española de Organizaciones Empresariales.
CNC: Computer Numerical Control.
DIY: Do it Yourself.
FLOSS: Free Libre Open Source Software.
GDP: Gross Domestic Product.
HEI: Higuer Education Institution.
HTML: Hypertext Markup Language.
ICT: Information and Communications Technology.
IoT: Internet of Things.
KETs: Key Enabling Technologies.
MIT: Massachusetts Institute of Technology.
MT: Manifattura Tabacchi.
P2P: Peer to Peer.
PhD: Degree awarded to people who have done advanced research into a particular subject. It is an abbreviation for 'Doctor of Philosophy'.
R&D: Research and development.
REBEL framework: Recognition of Experience Based Education and Learning.
SME: Small to Mid-size Enterprise.
STEM: Educational program developed to prepare primary and secondary students for college and graduate study in the fields of science, technology, engineering, and mathematics.
TMRC: Tech Model Railroad Club.

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1. INTRODUCTION

The OD&M project had an important challenge when starting 3 years ago: **to validate a new training method based on active collaboration between universities, makerspaces and manufacturing companies.**

The process has been arduous and not without difficulties. Cultural and methodological differences in the 4 nodes have made difficult to find a common framework on which to work. In this document we describe the particularities of the maker movement and the skills and competences commonly associated. We also explain how difficult has been to set up a common framework and validate it through training prototypes for the introduction of several concepts related to open manufacturing (soft skills, open technologies, rapid prototyping, team working ...) in HEIs. We also stressed how challenge-based learning can be beneficial not only for students, but also teachers and other stakeholder participating in the open learning ecosystem, such as makerspaces or traditional manufacturing companies.

The aim of this report is to gather the conclusions and findings observed during the lifespan of the project, that has involved the research phase, the methodological design of the training prototypes, the development of the training materials and the evaluation model, as well as the online platform that supported the interactions at the digital realm. In addition, interviews and focus group discussions held with the different gents of the project triangle have also been analyzed in order to obtain conclusions not only based on observation and experimentation, but also on the feedback received by the different agents involved. In this sense, different findings, challenges, problems and opportunities have been mapped out for strengthening connections and collaborations on the OD&M Knowledge Triangle.

OD&M project represents an important case, providing insights and identifying possible future scenarios of education, training and business innovation built upon an unedited alliance between HEIs, manufacturing businesses and maker communities, that are able to spur innovation – and, in particular, social innovation - across the whole open design and manufacturing value chain.

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2. MAKERSPACES IN EDUCATION. A COMPREHENSIVE VISION

After almost a decade since the inception and popularization of the "maker movement" phenomenon has taken place across the globe (C Anderson, 2012; Dougherty, 2012; Hatch, 2013), several sectors and domains have explored the potentialities that lie in this grassroot innovation movement (Browder, Aldrich, & Bradley, 2019; Rosa, Guimaraes Pereira, & Ferretti, 2018; Smith, Fressoli, Abrol, Arond, & Ely, 2017; Turner, 2018). Thanks to the quick spread of hackerspaces, makerspaces and fab labs in many urban areas (Niaros, Kostakis, & Drechsler, 2017), maker culture has been disseminated widely in different countries and domains, as well as many institutions and organizations have tried to establish synergies and collaborations with these kind of digital fabrication labs (Dellot, 2015; Deloitte Center for the Edge & MakerMedia, 2013; Gutiérrez, 2018, 2019b; Halbinger, 2018). These encounters of maker movement with different domains of society such as design, engineering, education or policy among many others , have made possible different kinds of unplanned collaborations that have spurred significant innovation projects, as well as new kind of socio-technical configurations (Halverson & Sheridan, 2014; S. Lindtner, 2015; Silvia Lindtner, Hertz, & Dourish, 2014; Rosa, Ferretti, Guimarães Pereira, Panella, & Wanner, 2017).

The term "Maker movement" was originally used by Dale Dougherty (2012) for referring to people that engage passionately with new digital technologies such as 3D printers, Internet of Things (IoT), Computer Numerical Control (CNC) machines or 3D Computer-aided Design (CAD) among others, as well as they are keen on creating new objects or developing cutting-edge projects. Previously, Chris Anderson also referred to these individuals as "makers" (Chris Anderson, 2010), and other scholars also speak about "maker culture" (S. Lindtner, 2015; Silvia Lindtner & Li, 2012) for characterizing this global phenomenon whilst they stress some of the values, ethos and behaviors that are behind this philosophy of engagement with new digital technologies. The expansion of this phenomenon has been favored by the popularization of makerspaces in urban areas (Niaros et al., 2017), but not only, as some digital fabrication labs have also emerged in rural areas (Gutiérrez, 2018). During this text we will employ the term "makerspace", for referring to this kind of spaces that host a community of practitioners, as well as providing a space that can offer digital fabrication tools for developing collaborative projects. Other definitions in the literature refer to "makerspaces ", in a very similar way, as an umbrella term *"for community-run physical places where people can utilize local manufacturing technologies"* (Niaros et al., 2017, p2)

One of the domains that have largely benefited from the popularization of makerspaces in society has been the educational sector (Halverson & Sheridan, 2014; Sheridan et al., 2014; Vuorikari, Ferrari, & Punie, 2019), as it currently faces significant challenges due to the quick pace of change that digitization is imposing in society and specially, in the labor market. This strain is also emphasizing the importance of being adequately equipped with the right skills and competences to navigate the turbulent waters when looking for a job. In this sense, the irruption of Industry 4.0 paradigm, where smart, connected and automated factories will be

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gaining importance in the industrial sector has facilitated the positioning of Science, Engineering, Technology and Mathematics (STEM) degrees (Davies, 2015; Gutiérrez, 2019a; Smit, Kreutzer, Moeller, & Carlberg, 2016). Other global trends such as globalization, multiculturalism and distributed knowledge are contributing to the growing complexity in the labor market, which confers education a vital role for training the new professionals that will deal with this new and complex environment.

In this sense, education has seen in the maker movement an interesting opportunity for reinvigorating STEM education with a more practical approach focused on problem solving, teamwork, knowledge sharing and knowledge generation, networking, prototyping and experimentation among other aspects (Burke & McNeill, 2011; Martin, 2015). This move has been also facilitated by the many challenges that education face nowadays, which comprise its different levels (primary, secondary, tertiary), the profile of already settled instructors (ageing, digitization, entrepreneurship, creativity) and the infrastructures where it takes place (lack of technological labs, classical rooms, non-dynamic spaces).

Maker culture offers several opportunities to renew pedagogical approaches for approaching to scientific and technological disciplines such as robotics, electronics or computer science, but not only (Martin, 2015). For instance, some projects aimed to use 3D printing for building up a Gothic cathedral allow to pupils acquire concepts coming from different fields such as architecture, physics, materials and digital manufacturing, but it also can entail curricula coming from art history, history or philosophy, if adequate measures are taken[1]. This is one of the reasons to argue that makerspaces can provide room for different tools, methodologies and technologies to develop collaborative projects that require multiple knowledges that allow to break the classic division between disciplines imposed by traditional educational systems (Sheridan et al., 2014). In addition, maker culture can also facilitate the development of soft skills such as teamwork, self-management, communication skills, creativity, critical thinking, resilience, networking and other skills that are increasingly demanded by the job market, and more specifically, in sectors where digitization is becoming more pervasive (Grundke, Marcolin, Nguyen, & Squicciarini, 2018). Already mentioned global trends are also favoring the increasing expansion of a knowledge-based economy and the imperative of developing high-added value services throughout the collection, management, store, analysis and re-use of data. This is also contributing to the emergence of new jobs intimately associated with disruptive technologies such as 3D printing, IoT, AI, cybersecurity or robotics among others, which demand a high relational capacity between developers, procurers, users and stakeholders, as well as other kinds of soft and hard skills and associated abilities.

[1] See for instance “Dando forma al Medievo”, an interesting and awarded educational project dealing with these issues: https://dandoformamedievo.wordpress.com/

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Skills also present several problems from a traditional educational model perspective, as cooperative work and practical orientation, among other issues, have not traditionally favored in formal learning environments (Ferrari, 2013). In regard with this issue, we have to acknowledge that the pedagogical foundations that lie in the maker culture are also not radically new at all. In fact, the ideas behind this philosophy hinder its roots into three classical pillars that have tried to renew educational practices since several decades ago. These pillars are experiential education, constructionism and critical pedagogy (Blikstein, 2013). Those ideas were promoted by great thinkers like John Dewey, Seymourt Papert and Paulo Freire respectively and have in common the need to promote a meaningful learning that must be attached with the real world, that allow pupils to develop projects that can be hands-on, and to connect the curricula with the cultural particularities that surrounds the student´s context. Those claims underline the need to promote educational activities that prioritizes the connection with the real world, that allows students to develop projects that can be seen and touched, and that allow to connect curricula contents with the cultural particularities of the students' reality.

In particular, John Dewey was one of the first pioneers that stressed the massive mechanization of kids, the passivity of attitudes and the uniformity in methods and contents (Dewey, 2009). That is why he founded in 1896 the "*Laboratory School*" at the University of Chicago, to set up an space where testing its famous methodology called "*learning by doing*" (Romero-Frías & Robinson-García, 2017). Together with this approach, the ideas of Papert (constructionism) and Freire (critical pedagogy) can be seen in action at several makerspaces where a focus on more participatory, reflexive and contextualized learning is promoted (Blikstein, 2013). Throughout the construction of prototypes, artifacts and critical engagements in the development of technology development projects, makerspaces are also promoting non-formal and informal learning dynamics embedded in local contexts. The second theoretical foundation of making, constructionism, stress the intrinsic value of "*making things*" as Papert claimed several decades ago. This theory argues that the construction of knowledge occurs much better when students build, make and share their own objects, favoring its exposition, interpretation, discussion and examination (Papert & Harel, 1991). In this sense, the development of prototypes, machines, tools, artefacts or objects through different digital fabrication tools also contribute to the development of creativity and critical thinking among other competences (Kostakis, Niaros, & Giotitsas, 2015). This theory has been particularly extended through makerspaces and new scholars working in this field and proposing what has been framed as "critical making" (Ratto, 2011; Ratto & Ree, 2012). Similarly, Freire´s critical pedagogy also criticized the industrial character of education at his time and introduced the need of providing a culturally meaningful curriculum to establish a strong relation with the local context, and also, as a form of empowerment for students (Freire, 1974).

This is what commonly happens when a set of FLOSS technologies are introduced in the classroom thanks to makerspaces allowing students to inspect, to repair, to produce and to modify individually and/or collectively different kinds of objects and artifacts. This set the

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basis for establishing dynamics of personal and / or collective empowerment through the development of skills and competences that increase the motivation and involvement of students in their learning processes (Halverson & Sheridan, 2014). However, this also demands to modify the teacher´s role, as it becomes a facilitator of learning processes instead an instructor, where a flexible curriculum emerge and the need to adapt it to the particular needs of the students is of paramount importance (Blikstein, 2013). This new configuration requires that both students and teachers become active members in the learning space that happens, where specific and individualized needs occur, but also where cooperation dynamics are flourished between participants at different levels. This implies that methodological skills, as well as technical knowledge of teachers must be actively updated, as the increasing speed of innovation imposes several challenges around this issue. This is probably one of the great barriers that classical education has to face when adopting maker education, as the training of teachers, as well as the acquisition of specific equipment and the involvement of teachers in multi/trans/interdisciplinarity dynamics can create great tensions and resistance to its adoption (Liang, 2019).

This is one of the main reasons for avoiding a technocentric or a techno-determinist approach, but to adopt another one that could be context-sensitive, as well as paying attention to the cultural particularities of the communities to be involved. Maker education can raise interest and motivation of students (Jun, 2019), but at the same time represents an opportunity to create a more systemic vision of learning processes and reinvigorating pedagogical and didactic approaches employed in STEM disciplines. This is caused for the high level of social exchange and collaboration among diverse actors, the enhance knowledge creation through sharing physical and virtual spaces, as well as the production of material artifacts using technological resources (Browder et al., 2019). In this sense, makerspaces are becoming increasingly popular, but we have to argue that this popularity also demands a renewal of educational methodologies and approaches (Fehringer, Kaar, & Stary, 2019; Vuorikari et al., 2019).

2.1 Values and principles

Since its beginning, maker movement has lied in several values that were already present in previous trends, associations and philosophies such as crafts movement, Do It Yourself (DIY) ethos, hacker culture, Free Libre Open Source Software (FLOSS), Tech Model Railroad Club (TMRC), pirate radio broadcasting, cyberculture or American counterculture (Barbrook & Cameron, 1996; Haring, 2008; Himanen, 2002; Levy, 2010; Turner, 2006, 2018). All these previous movements predicated about the benefits of tinkering, playing and experimenting with technology, as well as they conceive to technology a transformative power for making a better world through its mastery.

Although it is usually argued that there is not an unique maker movement that shares a coherent set of values across the globe (Silvia Lindtner, Bardzell, & Bardzell, 2016),

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several values are usually shared in different communities across countries such as collaboration, creativity, critical thinking, empowerment, innovation, sharing, openness and community resilience (Martelloni et al., 2017). These particular ethos confer to the movement a set of attitudes and behaviors that can comprise peer to peer (P2P) learning, common ownership of production results, knowledge sharing, altruism, digital hedonism and others related that trigger curiosity, discovery, entrepreneurship, solidarity, commonality and self-learning in a variety of ways.

2.2 Business collaborations, skills and global trends

Due to the global reach of the maker movement and their potentialities regarding entrepreneurship and innovation, several efforts have been developed in the last years for bridging businesses and maker culture. From startups to company labs, several initiatives have aimed to promote businesses with a maker mindset. Popular examples like Opendesk, WikiHouse, Fairphone, RepRap, DFRobot, OpenROV, TokyLabs, Arduino or Raspberry Pi have gone mainstream due to its commercial success. However, the fragility of the maker ecosystem from an economic point of view, as well as the lack of marketing and financing expertise in these spaces (Mortara & Parisot, 2016), as well as the different motivations to innovate that can be found (von Hippel, 2017) does not help to promote stable incubation and acceleration mechanisms in these settings.

On the contrary, we can observe the limited impact of the maker movement in business, and specifically in manufacturing (Gutiérrez et al., 2018; Martelloni et al., 2017). Of course there are some initiatives from big companies that have tried to establish bridges with these grassroot innovation movements (Deloitte Center for the Edge & MakerMedia, 2013; Hagel, Brown, & Kulasooriya, 2013), but their impact is very limited and it seems that the maker movement primary impact has been mainly at the educational sector.

However, open design (Bakırlıoğlu & Kohtala, 2019; Bauwens, 2010) seems to be completely trendy in the business sector as several companies are stressing how the value of commodities have been displaced to this part of the value chain instead of manufacturing. In this sense, maker culture can help to companies to be more profitable, innovative and competitive.

2.3 Institutionalization of makerspaces

In recent years and thanks to the growing pressures for updating educational methods and releasing new technical degrees aligned to the market needs posed by the digitization of industry, we can clearly see how makerspaces have become common in the educational sector. In this sense, we can speak about an institutionalization of makerspaces into the educational sector (Gutiérrez, 2018) with the US as a prominent example. Under the Obama administration, different policies

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aimed to promote STEM disciplines and innovation culture were raised due to the general consideration that implied a STEM-educated workforce as a requirement for making industry globally competitive. The most significant effort was the "Educate to Innovate"[2] programme which helped to provide a special financing line for makerspaces and fab labs across the country to strengthen project-based learning methods, through public administration, large companies and philanthropists (Burke & McNeill, 2011; Ramella & Manzo, 2018). Other important initiatives such as the "National Week of Making", "Maker Cities" and the "White House Maker Faire" were also spurred during his mandate[3]. Other educational initiatives such as International symposium on academic makerspaces, and association and a journal on this field have also contributed to the popularity of the topic in the country[4]. However, the Trump administration discontinued this line of action of his predecessor (Gutiérrez et al., 2018).

China has been another of the main supporters of makerspaces, where several cities like Shanghai, Nanjing, Beijing, Hangzhou, Haerbing and Shenzhen have promoted the setting up and development of these labs commonly known as "XinCheJian" (usually translated as new workshop or new factory) (Silvia Lindtner & Li, 2012). The rapid and massive expansion of these labs across the country in educational settings, but also in industrial spaces, that is in concordance with the efforts of the Chinese Government for favoring the diffusion and popularization of disruptive technologies such as 3D printing, AI or IoT in society (Li 2014), which are of critical importance for the future of the country (Saunders & Kingsley, 2016). Some renowned companies such as Foxconn or Xiaomi have also embraced P2P practices for reducing costs and establishing collaborative innovation ecosystems (Silvia Lindtner, Greenspan, & Li, 2015).

[2] More information at this link https://obamawhitehouse.archives.gov/issues/education/k-12/educate-innovate

[3] Check https://obamawhitehouse.archives.gov/blog/2014/06/18/president-obama-white-house-maker-faire-today-s-diy-tomorrow-s-made-america, https://nationofmakers.us/ and https://www.weekofmaking.org/

[4] See https://isam2019.hemi-makers.org/, https://hemi-makers.org/ and https://ijamm.pubpub.org/

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3. OD&M APPROACH

From the very beginning the objective of the OD&M project has focused on creating, developing and maintaining a learning ecosystem that can create and support communities of practices focused on the Open Design &Manufacturing paradigm. For this, different initiatives have been carried out: inspiring international mobilities, dedicated events, project-based trainings, challenge solving and innovative systems of learning outcomes certification. In this sense, OD&M project also delivered a digital platform for supporting the different communities and their activities that were carried out during the lifespan of this initiative, as well as a training prototype that can be tailored to the specific needs and particularities of the node where the project has been implemented. The following sections provides dedicated information about how the general philosophy behind the project and how it has been tailored to the specific needs of the nodes taking part on it, as well as their stakeholders.

3.1 OD&M Platform

One of the pillars of the OD&M project has lied in the generation of a tool that was able to support the recognition and certification of competencies and skills that are demanded by the knowledge economy but are not recognized yet by formal education. This is due to the fact that traditional educational systems are becoming rapidly obsolete due to technological development, labor polarization, globalization and other societal challenges that society is facing. In this sense, education is of utmost importance for developing new competences and skills that can be uptake by young people towards its operationalization in the labor market. The role of informal and non-formal education is of increasing importance as its flexibility and agility can contribute to set up new incipient fields of expertise long before its recognition by formal educational systems. As it has shown before, makerspaces and fab labs are increasingly being incorporated to the formal educational landscape for facilitating this transition, but still there is a long way to go.

That is exactly where the OD&M platform stands by, as a digital tool that can support the recognition and certification of competencies and skills developed with the OD&M learning environment. The tool aims to support learning capture and recognition relevant to experience-based and challenge-driven learning, adaptable for non-formal distributed learning. It is based on the Open Badges system and is integrated with Badgr, allowing that every badge earned by a learner can be exported and publicly shared with a simple link, an image or by embedding the badge itself into a website, a personal e-portfolio or a resume.

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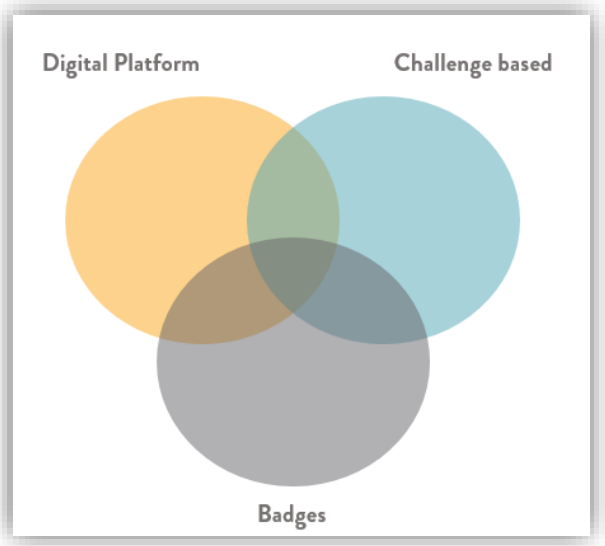

Figure 1. OD&M platform triangle.

This platform was also envisioned for providing common features for all badges that allowed to specify evidences of the badges granted by the learning institution, conducting expert, peer and self-assessment of participants, and allowing an alignment with the REBEL framework for the recognition and the endorsement of key competences promoted throughout the challenges. The OD&M Platform also builds on the following five key functionalities:

1- **Challenge Based Learning:** the OD&M platform is conceived as the supporting tool for the challenge-based learning process. Challenges are the core of the platform and each challenge that has been created by HEIs have a description, a timeline, different stages, training materials, a number of badges associated to its fulfillment, uploaded solutions by solvers, and the possibility of issuing badges.

2- **Competence Recognition:** The successful competition of a challenge guarantees (ideally) that a learner acquires a competence, or a set of competences previously defined by the HEI.

3- **Open Badges Issuing:** When competences have been acquired successfully, an open badge can be issued to the learner throughout the OD&M platform. This open badge can be audited in OD&M Platform and in BADGR platform. Open Badges are a symbol of achievement and they are **Verifiable** (data inside proves what have been achieved by the owners), **Shareable** (badges can be posted by its owners all over the web) and **Portable** (owners can take them in their

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backpacks). Open badges also empower individuals to take their learnings with them, wherever they go, building a rich picture of their lifelong learning journey.

4- **Not an assessment/evaluation platform:** the teacher, tutor, etc., will have to assess or evaluate whether a student acquire a competence or not with his/her own methods or tools. The platform is aimed to create and manage challenges and issuing open badges, but the assessment should be done outside the platform. With this way of working, with open results, allow that in liaison with the evaluation carried out by the tutor, it can be a peer to peer evaluation among students.

5- **A common competencies framework** behind the construction of the badges, the Rebel Framework, developed by UAL in collaboration with other institutions across Europe. The Rebel framework is a reference framework for the recognition of life-wide learning and the endorsement of flexible, non-formal and informal education, that builds on the European Key Transversal Skills and Competencies Framework.

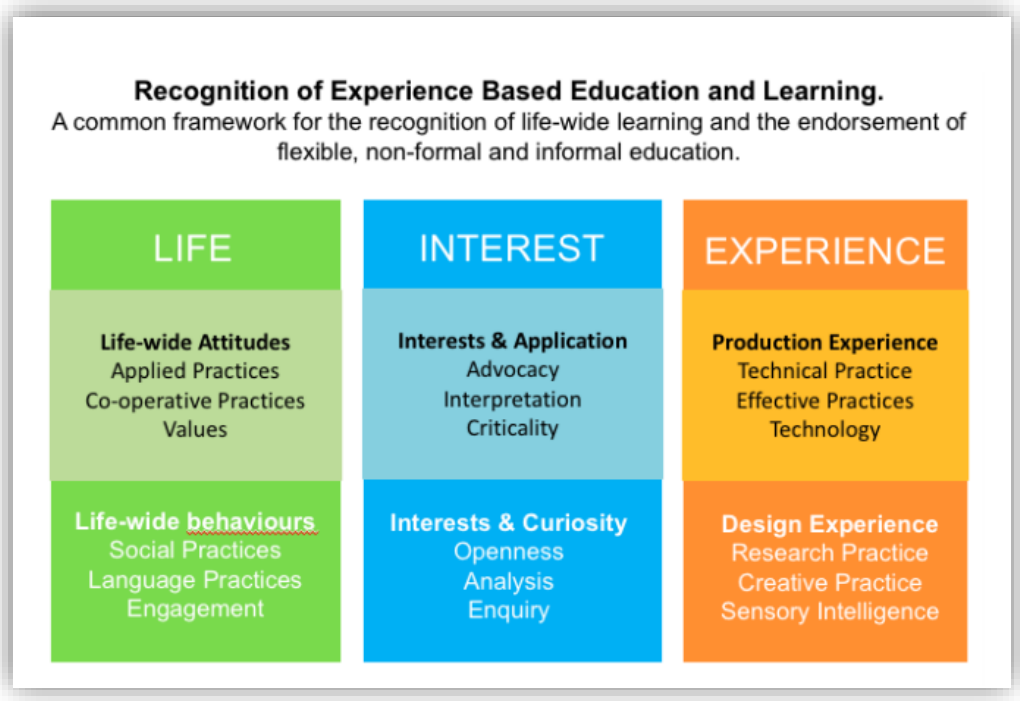

Figure 2. The Rebel framework developed by UAL.

The existence of the OD&M platform has allowed to the different nodes to introduce different challenges and different tasks in relation to their particular needs and

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networks of stakeholders that have been involved into the training prototypes. This has introduced into the nodes a component of flexibility and agility to deal with the development of the different learning paths envisioned for all the students that took part in their courses. Some general figures about the use of the platform by the different nodes are graphically listed in image 3 and in image 4 there is a breakdown per node.

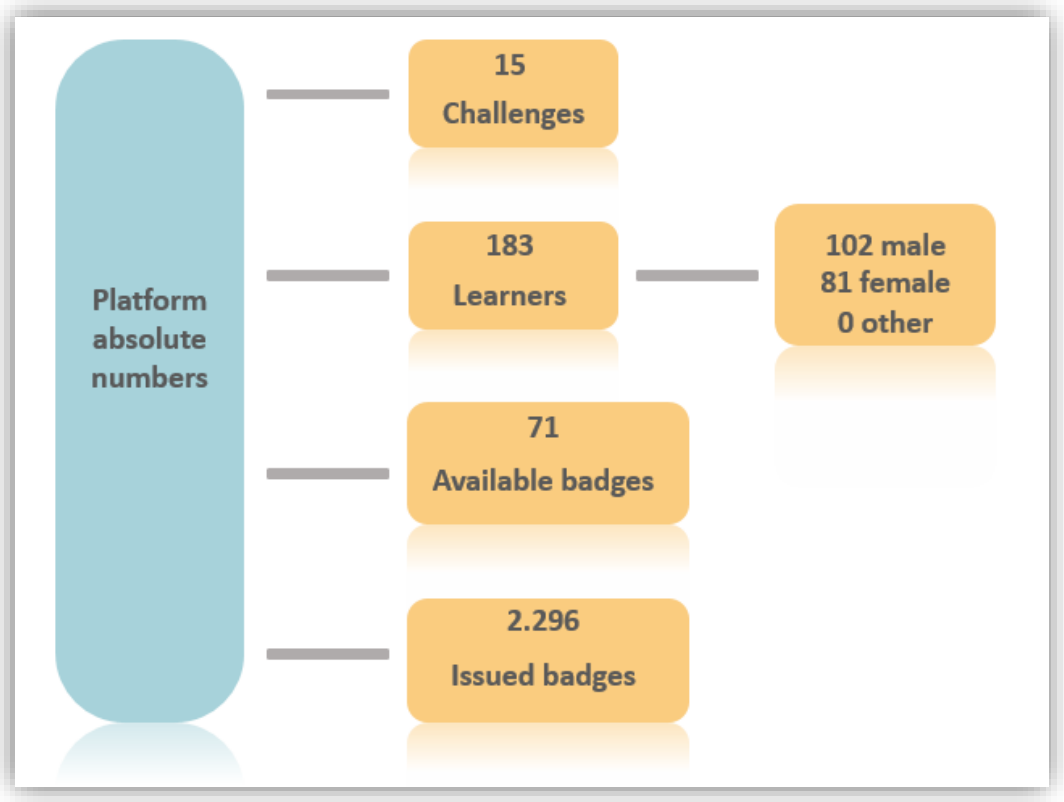

Figure 3. OD&M Platform general use.

As it can be seen in the next image, the use of the platform has been widely diverse depending on the node, especially in the number of students per node, and the number of available badges created by them. This has been one of the most problematic components of the project as several instructors and students argued that there was not a clear and shared approach behind the badges allocation, what has led to a misuse of this system in all nodes. Later on, we will dig in on this matter at the project learnings section.

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	Spain	Poland	UK	Italy
Number of Learning Institutions	1	1	2	2
Number of Challenges	1	8	4	4
Number of Learners	8	28	38	108
Gender (male/female/Prefer not to disclose)	7/2/0	22/6/0	23/15/0	48/60/
Available badges created by hub	1	13	6	11
Total badges per hub, issued to all students	12	419	1064	782
Badges per participant average	1,33	14,96	28	7,24

Figure 4. OD&M Platform detailed use by node.

3.2 Training prototypes

Another of the backbones of the OD&M project has been focused in the **development of a training prototype oriented to meet the different requirements for developing a new course in the four nodes to pilot learning and knowledge exchange in the open design and manufacturing context, as well as allowing to incorporate to the nodes the different requirements and particularities according to their contexts**. This exercise was triggered in a workshop organized in London at the facilities of UAL on January 15-17 in 2018. This workshop allowed to deliver 4 briefing documents that contained specific training programmes that were tested in the territorial nodes during the fall of 2018.

After the workshop was held, a report was also produced gathering a range of strategies and considerations for curriculum planning and delivery in the OD&M context. It also included considerations lifted and extrapolated from the co-design workshop such as training content and methods, accreditation and assessment strategies. Timelines, modalities for subscription, expected learning outcomes were also detailed in the individual challenge briefs produced. These were informed by the common lexicon and the strategies that emerged from the workshop, that hosted 4 co-design sessions over 3 days: common lexicon, understanding of salience in open design and manufacture curriculum, definition of learning attributes and learning gain with the intention of developing how this can be applied in the OD&M paradigm. Afterwards, the nodes developed and implemented 4 full training prototypes in their institutions:

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- **Design driven strategies for manufacturing 4.0 and social innovation (Italy) is** a course and laboratory based on systemic thinking and design thinking in the 4.0 paradigm. The goal has been focused on training professionals to be able to use design as a lever for the creation of collaborative and multi-disciplinary processes between companies, research centers and social innovators, with the aim of contributing to the competitiveness of businesses and territories in view of sustainability of the development model. The course has been aimed at the training of a figure that acts as a builder of 'bridges' and to foster strategic connections between different actors, facilitating collaborative and interdisciplinary communities around business challenges that also have social / environmental implications, through a design-driven approach. Design driven strategies uses a training method inspired by the principles and methods of the communities of practice (Wenger, 1998). Guided by expert facilitators, the students work in teams to create prototypes and innovative projects, in response to real challenges and problems. Thematic workshops, events with international guests, theoretical lessons, peer review and networking activities has accompanied students along the way, allowing them to experiment with experiential training methods, and to build networks and connections useful for personal and professional growth.

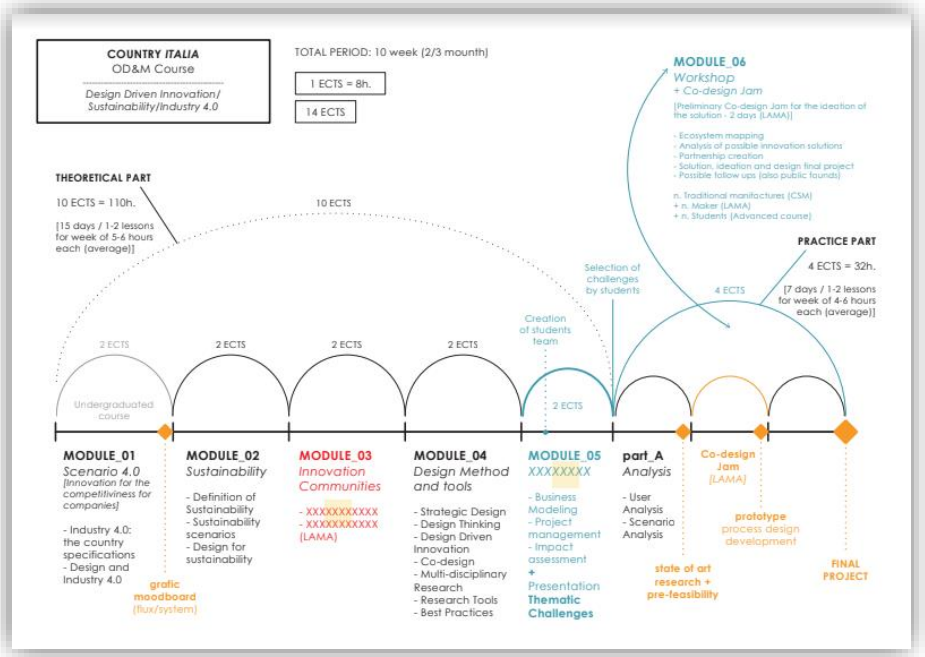

Figure 5. Design driven strategies for manufacturing 4.0 and social innovation (Italy).

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- **Open design and manufacturing trough event-based learning (Poland). This** training course has been composed by several meetings, hackathons, webinars and lectures, all focused on developing creative and innovative skills used in technical examples of ICT world. Each event has taken place in the two Polish cities, Dąbrowa Górnicza and Lodz, and has been supported by mentors based on each city. The orientation of these activities and events have been mainly technical. The following list comprise some of the main activities that have been undertaken: heuristic methods (meetings focused on allowing the group of strangers become a group of cooperating friends, and s providing the group with methods allowing to approach any task in open mind and creative way), Coding and designing of embedded systems (lectures focused on creating solutions based on HTML forms and JavaScript for control mobile robot platform, and receiving data from telemetry sensors by using ESP8266 hardware platform), Designing web applications (lectures focused on acquainting the students of various backgrounds with elements of preparing website, collect data by using relational databases and PHP language), webinars (discussing ICT for makers' movement and introducing rapid prototyping methods), soft skills workshops and hackathons focused on IoT, LoRaWAN infrastructure, the Things network, Textronics and others.

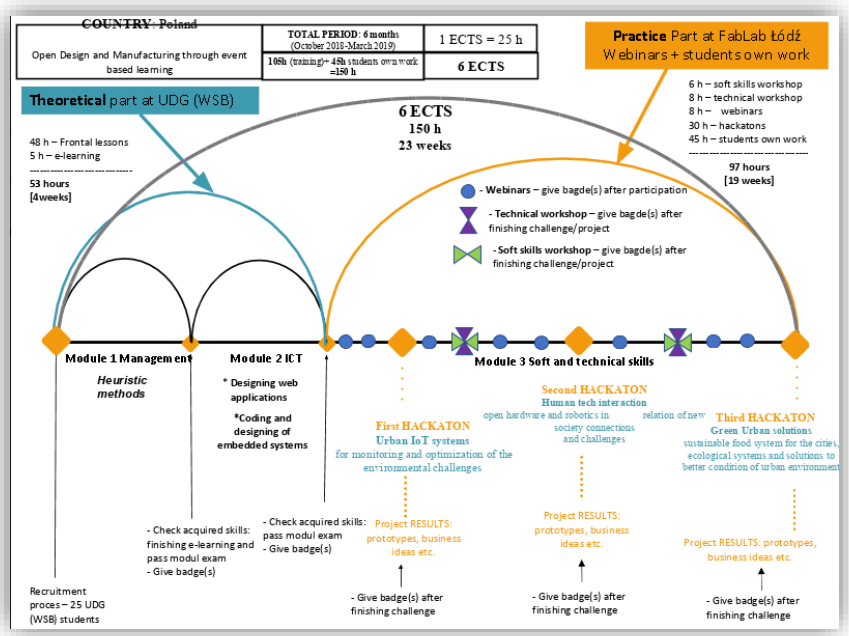

Figure 6. Open design and manufacturing trough event-based learning (Poland).

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- **Open design, manufacturing & design for all (Spain)** that was smoothed into the subject "Prototyping and Digital Manufacturing" of the degree in Industrial Design Engineering in September 2018 at the University of Deusto. The challenge of participating in this project has been focused in solving real problems of a disabled people group. These people, with different types of physical and organic disabilities, were part of Etxegoki, a community of 34 neighbors. This group is settled in an innovative building that has floors adapted to facilitate maximum independence and self-management of its inhabitants in their everyday living. The different degrees of disability that this group of neighbors possesses require customized solutions of objects for domestic use, that suits to their particular problems for facilitating their daily life. It is at this point where social innovation, new manufacturing technologies and industrial design come together to solve this challenge. The specific problems of Etxegoki residents became an opportunity for teachers and students to solve real problems by applying design thinking methodology. Considering that this group of users presents very particular disabilities, the application of new digital manufacturing technologies became a strategic tool for prototyping unique pieces or very small series of products. Following the five phases of design thinking: empathize, define, create, prototype and evaluate. Thus, in the third phase of creation, ideas emerged to cut fruits and vegetables, drink liquids, serve ingredients or salt food, actions that took shape in a varied typology of objects designed in two dimensions through sketches, perspectives and technical drawings. For the prototyping phase, there were professionals and facilities of Deusto FabLab, a center specifically created to develop these activities, where the students made scale models of study and applied different basic techniques of representation, with foams of different densities, cardboard or wood. In the last phase (evaluation) residents of Etxegoki building were invited to get to know the different projects delivered by each team of students and test the usefulness and quality of each prototype, whilst giving feedback to the designers. Principles of Design for all were applied during the lifetime of the training prototype, so the resulting products are valid for people with or without disabilities, and they have also been designed with a clean and inclusive formal language that communicates their use without possible discriminations.

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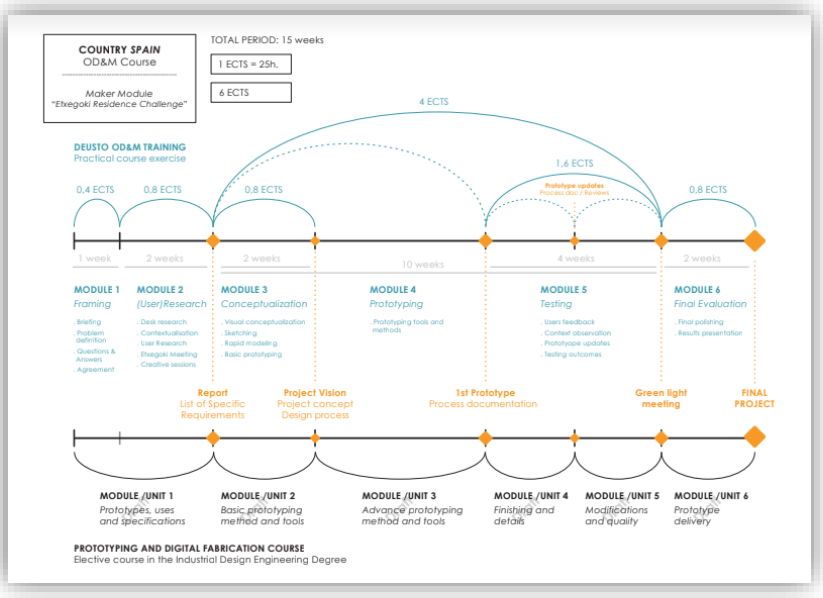

Figure 7. Open design, manufacturing & design for all (Spain).

- **Citizen centered innovation through citizen-centered innovation through open design and manufacturing (UK) delivered a** challenge-based learning through open design principles. It engaged 3 socially responsive thematic in a context of Industry 4.0: *Open design for inclusive neighborhood development in collaboration with the London Borough of Camden*, *Open design for future sustainable living focused on bio material innovations in algae material for healthier urban environments in collaboration with Green Lab* and *How can we design locally, make globally?.* The first challenge considered how design-led creative activities and collaborative processes can be applied to engage local residents and other stakeholders in generating insights into what the different people and publics of Somers Town think is needed to create a more sociable streetscape in Chalton Street. Working with community stakeholder's 'furniture' which can be manufactured using digital production methods and, that creates positive social value by making the streetscape a welcoming place for meaningful encounters between people, has been co-designed. This 'furniture' can help to 'reframe' part of Chalton Street Market as a 'public living room' that welcomes people to the market and helps to stage encounters that enable meaningful connections between people. The second challenge explored how open design-led process can be used to develop future products, materials, new processes or services that use algae

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as the core material; whether at an industrial level such as a future biofuel, at a much more personal level for cosmetics, food source, a new material, decorative perspectives or as a bioremediation (cleaning our air and landmass). The scope for the sustainable future living project considered diverse scenarios with algae. Third and last challenge questioned how the role of the designer is changing at this period of time. This question introduced the debate of how the role of a designer must be considered in the near future. Real and significant consequences of the linear 'make-use-dispose' paradigm that has traditionally existed in the design and manufacturing industries were discussed, as well as new alternatives as designed interventions that enable more circular flows of resources or perhaps map opportunities and threats in product development were stressed. Concepts like the Circular Economy, Cradle to Cradle, Industrial Ecology, Natural Capitalism, the Blue Economy and Regenerative Design which promote new strategic approaches to resource efficiency. Were introduced. The training programme also involved working with local authorities, industries and makerspaces to establish and develop the thematic contexts for each challenge.

Node	UK
Title of your training	Open design for inclusive neighbourhood development: Chalton Street: Co-designing a market of social value
Department(s)	University of the Arts London: Central Saint Martins Product Ceramic and Industrial Design Programme MA Industrial Design
University level	Post-Graduate Diploma
Target-group	12 MA Industrial Design Students Age range 19-32. Educated to Bachelors Level. Areas of Study: Product Design; Service Design; International Development; Product Design Engineering; Architecture. x community participants (to be detailed)
Selection	Selection is via a diagnostic workshop within the MA Industrial Design Postgraduate Programme. Students are asked to position their practice in relation to one of 4 emphases in practice: Industrial Design for Enterprise; Discourse; Service; or Publics. Programme Specification can be seen here Students with an interest in Open Design, Design Led Social Innovation and Participatory Design Practice declare an interest in participating in the training brief from within a cohort of 40 PG students. The call was framed within the context of OD&M and positioned in relation to the MA Industrial Design for Publics Curriculum. Industrial design for publics applies industrial design processes in response to societal issues and the dynamic challenges that require new ways of thinking and doing. The traditional tools of government policy making and market-driven solutions are proving inadequate in the face of the radical innovation required to deliver sustainable, rewarding and more equitable futures for all. The industrial designer's ability to engage complex problems, equips them with the ability to engage complex societal challenges. Industrial design for publics develops and applies co-design and participatory design methods

Figure 8. Citizen centered innovation through citizen-centered innovation through open design and manufacturing (UK).

The OD&M initiative has allowed to the different nodes involved to test, to experiment and to prototype different design-driven solutions for the challenges that the local contexts were facing in relation to different societal challenges. In the next

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sections we provide a dedicated focus on each of the nodes for understanding their particularities and how they delivered their training experiences.

3.3 Italian node

The Italian node of OD&M has been led by the **University of Florence** throughout **DIDALABS** and the **Centro Sperimentale del Mobile e Dell´arrendamento**. DIDALABS is the system of laboratories of the Architecture Department in Florence (DIDA) and its focus is oriented around certain fields of design such as strategic design, product design, communication design and services design, with a special focus on environmental, social, cultural and economic sustainability. This department involves teachers, researchers, PhD students and trainees working in the aforementioned areas. This node has been working on the development of an advanced university course titled **"Design Driven Strategies"**, oriented focused on system thinking and design thinking in the Industry 4.0 paradigm. Its ultimate goal has been to empower students and professionals for using design as a strategic lever for shaping multi-sectorial, collaborative and distributed processes of co-creation, going beyond the conception of innovation (and social innovation) as a linear process. In this sense, it has aimed to boost sustainable social innovations across design and manufacturing for thriving competitiveness hand in hand with territorial enhancement. The course has allowed to shape **"Enablers of Innovation and Social Innovation"** across diverse communities and stakeholders, facilitating horizontal collaboration and bridging real challenges with economy and society, through a design driven approach.

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Figure 9. University of Florence.

3.3.1 Country context

The maker movement in Italy sparked around 2012 and it has been growing rapidly and consistently. Most 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, equipment's and programmes, but also as places for developing and sharing new cultures of collaboration and cooperation different disciplines and sectors.

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 are relatively few. From a geographical perspective, makerspaces in Italy can be primarily found in the main urban areas of Milan, Turin, Rome, Naples and Florence, as well as they are particularly concentrated in the Central-Northern regions, where SMEs are largely predominant. On the contrast, regions in the South have a lower presence of makerspaces, even if we can still find pioneering initiatives of making and open source education.

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Maker movement in Italy has primarily had an impact on educational sector, with specific policy measures and investments from the national government launched since 2014 and embedded into the **National Digital Agenda**. Thanks to these measures, many schools have embarked in the creation of internal fab labs and makerspaces, with the aim of supporting alternative and complementary teaching and learning, specifically in creative and scientific disciplines. Higher education has been benefited as well, with new makerspaces set up into technical universities. At the same time, new courses related to digital and advanced manufacturing have been also become popular in design, engineering and hard sciences degrees. This is in line with the recent Industry 4.0 Plan launched by the national government, as well as the new status of Competence Centers 4.0 acquired by several Italian universities. Most of these new courses are conceived and positioned within a scenario of advanced manufacturing that needs highly specialized professionals. Synergies between companies and maker movement can be generally framed in two types: companies founded by makers, that are strongly guided by maker culture values, and companies that are aware about maker movement and have structured collaborations with maker communities. The latter ones adopt an open approach to these kind of collaborations in different ways, but mainly in production processes and business models. Nowadays, the current debate around maker movement in Italy is focused about its potential contributions to renew innovation governance, as well as to reformulate the classical district-based economic system that still rules the country in favor of a more decentralized approach.

3.3.2 Training experiences

The Italian node has oriented the structure of its training prototype around 7 modules: **Innovation trends, Communities of impact, Design for social innovation, challenges launch and teambuilding, Exploration and open inquiry, Ideation,** and **Prototype & deliver**. 22 Students (7 males and 15 females) benefited from these modules with a range of age from 20 to 43 years old and with different nationalities: Italy (14), China (6), Mexico (1) and Greece (1). Most of them come from design (90%), mainly from product design and communication design. First module was held during November and December 2018 and it comprised theoretical concepts about several "Innovation trends" such as the fourth industrial revolution, key enabling technologies (KETs), circular economy, platform economy, maker movement and open design. Second module was organized around different workshops and labs held during January 2019 with a focus on Theory U, Art of Hosting and the experience of the Impact Hub network. Third module was also organized around workshops with a focus on "design for social innovation" and other design thinking related issues. The fourth module was also held during February 2019 and it comprised the launching of two macro-challenges:

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1. **Manifattura Tabacchi** - The square of the new millennium and digital manufacturing (see: https://www.manifatturatabacchi.com/en/) MT Florence is one of the biggest regeneration project ever seen in the city over the past decade. With an overall investment of 200 million euros, the project aims to regenerate former industrial buildings surfacing an area of around 100.000 square meters and their transformation into a highly connected, open and sustainable hub of new lifestyles, urban uses and experiences. The masterplan concept revolves around 2, yet integrated aspects: modernity (=digital innovation) and tradition (= Florentine handicraft). The main square of MT shall be the engine of the whole project, becoming a space dedicated to host co-working spaces, prototyping spaces, studios, galleries and places for meetups and partnerships between 'traditional' artisans and young makers, creatives and designers.
2. **Open Innovation for local manufacturing SMEs -** Territorial competitiveness and companies' competitiveness is more and more connected to the capacity to innovate, to develop skills and the know-how that is intimately associated. Next to traditional innovation providers such as Universities, new actors are emerging that can bring radically new competences for innovation and social innovation. Indeed, makers and local innovation communities such as Impact Hub are relevant actors in this shift; yet, we need to build new infrastructures of relation and collaboration. The challenge is how to build such infrastructure, creating incentives to collaboration, overcoming cultural barriers, and making all the actors of the innovation journey aware of the latent capacities of the local context. In our course, this challenge has been further contextualized within the critical topic of 'remote areas' (mostly rural and mountain areas that in Italy are widespread, and that are suffering increasing depopulation and lack of basic services such as health and education) and combined with the 'motorhome' sector.

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Figure 10. Italian node training Session.

Using these two challenges, 5 groups of students were organized using a world café methodology for aligning their own interests and to identify synergies between their members. Fifth module was aimed to set up a generic design to approach the challenges during March 2019 throughout several questions in the different groups:

- **Group 1:** How can we create a narrative around MT able to engage all generations? How can we avoid MT to become a niche space?
- **Group 2:** How can we make MT a hub of circular economy? How can we attract makers in MT and make them able to form a vibrant community around circular practices?
- **Group 3:** How can we turn MT into a place of creativity and experimentation for young students and creatives (=how can we provide opportunities to young people - study and work - considering that the city is almost lacking alternatives, cheap spaces and opportunities for this target?)
- **Group 4:** How can we redesign the motorhome into a servitized product providing educational services in remote areas?
- **Group 5:** How can we redesign motorhomes into a servitized product providing new services to job seekers in remote areas? How can we reactivate remote areas?

Based on these triggering questions, the 5 groups start an exploration phase that combined desk research, fieldwork, interviews and surveys. Sixth module was deployed in March 2019 too and it was focused on “ideation”. Students delivered several presentations about their potential solutions and they gathered a numerous feedback from different stakeholders to improve their designs in coming weeks. The

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last module “Prototype and deliver” lasted during the last weeks of march and April, and it helped to present the 5 prototypes at the International Craftmanship Fair in Florence (24th April 2019).

Most students were very satisfied about the whole experience although they usually stressed how challenging it was to meet and closing the prototyping phase. They also appreciate the lectures delivered in the modules and the challenges proposed, but they usually acknowledged how difficult it was to touch base with the involved stakeholders. They also stressed how so much time was spent on the last modules (ideation and prototyping) and how difficult it was to present concrete results. They also suggest that smaller projects with smaller groups and whole year lasting could be desirable.

3.4 Polish node

The polish node of OD&M was conducted in two different locations. The main headquarters were in the facilities of **WSB University at Dąbrowa Górnicza** (Śląskie Region), but workshops and hackathons took place in Lodz (Łódzkie Region). This was due to the fact **Fab Lab Lodz Foundation**, **Textilab** and **Lodz University of Technology** have significant infrastructures, equipment and tools needed to perform the activities that were envisioned by the polish training prototype. In the past, Lodz was the largest concentration of the textile industry in Poland and one of the largest in the world. Textile heritage was one of main triggers to choose **“smart clothes”** as a challenge for the final Hackathon. Dąbrowa Górnicza is the largest city in the Slaskie Region (the 10th in the country) and the largest industrial center of the Dąbrowski Basin. It is one of the main centers of the Upper Silesian conurbation and part of the Upper Silesian-Zagłębie metropolis, whose population is about 2.28 million inhabitants.

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Figure 11. Polish node training session.

3.4.1 Country context

Polish business agents in the implementation of the training were: Fab Lab Lodz Foundation, TEXTILAB - Lodz Collective Krawiecki and the Lodz University of Technology. The students that took part in the training had the opportunity to cooperate with students of the Lodz University of Technology, makers, traditional manufactures and other companies well recognized on the international market such as ABB, Printor. or Transfer Multisort Elektronik sp.z o.o.

3.4.2 Training experiences

The activities delivered in the polish node have been carried out thanks to the funding coming from the OD&M project and have been oriented towards the combination of knowledge, competences and skills in diverse fields such as industrial engineering, computer science, robotics, management, creativity and entrepreneurship. Students

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coming from WSB University as well as from Lodz University of Technology had the opportunity to work together with the associated partners (Fab Lab Lodz Foundation and Textilab) and other agents such as makers, entrepreneurs and different companies. All training activities were conducted in English in a multidisciplinary and multicultural environment that was really energizing. Noteworthy, students that took part in the different activities comprised 13 different nationalities (Poland, Turkmenistan, Georgia, Azerbaijan, Mongolia, Swaziland, Kazakhstan, Peru, Ukraine, Moldova, Colombia, Egypt and Honduras) and 3 different BA courses held on WSB University (computer science, international relations and management). Students took part in different activities such as lectures (heuristics methods, web design, embedded systems coding), workshops (cultural psychology for interdisciplinary problem solving, textronics and smart clothing), hackathons (Urban IoT for monitoring environmental challenges, textronics, human-robot interaction) and webinars.

Figure 12. Polish node prototypes.

The different activities pivoted around the topic of “smart clothes prototyping” for protecting citizens against dangers in the city. Some of the most successful prototypes delivered during the experience were a hat for pulse and temperature monitoring that was designed for car drivers and a smart t-shirt designed to protect women and children from assault.

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3.5 Spanish node

The **University of Deusto** is the HEI that has run the OD&M course in the Spanish node. Deusto is a private university owned by the Society of Jesus, with campuses in Bilbao and San Sebastián, and the Deusto Business School branch in Madrid. The University of Deusto is the oldest private university in Spain. According to the 2019 Times Higher Education World University Ranking, the University of Deusto is internationally ranked between 601-800. Alongside, in the 2019 University Impact Ranking, Deusto sits between 101–200 and in the 2019 European Teaching Rankings, between 126-150. This project has been held by members of the Faculty of Engineering that is composed by two main departments: the department of Computer Engineering and the department of Mechanics, Design and Industrial Management. Within the latter department, the area of Industrial Design runs an Engineering degree of Industrial Design and an official master's program in Strategic Design. As a special feature, the department owns **Fab Lab Deusto**, a rapid prototyping laboratory which is part of the MIT-based network of fab labs. Students of the bachelor's degree regularly make use of the facilities of Deusto Fab Lab to build prototypes of their designs, no matter which level of detail they are aiming for. They work in basic mockups using foam-cutting machines and sanding paper when they want to work on a conceptual level, but they are also able to produce 3-D printing parts, CNC-machining or laser cutting fully defined and detailed 3-D prototypes of their more advanced prototypes. In some cases, students can develop fully functional products by combining different techniques and machines of the fab lab. When the implementation of the OD&M training was defined, the main goal of the node was to make better use of the existing facilities and machinery. Since the degree is still in its initial years, a better use of the fab lab was still an issue to be solved and OD&M fitted as a great opportunity to do so. On the other hand, the project wanted not only to make better use of Open Design and Manufacturing equipment and tools, but also to use them for a social issue: Design for All.

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Figure 13. Spanish node training session.

One important partner of the Industrial Design area is **FEKOOR (Bizkaia Coordinating Federation for Persons with Physical and Organic Disabilities).** Fekoor is a non-profit organization that was declared of 'public interest' by the Basque Government, bringing together the largest 20 associations for persons with physical and/or organic disabilities in Bizkaia. Specifically, this federation runs a special apartment building called **"Etxegoki"**, where 34 people with severe mobility disabilities have the opportunity of living in a fully equipped automated house where they can live an autonomous life. This project has been awarded in 2015 with the **"Design for All Good Practice"** award and it is a successful place for technological and social innovation located in Txurdinaga, Bilbao. Although Etxegoki is an advanced home environment, the inhabitants of the building still face many difficulties that can be better addressed with small interventions or products that can be built using Open Manufacturing technologies. In previous works developed together with Etxegoki (the Bienestar project), several design opportunities were found, and the training pilot project aimed at solving one of them: autonomy in the kitchen and dining room. Therefore, students were challenged to create new products that could enhance the performance of people with mobility-related disabilities when cooking or eating/drinking on their own.

3.5.1 Country context

The Spanish economy is the fifth largest in the European Union, and the fourth largest in the Eurozone, based on nominal GDP statistics. Spain is also one of the largest producers in Western Europe and it has an important presence in sectors such as

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renewable energy, biotechnology, transport, and technology industries, throughout a myriad of SMEs. The main problems of the Spanish economy are unemployment and inflation. According to the report of the CEOE, "The industry, engine of growth[5]", the importance of industrial activity in Spain has progressively increased since the lows of the 2009-2012 period, now representing 14% of the national GDP. Regarding employment, more than 2 million individuals work in the manufacturing industry and in 90% of cases they are full-time, this being much higher than the average of other sectors of the country. The Spanish industry plays a fundamental role in investment in innovation that is carried out in the whole country. Specifically, 4 out of 10 companies that invest in innovation are framed in the industrial sector. If we analyze the situation within the industrial sector, we see how 13.6% of companies invest in R&D, compared to 5.3% in other sectors. In the near future, the Internet is expected to merge with industrial activity thanks to digital transformation and it will be necessary that companies in the sector consider digitalization of industrial processes as one of their main objectives for entering into the design and development of new products, maintenance of infrastructures, as well as establishing commercial and communication channels with their customers. Spain intends to become a reference at European and Latin American level in the modernization of the industry, combining digitalization actions with others in the environmental and social fields where public-private collaboration is essential. In this sense, the "Connected Industry 4.0[6]" strategy, of the Ministry of Economy, Industry and Competitiveness, seeks to address the digital transformation in the Spanish industrial sector. First, it seeks to increase the added value and qualified employment, adapting the Spanish model to the industry of the future. Then, it is intended to strengthen the implementation of digital solutions in SMEs for improving the local supply chain situation. Likewise, this strategy also works on the development of competitive levers to boost exports.

In Spain, the maker movement has grown exponentially during the past recent years and it has been on the media since a relatively while. However, there are still few collaborations and an enough understanding from the industry, as its origins from the DIY ethos has prevented its formal acceptance from corporate decision makers. 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. A new generation of several self-employed entrepreneurs who design and produce from craftsmanship, but also from high technology are also starting to being consolidated, but not with the ideal conditions as the crisis has

[5] CEOE presents in parliament its report "Industry, the engine that drives growth" https://www.ceoe.es/en/contenido/news/news-all/ceoe-presents-in-parliament-its-report-industry-the-engine-that-drives-growth

[6] https://www.industriaconectada40.gob.es/Paginas/index.aspx

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pushed back a complete generation of talented and well-educated individuals. Precarious labor and overworked agendas can be usually found on these representatives. They commonly produce small batches, or unique pieces on special requests, characterized by a high degree of customization. In this way, they take advantage of the control of all stages of the process and maintain a direct and personal relationship with the final user, something hard or almost unrealistic for the traditional industry.

3.5.2 Training experiences

In this node, the training activity was intended to be developed within an existing elective course called "Prototyping and digital fabrication", held in the last year (4th) of the Industrial Design Engineering degree of the University of Deusto. Since it was the first year that this course was going to be delivered, the possibilities were quite open and that was one of the reasons to use this course as a training opportunity. The planning and execution of the project was done in collaboration with a course teacher that is not regularly involved in the activities of the university (Part-time instructor professor who works in a design studio) and it was his first experience in teaching in our HEI. Furthermore, his professional profile is strongly linked to more traditional prototyping methods like foam cutting and hand sculpting mock-ups. Besides, his digital skills were not very advanced, which made the integration of the platform a little bit trickier than expected at the beginning. However, with the help of this collaborator and in liaison with OD&M Deusto team, the experience delivered great learning opportunities. The students were able to meet the institution that demanded their services, FEKOOR-Etxegoki and its buildings and inhabitants, at the beginning of the project. They were also able by the end of this experience to show their designs in the buildings and delivering some prototypes and explanatory posters. Feedback from clients and users was very positive in most of all cases. Users of the space really appreciated the effort of the students that were put into identifying and solving everyday problems of people living in Etxegoki buildings. Not only much appreciated but also wondering if these kinds of prototypes could be personalized according to the specific needs of the users and testing them into real life contexts.

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Figure 14. Spanish node prototype.

Alongside this main pilot experience, other projects have been carried out with Etxegoki based on the framework of OD&M. All in all, **more than 8 products have been developed and ambitious plans to developing further 4 of them in the near future are envisioned**. At the same time, students have been also really happy with the development of the project as they really appreciated the exchange week in other OD&M nodes and actually all of the groups have shown interest in the continuation of their prototypes. Therefore, we can agree that the experience has been really fruitful and interesting for all involved stakeholders and this experience has been a steppingstone for establishing new active collaborations outside the HEI.

3.6 British node

The British node of OD&M has been led by **University of Arts** in **London**, in combination with **Green Lab**. University of the Arts London (UAL) is a collegiate university in London, England, specialising in arts, design, fashion and the performing arts. It is a federation of six arts colleges: Camberwell College of Arts, Central Saint Martins, Chelsea College of Arts, the London College of Communication, the London College of Fashion, and the Wimbledon College of Arts. UAL is ranked second in the world for Art and Design in the 2019 QS World University Rankings®.

The University has a world-class reputation and is made up of 6 equally renowned Colleges: Camberwell College of Arts, Central Saint Martins, Chelsea College of Arts,

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London College of Communication, London College of Fashion and Wimbledon College of Arts. The project was delivered through a cross institutional team from within the the Product Ceramic and Industrial Design Programme at Central Saint Martins, the Digital Maker Collective Chelsea, Camberwell Wimbledon, Carreres and employability department research and academic enterprise. The training was delivered through challenge-based learning in a context of open design, engaging socially responsive thematic or briefs, testing learning recognition models in formal and informal learning contexts. The training introduces learners to principles of design led social innovation through the introduction of methodological and critical approaches in this context of design and innovation working with maker communities in London spearheaded by Green Lab London.

Figure 15. UAL training session.

Green Lab is a private fab lab funded by a former founder of Fab Lab London hailing from the MIT model of distributed design and manufacture. The Green Lab focuses on sustainable and circular economy principles across food systems, new materials and waste. The primary strategy is to educate, create communities of innovation and help early stage startups to grow. It also provides access to four labs: bio, material, fabrication and grow.

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3.6.1 Country context

The Open Design and Manufacture Project was coordinated from within the Product Ceramic and Industrial Design department at UAL: CSM, The Socially Responsive Design and Innovation Hub and Digital Maker Collective. Traditionally, industrial design is associated with the improvement of goods and services through creative intervention. However, as the nature of production and consumption has changed, so has the role of the industrial designer. Increasingly, they are required to conceptualise new products and systems with limited user experience. Inevitably, this places an emphasis on the social value and accessibility of technologies. In this context, psychological and emotional factors are often as important as rational and physical ones. This requires a different set of critical skills. Exploring this field the collaboration within these UAL departments explored the role of industry 4.0 and the interaction between the three sectors Maker HEI and Industry. Strategically this created space within the institution to challenge formal design and making education (curricula that takes place in a structured environment, specifically dedicated to learning and typically leading towards a qualification). Learners that engaged with the OD&M project within UAL were typically working towards postgraduate study namely a Masters in industrial Design. However extra-curricular events were established to engage learners in activities and training outside of standard models of curriculum and delivery. This was essentially driven by the Digital Maker collective an open group of University of the Arts staff, students, alumni who share common goals of exploring digital & emerging technologies in the context of arts, education, society and the creative industries. The project allowed us to look at blended modes of training delivery where non-formal learning took place interfacing with formal models of curriculum and encouraging the sort of proximate learning common within the maker context. This would go on to infor course developments that draw on the entrepenerial and learning culures that exist with in maker space innovation communities. The project benefited from a vibrant maker, design and innovation culture in London and UALs position within and access to this culture.

London is a large city 8+ million population with huge challenges around waste and use of non-recyclable materials. The city provides a huge landscape for ideation and opportunity in the context of reducing waste and sharing open design practices across not just UAL but within other Universities located within the city.

3.6.2 Training experiences

English partners delivers challenge-based learning through open design principles. It engages 3 socially responsive thematic in a context of Industry 4.0:

- Open Design for Inclusive Neighbourhood Development in collaboration with the ondon Borough of Camden.

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- Open Design for Future Sustainable Living: focused on bio material innovations in algae material for healthier urban environments in collaboration with Green Lab.
- How Can We Design Locally, Make Globally? Aliged to principles of the Fabcity.

Figure 16. Green Lab training session.

The programmes took place over 15 weeks and were followed by 5 weeks of training which focussed on dissemination and engagement activities related to the outcomes developed. A total of 36 learners subscribed to the three challenges.

Also during the 5th to 10th March 2019, the UAL Digital Maker Collective, OD&M project affiliates, industry and community partners were in residence at the Tate Exchange for the launch of Beta Society[7]. The event was structured around participatory workshops, round-table discussions and debates on the following themes:

• Citizen-centered innovation
• Socially engaged practice

[7] For more detailed information on the Beta Society and OD&M at the Tate Exchange, please see report 'Open Design & Manufacturing Project at Tate Exchange 2019, which can be found here: https://odmplatform.eu/wp-content/uploads/2017/05/odm-x-tate-19_report.pdf

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- Community perspectives and community/organisation led provocations
- Open design and open practice
- Building a sustainable open education infrastructure
- Equality of opportunities

The intention was to develop a new network of organisations, academia, industry and public to explore and reimagine a speculative society of equal opportunities. The 'Beta Society' network is an evolving concept and the event at Tate was the beginning of the journey.

As part of the training conducted in the Green Lab, the team involved in the training prototype decided to focus on three main aspects.

1. **Training and raising awareness of organic based materials as part of an open design methodology** – using sustainable and ecological design principles to develop solutions to an ever increasing 'waste culture' within our society. The training we developed with our partner UAL focused on algae as a future material source.
2. **Developing an open access material library** for UAL students to understand the breadth and depth of sustainable materials that can be developed using sustainable and ecological principles.
3. **Setting up an open access material lab** to permit UAL student to develop their ideas and prototype early stage concepts using the facilities as part of the OD&M training. As a consequence the output from the activities created a series of openly accessible recipes on Green Lab´s wiki https://wiki.greenlab.org/2018/11/20/eu-erasmus-odm/

Overall Students that participated in the training programme found that they had an increased knowledge regarding the terms 'OD&M' and 'makers' as well as an increase in knowledge about business models, production processes and techniques found in the OD&M paradigm.

Most students highlighted that their technical and soft skills (e.g. skills gained in rapid prototyping with software, machines and materials) had improved due to engagement with the training programmes as well as their skills in group dynamics and management, organisation, teamwork, communication, presentation, stress-management and time management.

A key advantage for those students who participated was a holistic approach to combining theory and practice, which was achieved through working in hybrid teams.

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According to students' opinions, a key competency that was achieved by the project was the ability to see the design process more holistically, to be more aware of the design environment in both an academic and commercial perspective. A challange however was engagement with Enterprise and busness partners and resolving design led social innovation drivers with comercial industries interested in the OD&M thematics.

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4. METHODS

During the implementation of OD&M initiative across the four nodes, several opportunities and challenges have been raised in the already involved HEIs. Different drivers and tensions have been mapped out throughout qualitative feedback that has been gathered by several interviews, focus groups and workshops conducted with students, teachers, stakeholders and project partners, as well as quantitative feedback recapped from surveys and platform analytics. This has allowed to gather a significant amount of data that can illustrate different learnings acquired during the project lifespan, as well as to fuel several recommendations that stem from the empirical evidence gathered during this 3-year EU funded project.

The main methods employed in the quantitative side were the survey that was conducted among 12 students participating in the training prototypes delivered in the 4 nodes, (3 Italy, 3 Poland, 4 Spain and 2 UK), and the analytics that were coming from the use of the OD&M platform by each of the nodes (students, mentors and teachers). Both methods were aimed to assess the impact of the project in the students learning path, the adequacy and feasibility of the badge accreditation system, as well as identifying room for improvement.

On the qualitative side there were several methods employed such as semi-structured interviews, focus groups discussions and participatory workshops. In this sense, a total of 36 interviews following a pre-designed script were delivered before the summer of 2019 and speaking more specifically, 10 were conducted between manufacturers in all nodes (Italy 3, Poland 4, Spain 2, UK 1), 11 were conducted between teachers (Italy 3, Poland 2, Spain 3, UK 3) and finally, 12 interviews (Italy 3, Poland 3, Spain 4, UK 2) were conducted with students that took part in the mobility actions. Regarding the focus group discussions, 8 sessions were delivered across the 4 nodes in two rounds and during June and July 2019, focusing in representatives of innovation communities (Italy 4, Poland 2, Spain 4, UK 4) and students that were involved in the OD&M project (Italy 7, Poland 5, Spain 4, UK 5). Both methods were oriented to understand the barriers that were face during the implementation of the training prototype, as well the opportunities that were identified during the lifespan and the skills, competences and knowledge fueled due to the implementation of the project.

Last, an internal participatory workshop conducted in Dąbrowa Górnicza the 6th of June of 2019, with representatives of all members of the consortium (18 people) was organized with the objective of identifying challenges and opportunities during the training prototypes development, as well as recapping the whole experience and building up lessons, findings and learnings that are commonly shared by all practitioners involved. The session was set up in different small groups of 4-5 people and ending with an open space setting for drawing up some of the main drivers and barriers faced during the implementation of the training prototype and the project as a whole. This helped to frame specific-node conclusions upon their context particularities and generating main and shared conclusions by all nodes.

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The numerous and variety of the methods implied across the lifespan of the project has contributed to deliver a wide and integral perspective of the work delivered in the 4 nodes, as well as providing a reliable panoramic view. However, we cannot deny the limitations of the methods employed as the relatively limited number of people involved in the different methodologies also point to future research in the designated field.

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5. PROJECT LEARNINGS

As it has been explained in previous sections, several methodologies have been employed across the lifespan of the project and with multiple stakeholders. These tools and exercises have provided a considerable richness in the empirical evidence gathered, that supports the learnings uptake and shared among the members of the consortium. With this aim, this section wants to strategically frame the lessons collected during the project implementation across 5 thematic remarks that try to recap the complexity observed during the OD&M project. These observations are detailed further throughout the following points.

5.1 Maker culture creates tensions within academic structures, but it can reinvigorate educational institutions

One of the most visible facts that has emerged during the OD&M experience has been the number of tensions that has provoked the implementation of the project in the different HEIs were it has taken place. These tensions have not only been restricted to the methodological side, where numerous testimonies of students and teachers stressed the differences between the daily routines and the dynamics that the project has imposed, but also in the timing of the activities delivered (out of classes time, even weekends) and the extra work needed to comply with the requirements of the training prototype (different stages to be finished outside their daily activities). These tensions are provoked by the collaborative nature of maker culture and the differences between project-based learning and the traditional lectures that occur at a learning institution.

The difficulties that arise when combining project activities with the official programs that were running in the four nodes is something that usually happens in Erasmus+ projects, but in this case, this has been aggravated by the dynamics that imposes maker culture into learning institutions. Trainings offered by the project were not in official calendars and this affected the attendance of the students that were mainly involved in a voluntary basis. In addition, *"learning by doing"* didn´t work as it was supposed to be, and many students needed constant advice, assessment and training in order to keep up the pace of the course. Some of them also stress that some challenges were *"overwhelming",* as they forced to challenge traditional models of practice and design processes delivered in HEIs. According to some teachers this was due to the different levels of expertise gathered into the involved students and the lack of familiarity with open source technologies.

Nevertheless, the majority of students involved in the four nodes acknowledged that their participation in the project was really stimulating as they had the opportunity to work outside the college context, giving them a sense of *"urgency"* and *"realness"* to their activities, as well as providing them with opportunities to strength their soft

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skills in relation with communication, teamwork, self-management or creativity, among others. This improvement in soft skills also trigger their interest for acquiring technical skills too, but they commonly stressed the need of offering more structured content about it. Students generally highlight the validity of what they learned during the experience towards a future work and the suitability of participating in a challenge, simulating a real situation in society. They commonly argue that this different approach regarding traditional education, has obliged to think about openness, sharing and collaboration as general drivers. Last, pupils also argue that this type of training should be recognize by an official document issued by the university for certifying the knowledge acquisition.

Teachers also stressed how difficult it was to generate and establish collaborations with other departments, as well as establishing balancing teams for meeting the challenges objectives and making structured learning paths. In general, a lack of flexibility, agility and collaboration was commonly argued by teachers involved from all nodes. Usually, they also stressed a general need for developing and learning about different techniques of participatory workshop techniques, cultivating soft skills in students and related stuff. They generally argued that establishing teams into HEIs oriented towards a shared purpose around creative collaborations and social innovation can be more difficult than expected. They also argued that they have been *"forced"* to look for new ways for establishing collaborations and communication channels between university and society. Last, they also reflect about the lack of competencies that can found in maker communities regarding long-term thinking, sustainability, marketing, management or strategy.

In this sense, we can state that OD&M project has successfully introduced the maker movement, its philosophy and its way of working, to a much wider audience. It can also be said that it has opened doors in different academic environments towards the promotion of an uunderstanding of the role of makerspaces as catalysts of grassroots innovation, creativity and collective action. This has provoked that not only students have been benefited from alternative educational approaches, but also teachers and other stakeholders have been able to take part on this collective learning ecosystem. Nevertheless, adopting new practices and values have shortcomings too, and this has been shown in the different number of tensions that students and teachers have had to confront. Of particular importance is the key matter of the physical place where the collaborations and different activities have been taking place, because a makerspace doesn´t exist if there is not a community behind it. In this sense, much of the teachers involved in the experience have been working with different professionals that they were not used to for accessing these communities and establishing meaningful collaborations that their students can benefit from them. This is very much in line to what many stakeholders in society are demanding to HEIs as the role of universities must change in the coming years, offering a more open character of knowledge and accessibility.

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5.2 Involvement of stakeholders is not always easy, and they are not usually concerned about societal challenges

Another of the shared lessons that can be extracted from the OD&M project has been the several difficulties experienced by HEIs, when involving different stakeholders into the training prototypes, and more specifically when involving manufacturers. This problem has been shared by all nodes as the lack of representatives from the manufacturing sector has been common, and specifically traditional manufacturers, that have not been really involved into the four training prototypes. Most teachers that took part in the project reported that it was difficult for them to establish attractive and sustainable collaborations, as well as they commonly stressed that manufacturers were not aware or interested in societal challenges. We must remind that one common characteristic of the four training prototypes was that all of them had a focus on societal challenges, and this shortcoming forced the nodes to look for new allies or partners that were aligned with this vision. These kinds of difficulties for establishing collaborations were due for several reasons that comprised no previous collaboration agreements or traditions, lack of adequate funds or incentives or language barriers among others.

However, the companies that have taken part in the OD&M project have contributed to create an attractive ecosystem of open innovation, where new ideas were co-created, knowledge exchange was produced, and new fields of work were identified. This has benefited HEIs in a significant way, with an environment that has connected maker communities, companies and stakeholders delivering specific fields of experimentation, and where new services, prototypes and collaborations have popped up along students' learnings. Moreover, these new collaborations have also been guided from open design and open manufacturing oriented to social good, sharing knowledge, tools and training materials openly and establishing new synergies for meeting societal challenges. This focus on societal challenges has contributed to cultivate soft skills but it also has allowed to trigger the interest on learning technical skills by different participants, as it has been commonly stated by a great number of them.

Of special importance has been the collaborations with fab labs and makerspaces with HEIs, that have adopted the role of trainers in many of the nodes, sharing their knowledge about particular technical domains (IoT, AI, etc.), but not only, (also urban planning, social innovation or open design), and most importantly, being involved in teaching (formal training). These kinds of collaborations are not usually easy to handle, but in this case the *"cross-academic collaboration"* that have happened into the project has largely benefited students as they have had the opportunity to work in real-life problems, as teachers and students stressed. These collaborations also allowed to have another kind of tutors, mentors and teachers coming from non-

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formal and informal learning domains, performing the roles of primary instructors in HEIs. These tutors and mentors outside the academia have provided their expertise to students, offering new perspectives, lecturing in their own terms and managing their classes, what has contributed to enriching learners experience.

In addition to this, a much more horizontal communication between the different agents have been established as a result of the incorporation of these tutors outside the academia and the establishment of this open learning ecosystem. This has avoided to maintain the classical hierarchical structure where the relationship of student and teacher is based, as well as it has created room for closeness and flatness between learners and tutors. This has provoked a much more closer relation and horizontal communication between learners and tutors, stimulating discovery, playing and tinkering into the learning paths. Many students have argued that this has been critical for developing confidence in their ideas, capacities and projects, fueling on them several skills such as creativity, flexibility, self-discovery, resilience or critical thinking. Most students appreciate the training offered from the makers engaged as really “overwhelming”.

Last, we can observe how the introduction of new agents, materials, behaviors and cultures into learning ecosystems can be beneficial for students as well as teachers. Both of them valued very positively their introduction in order to extend their perspectives, networks and visions about particular subjects. Moreover, teachers also particularly acknowledged that a place outside classrooms where students can work in their own ideas at their own terms and with enough resources is of outmost importance for their learning paths. This has been one of the elements where the training prototype has pivoted around and where future research is needed for understanding what the potentialities of these collaborations are.

5.3 Alternative learning recognition systems still requires research, cooperation and a new approach to evaluation.

The last of the shared lessons of the OD&M project that we want to bring into this document is the difficulties associated with the implementation of alternative learning recognition systems into HEIs. Initially identified as an agile and flexible approach to endorse key competences to learners throughout the achievement of different tasks into the challenges proposed, the Open Badge system was not able to meet the expectations raised during the first part of the project, as it has been widely recognized by all actors involved on their testing. Neither students, teachers or tutors were confident and satisfied about the use of the system and its implementation on the digital platform. We have to remember that the Open Badge system was designed as an approach that will allow to the OD&M platform to recognize and provide evidences of the acquisition of certain skills deployed by learners throughout

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challenge-based tasks. These badges could be audited throughout OD&M and BADGR platform and are *Verifiable, Shareable* and *Portable.* However, the reality is that after several months of training implementation in the four nodes, the expectations of many of the participants about this have not been met.

Students didn´t understand the badge system and they usually argued that it must be rebuilt and expanded. They perceived the system as too complex in the digital platform as well as and its use. They usually stress that badges and their relationship with the assessment offline required several explanations regarding its context and the formal assessment that was carried out too. We also have to explain that students were primarily focused on satisfying the formal requirements of the degree/course where the challenges were embodied, and they were not really fully aligned with the philosophy and procedures that the badges were part of. Nevertheless, students speak positively about badges because they forced them to think in a different way about evaluation and prompting them to be more creative and not following traditional patterns of problem resolution. This also helped to work on different soft skills. In this sense, badges were valued and considered as a tool to reflect on the learnings achieved by the students.

Badges were seen as problematic by teachers too, as they didn´t understand properly the digital platform and their inner workings, what lead to a poor use of it by them. Most teachers interviewed argued that they were not able to translate their methodologies to their pupils throughout the platform. They also stressed that the features didn´t work as initially planned and there were no common and clear criteria for awarding the badges to the learners on the different tasks that contained the challenges presented by the nodes. These testimonies are also in line with the data coming from the OD&M platform, where an uneven allocation of badges can be found between the nodes (major differences in number of badge allocation between the nodes) to the different participants, as well as an irregular description and implementation of the challenges between the nodes (no common criteria for developing the tasks or awarding the badges in all nodes). However, teachers usually argued that the challenge-based approach requires constant evaluation and improvement for narrowing goals, expected outputs and tasks associated. In this sense, they stress that more research and implementation is needed to tailor the badge system to the particularities of the different HEIs and their needs. A common emphasis in the technical specifications of the challenges, as well as clear and shared guidelines were usually addressed by many educational experts.

All in all, the Open Badge system was an innovative component of the OD&M project that was not implemented properly into the lifespan of the project, but it has raised the interest of other stakeholders that were involved in the learning ecosystem. This is the case of some innovation communities and companies in Italy, that have been regularly using the platform for their own purposes. Apart from this, many feedbacks

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coming from other companies and experts from all nodes have been gathered to improve the badges and the platform. In this sense, it is of utmost importance to reflect about the need of deepening our knowledge about the interactions between learners, trainers and stakeholders in order to strength its collaboration for acting as a single certification body that can be represented in a digital platform. In addition, interoperability with other platforms for transferring the skills awarded in these platforms to others will be another point of interest for future iterations of the OD&M platform.

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6. POLICY RECOMMENDATIONS

The last section of this paper aims to point to future directions that can be taken by policy makers, teachers, managers and other kind of profiles working in the higher educational sector for supporting the embracement of maker culture potentialities into universities at European level. In this sense, a set of policy recommendations are presented through the following guidelines.

6.1 To extend funding for student's mobility actions

One of the most unanimous recommendations that stem from all actors engaged (teachers and students mainly, but not only) is how invaluable experiences have been the training mobility actions in this project. The students involved in this activity have had the opportunity to visit their counterparts in the other nodes, as well as getting in touch with other students, professors and other experts that have participated in the development of the activities that comprised the training prototype. Many students have positively evaluated the opportunity to learn from others with a different mindset, cultures, contexts and challenges. Teachers also widely acknowledged and valued this activity as really enriching, not only for their pupils, but also for themselves hosting foreign students. In addition, students also particularly stressed the importance of speaking and working in English with other students and teachers in foreign countries, which have allowed to take real-life situations where they can use their knowledge. Many students also stress that been forced to speak in English at local level was also really positive.

However, and due to budget constraints, mobility actions in the project have not been really massive as these kinds of activities are usually costly. In this sense, we must argue that extending the funding in the next Erasmus+ programme for these kinds of activities will benefit enormously to the main recipients (students), but also other agents such as teachers and other agents participating on it. At the time that this is being written, it seems that Erasmus+ next budget programme will be significantly increased[8], and we would like to clap this line of action, as this is the first step to democratize these mobility opportunities.

[8] More information at https://ec.europa.eu/programmes/erasmus-plus/news/commission-adopts-proposal-next-erasmus-programme-2021-2027_en

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6.2 To provide the right incentives for establishing sustainable collaborations between stakeholders and HEIs

The second policy recommendation that we would like to emphasize is focused in the need of establishing the right incentives to promote stable and long-term collaborations between HEI´s and other stakeholders such as companies, research institutes, hospitals, private foundations, civil society organizations, think tanks, NGOs, associations , citizen collectivities and many others that can be of interest for hands-on training and educational purposes. This rationale stem from the difficulties that have been faced by the consortium in general, and the nodes in particular, to establish strong collaborations with manufacturers during the lifespan of the project.

Of course, companies usually valued the fresh ideas developed by students, as well as the experience, but generally speaking, manufacturing companies in the 4 nodes were not prone to be involved in the project. Some nodes had more linkages and connections than others, but as we can see in the interviews their presence has been not steady. In this sense, this seems to be a general problem at the Erasmus+ programme that it is probably aligned with the incentives or rewards that can obtain stakeholders for their participation on projects without being formal members of the consortium. In this sense, a closer cooperation based on clear incentives and tangible rewards must be fueled for enriching the learning ecosystem.

6.3 To allocate adequate resources for the institutionalization of makerspaces

As we have presented in the first section of this document, the institutionalization of makerspaces is a growing trend that has been led by great technological states such as US and China. However, this institutionalization in Europe has follow a different pattern in Europe due to a number of different reasons in concordance to the cultural particularities of the different macro-regions in the EU (Ramella & Manzo, 2018; Rosa et al., 2017). We have been argued during the whole document how makerspaces can be a useful tool for equipping our next generation of pupils with the right skills that will be demanded by the digitization of the economy.

To this extent, policy plans or national strategies oriented to renew educational approaches must bear in mind that there is an important need to adequately fund the investment in these kind of spaces at HEIs. There are some specific tools that are probably critical in a makerspace (such as a 3d printer or a CNC) and that needs adequate funding for establishing appropriate settings. However, we would like also to stress, that allocate funding for building up makerspaces into educational spaces is not always the best way to promote this social appropriation of makerspaces into the educational community. As we have observed into the project, some HEIs have

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been actively collaborating with other fab labs that were outside its physical domains, and that has led to great results. Students have been actively participated in the different innovation communities established and have experienced how co-creation works in real-life situations, they have had the opportunity to use their infrastructures and accessing to new perspectives and challenges that are completely outside the formal educational mindset. In this sense and echoing the rationale that we have stressed at the introduction, communities are the cornerstone of makerspaces and probably the best way to promote institutionalization of makerspaces is bridging them with HEIs, instead of setting up new ones.

6.4 To foster individualized learning paths throughout participatory processes, group dynamics and teamwork

Flexibility, self-discovery, creativity, resilience, critical thinking and many other soft skills that will be demanded by different employers in the future labor market cannot be easily instructed if there is no group interaction and feedback. The vast majority of interviews with students in this project show how participatory dynamics and teamwork helped to pupils to gain confidence and test their soft skills, but also to trigger their interest in learning hard skills such as AI or IoT.

Communities of practice, social labs, open space technology, flipped classroom methodologies and many other will be needed in order to cultivate individual needs, but also group dynamics that can favor the employability of many students in coming years.

6.5 To promote new ways of formal recognition of skills and knowledge gathered throughout non-formal or informal learnings.

One of the most problematic issues during the lifespan of OD&M project has been the adoption of the Open Badge system. Students and teachers were both discomfort with its implementation and the analytics coming from the platform has only stressed this matter. It seems that there was also a lack of coordination between the different nodes in terms of how allocating badges and through which measures and tests to the students. In this sense, we must argue that this project has provide the opportunity to experiment with this system, but it is far from being adapted to the reality of the different HEIs that have participated in the project. Of course, more research and projects are needed, but there is a strong need to promote further cooperation between the different HEIs and other organizations that promote non-formal learning and informal learning to meet the gap. Digitization is imposing new trends, and this is clearly one of the most recognizable ones with new digital platforms, resources and materials that are populating the Internet.

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6.6 To promote diversity, equity, inclusivity and responsibility through maker culture.

Maker culture and maker movement are not a panacea and we will be naïve if we think that this new philosophy of DIY is here to revolutionize the educational sector. Of course, making is far from perfect and it has their own mistakes and shortcomings. One of the most cited is how the white-male engineering culture is continually promoted throughout these spaces. Of course, this is an endemic problem in STEM disciplines and specially in ICT industry, with women and other social minorities clearly underrepresented, and makerspaces are no exception to this rule. They usually face several resource constraints, as well as they lack dedicated profiles to address this problem from early ages.

However, HEIs have the resources, knowledge and skills needed to properly address these issues and to promote fair and quality education that can guarantee diversity, equity, inclusivity and responsibility through STEM project-based learning.

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7. BIBLIOGRAPHY

Anderson, C. (2012). *Makers: the new industrial revolution*. Random House.

Anderson, Chris. (2010). In the Next Industrial Revolution, Atoms Are the New Bits. Retrieved May 12, 2014, from http://www.wired.com/2010/01/ff_newrevolution/

Bakırlıoğlu, Y., & Kohtala, C. (2019). Framing Open Design through Theoretical Concepts and Practical Applications: A Systematic Literature Review. *Human-Computer Interaction*, 1–44. https://doi.org/10.1080/07370024.2019.1574225

Barbrook, R., & Cameron, A. (1996). The Californian ideology. *Science as Culture*, *6*(1), 44–72. https://doi.org/10.1080/09505439609526455

Bauwens, M. (2010). The Emergence of Open Design and Open Manufacturing. Retrieved April 5, 2017, from http://www.we-magazine.net/we-volume-02/the-emergence-of-open-design-and-open-manufacturing/#.WOSgTWclHIU

Blikstein, P. (2013). Digital Fabrication and 'Making' in Education: The Democratization of Invention. In J. Walter-Herrmann & C. Büching (Eds.), *FabLabs: Of Machines, Makers and Inventors* (Bielefeld, pp. 1–21). Transcript Publishers. https://doi.org/10.1080/10749039.2014.939762

Browder, R. E., Aldrich, H. E., & Bradley, S. W. (2019). The emergence of the maker movement: Implications for entrepreneurship research. *Journal of Business Venturing*, *34*(3), 459–476. https://doi.org/10.1016/j.jbusvent.2019.01.005

Burke, L. M., & McNeill, J. B. (2011). *"Educate to innovate": How the Obama plan for STEM education falls short*. *Backgrounder*. Washington D.C. Retrieved from http://report.heritage.org/bg2504

Davies, R. (2015). *Industry 4.0 Digitalisation for productivity and growth*. Retrieved from http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf

Dellot, B. (2015). *Ours to Master: How makerspaces can help us master technology for a more human end*. London.

Deloitte Center for the Edge & MakerMedia. (2013). *Impact of the maker movement*. *Maker Impact Summit Dec. 2013*. Retrieved from http://makermedia.com/wp-content/uploads/2014/10/impact-of-the-maker-movement.pdf

Dewey, J. (2009). *Democracia y escuela*. Madrid: Popular.

Dougherty, D. (2012). The Maker Movement. *Innovations: Technology, Governance,*

Co-funded by the Erasmus+ Programme of the European Union

Globalization, *7*(3), 11–14. https://doi.org/10.1162/INOV_a_00135

Fehringer, H., Kaar, C., & Stary, C. (2019). Makerspaces in academic education: An exploratory analysis and design framework. *2019 18th International Conference on Information Technology Based Higher Education and Training, ITHET 2019*, 1–10. https://doi.org/10.1109/ITHET46829.2019.8937350

Ferrari, A. (2013). *DIGCOMP: a Framework for Developing and Understanding Digital Competence in Europe*. *eLearning Papers*. Seville. https://doi.org/10.2788/52966

Freire, P. (1974). *Pedagogy of the Oppressed*. *Pedagogy of the Oppressed*. New York: Seabury Press.

Grundke, R., Marcolin, L., Nguyen, T. L. B., & Squicciarini, M. (2018). *Which skills for the digital era? Returns to skills analysis* (OECD Science, Technology and Industry Working Papers). Paris. https://doi.org/10.1787/9a9479b5-en

Gutiérrez, R. T. (2018). La importancia de la cultura tecnológica en el movimiento maker. *Arbor*, *194*((789): a471). https://doi.org/https://doi.org/10.3989/ arbor.2018.789n3013

Gutiérrez, R. T. (2019a). La fabricación abierta : ¿un camino alternativo a la industria 4.0? *Revista Iberoamericana de Ciencia, Tecnología y Sociedad*, *14*(41), 263–285. Retrieved from http://www.revistacts.net/files/Volumen_14_Numero_41/14Tabares.pdf

Gutiérrez, R. T. (2019b). Makerspaces as Knowledge Infrastructures for the Factory of the Future. In I. P. Benjamín Tejerina, Cristina Miranda de Almeida (Ed.), *Sharing Society: The Impact of Collaborative Collective Actions in the Transformation of Contemporary Societies* (pp. 538–548). Bilbao: UPV-EHU. Retrieved from https://sharingsocietyproject.org/2019/05/08/conference-proceedings/

Gutiérrez, R. T., Bartolomé, T., Martelloni, L., Amicis, L. De, Binenti, S., Rushton, E., … Binenti, S. (2018). *Towards the popularization of Open Manufacturing in European Industry (OPENMAKER White Paper 2.0)*. https://doi.org/10.13140/RG.2.2.20410.64964

Hagel, J., Brown, J. S., & Kulasooriya, D. (2013). *A movement in the making*.

Halbinger, M. A. (2018). The role of makerspaces in supporting consumer innovation and diffusion: An empirical analysis. *Research Policy*, *47*(10), 2028–2036. https://doi.org/10.1016/j.respol.2018.07.008

Halverson, E. R., & Sheridan, K. (2014). The Maker Movement in Education. *Harvard Educational Review*, *84*(4), 495–504. https://doi.org/10.17763/haer.84.4.34j1g68140382063

Haring, K. (2008). *Ham Radio´s Technical Culture*. Cambridge, Mass: The MIT Press.

Co-funded by the Erasmus+ Programme of the European Union

Hatch, M. (2013). *The maker movement manifesto: rules for innovation in the new world of crafters, hackers, and tinkerers.* London: McGraw Hill.

Himanen, P. (2002). *La ética del hacker y el espíritu de la era de la información*. Barcelona: Destino.

Jun, W. (2019). Development of teaching AIDS selection standards in maker education. *Advances in Science, Technology and Engineering Systems*, *4*(5), 139–142. https://doi.org/10.25046/aj040518

Kostakis, V., Niaros, V., & Giotitsas, C. (2015). Open source 3D printing as a means of learning: An educational experiment in two high schools in Greece. *Telematics and Informatics*, *32*(1), 118–128. https://doi.org/10.1016/j.tele.2014.05.001

Levy, S. (2010). *Hackers: Heroes of the Computer Revolution*. *O'Reilly*. New York: Dell Publishing. https://doi.org/10.1016/0267-3649(86)90036-1

Liang, W. (2019). Research on the Application of Maker Education in K-12 Science Curriculum. *Advances in Social Science, Education and Humanities Research*, *341*(ICADCE 2019), 800–805. https://doi.org/10.2991/icadce-19.2019.170

Lindtner, S. (2015). Hacking with Chinese Characteristics: The Promises of the Maker Movement against China's Manufacturing Culture. *Science, Technology & Human Values*, *40*(5), 1–26. https://doi.org/10.1177/0162243915590861

Lindtner, Silvia, Bardzell, S., & Bardzell, J. (2016). Reconstituting the Utopian Vision of Making. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16* (pp. 1390–1402). San Jose. https://doi.org/10.1145/2858036.2858506

Lindtner, Silvia, Greenspan, A., & Li, D. (2015). Designed in Shenzhen: Shanzhai Manufacturing and Maker Entrepreneurs. In *Aarhus Series on Human Centered Computing* (Vol. 1, p. 12). Aarhus: ACM. https://doi.org/10.7146/aahcc.v1i1.21265

Lindtner, Silvia, Hertz, G. D., & Dourish, P. (2014). Emerging sites of HCI innovation. *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems - CHI '14*, 439–448. https://doi.org/10.1145/2556288.2557132

Lindtner, Silvia, & Li, D. (2012). Created in China: The Makings of China's Hackerspace Community. *Interactions*, *19*, 18–22. https://doi.org/10.1145/2377783.2377789

Martelloni, L., Lobascio, A., Como, E., Giorgi, D., Lotti, G., Fiesoli, I., … Gutiérrez, R. T. (2017). *Universities , Enterprises and Maker Communities in Open Design & Manufacturing across Europe : An exploratory study*. Retrieved from http://odmplatform.eu/wp-content/uploads/2017/05/D3.1-ODM-Research-Report-Integral.pdf

Co-funded by the Erasmus+ Programme of the European Union

Martin, L. (2015). The Promise of the Maker Movement for Education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *5*(1). https://doi.org/10.7771/2157-9288.1099

Mortara, L., & Parisot, N. G. (2016). Through entrepreneurs' eyes: the Fab-spaces constellation. *International Journal of Production Research*, *54*(23), 7158–7180. https://doi.org/10.1080/00207543.2016.1198505

Niaros, V., Kostakis, V., & Drechsler, W. (2017). Making (in) the Smart City: The Emergence of Makerspaces. *Telematics and Informatics*. https://doi.org/10.1016/j.tele.2017.05.004

Papert, S., & Harel, I. (1991). Situating Constructionism. In *Constructionism*. Cambridge, MA: MIT Press. https://doi.org/10.1111/1467-9752.00269

Ramella, F., & Manzo, C. (2018). Into the crisis: Fab Labs – a European story. *The Sociological Review*, *66*(2), 341–364. https://doi.org/10.1177/0038026118758535

Ratto, M. (2011). Critical Making: Conceptual and Material Studies in Technology and Social Life. *The Information Society*, *27*(4), 252–260. https://doi.org/10.1080/01972243.2011.583819

Ratto, M., & Ree, R. (2012). Materializing information: 3D printing and social change. *First Monday*, *17*(7), 1–25.

Romero-Frías, E., & Robinson-García, N. (2017). Laboratorios sociales en Universidades: Innovación e impacto en Medialab UGR. *Comunicar*, *51*(XXV), 29–38. https://doi.org/https://doi.org/10.3916/C51-2017-03 |

Rosa, P., Ferretti, F., Guimarães Pereira, Â., Panella, F., & Wanner, M. (2017). *Overview of the Maker Movement in the European Union*. Luxembourg. https://doi.org/10.2760/227356

Rosa, P., Guimaraes Pereira, A., & Ferretti, F. (2018). *Futures of Work: Perspectives from the Maker Movement*. Luxembourg. https://doi.org/10.2760/96812

Saunders, T., & Kingsley, J. (2016). *Made in China - Makerspaces and the search for mass innovation*. London.

Sheridan, K., Halverson, E. R., Litts, B., Brahms, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the making. *Harvard Educational Review*, *84*(4), 505–532. https://doi.org/10.17763/haer.84.4.brr34733723j648u

Smit, J., Kreutzer, S., Moeller, C., & Carlberg, M. (2016). *Industry 4.0*. Brussels. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

Smith, A., Fressoli, M., Abrol, D., Arond, E., & Ely, A. (2017). *Grassroots Innovation Movements*.

Co-funded by the Erasmus+ Programme of the European Union

London: Routledge.

Turner, F. (2006). *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago Press.

Turner, F. (2018). Millenarian tinkering: The puritan roots of the maker movement. *Technology and Culture*, *59*(4), S160–S182. https://doi.org/10.1353/tech.2018.0153

von Hippel, E. (2017). *Free Innovation*. Cambridge, Mass: The MIT Press.

Vuorikari, R., Ferrari, A., & Punie, Y. (2019). *Makerspaces for Education and Training*. Luxembourg. https://doi.org/10.2760/946996

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Co-funded by the Erasmus+ Programme of the European Union