MAKE-IT

Understanding Collective Awareness Platforms
with the Maker Movement

D2.1
Conceptual and methodological framework

Understanding Collective Awareness Platforms with the Maker Movement

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WP2 Conceptual and methodological framework

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Annexes

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I	Annex I	Initial selection of *MAKE-IT* case studies
II	Annex II	Taxonomy definitions

Details

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Executive Summary

Objectives and rationale

Deliverable 2.1 provides an early conceptual, methodological and scientific framework for the *MAKE-IT* project. Although no formal updates of this deliverable are planned, the clear intention is that it will be updated in light of experience during the course of the project. This work will also feed into *MAKE-IT*'s final deliverable at the end of the project. The deliverable is based and draws upon the project's DoA, initial desk research and investigation during the first three months of the project, plus the expert knowledge of project partners. No empirical testing or operationalisation has yet taken place.

The framework represents work in progress as it will be applied and operationalized in subsequent work-packages (initially and notably in WP3 on case explorations), and on this basis updated, refined and adapted as necessary to fulfil the overall objectives of the project. The framework thus has two overarching objectives:

1. To function as a flexible conceptual and analytical tool for *MAKE-IT* during the project.
2. As a project output at its termination, to offer a robust and fully tested conceptual and analytical framework to the Maker movement for wider use and refinement.

The various features of the conceptual framework presented here are designed to constitute a flexible and expandable toolbox of resources for interrogation, testing and operationalization in subsequent WPs. The intention is that the main components will be deployed but in flexible ways and with flexible constituent features to meet specific needs as they arise.

Maker movement focus, scope and definition

The Maker movement is a rapidly expanding field with innumerable perspectives, interpretations and definitions. In the specific context of the *MAKE-IT* project, the approach to and definition of the Maker movement focuses on the overlap between three main strands and fields of activity:

1. *Digital fabrication*: provides the technological underpinning of the Maker movement. Digital modeling and fabrication is a process that joins design with production through the use of 3D modeling software or computer-aided design (CAD) and additive and subtractive manufacturing processes. The initial focus on simple 3D printers has now progressed to an awareness that the real Maker revolution comes when these are combined with laser cutters, precision mills, large and small format mills, as well as digital assemblers and re-assemblers. These are all various combinations of feedstocks in the form of pulverised, sintered or melted plastic, rubber, metal, glass, wood, ceramics, paper, etc., much of which is very inexpensive and sourced locally.
2. *Crafts, do-it-yourself and creative activities*: The tradition of craft production is the process of manufacturing by hand with or without the aid of advanced or power tools. In parallel with this, do-it-yourself presents gateway opportunities for the un-skilled or novices to build, modifying or repair something without the direct aid of experts or professionals. Both can also express themselves

through developing an ethos of self-help, learning and competence building, often in shared and collaborative spaces like libraries and other common or public spaces.

3. *Community Awareness Platforms (CAPs)*: Communities such as the Makers may build and exploit communication infrastructures to collaborate. CAPs is the European Commission's initiative on Collective Awareness Platforms for Sustainability and Social Innovation. It aims at designing and piloting online platforms that create awareness of sustainability problems and offer collaborative solutions. These solutions are based on networks - of people, of ideas, of sensors - thereby enabling new forms of social innovation which aim to harness bottom-up 'network effect's and support behavioural change. These can express themselves, for example, in new life styles and in consumption and production patterns, and give power not only to for-profit platforms but also to those which have, at least in part, non-commercial objectives.

The three main components of the conceptual framework

The conceptual framework consists of three main components:

1. *Component 1: three analytical pillars* for examining single examples and case studies of Makers: i) organization and governance, ii) peer and collaborative activities and behaviours, and iii) value creation and impact. Both the internal features and the external relations and interactions of Maker examples can be empirically examined using these three pillars. Additionally, they can guide the examination of secondary evidence from the academic and grey literature in support of the empirical analyses.
2. *Component 2: dimensions for sampling and comparison* are presented as deductive tools derived from both desk research and expert knowledge for two purposes. First, to guide the selection of case studies in subsequent *MAKE-IT* WPs in order to ensure that a range of different types are examined within the scope of the project and based on evidence from the literature, rather than this being an ad hoc random sampling decision. Second, to make direct comparisons between the individual examples analysed in Component 1 by examining the differences and similarities in their results across the three analytical pillars. Thus, Component 2 can later be crossed with Component 1, for example in WP6, in order to make comparisons and draw synthetic inferences concerning specific types or configurations of Makers (depending on the dimension). These inferences can also be validated and further developed by additional desk research, interviews and other evidence gathering activities.
3. *Component 3: taxonomy and definitions, classifications and relationships* designed to inform and draw from all other elements of the conceptual framework as this develops. This includes making research replicable and insights comparable, understanding how and why meanings change, and an examination of folksonomies as concepts derived from social media. Together, these elements help to form a common glue and terminology for underpinning the project objectives and scope, and thereby assist in delimiting its focus.

Table of Contents

1. Introduction

This introduction outlines the overall purpose, objectives and target audience of Deliverable 2.1, and outlines the Maker movement focus and definition which informs and provides the scope and context for the conceptual framework.

1.1 Purpose and objectives

1.1.1. Work-package 2: Conceptual and methodological framework

Drawing on the *MAKE-IT* project's Description of Activities (DoA), work-package (WP) 2 focuses on the following core objectives:

1. To develop and validate the conceptual framework and the overall theoretical, scientific and methodological coherence of all aspects of the project and to monitor its operationalization across the project and especially by the main scientific WPs: 3, 4, 5 and 6. Although the main work of WP2 will take place in the first six months of the project, it will exercise a watching brief on developments throughout its duration.
2. To provide overviews of and monitor the development and forward trajectory of the Maker movement in the context of the CAPs approach, with a focus on Europe but also ensuring clear understanding of and linkage to global developments and especially to global leaders in this fast changing environment.

1.1.2. Deliverable 2.1: Conceptual and methodological framework

Deliverable 2.1 provides an early conceptual, methodological and scientific framework for the *MAKE-IT* project. Although no formal updates of this deliverable are planned, the clear intention is that it will be updated in light of experience during the course of the project. This work will also feed into *MAKE-IT*'s final deliverable at the end of the project. The deliverable is based and draws upon the project's DoA, initial desk research and investigation during the first three months of the project, plus the expert knowledge of project partners. No empirical testing or operationalisation has yet taken place.

The framework represents work in progress as it will be applied and operationalized in subsequent work-packages (initially and notably in WP3 on case explorations), and on this basis updated, refined and adapted as necessary to fulfil the overall objectives of the project. The framework thus has two overarching objectives:

1. To function as a flexible conceptual and analytical tool for *MAKE-IT* during the project.
2. As a project output at its termination, to offer a robust and fully tested conceptual and analytical framework to the Maker movement for wider use and refinement.

1.1.3. Rationale: the conceptual framework as a flexible and expandable toolbox

The various features of the conceptual framework presented here are designed to constitute a flexible and expandable toolbox of resources for interrogation, testing and operationalization in subsequent WPs. The intention is that the main components will be deployed but in flexible ways and with flexible constituent features to meet specific needs as they arise. It is clear that other features might also be developed and applied if the evidence emerging suggests this. It is not possible at this stage, before detailed case study and related desk research takes place, to know precisely which parts of the framework will be most suitable in practice. However, selection and adjustment will need as far as necessary to be consistently undertaken, also between WPs, in order to ensure overall coherence in support of MAKE-IT's unified research approach. Figure 1 illustrates the three main components of the framework with their complementary roles and mutual relationships, as summarised in the following text.

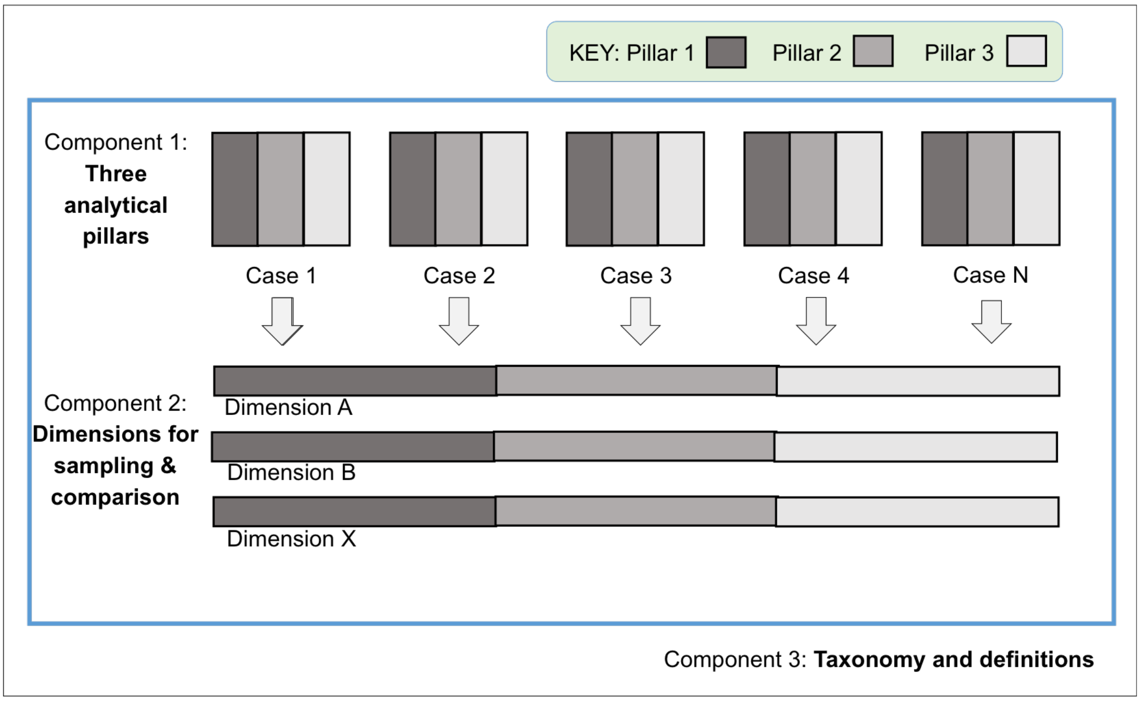

Figure 1: The three components of the conceptual framework

1. **Component 1** of the conceptual framework: a detailed presentation of three analytical pillars for examining single examples and case studies of Makers: i) organization and governance, ii) peer and collaborative activities and behaviours, and iii) value creation and impact. Both the internal features and the external relations and interactions of Maker examples can be empirically examined using these three pillars. Additionally, they can guide the examination of secondary evidence from the academic and grey literature in support of the empirical analyses.
2. **Component 2** of the conceptual framework: a small number of dimensions are examined as deductive tools derived from both desk research and expert knowledge for two purposes. First, to guide the selection of case studies in subsequent *MAKE-IT* WPs in order to ensure that a range of different types are examined within the scope of the project and based on evidence from the literature, rather than this being an ad hoc random sampling decision. Second, to make direct comparisons between the individual examples analysed in Component 1 by examining the differences and similarities in their results across the three analytical pillars. Thus, Component 2 can later be crossed with Component 1, for example in WP6, in order to make comparisons and draw synthetic inferences concerning specific types or configurations of Makers (depending on the dimension). These inferences can also be validated and further developed by additional desk research, interviews and other evidence gathering activities.
3. **Component 3** of the conceptual framework: taxonomy, definitions, classifications and relationships, designed to inform and draw from all other elements of the conceptual framework as this develops. These constitute the common glue and terminology that aims to underpin the project objectives as well as scope and delimit its focus.

More information about each of the above four components is provided in the respective sections below.

1.1.4. Target audience

Given that Deliverable 2.1 is designed to constitute a flexible and expandable toolbox of resources for interrogation, testing and operationalization in subsequent WPs, its target audience is mainly internal to the project. However, as also stated, the deliverable will be updated as needed on an on-going basis to meet the changing needs of the project, so that by the end of the project a refined version will be made available to other Maker movement practitioners, researchers and policy-makers.

1.1.5. Deliverable structure

This deliverable thus consists of four main parts:

1. This introduction incorporating the Maker movement focus and definition which informs and provides the scope and context for the conceptual framework.
2. Component 1 of the conceptual framework: a detailed presentation of three analytical pillars for examining individual examples and case studies of Makers.
3. Component 2 of the conceptual framework: a small number of dimensions are examined as a deductive approach for selecting and comparing cases.

4. Component 3 of the conceptual framework: taxonomy, classifications and relationships.

In addition there are also references, lists of acronyms and abbreviations, plus two annexes: 1) a short summary of the initial case studies identified in the DoA but which still requires validation; and 2) an initial set of definitions in support of the taxonomy in chapter 4.

More information about each of the above parts is provided in the respective sections below.

1.2 Maker movement focus, scope and definition

The Maker movement is a rapidly expanding field with innumerable perspectives, interpretations and definitions. (For example, see Anderson 2012, Dougherty 2012 and Rifkin 2014.) In the specific context of the *MAKE-IT* project, the approach to and definition of the Maker movement focuses on the overlap between three main strands and fields of activity: 1) digital fabrication, 2) crafts, do-it-yourself and creative activities, and 3) Community Awareness Platforms (CAPs), as examined in the following.

1.1.6. Digital fabrication

Digital fabrication provides the technological underpinning of the Maker movement. Digital modeling and fabrication is a process that joins design with production through the use of 3D modeling software or computer-aided design (CAD) and additive and subtractive manufacturing processes. 3D printing falls under additive fabrication, while machining falls under subtractive fabrication.[1] Digital fabrication tools allow designers to produce material digitally, which is something greater than an image on screen, and actually tests the accuracy of the software and computer lines. The initial focus on simple 3D printers has now progressed to an awareness that the real Maker revolution comes when these are combined with laser cutters, precision mills, large and small format mills, as well as digital assemblers and re-assemblers. These are all various combinations of feedstocks in the form of pulverised, sintered or melted plastic, rubber, metal, glass, wood, ceramics, paper, etc., much of which is very inexpensive and sourced locally. Tools and materials like these used together give Makers at any scale and size a whole suite of capabilities for additive and subtractive manufacturing, 2D and 3D printing, form, function, electronic, actuator, sensors, etc. They are being installed and used, not just in industry and research labs, but in many communities by SMEs, start-ups, civil organisations and even individuals. As in the ICT revolution over the last twenty years, their costs are tumbling fast and their quality and ease of use dramatically improving (Rifkin 2014), and just like its digital predecessor that saw the disruption driven by personal computers and co-creation online, much of the energy and innovation of the digital fabrication revolution is being driven from the bottom.

At the macro scale digital manufacturing (such as computer-controlled production lines and automotive/robotic production and assembly, typically undertaken by large and often multi-national corporations) is challenging to, and

1. https://en.wikipedia.org/wiki/Digital_modeling_and_fabrication (retrieved March 2016).

being challenged by, the mainly micro small scale manifestations of digital fabrication. The latter is being driven by so-called 'backyard and garage' manufacture, emulating the early days of personal computing in the 1970s and 1980s, using a multitude of new tools and applications with rapidly decreasing prices, ease of use and accessibility to ordinary people. Although *MAKE-IT* focuses on the small scale, bottom-up and local models of manufacturing, the relationships between the micro and the macro are highly significant and will help determine future industrial and economic systems. This is important because the large scale established players are already being existentially threatened by the small scale makers, in the same way that very few mainframe computer era companies survived the ensuing creative destruction brought about by personal computing (see also Christensen 1997). The 'garage and basement' upstarts of the 70s, 80s and early 90s, like Microsoft, Google, Apple and Facebook, destroyed and then recreated computing and ICT, and the music, publishing and media industries alongside it. These upstarts have now become global giants in their own right – but for how long? Perhaps this pattern is now starting to repeat itself in manufacturing.

Will the trajectory followed in the digital virtual world over the last thirty years be emulated in the digital-physical world? If it does, even with many new twists and surprises, the future of manufacturing, work, behaviour and local and city development, not to mention global politics and value chains, will be turned upside down in the near and medium-term future. Perhaps of even greater significance will be the potential impact on the environment and sustainability more generally. If in the future the only economically traded (i.e. physically transported or communicated over large distances) commodities consist of i) talent (high calibre skilled people), ii) raw materials and energy inputs the occurrences of which are still geographically fixed, and iii) digital algorithms, this will have a huge and beneficial environment impact as the number of physical goods transported over even medium distances shrinks.

For example, buying a Toyota car from Japan whilst living in Europe will consist of the online customisation of the design you want, the purchase of an algorithm over the Internet, which is then printed locally and assembled by robots. And, this might only be the first step. In principle anyone will be able to design and then build their own car, anytime and anywhere, so why purchase anything from Toyota? The Toyota Company might no longer exist unless it adapts dramatically to the coming reality and, like many other incumbents in traditional industries such as computing and media, killed off by the forces of creative destruction. (Schumpeter 1942, PwC 2015) Globalisation has generally been a beneficial set of developments, but it also has serious downsides, such as long and vulnerable supply chains, political risks, huge carbon costs, the decimation of manufacturing jobs in the developed world through extremely low cost wages elsewhere, and the limited choice consumers have when this is limited to products which can only be mass produced. The environmental and carbon reduction benefits of reversing this trend are potentially huge. Can the burgeoning interplay between the largely bottom-up Maker movement and large scale global trade involving multi-nationals experimenting with digital and additive manufacturing processes and the circular economy, result in system change with consequential social, economic and environmental benefits?

As noted, digital modelling, design and production is no longer confined to the virtual world of bits, where it has transformed industries and whole sectors over the last thirty years, but is now also moving into the physical world of atoms, and promises further to transform the biological world of genes and biological systems. Indeed, the use of biological systems is also changing digital fabrication, so it's a two-way influence (Myers and Antonelli 2012; Ginsberg et al. 2014; Church and Regis 2014; Mims 2011) Seen in this light, the new world of digital fabrication and its developments is indeed a cornerstone of the emerging so-called fourth industrial revolution as defined by the World Economic Forum in 2016: *"The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last* *century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres".*[2]

1.1.7. Crafts, do-it-yourself, creative and learning activities

The tradition of craft production is the process of manufacturing by hand with or without the aid of advanced or power tools and is often part of the informal economy, having been largely superseded in purely economic terms during the first industrial revolution. However, it has more recently seen an economic revival due to its ability to focus on high quality and uniqueness, as well as spilling over into hobbies and handicrafts with the rise of the so-called middle and leisure classes.[3] Do-it-yourself, also known as DIY, is the method of building, modifying, or repairing something without the direct aid of experts or professionals. DIY behaviors see "individuals engage raw and semi-raw materials and component parts to produce, transform, or reconstruct material possessions, including those drawn from the natural environment (e.g. landscaping)". DIY behavior can be triggered by various motivations previously categorized as marketplace motivations (economic benefits, lack of product availability, lack of product quality, need for customization), and identity enhancement (craftsmanship, empowerment, community seeking, uniqueness).[4]

More recently creative, arts and cultural based economic activities have become important, with the so-called creative industries referring to a range of economic activities which are concerned with the generation or exploitation of knowledge and information. They may variously also be referred to as the cultural industries or the creative economy, for example in Europe. Howkins' (2001) creative economy comprises advertising, architecture, art, crafts, design, fashion, film, music, performing arts, publishing, R&D, software, toys and games, TV and radio, and video games.[5]

Fourie & Meyer (2015) underline the traditional importance of libraries as shared spaces for acquiring information and knowledge as well as for self-help, learning and competence building. Marrying the library concept as a space providing resources, help and interaction, with the DIY movement and other self-help and creative activities, the authors analysethe current development of maker spaces as places for innovation and creativity. These are filled not just with laser cutters and 3D printers, but also sewing machines, bike repair facilities, microcontrollers, circuits, clay and porcelain. Such spaces are associated with creating, building and crafting and getting hands-on experience in activities ranging from woodworking, sewing and building computers to audio-recordings and video editing.

Such maker spaces can be of many different types, in schools, for academics and students, to reach the "poorest of the poor", as mobile resource centres, and as social spaces for all types of practical and creative activities aimed at specific target groups, often those who are marginalised or vulnerable in some way. They are generally characterised by hands-on experience and creative ideas development and production. Many become "constructionist learning environments"

2. http://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond (retrieved March 2016).

3. https://en.wikipedia.org/wiki/Craft_production (retrieved March 2016).

4. https://en.wikipedia.org/wiki/Do_it_yourself (retrieved March 2016).

5. https://en.wikipedia.org/wiki/Creative_industries (retrieved March 2016).

for building “social-emotional competencies” with strong “social-political potential, social capital and social inclusion.” The focus is on providing physical spaces providing physical tools, ensuring an environment encouraging “trying”, “doing”, “creating spontaneously”, “enjoying” and “having fun”. The very essence of maker spaces lies in creativity, informality, doing things without pressure and a try-and-fail-and-try-again approach. Fourie & Meyer (2015) also emphasise maker learning, maker empowerment and maker caring through the creative means of caring in a community and society at large, not only by acknowledging maker spaces as physical DIY and creative spaces, but exploring the value for applying this opportunity to emotional and caring issues. In this way there is often an ethical and inclusion imperative in making things, nurtured through capacity building and empowerment, exploration, experimentation, fun and absence of pressure to excel, coupled with sharing and gaining new knowledge. (Fourie & Meyer 2015).

1.1.8. Community Awareness Platforms (CAPs)

Communities such as the Makers may build and exploit communication infrastructures to collaborate. CAPS is the European Commission's initiative on Collective Awareness Platforms for Sustainability and Social Innovation. It aims at designing and piloting online platforms that create awareness of sustainability problems and offer collaborative solutions. These solutions are based on networks - of people, of ideas, of sensors - thus enabling new forms of social innovation.[6]

CAPs use ICT tools and networks for supporting and propelling new forms of sustainability and social innovation. This is done through a people-centric approach that aims to actively involve citizens in creating new multi-dimensional communities at the grassroots, whilst at the same time linking into wider social, economic, environmental and democratic systems. It is important to see the purpose of CAPs within the broader context of the EU 2020 Strategy[7] which in 2010 established three priority areas designed to help Europe “emerge from the crisis stronger”: smart growth, sustainable growth and inclusive growth. It is also derived from the Digital Agenda Europe Flagship initiative[8] setting out the key enabling role of ICT in achieving these goals. Moreover, CAPs aim to support extended awareness of the social world, the environment and the consequences of people’s actions in developing environmentally friendly lifestyles, new economic models and participatory global governance. More specifically, the ambition underpinning CAPs is to:

1. harness the ‘network effect’
2. support behavioural change, reputational processes and self-regulation to the maximum degree so that these are trustable and effective, for example in new life styles and in consumption and production patterns
3. be both bottom-up supporting situational awareness, and dispersed supporting distributed awareness
4. give power not only to for-profit platforms but also to those which have, at least in part, non-commercial objectives

6. https://ec.europa.eu/digital-single-market/en/caps-projects (retrieved March 2016).

7. http://ec.europa.eu/europe2020/index_en.htm (retrieved February 2016).

8. http://ec.europa.eu/digital-agenda (retrieved February 2016).

5. promote new individual motivations and behaviours in the context of collective models for new forms of value creation
6. stimulate sustainability and social innovation, alongside jobs, growth and economic recovery.

Sestini (2012) describes CAPs as mobilizing the network effect of collective intelligence for the public good, where collective intelligence is seen as expressing itself through such phenomena as crowdsourcing and connective communities, and is often the result of forms of bottom-up and self organisation. Millard (2014) has also related many of the attributes of CAPs approaches to co-creation, collaborative production and consumption, and the sharing economy. Sestini describes how the concept of CAPs has arisen from three trends each of which can harness and deploy different forms of collective intelligence and lead to better policies and actions in tackling the many societal challenges we are facing, allthree can lead to what Sestini calls 'hyper-connected humanity', the ultimate goal being to foster a more sustainable future based on a low-carbon, beyond GDP economy, and a resilient, cooperative democratic community:

1. Social networking
2. Direct contact with the environment through the Internet of Things, i.e. electronic tags embedded in everything, potentially providing pervasive sensory awareness and capabilities, as well as serious risks to our privacy and intellectual property
3. The collaborative production of knowledge, such as Wikipedia.

A fourth major trend can be added to this repertoire, i.e. not only the collaborative production of knowledge and other forms of intangible content, but also the collaborative production and consumption of tangible forms of physical objects, as currently being realized by the burgeoning Maker movement.

1.1.9. A framework for defining the Maker movement scope of the *MAKE-IT* project

Figure 2 sketches a framework for defining the Maker movement scope of the *MAKE-IT* project focusing on the overlap between the three fields of activity described in 1.1.6 to 1.1.8. Although the project will recognise the conjunction of the three fields as the basis of its interest, it will not attempt to insist on a rigid definition. This is both because this might only be possible towards the end of the project, and because, as will be clear from the above, rigid definitions are not forthcoming for any of the Maker movement elements, and it would likely be counter productive to attempt to construct any.

According to the European Parliament report (2015) the Maker movement is made up of 'makers' who make use of new technologies like 3D printing. They are individual actors who are grouped together in Fab Labs, Makerspaces or Hackerspaces. In other words the makers are among the key actors of the so-called open manufacturing and digital fabrication environment. The Maker movement started in garages and workshops but soon formed communities on the Web. 'Maker' is the most quoted figure in the discussion about 3D printing and has strong roots in the open source movement (Grassmuck 2010, Walter-Herrmann 2013).

Anderson (2012) suggests three key assets of the new Maker movement:

1. people who design and prototype new products by digital desktop-means (digital do-it-yourself)
2. a cultural norm committed to the idea that the design and prototypes are shared and further developed within the community
3. the use of common standards for blueprints that aims at closing or shortening the gap between maker and commercial service provider.

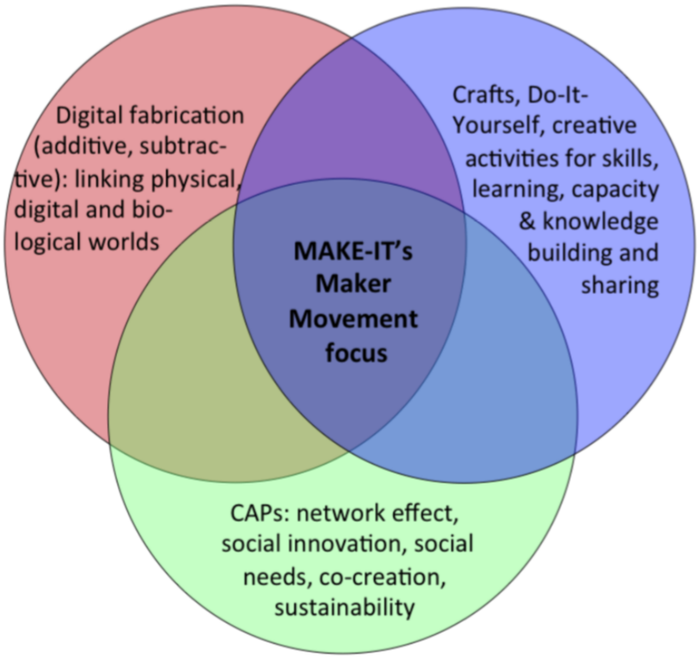

Figure 2: Venn diagram illustrating the Maker movement focus of the MAKE-IT project at the conjunction of three overlapping fields

According to Deloitte[9], the Maker movement represents the next generation of inventing and do-it-yourself. The platforms for learning, sharing and selling employed by the Maker movement are amplifying that impact and leading to new possibilities for innovation in products, materials and business models. Buxmann & Hinz (2013) note that, similar to open source projects, digital designs are often shared and then used or extended by third parties. This culture is a key driver for innovations and might fundamentally change the way physical products are designed and produced. The Maker movement is largely supported by the rise of a supporting ecosystem with new platforms and service providers that offer different kinds of services in the Maker environment.

The Techopedia[10] definition of the Maker movement is as a trend in which individuals or groups of individuals create and market products that are recreated and assembled using unused, discarded or broken electronic, plastic, silicon

9. http://www2.deloitte.com/us/en/pages/center-for-the-edge/topics/maker-movement.html# (retrieved March 2016).

10. https://www.techopedia.com/definition/28408/maker-movement (retrieved March 2016).

or virtually any raw material and/or product from a computer-related device. The Maker movement has led to the creation of a number of technology products and solutions by typical individuals working without supportive infrastructures. This is facilitated by the increasing amount of information available to individuals and the decreasing cost of electronic components. The Maker movement is primarily the name given to the increasing number of people employing do-it-yourself (DIY) and do-it-with-others (DIWO) techniques and processes to develop unique technology products. Generally, DIY and DIWO enables individuals to create sophisticated devices and gadgets, such as printers, robotics and electronic devices, using diagrammed, textual and or video demonstration. With all the resources now available over the Internet, virtually anyone can create simple devices, which in some cases are widely adopted by users. Most of the products created under the Maker movement are open source, as anyone can access and create them using available documentation and manuals. However, the Maker movement also incorporates creations and inventions that never existed before and were developed by individuals in their homes, garages or a place with limited manufacturing resources.

Probably the earliest proponent of the Maker movement was Dale Dougherty when he launched the *MAKE* Magazine in 2005, which provided a catalyst for this tech-influenced movement. As the movement gathered increasing momentum, Makers started to create their own market ecosystem, developing new products and services. The combination of ingenious Makers and innovative technologies such as the Arduino microcontroller and personal 3D printers are driving innovation in manufacturing, engineering, industrial design, hardware technology and education. Many makers are hobbyists, enthusiasts or students and are often amateurs, but they are also a wellspring of innovation, creating new products and producing value in the community. Some makers become entrepreneurs and launch start-up companies.[11]

The Maker movement has spawned its own culture as a technology-based extension of DIY culture that intersects with hacker culture (which is less concerned with physical objects as it mainly focuses on software), and revels in the creation of new devices as well as tinkering with existing ones. This Maker culture in general supports open-source hardware and design. Typical interests enjoyed by the Maker culture include engineering-oriented pursuits such as electronics, robotics, 3D printing, and the use of CNC tools, as well as more traditional activities such as metalworking, woodworking, and, mainly, its predecessor, the traditional arts and crafts. The culture stresses a cut-and-paste approach to standardized hobbyist technologies, and encourages cookbook re-use of designs published on websites and maker-oriented publications. There is a strong focus on using and learning practical skills and applying them to reference designs.[12]

A recent Social Innovation Europe publication (2015) put a spotlight on opportunities which are crystallizing at the cross roads between social innovation, open source ICT and manufacturing. This has the potential to reform manufacturing by enhancing productivity, creating more rewarding jobs, generating private and public value and, eventually, embedding new democratic practice at the core of industrial production. Three dimensions for this kind of innovation in manufacturing are identified:

1. A horizontal dimension, the democratisation of making. A combination of values-based movements (the Makers), new professional institutions (the Fab Labs), open tools (3D printers) and open source protocols are turning manufacturing into a participatory process in which the agents share risks and benefits and increase

11. http://makerfaire.com/maker-movement (retrieved March 2016),
12. https://en.wikipedia.org/wiki/Maker_culture (retrieved March 2016).

the value of production. Highly networked regional clusters provide the infrastructure for communication and collaboration.

2. A vertical dimension, supply chains for good. Full transparency of the sources of materials used in manufacturing and the conditions of production in the supply chain reveals the real footprint of a company and its commitment towards the environment and society. It is a simple but powerful drive to transform corporate strategy and consumer choice.
3. A transversal dimension, corporate citizenship. The next frontier of corporate social responsibility (CSR) sees social and environmental impact in their relation to the business strategies and decision-making processes of companies. It makes apparent that achieving positive social and environmental impact is not only compatible with making profits, but, in the medium term, is a pre-condition for making profits. Corporate Citizenship requires a company to examine its footprint on the environment and society at every stage of the value chain. The availability of talent, intellectual property protection, rule of law and neighbourhood employment might be external to the company's perimeter of action, but they will have a material impact on its performance and are strategic intervention points for CSR.

1.1.10. Main manifestations of the Maker movement

As described above, the Maker movement from very small beginnings is growing very fast and already beginning to develop numerous and often quite diverse manifestations. Although section 4 of this deliverable provides a more comprehensive and systematic approach to the various Make movement definitions, an overview by way of introduction is provided in Figure 3 which also proposes three levels of understanding different levels of Makers[13].

13. Provided by Kasper Birkholm Munk of DTI, February 2016.

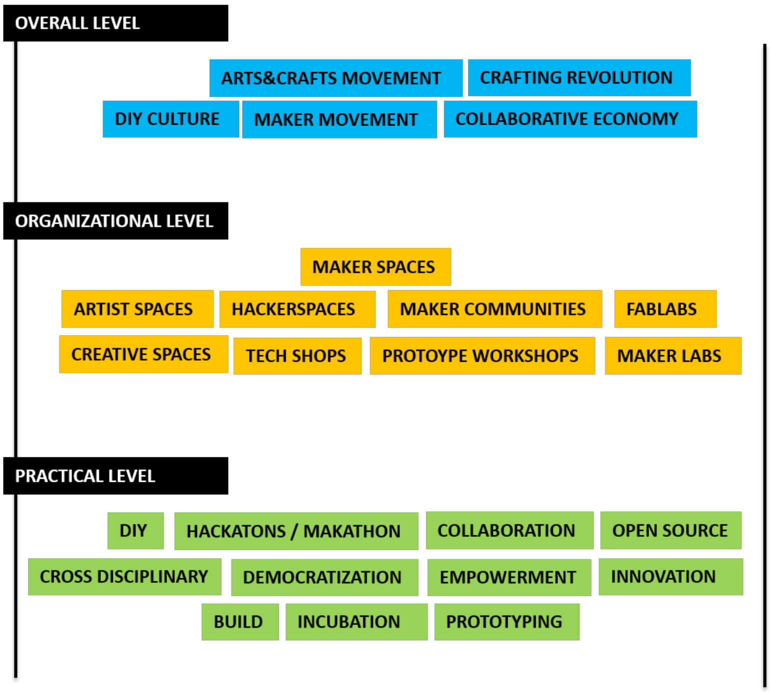

Figure 3: The diverse manifestations of the Maker movement

As indicated in section 1.1.7, maker spaces can comprise a large array of spaces for learning, community building, inclusion and cooperation, typically serving specific local and neighbourhood needs. These can include libraries, telecentres, culture clubs, schools, adult learning centres, workshops for people with disabilities and senior residencies[14]. Often Maker activities at the practical level are promoted and celebrated at so-called Maker Faires, that are events to "celebrate arts, crafts, engineering, science projects and the Do-It-Yourself (DIY) mindset". [15]

However, the most prominent current manifestation of the Maker movement is the Fab Lab. According to Menichinelli (2015), Fab Labs have emerged as the main place for the democratization of digital fabrication: here citizens learn how to design and make with tools and machines that work at the interactions of information technologies and physical processes and materials. In the Fab Lab network, bits and atoms and their interactions becomes the basis of empowered local communities that become networked with global networks of collaboration and sharing. Fab Labs started as a way of democratizing digital manufacturing technologies, and they have expanded in many more directions: but the social dimension of Fab Labs is still of strategic importance. Fab Labs are therefore a very good example of social innovation, an innovation that starts with technology but that is ultimately social: new scenarios emerge from the public access of technologies. Fab Labs are also a very good example of an often sought feature: the ability to develop a social innovation that works locally and that at the same time can be scaled up globally, whilst still working at both levels.

14. Provided by Bastian Pelka of TUDO, February 2016.

15. https://en.wikipedia.org/wiki/Maker_Faire (retrieved March 2016).

These fact shows that Fab Labs are actually entities that are designed, developed and managed along different dimensions, and the business dimensions is always present. Whether a Fab Lab gives access for free or whether access is purchased, whether a Fab Lab works on one specific kind of project or in a more generic way, it is ultimately a question of business model and business plan. Democratization and community building need resources that have to be found, allocated and continuously replenished: the business side is always important. Business models and business plans are needed both for the Fab Labs and for their projects and for the users' ones. Focusing on the business side of Fab Labs is also important for having a real impact on the specific localities and their communities. The business side is probably not the most attractive part (there are more profitable businesses than Fab Labs at the moment), but it is crucial for enabling the social innovations of Fab Labs. For example, having volunteers in a lab is very important for its life, but only (and few) small labs can count on volunteering work.

A little more than ten years is the time that has passed by since the first Fab Lab was launched, and even if this seems a long time, the development of the Fab Lab network has grown almost exponentially, so its boom is a quite recent phenomenon. While in the first period, Fab Labs tended to be similar, they are increasingly becoming differentiated and specialized, but this is a more recent evolution. Therefore, we know much more about some formats and business models, and less about others. For example, we know much more how to design and manage a lab hosted by an institution, much less about an independent lab.

Moreover, both digital fabrication and the Makers / DIY markets have been emerging recently: there are many optimistic predictions about present and future growth, but we still have to understand how big and relevant these markets will be, which sectors will be impacted by them and which countries and regions will have a stronger role in them. The good news is that this is the best moment for taking an active role in this exploration, in order to design or discover future scenarios for both society and the economy.

2. Component 1: Three analytical pillars

In *MAKE-IT*, we focus the research specifically on the role of CAPs in: first, how Maker communities are organised and governed; second, what Maker participants do and how they behave; and three, the various ways this impacts on and adds value to society. These three perspectives, which we call 'analytical pillars', will provide a comprehensive but also simple set of insights which show both the 'means' by which CAPs operate in maker communities and the 'ends' these 'means' produce, as illustrated in Figure 4. The three analytical pillars are ambitious in being broad and comprehensive, but aim to also be achievable as they focus firmly on the use of CAPs approaches by the maker movement.

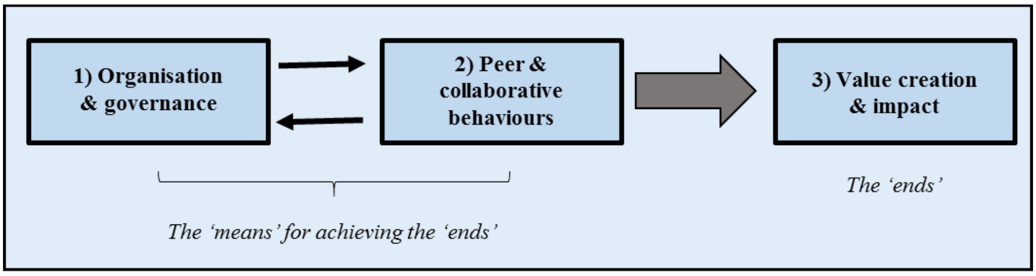

Figure 4: The three analytical pillars of *MAKE-IT*

The purpose for these analytical pillars is to provide a framework to guide the research in the following work packages of MAKE-IT; both the case explorations (WP3) and the innovation action research (WP4). Due to the description of the three analytical pillars, and the elucidation of the underlying scientific research, which we present in the next three subsections, those work packages will be aided in focussing on the key research questions and therefore will efficiently contribute important findings.

The objective of this part of this document is to provide a framework which forms the basis for a clearer understanding of what this particular analytical pillar entails, in order to aid other WP beneficiaries and partners in the design of their research activities.

The focus is on summarizing the key areas of each pillar, highlighting the relevant underlying research domains, and posing the most important research questions. In this sense, "important" relates to their key influence on our understanding of the Maker movement as well as the use of CAPS by Makers.

As we are concerned that there are too many topics to focus on, whereby there is a danger in getting stuck in describing an overview and not developing new actionable findings, we choose key topics for analysis. In order to achieve this, we first carry out an initial literature scan, and then bring together a range of related topics from the above mentioned research areas. From this overview, we select a small number of key topics for analysis, which we believe, at this stage, hold important potential insights for both understanding the Maker movement and being able to help improve the use of CAPs within it.

2.1. Pillar 1: Organization and Governance

This section is a description of the analytical pillar 1: Organisation and governance.

2.1.1. Key research areas, literature and research questions

In the DoA, this pillar is described as follows:

"The ways that maker communities using CAPs are organised both internally and externally, the legal and regulatory frameworks that promote or retard them, their IPR implications, security, safety and privacy issues, and the interfaces they have with their institutional and policy environments which include social, economic, environmental and technological systems." (page 4)

"Organisation and governance: the ways that maker communities using CAPs are organised both internally and externally, the legal and regulatory frameworks that promote or retard them, their IPR implications, and the interfaces they have with their institutional and policy environments. The main multidisciplinary research foci include:

1. *organisational and management studies*
2. *studies of open coordination mechanisms, and self- and co-regulation*
3. *legal and governance systems and political science*
4. *network theory, including examining the roles of random (potentially viral) networks, scale-free networks and small-world networks*
5. *Internet studies and policies, including collective internet governance, network neutrality, non-discriminatory access, security, safety, as well as privacy, identity, online reputation and anonymity issues*
6. *ethics, corporate social responsibility and responsible research and innovation (RRI)."*

(page 14)

The organisation and governance pillar includes all critical questions concerning the management, organization and external environment of the Maker movement. The Maker movement is not an island: it interacts with stakeholders in the wider ecosystem, for example investors, citizens and firms.

Figure 5 provides an overview of the external stakeholders (amongst others). The external environment stimulates or hampers the Maker movement, but at the same time is shaped by the movement as a political actor (e.g. promoting self-production or changes in intellectual property regulation). The stakeholders in the inner ellipse are part of the internal environment, while the stakeholders outside the ellipse are the external environment (including regulations). Given the increasingly permeable boundaries of organizations (e.g. due to open collaborations), the distinction between internal and external environment is not strict. Besides the external relationships and ecosystem depicted in, there are many other Organization and Governance issues which pertain to matters internal to a single Maker community.

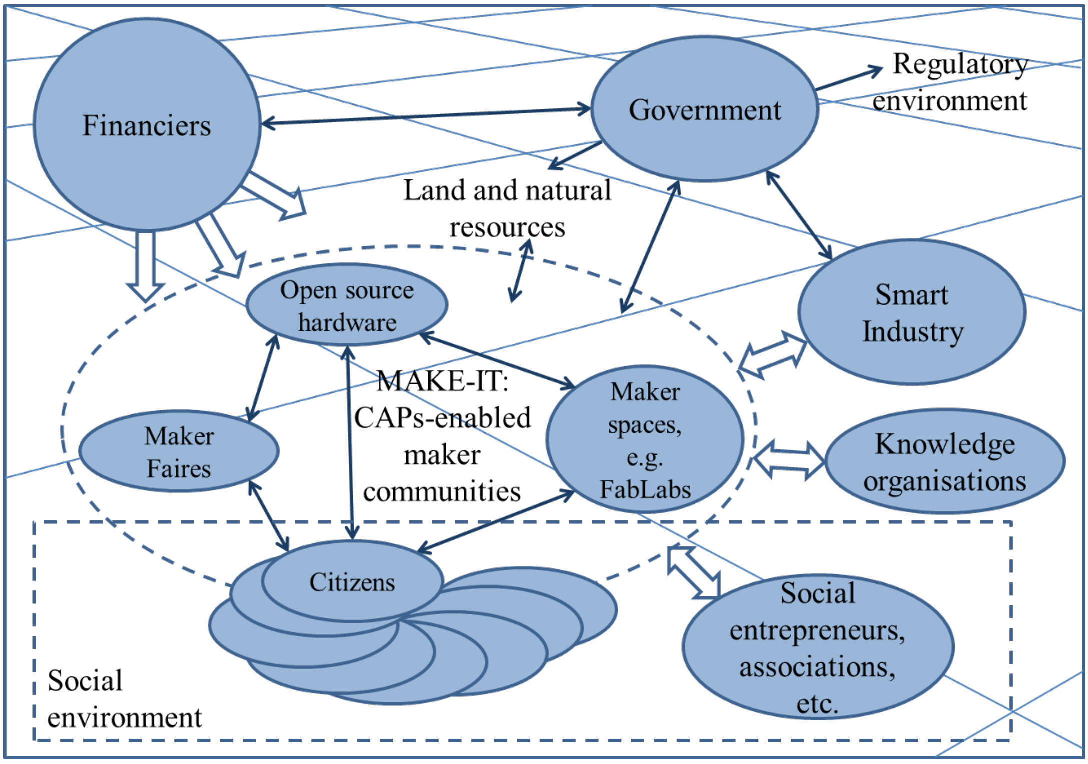

Figure 5: Ecosystem of the Maker Movement

To better understand the relation between the Maker movement and its environment, we have an initial selection of seven key topics for analysis related to the Organization and Governance pillar:

- Strategy and financing: from sponsorship to crowdsourcing
- Supply chain: disrupting the producer-consumer relation
- Collaboration in complex networks: between control and autonomy
- Knowledge production and management: Makerspaces as learning spaces
- Open innovation: balancing openness and competitive advantage
- The institutional environment: shaping and being shaped
- The ethics of Maker communities

2.1.2. Strategy and financing: from sponsorship to crowdsourcing

2.1.2.1. Summary

Actors in the Maker movement may vary in strategy and how they are financed. Strategy refers to the vision, mission and goals of an organization as well as how these are to be carried out. The process where the organization's decision-makers set the strategy is known as strategic planning. Communities, apart from their legal entity, tend to have open and emergent strategic planning processes rather than a planned strategy. Strategies include a business model to guarantee the survival of communities in the Maker movement. Literature distinguishes public business models (e.g. education, donations or research subsidies) and private models (e.g. spin-offs, firms, sponsorship and investment) that are often mixed in practice (Franck, & Jungwirth, 2003). The strategy and business model influence the governance required in the organization.

2.1.2.2. Possible research questions

- What are the vision, mission and goals of communities in the Maker movement?
- What alternative funding sources do communities in the Maker movement employ?
- What business models do communities in the Maker movement employ?
- How does the funding or business model influence the governance of communities in the Maker movement?

2.1.2.3. Relevant literature

- Franck, E., & Jungwirth, C. 2003. 'Reconciling rent-seekers and donators–The governance structure of open source'. *Journal of Management and Governance*, 7(4), 401-421.
- Weber, Steven. 2005. '*The Success of Open Source*'. Harvard University Press.

2.1.3. Supply chain: disrupting the producer-consumer relation

2.1.3.1. Summary

The Maker movement has the potential to change supply chain design and management. For example, the digitalization of production may decentralise production and move it to local communities, reduce product innovation cycle times, blur the traditional relationship between producer and consumers, and offer diversification and personalization. Self-production may add to current supply chains, for example as after-market for existing products, or replace existing supply chains as in the case of prosthetics.

2.1.3.2. Possible research questions

- In what ways do communities in the Maker movement change production, logistics and supply chains?
- How does the Maker movement change the relationship between producer and consumer?
- To what extent are open source business models applied by Maker communities?

2.1.3.3. Relevant literature

- Feller, Joseph, Patrick Finnegan, Brian Fitzgerald, and Jeremy Hayes. 2008. 'From peer production to productization: A study of socially enabled business exchanges in open source service networks'. *Information Systems Research* 19, no. 4: 475-493.
- Waller, Matthew A., and Stanley E. Fawcett. 2014. Click here to print a maker movement supply chain: how invention and entrepreneurship will disrupt supply chain design. *Journal of Business Logistics* 35, no. 2: 99-102.

2.1.4. Collaboration in complex communities: between control and autonomy

2.1.4.1. Summary

Actors in the Maker movement collaborate in boundary-spanning networks that may include public and private stakeholders, such as knowledge institutions, firms and government agencies. Instead of hierarchical or legal mechanisms, these inter-organizational networks are based on social contracts and open licensing between network members that promotes openness, efficient transactions and positive network externalities (e.g. Demil & Lecocq, 2006). In contrast to formal organizations, these open communities are often complex (due to multiple layers), lateral, dynamic in their constellation and have weak control over incentives. A key question is how coordinators can balance the autonomy of its members (e.g. to stimulate creativity) while maintaining control (e.g. to ensure efficiency and accountability). The governance of these networks include normative basis, incentives to engage network members, sanctions, rules on the control over the resource and incentives, flexibility and duration of the collaboration and the nature of the social interactions (e.g. formal vs. informal). Both social network analysis and social capital theory may help to reveal how actors collaborate.

2.1.4.2. Possible research questions

- What are the networks of communities in the Maker movement?
- What are the networks generated by governance structure in Maker communities?
- How does the governance (e.g. coordination, rules and agreements) in networks of communities differ?
- In what ways, and to what extent, do Maker communities make use of Intellectual Pro protection?

2.1.4.3. Relevant literature

- Demil, Benoit, and Xavier Lecocq. 2006. 'Neither market nor hierarchy nor network: The emergence of bazaar governance.' Organization studies 27, no. 10 (2006): 1447-1466.
- Feller, Joseph, Patrick Finnegan, Brian Fitzgerald, and Jeremy Hayes. 2008. 'From peer production to productization: A study of socially enabled business exchanges in open source service networks'. *Information Systems Research* 19, no. 4: 475-493.
- Jones, C., Hesterly, W. S., & Borgatti, S. P. 1997. 'A general theory of network governance: Exchange conditions and social mechanisms'. *Academy of management review*, 22(4), 911-945.
- Lima, Antonio, Luca Rossi, and Mirco Musolesi. 2014. 'Coding Together at Scale: GitHub as a Collaborative Social Network'. arXiv:1407.2535 [physics], July. http://arxiv.org/abs/1407.2535.
- Nohria, Nitin, and Robert G. Eccles, eds. 1992. '*Networks and Organizations: Structure, Form and Action*'. Harvard Business Press.
- Singh, P. V., Tan, Y., & Mookerjee, V. 2011. 'Network effects: the influence of structural capital on open source project success'. *MIS Quarterly*, 35(4), 813-830.
- Zanetti, Marcelo Serrano, Emre Sarigol, Ingo Scholtes, Claudio Juan Tessone, and Frank Schweitzer. 2012. 'A Quantitative Study of Social Organisation in Open Source Software Communities'. In OASIcs 2012 - Imperial College Computing Student Workshop 2012, Jones A.V. (Ed.), 28:116–22. Schloss Dagstuhl. doi:10.4230/OASIcs.ICCSW.2012.116.

2.1.5. Knowledge production and management: (online) Makerspaces as learning spaces

2.1.5.1. Summary

The Maker movement is not only a source of innovation, but also offers virtual and physical spaces to citizens to learn new (technological) skills and knowledge (Halversno & Sheridan, 2014). Theoretically, Makerspaces may be considered as learning spaces. Learning spaces focus on the relationship between the learner, the space, the principles and learning activities, and the role of (collaborative) technologies in the learning process. Similar to the Open Source movement, the Maker movement produces knowledge and reflects on its own functioning. To reach the educational goal, the organization and governance of the Maker movement needs to stimulate reflection, openness, a culture of sharing, etc.

2.1.5.2. Possible research questions

- How is the production and sharing of knowledge organized in Makerspaces?
- How can the governance and organization of Makerspaces stimulate the production and sharing of knowledge?
- What is the optimal mix of virtual and physical space to stimulate the production and sharing of knowledge in Makerspaces?

2.1.5.3. Relevant literature

- Halverson, E. R., & Sheridan, K. 2014. 'The maker movement in education'. *Harvard Educational Review*, 84(4), 495-504
- Miller, R., Shapiro, H., & Hilding-Hamann, K. E. 2008. 'School's Over: Learning Spaces in Europe in 2020: An Imagining Exercise on the Future of Learning'. *JRC Scientific and Technical Reports*.
- Wolf, Patricia, Peter Troxler, Pierre-Yves Kocher, Julie Harboe, and Urs Gaudenz. 2014. 'Sharing Is Sparing: Open Knowledge Sharing in Fab Labs'. *Journal of Peer Production*, no. 5 (September). http://peerproduction.net/issues/issue-5-shared-machine-shops/.

2.1.6. Open innovation: balancing openness with competitive advantage

2.1.6.1. Summary

The Maker movement is a source of innovation (e.g. Pearce, 2015). The Maker movement may promote a closed or open model of innovation, in which actors privately or openly collaborate on new products or services. This culture of sharing requires members to openly share their knowledge. Open innovation, however, may need hybrid models to accommodate innovation with private actors (Von Hippel & Von Kroch, 2003; West, 2003). When the Maker movement operates in educational or commercial activities, for example by promoting entrepreneurship among its members or collaborating with large firms on joint intellectual property, governance mechanisms are required. How innovation processes of Maker communities in collaboration with firms are governed depends on the relationship between the Maker community and the firm: for e.g. firm initiated collaboration (co-creation or crowdsourcing) or community initiated (e.g. sponsorships, investment or spin-offs).

2.1.6.2. Possible research questions

- How many and which kind of Maker communities are open source, proprietary or with an hybrid model?
- How do maker communities reconcile their Maker values (e.g. openness) with market values?
- How do maker communities collaborate with companies given the Makers' open source ethos?
- How do companies reconcile engaging with Makers known for priding themselves on being open source with companies' desires to maintain a competitive edge?
- How do Maker communities put to right the legal use of open source 3D printing to re-create copies of existing products without permission from and compensation to the original creator?

2.1.6.3. Relevant literature

- De Laat, P. B. 2007. 'Governance of open source software: state of the art'. *Journal of Management & Governance*, 11(2), 165-177.
- Pearce, J.M., 2015. 'Return on investment for open source scientific hardware development'. *Science and Public Policy*, p.scv034.
- Sawhney, M., & Prandelli, E. 2000. 'Communities of creation: managing distributed innovation in turbulent markets'. *California management review*, 42(4), 24-54.

2.1.7. The institutional environment: shaping and being shaped

2.1.7.1. Summary

The Maker movement operates in an institutional environment, which entails all norms and regulations that concern self-production and fabrication. In organizational studies and sociology, institutions refer to all socially constructed, routine-reproduced norms and rule systems that steer the behaviour of individuals and organizations in society (Seo & Creed, 2002). Actors in the Maker movement need to take into account the institutional environment to be considered legitimate actors. Examples of relevant norms and regulations are privacy and data protection, intellectual property rights, liability, labour rights, safety, environmental regulations, etc. These norms and regulations may hamper or stimulate the Maker movement.

2.1.7.2. Possible research questions

- What norms and regulations on national and European level are relevant to the Maker movement?
- How does the institutional environment hamper or stimulate the activities of the Maker movement in Europe?

2.1.7.3. Relevant literature

- DiDiy, 2016. Workpackage 6: Exploring the impact of DiDIY on laws, rights and responsibilities, study commissioned by the European Commission, http://www.didiy.eu/didiy-rights-and-obligations-legal
- Moilanen, J.; Daly, A.; Lobato, R. and Allen, D. 2015, 'Cultures of Sharing in 3D Printing: What Can We Learn from the Licence Choices of Thingiverse Users?'. *Journal of Peer Production*, 6. http://peerproduction.net/issues/issue-6-disruption-and-the-law/peer-reviewed-articles/cultures-of-sharing-in-thingiverse-what-can-we-learn-from-the-licence-choices-of-thingiverse-users
- Zimmer, S. 2013. 'The right to print arms: the effect on civil liberties of government restrictions on computer-aided design files shared on the Internet'. *Information & Communications Technology Law*, 22(3), 251-263.

2.1.8. How the Maker movement shapes its institutional context

2.1.8.1. Summary

The Maker movement, however, is not only shaped by the institutional environment, but also functions as a political actor that shapes the institutional environment. The word movement in Maker movement refers to social movement. Social movements are *"collectivities acting with some degree of organization and continuity outside of institutional or organizational channels for the purpose of challenging or defending extant authority…"* (Snow et al., 2004, p. 11). The main activity of social movements is the organization of collective action outside the conventional channels of institutional change. Social movements pursue and achieve institutional change in society, and specifically in markets (Davis, 2005; Davis et al., 2008; Den Hond & De Bakker, 2007; Hargrave & Van de Ven, 2006; Hensmans, 2003; Schneiberg & Lounsbury, 2008). Social movement theory emphasizes that institutional change in markets result from the actions of change agents, such as activist groups that promote new products or practices in markets (King & Pearce, 2010). The Maker movement, similar to other social movements, aims to contribute to institutional change (Dougherty, 2012): in interaction with policy-makers and politicians, but also by promoting its activities that alters the dominant production model.

2.1.8.2. Possible research questions

- What norms and regulations on national and European level does the Maker movement influence?
- How does the Maker movement influence current norms and regulations on national and European level?
- Under what conditions does the Maker movement matter for the institutional environment?

2.1.8.3. Relevant literature

- Davis, G. F., & McAdam, D. 2000. 'Corporations, classes, and social movements after managerialism'. *Research in organizational behavior*, 22, 193-236.
- Dougherty, D. 2012. 'The maker movement'. Innovations, 7(3), 11-14.
- Morozov, E. 2014. 'Making it'. The New Yorker, 13.
- Schneiberg, M., King, M., & Smith, T. 2008. ‚Social movements and organizational form: Cooperative alternatives to corporations in the American insurance, dairy, and grain industries'. *American Sociological Review*, 73(4), 635-667.

2.1.9. The ethics of maker communities

2.1.9.1. Summary

Research points at several ethical considerations that open source communities, such as Maker communities, need to address in their governance. First, the consequence of digitalization of production increases the risk of privacy infringements. For example, low-cost sensor technologies will increase the volume of intimate data about human behaviour (e.g. energy use, logistics, health, etc.). Maker communities should be aware about their responsibility regarding privacy and data protection and mitigate risks in their governance (Waller & Fawcett, 2013). Second, critical scholars warn for the commercialization and exploitation of user-generated content (Dujanier, 2015). Similar to the criticism that Uber replaces fulltime jobs in the taxi industry, the Maker communities may replace the work of professionals, for example from countries with low wages where production was outsourced to. Last, Maker communities may play an important role in promoting a DYI culture among girls in education (Halverson & Sheridan, 2014), and engineering knowledge and skills among women in general. Governance may ensure that Maker communities promote diversity and gender equality (Nascimento, 2015).

2.1.9.2. Possible research questions

- What are the ethical dilemmas of Maker communities?
- How can Maker communities mitigate privacy and data protection risks?
- How can Maker communities develop socially and environmentally sustainable business models?
- How can Maker communities promote diversity and gender equality?
- What measures can be put in place to cause Makers to be more cognizant of the bigger issues and/or the ripple effects associated with their desire to create and make
- How do Maker communities put to right the legal use of open source 3D printing, which can be utilized by virtually anyone to create potentially dangerous things?

2.1.9.3. Relevant literature

- Dujarier, M. A. 2015. 'The Activity of the Consumer: Strengthening, Transforming, or Contesting Capitalism?'.*The Sociological Quarterly*, 56(3), 460-471.
- Halverson, E. R., & Sheridan, K. 2014. 'The maker movement in education'. *Harvard Educational Review*, 84(4), 495-504.
- Nascimento, S. 2014. 'Critical notions of technology and the promises of empowerment in shared machine shops'. *Journal of Peer Production*, 5.

- Tierney, J. 2015. 'The Dilemmas of Maker Culture: thinking through the consequences of the proliferation of powerful tools and technologies.' The Atlantic. http://www.theatlantic.com/author/john-tierney/ (retrieved March 24, 2015)
- Waller, M. A., & Fawcett, S. E. 2013. 'Click here for a data scientist: big data, predictive analytics, and theory development in the era of a maker movement supply chain'. *Journal of Business Logistics*, 34(4), 249-252.

2.2. Pillar 2: Peer and Collaborative Activities and Behaviours

This section is a description of the analytical pillar 2: Peer and Collaborative Activities and Behaviours.

1.1.11. Key research areas, literature and research questions

In the DoA, this pillar is described as follows:

Peer and collaborative activities and behaviours: the mechanisms and activities, including generating awareness and leveraging peer pressure, to drive the behaviour to take-up maker activity and/or establish or join a maker community using CAPs approaches, and to stimulate for better lifestyles through behavioural and system change. These activities and behaviours include learning, sharing, collaborating and realizing new forms of production, including social, economic, environmental and technological issues. (page 4)

Peer and collaborative activities and behaviours: the mechanisms and activities driving the behaviour to take-up maker activity and/or establish or join a maker community using CAPs approaches, through learning, sharing, collaborating and realizing new forms of production. The main multidisciplinary research foci includes

- *behavioural studies, social psychology and sociology*
- *workplace organisation, management information systems, industrial production and micro economics*
- *ICT use in innovation and especially social innovation studies*
- *online collaboration studies, including motivation, incentives and management*
- *network theory and the study of social networks, social interactions, and the 'wisdom of the crowds' through co-creation as well as peer and collaborative production and consumption*
- *communities and networks of practice*

As stated above, in order to enable new actionable findings, we select a small number of key topics for analysis which we believe, at this stage, hold important potential insights for both understanding the Maker movement and being able to help improve the use of CAPS within it. As such, we have an initial selection of five key topics for analysis related to peer and collaborative activities and behaviours:

The process of social engagement in Maker communities

- Self-determination and participation in Maker communities
- Processes of social influence to stimulate collaboration and learning
- Community forming and development
- Activities and ambition for social innovation and commercialization

These five key topics for analysis are ordered from initial awareness and engagement, through participation and collaboration, to higher level community development and exploitation activities.

2.2.1. The process of social engagement in Maker communities

2.2.1.1. Summary

For many years, studies have shown that group development is driven by participation and engagement in forming a sense of community (Talò, Mannarini, & Rochira, 2014). For citizens or consumers to engage in a Maker community, a social process of engagement must occur. This involves awareness, activity, interaction, and social exchange. For Maker communities, exhibiting common-based peer production (Benkler, 2002), there is free participation whereby people decide to join in based entirely on their own wishes. In this sense, community engagement is "*the consumer's intrinsic motivation to interact and cooperate with community members*" (Algesheimer, Dholakia & Herrmann, 2005, p. 21). Increasingly, studies have addressed the concept of community engagement in the online setting (e.g. Baldus, Voorhees & Calantone, 2015; Dessart, Veloutsou & Morgan-Thomas, 2015). One study distinguishes between personal engagement, between individuals, and social-interactive engagement with the community as a whole (Calder, Malthouse & Schaedel, 2009). Related to online brand communities, from the marketing/business literature, there is also an emphasis on the will of a community member to remain active and engaged: "*Online brand community engagement is the compelling, intrinsic motivations to continue interacting with an online brand community*" (Baldus, Voorhees & Calantone, 2015).

As far as we are aware at the time of writing there has been no research published on the process of social engagement in Maker communities. To enhance our understanding of the role of social engagement in Maker communities, there are some key questions that need to be understood. One is to confirm that engagement drives participation in Maker communities, just as it does in other online and offline communities. However, we do not expect that all Maker community members are equally engaged or equally active (Nielsen, 2006). No one yet knows how the range of engagement and activity is distributed in Maker communities. Finally, if those stimulating the growth and performance of Maker communities are to be aided, they need to know how to encourage the social-interactive engagement of their members. As such it is important to know what drives social engagement, including awareness.

In terms of the measurement of community engagement, a good starting point is the scale developed by Baldus, Voorhees & Calantone (2015), which could be adapted to suit Maker communities (see Table 1).

Engagement dimensions	Definitions
Brand influence	The degree to which a community member wants to influence the brand.
Brand passion	The ardent affection a community member has for the brand.
Connecting	The extent to which a community member feels that being a member of the brand community connects them to some good thing bigger than themselves.
Helping	The degree to which a community member wants to help fellow community members by sharing knowledge, experience, or time.
Like-minded discussion	The extent to which a community member is interested in talking with people similar to themselves about the brand.
Rewards (hedonic)	The degree to which the community member wants to gain hedonic rewards (e.g., fun, enjoyment, entertainment, friendly environment, and social status) through their participation in the community.
Rewards (utilitarian)	The degree to which the community member wants to gain utilitarian rewards (e.g., monetary rewards, time savings, deals or incentives, merchandise, and prizes) through their participation in the community.
Seeking assistance	The degree to which a community member wants to receive help from fellow community members who share their knowledge, experience, or time with them.
Self-expression	The degree to which a community member feels that the community provides them with a forum where they can express their true interests and opinions.
Up-to-date information	The degree to which a community member feels that the brand community helps them to stay informed or keep up-to-date with brand and product related information
Validation	A community member's feeling of the extent to which other community members affirm the importance of their opinions, ideas, and interests.

Table 1: Online brand community engagement scale (Baldus, Voorhees & Calantone, 2015)

2.2.1.2. Possible research questions

- What drives awareness and engagement in Maker communities?
- Which kind of engagement and participation modalities are present in Maker communities?
- What is the distribution of engagement within Maker communities?
- To what extent does engagement drive participation in Maker communities

2.2.1.3. Relevant literature

- Algesheimer, R., Dholakia, U.M., & Herrmann, A. 2005. 'The social influence of brand community: Evidence from European car clubs'. *The Journal of Marketing*, 69(3), 19–34.
- Baldus, B. J., Voorhees, C., & Calantone, R. 2015. Online brand community engagement: Scale development and validation. *Journal of Business Research*, 68(5), 978-985.
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- Talò, C., Mannarini, T., & Rochira, A. 2014. 'Sense of community and community participation: A meta-analytic review'. *Social indicators research*, 117(1), 1-28.

2.2.2. Self-determination and participation in Maker communities

2.2.2.1. Summary

As described in the previous section, engagement in a Maker community is intrinsically driven. Therefore, if a person is to become an active member they must feel that they want to join in and they must feel they are able to join in. According to the psychological theory of self-determination (Ryan, & Deci, 2000), for the sorts of choices which individuals feel they are free to make themselves, such as participate in a Maker community, they are motivated to act based on three underlying, universal, psychological needs: Competence, developing skills in order to control the situation; Autonomy, the freedom to act and make choices independently; Psychological relatedness, wanting to interact and connect with others. When one or more of these needs is unfulfilled, then their behaviour, and subsequent growth, will be inhibited. Therefore, for a Maker community to thrive, its members need to experience no barriers to these psychological needs. In principle, it is possible for those organizing a Maker community to stimulate the competence, autonomy and psychological relatedness of its members or potential members.

There are no published studies of these psychological needs in relation to Maker communities, but there are numerous studies which make use of self-determination theory for participation in a range of online communities, such as learning communities (LaPointe & Reisetter, 2008), gaming (Ryan, Rigby, & Przybylski, 2006), and contributing to Wikipedia (Xu & Li, 2015). However, Maker communities are quite different to these other forms of communities and it is initially important to understand to what extent the psychological needs of participants in maker communities are fulfilled, and in what ways those responsible for the communities help to stimulate the self-determination of their members.

For the measurement of self-determination in Maker communities, a starting point is the scale developed by Broeck, et al. (2010), which can be adapted to suit the Maker situation (see Table 2).

Self-determination dimensions	Items
Need for autonomy	
	I feel like I can be myself at my job
	At work, I often feel like I have to follow other people's commands (R)
	If I could choose, I would do things at work differently (R)
	The tasks I have to do at work are in line with what I really want to do
	I feel free to do my job the way I think it could best be done
	In my job, I feel forced to do things I do not want to do (R)
Need for competence	
	I really master my tasks at my job
	I feel competent at my job
	I am good at the things I do in my job
	I have the feeling that I can even accomplish the most difficult tasks at work
Need for relatedness	
	I don't really feel connected with other people at my job (R)
	At work, I feel part of a group
	I don't really mix with other people at my job (R)
	At work, I can talk with people about things that really matter to me
	I often feel alone when I am with my colleagues (R)
	Some people I work with are close friends of mine

Table 2: Self-determination scale (Broeck, et al., 2010)

2.2.2.2. Possible research questions

- How do Maker participants develop their competence, autonomy and relatedness?
- What do Maker communities do to increase the competence, autonomy and relatedness of potential participants?

2.2.2.3. Relevant literature

- Broeck, A., Vansteenkiste, M., Witte, H., Soenens, B., & Lens, W. 2010. 'Capturing autonomy, competence, and relatedness at work: Construction and initial validation of the Work-related Basic Need Satisfaction scale'. *Journal of Occupational and Organizational Psychology*, 83(4), 981-1002.
- LaPointe, L., & Reisetter, M. 2008. 'Belonging online: Students' perceptions of the value and efficacy of an online learning community'. *International Journal on E-Learning*, 7(4), 641-665.
- Ryan, R. M., & Deci, E. L. 2000. 'Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being'. *American Psychologist*, 55(1), 68.
- Ryan, R. M., Rigby, C. S., & Przybylski, A. 2006. 'The motivational pull of video games: A self-determination theory approach'. *Motivation and emotion*, 30(4), 344-360.
- Xu, B., & Li, D. 2015. 'An empirical study of the motivations for content contribution and community participation in Wikipedia'. *Information & Management*, 52(3), 275-286.

2.2.3. Processes of social influence to stimulate collaboration and learning

2.2.3.1. Summary

Maker communities are characterized by people learning from each other, sharing ideas and techniques, and getting inspired by the fascinating ideas that they encounter. All these community-related behaviours are driven by processes of social influence (Algesheimer, Dholakia & Herrmann, 2005). Social influence has been a major topic of research, particularly in the field of social psychology. Social influence can be conscious and intended, like teaching-learning, persuading and rewarding, whereby participants comply with instructions or prompts. It can also be unconscious and undirected, such as in social contagion (copying behaviour), peer pressure and network effects, whereby participants conform to norms or dominant behaviours of others (Cialdini & Goldstein, 2004; Frith & Frith, 2012; Miller & Prentice, 2016). Furthermore, social influence may directly affect a person's behaviour, or it may influence their attitudes and opinions, which later lead to a change of behaviour (Friedkin, 2010).

In relation to Maker communities, we are aware of one conference paper which addresses the issue of social influence (Halbinger & Reichstein, 2015). This study looks at the relationship between a Maker participant's ability to socially influence others and their entrepreneurial experience, however there are serious concerns regarding the operationalization of the social influence construct. Therefore, there is an urgent need for clear insights into how processes of social influence to stimulate collaboration and learning in Maker communities. Studies in other online settings offer pointers regarding how social influence works, such as for product adoption (e.g. Herrera, Armelini & Salvaj, 2015; Langley et al., 2012) or for sending messages via social media (e.g. Aral & Walker, 2014). It is now important that we develop a better understanding of social influence processes in a number of areas. These include how they drive people to join up with a Maker community, an inventory of the behaviours which are spread through the community, and whether learning within a Maker community is directed or undirected.

In order to measure social influence, there are very many methods which have been proposed in the literature. These include large-scale network data (e.g. Aral & Walker, 2014), and expert-based questions regarding social contagion (e.g. Langley, et al., 2012). Both these approaches may be relevant for *MAKE-IT*.

2.2.3.2. Possible research questions

- How are people influenced to join a Maker community?
- Which behaviours are transmitted through a Maker community?
- To what extent is learning in Maker communities explicit/intended vs playful/undirected?

2.2.3.3. Relevant literature

- Algesheimer, R., Dholakia, U.M., & Herrmann, A. 2005. 'The social influence of brand community: Evidence from European car clubs'. *The Journal of Marketing*, 69(3), 19–34.
- Aral, S., & Walker, D. 2014. 'Tie strength, embeddedness, and social influence: A large-scale networked experiment'. *Management Science*, 60(6), 1352-1370.
- Cialdini, R. B., & Goldstein, N. J. 2004. ‚Social influence: Compliance and conformity'. *Annu. Rev. Psychol.*, 55, 591-621.
- Friedkin, N. E. 2010. 'The attitude-behavior linkage in behavioral cascades'. *Social Psychology Quarterly*, 73(2), 196-213.
- Frith, C. D., & Frith, U. 2012. 'Mechanisms of social cognition'. *Annual review of psychology*, 63, 287-313.
- Halbinger, M., & Reichstein, T. 2015. 'Entrepreneur's Social Skills: Experience, Hackers and Haikus'. *Druid Conference*, Rome, June 15-17, 2015. Available at http://druid8.sit.aau.dk/acc_papers/0883r40us72hnfmke49ibs3j4a07.pdf
- Herrera, M., Armelini, G., & Salvaj, E. 2015. 'Understanding Social Contagion in Adoption Processes Using Dynamic Social Networks'. *PloS one*, 10(10), e0140891.
- Langley, D. J., Bijmolt, T. H., Ortt, J. R., & Pals, N. 2012. 'Determinants of social contagion during new product adoption'. *Journal of Product Innovation Management*, 29(4), 623-638.
- Miller, D. T., & Prentice, D. A. 2016. 'Changing norms to change behavior'. *Annual review of psychology*, 67, 339-361.

2.2.4. Community forming and development

2.2.4.1. Summary

The development and fostering of a community can be understood on different levels of abstraction[16]. These can include a subgroup of people using one Maker laboratory, or large groups of people across a neighbourhood or region, as reflected in the UN's definition of the term "community development": *A process where community members come together to take collective action and generate solutions to common problems* (UNTERM, 2016). In the online setting, many studies have looked into the establishment and development of communities, generally addressing semi-formal organizational structures. On the one hand, these studies include the specification of formal steps in community development, such as described by Varlamis & Apostolakis (2010), which are requirements analysis, design, materialization, configuration, normal operation and improvement support. These steps may be relevant to some forms of Maker communities. On the other hand, computer studies literature also addresses the less formal emergence of self-organization within and between online communities (e.g. Flake, et al., 2002). This emergence leads to the idea of collective intelligence, whereby the whole is more than the sum of the parts (Mačiulienė & Skaržauskienė, 2015).

In contrast to the other topics for analysis on peer and collaborative behaviours, this topic of community forming and development has attracted research attention from a number of scientific domains. In engineering, scholars have assessed community development for robotics (Sheh, Komsuoglu & Jacoff, 2014). In information studies, the role of the public library in promoting Maker communities has been addressed (Kelly, 2013). In design, a technology-centric versus human-centric perspective on Makerspaces has been discussed (Wang, Dunn & Coulton, 2015). Nevertheless, there remain many unanswered issues related to how Maker communities are formed and developed, and there is a need to understand how to improve these processes. In particular, it is still not clear how the developmental stages of Maker communities work, how uniform they are across different communities, and the extent to which these stages are completed, as opposed to continually in a state of flux. We need a better understanding of what are the key activities and behaviours which drive Maker community development. There are very many ways to measure community formation and development, ranging from qualitative approaches (e.g. Mačiulienė & Skaržauskienė, 2015) through to quantitative social network analysis (e.g. Scott, 2012).

2.2.4.2. Possible research questions

- What are stages in the process of development of Maker communities?
- To what extent are Maker communities fully developed?
- Which peer behaviours are most influential in community development?

16. See the MAKE-IT taxonomy for a definition of community.

2.2.4.3. Relevant literature

- Flake, G. W., Lawrence, S., Giles, C. L., & Coetzee, F. M. 2002. 'Self-organization and identification of web communities'. *Computer*, 35(3), 66-70.
- Kelly, A. 2013. 'Why do we need one of those? The role of the public library in creating and promoting makerspaces'. In ALIA National Library & Information Technicians' Symposium, Canberra, Australia. Retrieved from http://www.alia.org.au/sites/default/files/Kelly.
- Mačiulienė, M., & Skaržauskienė, A. 2015. 'Emergence of collective intelligence in online communities'. *Journal of Business Research*. Pre-print available at http://www.sciencedirect.com/science/article/pii/S0148296315004671
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- UNTERM: United Nations Multilingual Terminology Database. 2016. 'Community development. Retrieved March 2016. Available at: http://unterm.un.org/DGAACS/unterm.nsf/8fa942046ff7601c85256983007ca4d8/526c2eaba978f007852569fd00036819
- Varlamis, I., & Apostolakis, I. 2010. 'Self-supportive virtual communities'. *International Journal of Web Based Communities*, 6(1), 43-61.
- Wang, D., Dunn, N., & Coulton, P. 2015. 'Grassroots maker spaces: a recipe for innovation?' *11th European Academy of Design Conference*, Paris, 22-24 April 2015.

2.2.5. Activities and ambition for social innovation and commercialization

2.2.5.1. Summary

Besides the behaviours related to designing and manufacturing within a maker community, as it were the core behaviours, participants may undertake exploitation activities and set themselves objectives for implementing social innovations or forming successful business opportunities (Dougherty, 2013; Aldrich, 2014; Jackson, 2014). These may include setting up a business themselves, for example making use of crowdfunding, or linking to established industry. In the past, user-driven innovation has offered ideas for product improvements (Von Hippel, 2005), and now users have access to advanced manufacturing technologies which mean they are no longer dependent on a firm to realize their ideas. Besides this, crowdfunding offers individuals and non-formal organizations the opportunity to invest substantial sums of money in developing and commercializing their products (Mollick, 2014).

Besides commercial opportunities, many Makers are driven by a social motivation to improve a situation for disadvantaged people. Often, such a motivation fills a gap left by a failure of firms or governments to fulfil a social need, such as employment, health, inclusion and access to facilities (Big Society Capital, 2015). This is the basis for social innovation (McGowan & Westley, 2015). Zahra, et al., (2009) suggest three levels on which social entrepreneurs may act: small-scale, local initiatives aimed at solving a specific social problem; larger-scale organization aimed at institutionalizing alternative structures to provide social goods and services; very large-scale redesign of social systems aimed at replacing those unsuited to address significant social needs. Such a typology reflects different levels of entrepreneurial ambition and this may be relevant for Maker communities.

There are many opinion pieces about the commercial potential of Maker communities, and about their ability to drive social innovations, but in the extant scientific literature there is a lack of peer-reviewed studies of this principle. It is important for us to better understand the ambition levels of Makers and Maker communities. No one has yet shown the balance between commercial versus social innovation objectives. However, 3-D service bureaus like Shapeways are reporting high numbers of products created, suggesting strong commercial opportunities. Furthermore, there is a lack of insight into how those organizing Maker communities can encourage the exploitation of Maker projects.

Measuring Makers' activities and ambition for exploitation may build on work in a number of areas. One starting point is the entrepreneurial literature, such as Hughes & Morgan (2007) who study the effect of entrepreneurial orientation on business performance. They assess five dimensions which can vary independently and may not be equally valuable at the embryonic stage of firm growth. They find that proactiveness and innovativeness have a positive influence on business performance while risk-taking has a negative relationship. Two other dimensions, competitive aggressiveness and autonomy, appear to hold no business performance value at this stage of firm growth (see Table 3).

Entrepreneurial orientation dimensions	Items
Risk-taking	
	The term 'risk taker' is considered a positive attribute for people in our business
	People in our business are encouraged to take calculated risks with new ideas
	Our business emphasizes both exploration and experimentation for opportunities
Innovativeness	
	We actively introduce improvements and innovations in our business
	Our business is creative in its methods of operation
	Our business seeks out new ways to do things
Proactiveness	
	We always try to take the initiative in every situation (e.g., against competitors, in projects and when working with others)
	We excel at identifying opportunities
	We initiate actions to which other organizations respond
Competitive aggressiveness	
	Our business is intensely competitive
	In general, our business takes a bold or aggressive approach when competing
	We try to undo and out-maneuver the competition as best as we can
Autonomy	
	Employees are permitted to act and think without interference
	Employees perform jobs that allow them to make and instigate changes in the way they perform their work tasks
	Employees are given freedom and independence to decide on their own how to go about doing their work
	Employees are given freedom to communicate without interference
	Employees are given authority and responsibility to act alone if they think it to be in the

	best interests of the business
	Employees have access to all vital information

Table 3: Entrepreneurial orientation scale (Hughes & Morgan, 2007)

2.2.5.2. Possible research questions

- What proportion of Maker community members have social innovation and/or commercial ambitions?
- How do Maker communities stimulate exploitation behaviours in their members?
- To what extent do Maker communities collaborate with commercial companies?
- What are antecedents of exploitation activities in Maker communities?

2.2.5.3. Relevant literature

- Aldrich, H. 2014. 'The democratization of entrepreneurship? Hackers, makerspaces, and crowdfunding'. *The Academy of Management Annual Meeting*, Philadelphia, PA, 4 August 2014.
- Big Society Capital. 2015. 'Good Finance Outcomes Matrix'. Accessible at http://www.goodfinance.org.uk/impact-matrix
- Dougherty, D. 2013. 'The maker mindset'. In: Honey, M. & Kanter, D.E. Design, make, play: Growing the next generation of STEM innovators, Routledge, New York, pp. 7-11.
- Hughes, M., & Morgan, R. E. 2007. 'Deconstructing the relationship between entrepreneurial orientation and business performance at the embryonic stage of firm growth'. *Industrial Marketing Management*, 36(5), 651-661.
- Jackson, A. 2014. 'Makers: The New Industrial Revolution'. *Journal of Design History*, ept048.
- McGowan, K., & Westley, F. 2015. 'At the Root of Change: The History of Social Innovation'. *New Frontiers in Social Innovation Research*, 52.
- Mollick, E. 2014. 'The dynamics of crowdfunding: An exploratory study'. *Journal of business venturing*, 29(1), 1-16.
- Von Hippel, E. 2005. Democratizing Innovation. Cambridge, MA, MIT Press.
- Zahra, S. A., Gedajlovic, E., Neubaum, D. O., & Shulman, J. M. 2009. 'A typology of social entrepreneurs: Motives, search processes and ethical challenges'. *Journal of Business Venturing*, 24(5), 519-532.

2.3. Pillar 3: Value creation and impact

This section is a description of the analytical pillar 3: Value creation and impact.

2.3.1. Key research areas, literature and research questions

In the DoA, this pillar is described as follows:

Value creation and impact: the ways and extent to which maker communities using CAPs approaches create and capture social, economic and environmental value, including through new forms of local, bottom-up business-, social- and sustainable-models, transversing between non-monetised and monetised accounting frameworks, and impact assessment methods. Local, national and global development issues will be examined. An historical perspective will also be adopted, for example in analysing the maker movement trajectory as compared to the development of personal computing and other technology innovations, as well as in the context of socio-economic and political developments in moving from a 20th Century characterised by mass production and consumption to a 21st Century characterised increasingly by the mass customisation of production and consumption, and the recent financial crisis and its aftermath. The main multidisciplinary focus is on impact and scalability effects in the following areas:

I. *Social value resulting from the use of CAPs approaches by the maker movement, including social cohesion and inclusion, wellbeing, quality of life, lifestyles, the growing need for authenticity and behaviour patterns, the role of awareness and peer pressure encouraging sustainable behaviours and lifestyles, etc.*
II. *Economic value resulting from the use of CAPs approaches by the maker movement, including macro-economic issues like jobs, growth, trade, manufacturing and services, the so-called 'factory of the future', work and workplace innovations, the knowledge economy, business model studies, the collaborative and sharing economy, non-capitalist (non-monetary and beyond GDP) forms of economic activity, the move towards 'zero marginal costs' and 'free' economic systems (see below), etc.*
III. *Environmental value resulting from the use of CAPs approaches by the maker movement, including environmental sustainability, resource efficiency, building the circular economy, carbon reduction, etc.*
(page 14, similar to page 4)

Within the field of impact assessment – there are several terms that require consistency of use. In general; input leads to output due to conducting activities. This output leads to an outcome, a short to medium-term effect. Impact is a much broader and high-over term – looking at long-term effects, positive and negative, intended or unintended. In the Maker movement an output could be a website with designs. The outcome could be that a number of people make their own design.

The pillar Value creation and Impact is divided in the different types of impact that Maker communities have: 1) Economic, 2) Environmental, and 3) Social. Furthermore, Maker communities often collaborate to create value, focusing on Shared Value creation. As stated above, in order to enable new actionable findings, we select a small number of key topics for analysis which we believe, at this stage, hold important potential insights for both understanding the Maker movement and being able to help improve the use of CAPS within it. As such, we have an initial selection of four topics to be addressed in this analytical pillar:

- Hybrid and shared value creation
- The economic impact of Maker communities
- The environmental impact of Maker communities
- The social impact of Maker communities

2.3.2. Hybrid and shared value creation

2.3.2.1. Summary

Maker communities can be conceptualized as social enterprises, or networks of social entrepreneurs (Dacin, Dacin & Tracey, 2011). Social entrepreneurs are entrepreneurs that recognize and exploit opportunities in order to create both social and economic value. Maker communities do recognize new societal and technological opportunities, create ideas for innovations (e.g. printing prostheses) and exploit these innovations (e.g. in the form of spin-offs) (Snow et al, 2011). The social value may range from fulfilling existing social needs to advocating and implementing social change (Van den Broek et al, 2012). To do so, social entrepreneurs often interact or cooperate in communities, both local or as inter-organizational networks between Maker communities (Montgomery, Dacin & Dacin, 2012). Similar to social entrepreneurship, hybrid forms of value creation, combining economic and social value, is coined as Shared Value Creation (Porter and Kramer,2011). Scholars developed several methods to analyse the value creation process (e.g. Osterwalder & Pigneur, 2010). Recently, the Value Creation Canvas is developed to extend conventional value creation analysis, incorporating economic, social and environmental value (Berkers et al, 2015). The Value Creation Canvas is useful in the *MAKE-IT* project to investigate the value creation within and between Maker communities and their stakeholders.

2.3.2.2. Possible research questions

- How do Maker communities create and perceive (Shared) Value?
- How do Maker communities balance the creation of economic and social value, and the ethical dilemmas that may occur?
- In historic perspective, does the Maker movement differ from earlier citizen-empowerment trajectories?

2.3.2.3. Relevant literature

- Broek, T. A. van den, Ehrenhard, M. L., Langley, D. J., & Groen, A. J. 2012. 'Dotcauses for sustainability: combining activism and entrepreneurship'. *Journal of public affairs*, 12(3), 214-223.
- Dacin, M. T., Dacin, P. A., & Tracey, P. 2011. 'Social entrepreneurship: A critique and future directions'. *Organization science*, 22(5), 1203-1213.
- Montgomery, A. W., Dacin, P. A., & Dacin, M. T. 2012. 'Collective social entrepreneurship: Collaboratively shaping social good'. *Journal of Business Ethics*, 111(3), 375-388.
- Osterwalder, A. & Y. Pigneur. 2010. '*Business Model Generation: A Handbook for Visionaries*', Game Changers, And Challengers Wiley.

- Osunyomi, B. D., Redlich, T., Buxbaum-Conradi, S., Moritz, M., & Wulfsberg, J.P. 2016. 'Impact of the Fablab Ecosystem in the Sustainable Value Creation Process'. *OIDA International Journal of Sustainable Development*, 9(01), 21-36.
- Porter, M. E. & M. R. Kramer. 2011. 'Creating shared value'. *Harvard business review* 89.1/2: 62-77.
- Snow, C. C., Fjeldstad, Ø. D., Lettl, C., & Miles, R. E. 2011. 'Organizing continuous product development and commercialization: the collaborative community of firms model'. *Journal of Product Innovation Management*, 28(1), 3-16.
- Waller, M. A. and Fawcett, S. E.. 2014, 'Click Here to Print a Maker Movement Supply Chain: How Invention and Entrepreneurship Will Disrupt Supply Chain Design'. *Journal of Business Logistics*, 35: 99–102. doi:10.1111/jbl.12045

2.3.3. The Economic impact of Maker communities

2.3.3.1. Summary

Open source communities are often a source of innovation. Rao (2009) calls these groups 'market rebels'. One example of such a market rebel is the Homebrew Computer Club, which led to large firms such as Apple. Open source communities may challenge incumbent firms when their innovations are commercialized. Makers aim to replace the dominant mass production with small-scale local production, thereby challenging the production by large companies that exploit old business models. This makes the Maker movement potentially disruptive. There are several domains in which the Maker community can have a large and potentially disruptive impact:

I. The change in the way production is organised can have a large influence on supply chains (Waler & Fawcett, 2014).
II. The knowledge and skills obtained in Maker communities may make a labour force more competitive.
III. The digitalization of production might have an impact on the labour force.
IV. The existing industry will either have to find a way to co-exist with the Maker movement, or it will change dramatically.

2.3.3.2. Possible research questions

- What is the (positive or negative) economic impact of Maker communities and their marketplaces?
- How does the Maker movement impact the European labour force?
- How can the existing industry be challenged, co-exist, actively engage and even profit from the Maker movement?
- How can the positive economic impact of the Maker movement be scaled?

2.3.3.3. Relevant literature

- Rao, H. Calvin Morrill, Mayer N. Zald. 2000. 'Power Plays: How social movements and collective action create new organizational forms.' *Research in Organizational Behavior* 22,
- Snow, C. C., Fjeldstad, Ø. D., Lettl, C., & Miles, R. E. 2011. 'Organizing continuous product development and commercialization: the collaborative community of firms model'. *Journal of Product Innovation Management*, 28(1), 3-16.
- Thiesse, F., Wirth, M., Kemper, H.G., Moisa, M., Morar, D., Lasi, H., Piller, F., Buxmann, P., Mortara, L., Ford, S. and Minshall, T., 2015. 'Economic Implications of Additive Manufacturing and the Contribution of MIS'. *Business & Information Systems Engineering*, 57(2), pp.139-148.
- Swaminanthan, A. and James B. Wade. 1999."Social movement theory and the evolution of new organizational forms'. http://webuser.bus.umich.edu/Organizations/smo/protected/resources/swamiwade.pdf
- Waller, M. A. and Fawcett, S. E.. 2014, 'Click Here to Print a Maker Movement Supply Chain: How Invention and Entrepreneurship Will Disrupt Supply Chain Design'. *Journal of Business Logistics*, 35: 99–102. doi:10.1111/jbl.12045

2.3.4. The Environmental Impact of Maker communities

2.3.4.1. Summary

Circular economy had gained a lot of attention in the last years. Techniques such as 3D printing change the waste flow. Since products are built in one piece, it is harder to separate the different materials when the product is demolished. On the other hand, these production techniques might open up new opportunities for recycling material and might increase the awareness on sustainable consumption among consumers.

On the one hand, the Maker community might result in more local production, which may lead to less traffic and thereby less pollution (e.g. Kothala, 2015; Kothala & Hyysalo, 2015). On the other hand, there is the question on how sustainable these products are and whether consumption will change due to customization of the products and changed access to the production process.

2.3.4.2. Possible research questions

- What is the environmental impact of Maker communities?
- How can we improve the environmental impact of Maker communities?

- How can the positive environmental impact of the Maker movement be scaled?

2.3.4.3. Relevant literature

- Kohtala, C. and Sampsa Hyysalo. 2015. 'Anticipated environmental sustainability of personal fabrication'. *Journal of Cleaner Production*, 99, pp 333-344. doi:10.1016/j.jclepro.2015.02.093
- Kohtala, C. 2015. 'Addressing sustainability in research on distributed production: an integrated literature review'. *Journal of Cleaner Production*, 106, pp 654-668. doi:10.1016/j.jclepro.2014.09.039
- Sine, W.D., and Brandon H. Lee. 2009. 'Tilting at Windmills? The environmental movement and the emergence of the U.S. Wind Energy Sector'. *Administrative Science Quarterly*, 54 (1) 123-155.

2.3.5. The Social Impact of Maker communities

2.3.5.1. Summary

The impact of the Maker communities could lead to an improvement in live quality for the users of the products. However, at the same time it could mean bankruptcy of shops which would have a social impact on the owner and employees of that shop. King and Pearce (2011) consider the introduction of an alternative market as a form of political action. Schneiberg et al (2008) perform research on the political and societal impact of social movements.

2.3.5.2. Possible research questions

- What is the societal impact of Maker communities?
- How can we improve the societal impact of Maker communities?
- How can the positive societal impact of the Maker movement be scaled?

2.3.5.3. Relevant literature

- Amenta, E., Caren, N., Chiarello, E. and Su, Y., 2010. 'The political consequences of social movements'. *Annual Review of Sociology*, 36, pp.287-307.
- Schneiberg, M., King, M. and Smith, T., 2008. 'Social movements and organizational form: Cooperative alternatives to corporations in the American insurance, dairy, and grain industries'. *American Sociological Review*, 73(4), pp.635-667.

3. Component 2: Dimensions for sampling and comparison

As elucidated in section 1.1.3, Component 2 of the conceptual framework suggests a small number of dimensions as deductive tools derived from both desk research and expert knowledge for two purposes. First, to guide the selection of case studies in subsequent *MAKE-IT* WPs in order to ensure that a range of different types are examined within the scope of the project and based on evidence from the literature, rather than this being an ad hoc random sampling decision. Random sampling would not be possible as we do not know what is the whole population, so cannot be sure we can sample across all possible occurrences. Second, to make direct comparisons between the individual examples analysed in Component 1 by examining the differences and similarities in their results across the three analytical pillars.

3.1. Introduction

The purpose of Component 2 is twofold:

- To explicitly ensure MAKE-IT's ten case studies in WPs 3 and 4 are sampled purposively (Yin 2014) to reflect the diversity of maker types to the extent possible, i.e. there should be a variety rather than too much similarity between cases.
- To compare between different 'types' of cases, examples, conditions, etc., as well as between individual cases (also perhaps compare individual cases within each type -- though this is probably not useful or feasible given MAKE-IT's sample size.)

The case types described in this section are based on desk research supplemented by the MAKE-IT team's expertise and experience. Along a given dimension, individual case types are not random or disconnected but are related together in some way which makes sense in terms of the dimension selected. The term 'dimension' is useful because it is a valid and simple way to depict such linked types, which collectively might become a typology. In other words, the dimensions provide an evidence-based rationale and framework for selecting and synthesizing case analyses.

Often dimensions are continuous, for example from high to low, or weak to strong, and numeric scales can be used. However, dimensions can also be discontinuous, but this means that the types along it still need to be related together as distinct examples of the same thing, and they should also be arrayed in some rational and perhaps sequential order. If the dimensions described in this section are successful in analyzing and understanding the cases through empirical research, they will become more robust and useful in further research.

As is typical of much scientific research, however, there is a methodological danger of some circularity of argument. This is because using a deductively derived dimension to select cases might make it more likely that the empirical testing will confirm the dimension and the types of cases it suggests, precisely because other aspects are by default not examined. The only real solution to this conundrum, which however itself throws up methodological problems, is to take a random or other appropriate sample of cases, and from this derive case types inductively from the wide population of all cases. Unfortunately, this option is not open to MAKE-IT given its limited resource and time constraints. Awareness of this challenge and critical questioning, cross checking and validation throughout the research process is presumed to be a sufficient alternative remedy, as long as this is undertaken transparently.

In the sections below, the following three dimension-pairs are introduced and described:

- Scale dimension and social innovation dimension
- Social-community dimension and business-market dimension
- Financial dimension and business-market dimension

3.2. Scale and social innovation dimensions

Figure 6 is built around two dimensions which can be used to select and compare case studies and their supportive desk research, as elucidated below:

1. a vertical scale and interaction dimension
2. a horizontal social innovation dimension.

Figure 6: Crossing the scale and interaction dimension with the social innovation dimension

3.2.1. Scale and interaction dimension

The vertical y axis of Figure 6 shows the scale and interaction dimension of maker initiatives. This ranges from 'situational awareness' where maker initiatives tend to be relatively isolated, unconnected and focused mainly on specific or local areas, to 'distributed awareness' where maker initiatives tend to be strongly networked, interconnected and collaborative over typically large and extensive areas. A number of positions are tentatively arrayed along this dimension, as follows:

- *Single*: an individual actor or initiative, locally or specifically focused. According to Dougherty's classification (2012) of three groups of makers, the first is 'zero to maker' where "every maker has a different starting point. However, the common thread begins with an inspiration to invent, the spark that turns an individual from purely consuming products to having a hand in actually making them. To go from zero to maker, the two most important aspects are the ability to learn the requisite skills and access to the necessary means of production."
- *Collaboration/partnering*: between actors without forming a community or network. This is a type from Dougherty's second group, 'maker to maker': "The distinction in this stage is that makers begin to collaborate

and access the expertise of others. At this stage, makers also contribute to existing platforms. Powerful undercurrents are at work, both from technological revolution as well as unleashing the innate desire for self-expression and creation. The desire to improve and share with others catalyzes the move to "maker to maker".
- *Community:* relatively intense collaboration between actors, though typically on a small scale with relationships built around common characteristics, common values and shared understanding. This is also a type from Dougherty's second group 'maker to maker'.
- *Ecosystem*: also tends to be smaller scale but manifests as a well-functioning collaboration between actors typically with different types of actors with different and complementary roles and interests. This is a type from Dougherty's third group, 'maker to market': "From the workshops and the digital communities, a new wave of invention and innovation springs forth. Knowledge flows and concentrates. Some of the inventions and creations will appeal to a broader audience than the original makers. Some may even find commercial appeal. However, even if only a few makers pursue market opportunities, the impact may be huge."
- *Network*: tends to be larger scale well-functioning collaboration between actors with relationships built on common needs and interests. This is also a type of Dougherty's third group 'maker to market'.

Figure 6 also maps the ten case study examples proposed for study in *MAKE-IT*, and shows a good balance along each dimension and between the four segments. (Brief summaries of these cases are present in section 7.)

3.2.2. Social innovation dimension

The horizontal x axis of Figure 6 shows the social innovation dimension of maker initiatives. According to Hochgerner (2013) sociologists refer to social change as the processes of change in social structures, institutions, culture, behavioural patterns and states of consciousness. Alterations of this kind may derive from impacts beyond purposeful societal control, for example from the volatile stream of societal and technological development and cultural evolution. Change sometimes remains in line with sources from previous stages of development, and sometimes change consists of major upheavals like revolutions or the collapse of political systems. Hence, change may be influenced by social innovations, i.e. intentional and successful attempts to modify existing social practices or to enable new ones. Hochgerner (2013) further elaborates on what he and BEPA (2010) term the three complementary perspectives on the societal dimension of social innovation resulting in different types of outcomes or impacts generated through new forms of processes and interactions. Also drawing on the Young Foundation (2010) Millard & Carpenter (2014) and NESTA (2015), these can also be described as a continuum of social change outcomes and impacts of which three distinct and often cumulative sequences are recognised (see Figure 7):

1. **The social demand perspective (micro level):** societal and technological innovations that respond to social demands that are traditionally not addressed by the market or existing institutions arising from specific individual or group needs, such as vulnerable groups in society. This is the narrowest view of social innovation outcomes focused on tackling problems in specific, possibly disparate, parts of society on a one-by-one, perhaps even piecemeal, basis. At this level, outcomes tend to be achieved in a specific sector or locality and directed at either social, economic or environmental objectives, although spill-overs between these are normally inevitable even if they are not intentional. Examples include combatting school drop-out, supporting drug rehabilitation, providing on-the-job training for unemployed youth, reducing the loneliness of old people. Clearly, also each of these micro level outcomes has the potential to feed into the next levels of social change.

2. **The societal challenge perspective (meso level):** societal and technological innovations that respond to those societal challenges in which the boundary between the social, the economic and the environmental becomes blurred as all can be involved and that are directed towards outcomes or impacts across society as a whole, where an important focus is on the relationships between actors and outcomes. Here the intention is normally some combination of social, economic and/or environmental objectives, perhaps cutting across sectors and localities. Examples include tackling ageing, migration, regional development, trade, sustainable economic growth, pollution and climate change. Again, each of these meso level outcomes or impacts has the potential to lead into macro level systemic change.
3. **The systemic changes perspective (macro level):** societal and technological innovations that contribute, often together and cumulatively, to the reform of the underlying structures, relationships and powers in society. Societal challenges are tackled by looking at root causes, rather than focusing only on their symptoms, and can include deep-seated organisational and institutional change, reform of public policies, new governance arrangements, and changing mindsets and cultures. In short, societal paradigm shifts as, for instance, identified by Perez (2004) in a social-technological context. Examples include: behaviour changing by reducing carbon footprints (by both individuals and organisations), gender equality by dismantling gender roles, decentralising democracy or decision-making (e.g. through participatory budgeting), moves towards the sharing and collaborative economy where the focus is on access to assets rather than ownership of them, and the 'democratisation' and decentralisation of manufacturing through the widespread take-up of 'maker' principles supported by technological developments which treat 'atoms' like 'bits' (Anderson 2012 and Rifkin 2014).

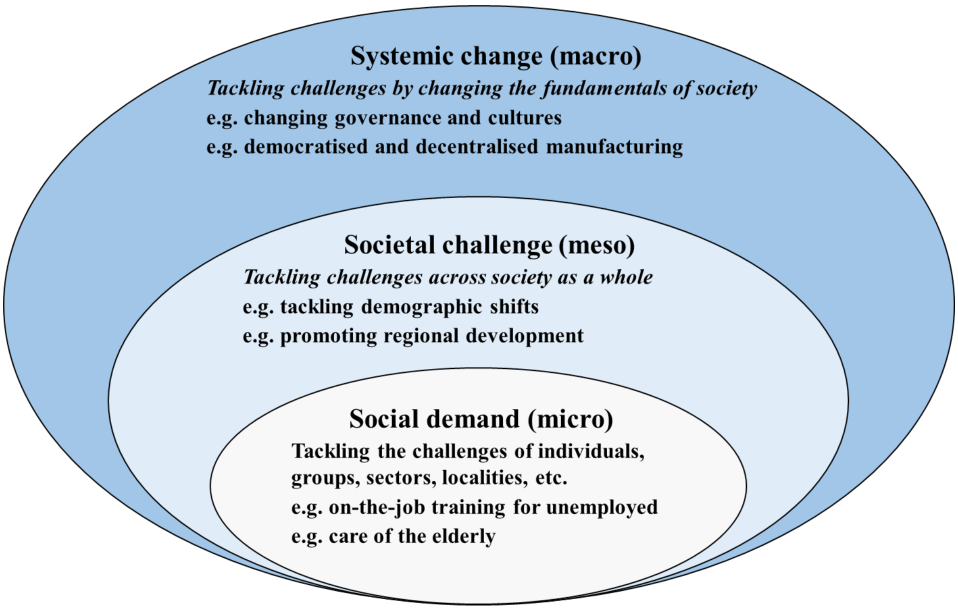


Figure 7: The cumulative nature of social change

As emphasised by Hochgerner (2013) social innovation can lead to social change, but it is also apparent from the above that the systemic change macro level leads to social change most directly, although the micro and meso levels can contribute to it, typically cumulatively over time if successful, as sketched in Figure 7. Broek et al (2012) used the distinction between social need and social change to examined different types of social entrepreneurs.

According to the SI-DRIVE project (2014), social change can be understood as the plethora of changes in the institutional structure of a society in a given time frame. Whether this structure as the subject of change is considered a value system from a structural functionalism perspective, a hierarchic shift from a perspective of conflict theory, or of a change in social relations, is both a matter of research interest and a corresponding theoretical approach. SI-DRIVE's predominant interest lies in a better understanding of social innovation as a mechanism of change at the micro- and meso-level, on the one hand, and its relation and contribution to social change on the macro-level, on the other. This is also cumulatively described by Zapf (2003) as a "process of change in the social structure of a society in its constitutive institutions, cultural patterns, associated social actions and conscious awareness".

3.3. Social-community dimension, business-market dimension and evolutionary pathways

Figure 8 is built around two dimensions which can be used to select and compare case studies and their supportive desk research, as elucidated below:

1. a vertical social-community dimension
2. a horizontal business-market dimension.

The figure distinguishes maker entities according to, first, their social value (i.e. their embeddedness in a maker community in terms of how closely do entities collaborate with each other) and, second, their economic value in terms of their embeddedness into a business/market perspective (e.g. is the objective to commercialise a product or service).

3.3.1. A dynamic view of Makers

Each dimension is analysed along a scale (weak to strong) through which the following movement can be perceived:

- On the social-community dimension: a movement from fragmented or non-existent communities (weak) to a united, concentrated or collaborative community (strong)
- On the business-market dimension: a dynamic starting with hobbyists and inventors (weak) to wannabe entrepreneurs (medium) to operating companies labelled here as "industrialists" (strong).

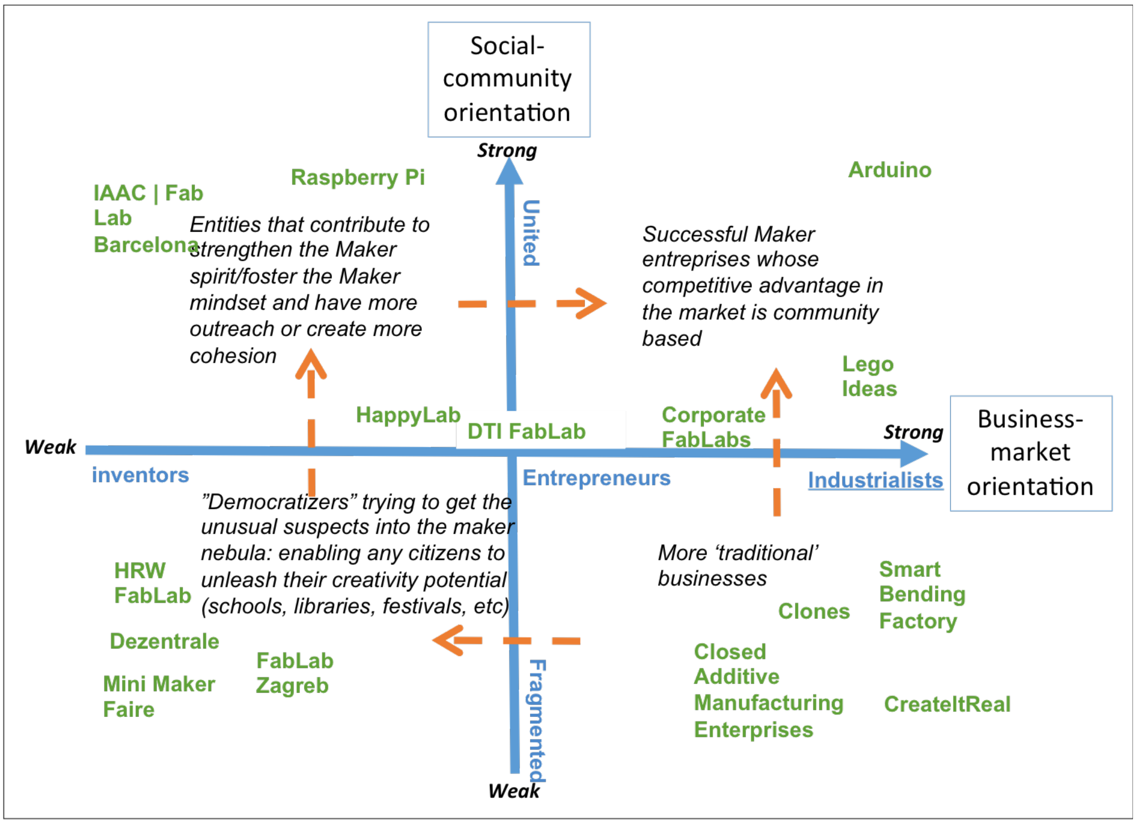


Figure 8: Crossing the social dimension with the business dimension

3.3.1.1. Possibilities for evolution (from weak to strong)

The orange arrows indicate the possibilities for evolution, as for example[17]:

- Small Fab Labs gaining scope and outreach, both towards non-makers and other makers and as such, moving up the social-community scale, while being unchanged on the business-market scale
- Traditional businesses which rank high on business-market but weak on social-community to develop their community base and get closer to exploiting the benefits of makers
- If entrepreneurial projects emerge in structures that do not rely on a strong, united community, these will probably be market oriented while lacking a community mind-set.
- On the contrary, if they originate from structures with higher embeddedness in community, they will probably be able to become "successful" maker companies relying both on the market to sell their products/services while having strong support from communities (which typically would happen in open-source projects, e.g. RepRap and Arduino.)

17. These are only illustrations, no example given aims to give an exhaustive picture of the entities present in Figure 8.

As evolutionary patterns can be observed in the study of Maker entities, and because these may be influential in relation to MAKE-IT's three analytical pillars, it is important to select cases which have different evolutionary paths. A recommendation to WPs 3 and 4 is to include, where possible, cases representing the four evolutionary patterns described above. In the cross-case analysis, the differences emerging between evolutionary paths can be discussed.

3.3.1.2. Possibilities of digression (the movement from strong to weak)

It is also possible to hypothesize the opposite movement, indicating a possibility of "digression" between the different boxes. For example:

- An open-source maker company deciding to adopt a closed approach. By doing so, the company will lose the input provided by the community and thus turn into a more stereotypical company, nurturing only a strong market focus.
- A maker entity located in the top left segment of Figure 8 which decides to focus only on a lower community scale, moving towards the bottom left segment.

Maker entities can follow a regressive pattern, losing anchor in community or in the market.

The inherent consequences and the motivations are of particular interest as it could lead an understanding of either why evolution is not conceivable or why it is not pursued.

3.3.1.3. Stagnation

As shown above, the orange arrows of Figure 8 are merely indicative of hypotheses of development (from weak to strong). Nevertheless, the maker entities studied may engage in divergent, regressive paths, such as companies going from open source to closed source, or maker spaces losing outreach, etc., and thereby following a path from strong to weak on either dimension.

A third possibility which can be explored deals with entities that do not engage in evolutionary nor regressive patterns and remain stationary. These may be:

- Small local communities of makers that do not intend to grow or gain more outreach
- Companies that do not have the ambition of being more open towards the community of users
- 'Inventors' who want to remain just that
- United communities that nurture no market vision.

Both dimensions of Figure 8 offer the possibility of analysing dynamism, but it is also applied to further understand why it is not always in the interest of an entity to change their position along either or both dimensions.

Maker entities may be stationary and not engage in evolutionary nor regressive patterns.

This may typically be the case for locally embedded maker entities which do not necessarily aim at gaining scope or outreach (Fab Labs taking place in libraries, maker experiences in schools, etc.) or companies not aiming to tap into the community potential to build a competitive advantage.

We might also observe entities that intend to move up on the community or market scale but do not manage to do so. In that case, questions are raised for research on the barriers to evolution. *Indeed, maker entities may encounter difficulties in evolving.*

3.3.2. Social value versus economic value?

Splitting maker entities between weak and strong business-market orientation enables an examination to take place of the different roles the left and right hand sides of Figure 8 play in the Maker movement, their relationships and interdependencies.

3.3.2.1. Building and strengthening the maker subculture

The left side covers that part of the Maker movement that is fundamental to Maker culture, such as having a sense of what is possible to do and what can be learnt, motivated by internal goals rather than extrinsic rewards. This culture is important in setting the principles, values and innovative spirit of the Maker movement, and for attracting new people into Maker culture by pulling edge communities into the core, democratising the tools of production and the skills necessary to design and make just about anything. It also helps to unleash creativity, amplify efforts to build viable commercial enterprises and helps to consolidate the movement.

3.3.2.2. Building a market for makers

The right side of Figure 8 covers the most market-oriented entities, which contribute to translate the Maker spirit into business opportunities. This will enable an analysis to be undertaken of the specificities of Maker business or businesses that intend to become more “Maker-anchored”.

3.3.2.3. The question of business models

Successful maker businesses (top-right segment of Figure 8) may be characterised by a strong integration of the community to build competitive advantage.

Anderson (2012) argues that the core characteristic of maker businesses is often to be open-source - which could be seen as a threat as this enables copying to take place by competitors. Yet according to Anderson, this openness is actually the strength of maker businesses as it suggests that the community actively contributes to the business with ideas, improvements, etc. "The community is the competitive advantage". The integration of the community into the business opportunity could be an analytical lens to adopt to differentiate and compare the businesses emerging from the Maker movement, as well as examining cases of corporations that wish to tap into the maker potential, or cases of maker start-ups that fail to integrate the community into their business model.

Many (but not all) enterprises currently located in the bottom right segment have an interest becoming more 'open' and to integrate the community.

It is possible to observe a tendency for large companies to integrate inputs from external stakeholders in order to progress higher up the social-community scale (such Lego Ideas, Corporate FabLabs at Renault, etc.), and thereby move away from closed innovation patterns to foster user-innovation coupled with open innovation (Von Hippel 2005).

The dynamic between the bottom right and the top right segments of Figure 8 raises questions in terms of business models and the issues of openness/closedness in business, with a link to competitive advantage.

Entities located on the left hand side of Figure 8 are regulated by a community logic which can be in conflict with market orientation. Business models are not / should not be a concern for these entities.

Some studies on Makerspaces suggest they are often directed by a 'community logic and ideology' and, as such, reject the idea of a business logic (Bottollier-Depois, 2012). One can argue that talking about business models is made irrelevant if we consider makerspaces on the left side of the graph to create a collective good: in that way, business models are not a priority. Others suggest business models for Fab Labs for example are important to discuss and relate to the sustainability of such initiatives (Menichinelli 2015). However, this does not necessarily concern spaces labelled as "democratizers".

3.3.3. Interdependencies between the dimensions

The borders between the four segments of Figure 8 are porous and suggest an interdependency between the various maker entities. For example:

- Major players in the tech and corporate world actively participate in Maker Faires, a 'hotbed' for innovation, which provide such traditional business with opportunities to support and spur innovation.
- Entities with stronger communities working together with 'democratizers' to create more cohesiveness and widespread inclusion, so that more fringe groups and/or like-minded people can join together and get interested in becoming makers, which in turn allows the Maker movement to reach its full potential.
- With core tech products from maker enterprises now within reach of normal consumers, these makers are provided with tools, technologies and inspiration to facilitate the development of their projects and move them from being passive consumers to active creators.

The overall dynamic between maker entities relies on collaboration rather than competition.

An important dynamic of the maker movement comprises new educational approaches and greater inclusiveness of students.

3.4. Financial dimension, business-market dimension and Maker independence

Figure 9 is a supplement to the social-community and business-market dimensions approach described in section 3.3. It retains the latter but replaces the former dimension, as follows:

1. a vertical financing dimension
2. a horizontal business-market dimension.

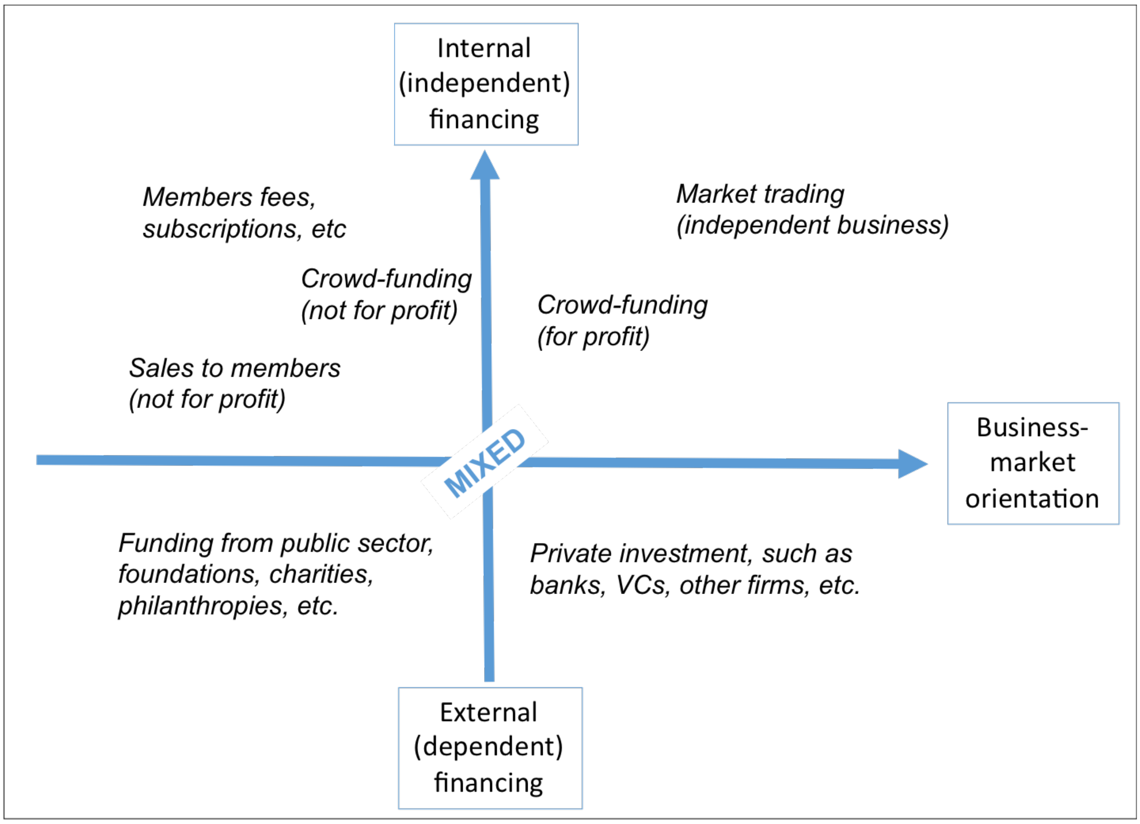


Figure 9: Crossing the financing dimension with the business dimension

Fundamental to any social and/or business model is financing and the source from which this is derived, as this is one of the main determinants of whether or not, and the extent to which, a maker is independent. The source of maker financing, whether self generated, externally sourced or a mixture of both, is often critical to the sustainability of a maker entity, and thus to its overall independence. Although other issues can also be important for the independence of, for example, action, decision-making, focus, etc., such as the composition of maker stakeholders, the entity's constitution, legal and regulatory issues, etc., financing and financial sustainability is clearly of utmost importance. A number of typical examples are suggested in the different segments of Figure 9. It is proposed, that where the need arises, a financing and business-market dimension approach be used to assist in case analysis, and perhaps also in case selection.

3.5. Crossing Component 1 with Component 2

Component 2 can later be crossed with Component 1, for example in WP6, in order to make comparisons and draw synthetic inferences concerning specific types or configurations of Makers (depending on the dimension). These inferences can also be validated and further developed by additional desk research, interviews and other evidence gathering activities.

As described in section 1, the prime role of Component 1's analytical pillars is to assist in examining how individual cases operate (see section 2), including looking at their external environments as part of this. The dimensions described in Component 2, on the other hand, specifically enable comparisons across and between these individual cases to be undertaken, thereby enabling a better understanding of the similarities, differences and complementarities between them. Thus, for example, it will be possible to compare the results of the pillar mapping of each case with other cases in a similar position in a dimension space, or in some sort of sequence along a dimension, to see whether these individual analyses (of for example management structure or finance) are similar or not. This will also assist in providing answers to research questions about how individual cases operate and the models which can be posited derived from the various dimensions in Component 2. Some of these models are likely to prove relatively robust, some not so can be discarded, whilst others can be developed further. Empirical research in subsequent WPs will test these and in turn feed overall model and theory development. Thus, the pillars and dimensions deploy different perspectives and operate at different levels, as illustrated in Figure 1. As made clear in section 1, however, other perspectives and additional content might also prove to be relevant during the implementation of WPs 3, 4, 5 and 6.

Figure 10 illustrates, in diagrammatic cross-matrix form, how a synthesis could be made between the three analytical pillars and three dimension pairs. Operationalisation of this approach can be thought of in three main steps:

1. Step 1 focuses on each case in turn: WP 3 categorizes each of the ten cases on the basis of some dimension pairs in terms of where each case is located. This will also help select cases in order to achieve some acceptable representation.
2. Step 2 also focuses on each case in turn: WP3 applies the three analytical pillars to each case, which means in effect the relevant individual cells in the cross-matrix are examined.
3. Step 3 takes different combinations of cases in order to generalise from the cases: as a result of steps 1 and 2, cells can be combined across cases:
    - Horizontally to examine, and thus draw conclusions, on each dimension and the points along it which are relevant.
    - Vertically to examine, and thus draw conclusions, on each analytical pillar and their individual issues which are relevant.

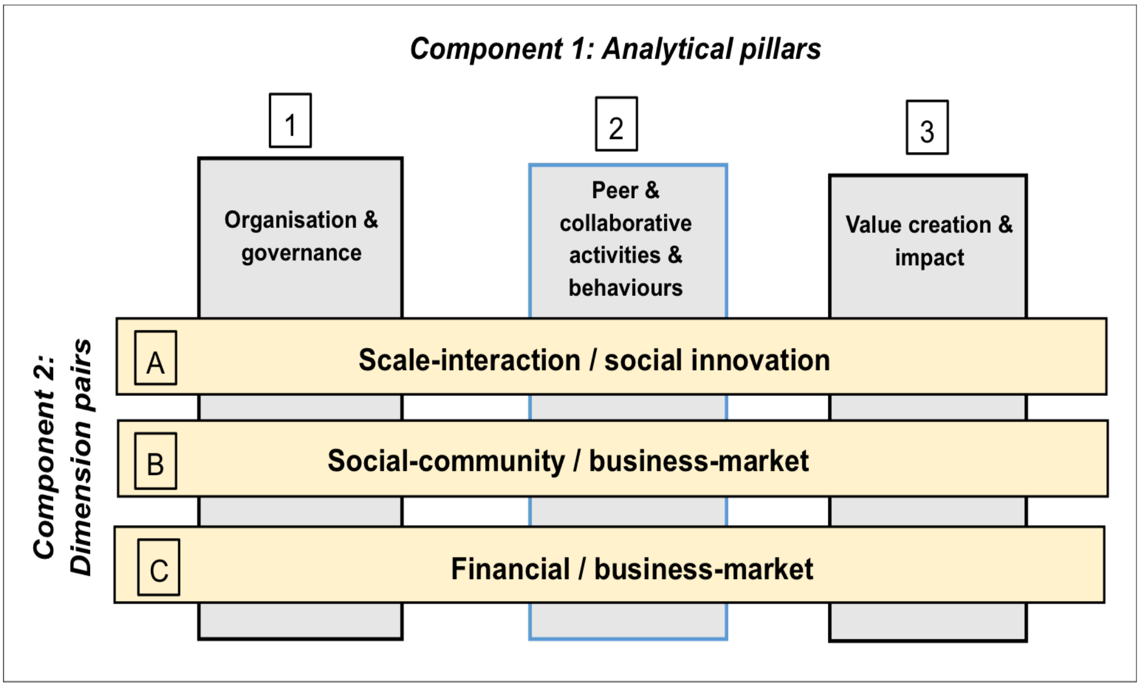


Figure 10: Cross-matrix diagram between 3 analytical pillars and 3 sets of dimension-pairs

Step 3 thus enables WP3 to undertake:

I. Multi-analysis of the ten **Maker cases** (as much as is useful, given the evidence.)
II. ….leading to multi-synthesis giving us a number of **Maker models** (as many as are useful, given the evidence.)
III. This can feed into WP4
IV. Both WPs 3 and 4 will also be served by WP5 in terms of technology use scenarios.
V. All this will support the analysis in WP6.

Important notes:

- The terminology of the dimensions will be tested, as will the different points along each dimension.
- Not all potential combinations which could be analysed by crossing the dimensions against pillars will be. It will be important to take a pragmatic approach within the project's time and resource constraints, fitting as close to reality as possible, as well as able to show how reality might develop (e.g. from WP5 work).
- Once validated, this methodology will be useful for analysing other Maker examples and for developing overall conclusions and research and policy recommendations (in WP6).
- This will need to be supported by the taxonomy, an initial development of which is provided in section 4.

4. Component 3: Towards a taxonomy and definitions, classifications and relationships

As introduced in section 1.1.3, Component 3 of the conceptual framework: taxonomy, definitions, classifications and relationships, is designed to inform and draw from all other elements of the conceptual framework as this develops. These constitute the common glue and terminology that aims to underpin the project objectives as well as scope and delimit its focus.

4.1. Introduction

The discussion of a taxonomy as part of D2.1 aims to support the conceptual, methodological and scientific framework by explicating the often tacit knowledge partners in the consortium bring to the analysis of the Maker movement. Although there is a broad overlap in the consortium's understanding of key terms, it is also clear that all concepts and associated labels are social constructs framed by everyone's group of peers. For example, though we will all have a similar understanding of business models, depending on the context in which a business model is discussed (for-profit, non-profit, legal status of organisation etc.) different aspects will come to the fore or completely disappear from the discussion. Whereas semantic differences may well be justified by the research questions raised, it is important to be aware of their existence and work towards the use of more formalised frameworks.

The section is organised as follows.

I. We briefly outline the specific benefits of working with a taxonomy and maintain a living document around taxonomic structure as they evolve throughout the project.
II. Establish a three direction from which suitable conceptualisations can be derived, including expert opinions, empirical observations of how maker spaces use terms as well as folksonomies derived from sites such as Twitter, Maker forums or Wikipedia.
III. Although we expect this to intensify as we dive deeper into specific case studies, we have already identified some first points of discussion around concepts. In concluding this section, these discussions are presented as indicators of possible research directions.

4.2. Why have a taxonomy discussion?

First we need to develop a contextual understanding of the maker terminology, considering that the same phenomena might be called differently depending on geography, time or reference community.

A long term goal is then to contribute to a more unified and commonly accepted terminology that precedes comparable and eventually generalizable knowledge.

4.2.1. Understanding changing meanings

Classifying concepts, i.e. building taxonomies, is a fundamental practice when developing a topic of interest into a research field. For our purpose we are going to distinguish typologies and taxonomies, the former being deductive assignments into a priori defined groups (ideal types) whereas the latter are inductively determined memberships of a posteriori identified categories (Fiedler, Grover, & Teng, 1996). Put differently, typologies are intuitive classifications, which might turn out to be exhaustive or too restrictive wherefore an on-going observation of how concepts are used over time can often reflect the development of a field. For example, even though 'maker spaces' as we understand them today most likely existed already earlier, the term itself gained currency only in 2011 and similar activities were subsumed under hacker spaces (see Google Trends[18] in Figure 11). Hence a taxonomy includes not only our understanding of defining characteristics, but also the tracking of geographical and time dependent changes.

18. Google Trends is an indicator of how often a particular search term is used in comparison to the entire search volume of Google https://www.google.com/trends/explore.

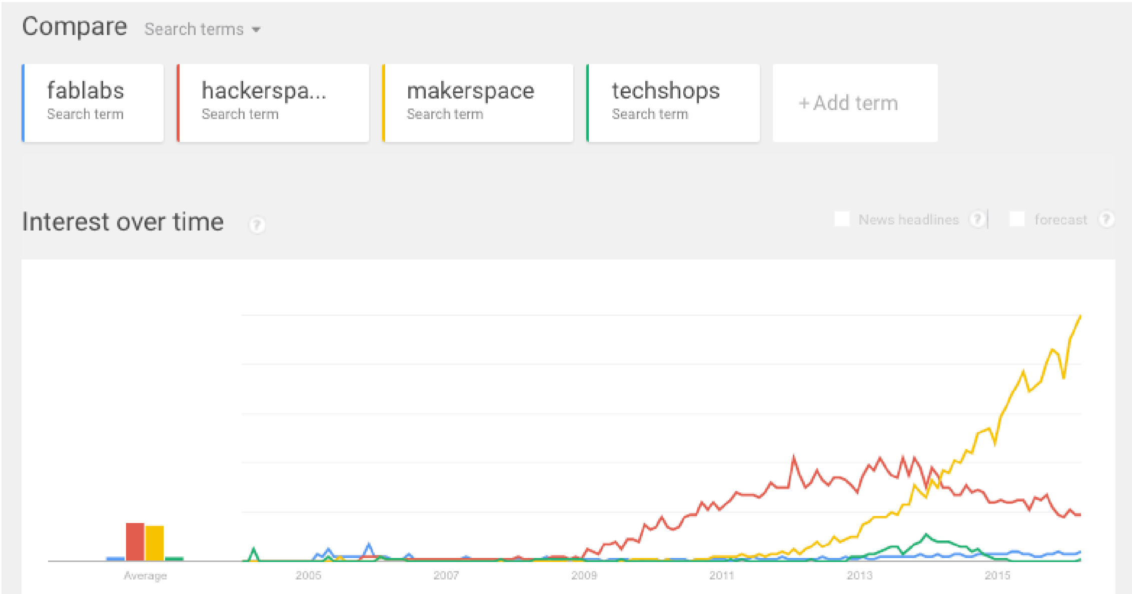


Figure 11: Comparison of 'fablabs', 'makerspace', 'hackerspace', 'techshops' (March, 2016)

4.2.2. Making research replicable and insights comparable

A further benefit of a taxonomy is that it provides some measure of unity to the description of research findings, which enables others to reconstruct and replicate the conditions under which a given method or procedure has been successful. Of course, this requires the taxonomy to be close to reality so that practitioners as well as researchers accept the taxonomy as a valid reflection of their experiences (Rich, 1992). At this early stage of the project the various partners of the consortium contributed definitions of candidate concepts. Future research and case studies needs then to go back and extent or change these definitions, so that the taxonomy can be a living, shared repository of continuously improving definitions.

4.2.3. Working towards predictive and more general knowledge

A clear terminology is usually a sign of an established research area, where there is a sufficiently large body of knowledge describing boundaries of term and interdependencies between terms (Horan & Lafky, 2006). Hence, a common language will be a necessary precondition to better describe developments around the maker community in a European context where we are expecting cultural and geographical differences even though we use the same labels.

4.3. Conceptual, empirical and democratic understandings of the maker movement

In this section we consider the different sources we should use in order to get to a unified terminology. Most importantly, a taxonomy has an empirical basis as in biological classifications, where hierarchies are built around central categories which are the broken down into more specific characteristics. In a making context, that could concern additive maker technologies which then includes different 3D printing technologies such as Stereolithography (SLA), Digital Light Processing (DLP), Fused deposition modelling (FDM), Selective Laser Sintering (SLS) etc. The same thinking could be applied to a process like 'Making in Education' - a first level differentiation might include the use of maker technology in formal, non-formal and informal education (Eisenberg, 2011) and even further differentiation might then distinguish between the use of electronic kits and fabrication kits which enable different types of learning (Bull, Haj-Hariri, Atkins, & Moran, 2015). Eventually, taxonomic structure could quite pragmatically inform the structure of case studies, for example if a case aims to describe the educational use of a maker space.

4.3.1. Overarching methodology

Working towards a taxonomy will comprise multiple steps (cf. Figure 12, based on Horan & Lafky, 2006). Since no new taxonomy can be created ex nihilo, we start with a typology based on heuristics and expertise of members of the consortium (step 1).

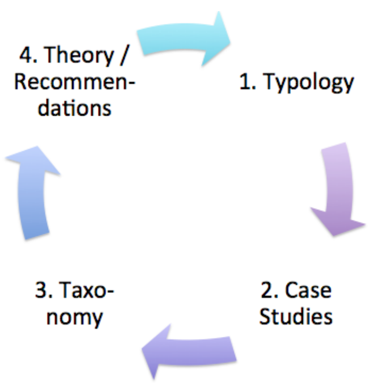


Figure 12: Typology and taxonomy

informing the Make-IT research

The terminology together with the other elements of the conceptual framework presented in this deliverable, will then inform structure, research and conceptualisation of the case studies (step 2), aggregating several experiences across multiple cases will then allow us to start building a taxonomy (step 3) which is then shaping the formulation of theory and pragmatic recommendations on a more abstract level.

4.3.2. Typologies and Taxonomies: Concepts from experts and observations

In accordance with step 1, members of the consortium were asked to contribute to the collection and discussion of concepts they found essential in describing the maker movement, the benchmark was members' academic and practical experience as well as the conceptual framework already laid out in the DoA. A first round resulted in *26 concepts* describing different aspects of the maker movement, which have been provisionally grouped under headings such as society, movements, values, tools, spaces and events, as displayed in Figure 13. However, the primary analytical categories are the three analytical components (see section 2) and the dimensions introduced in section 3. The subsequent grouping serves as a first orientation and is mapped to pillars and dimensions based on the information gained from the case studies.

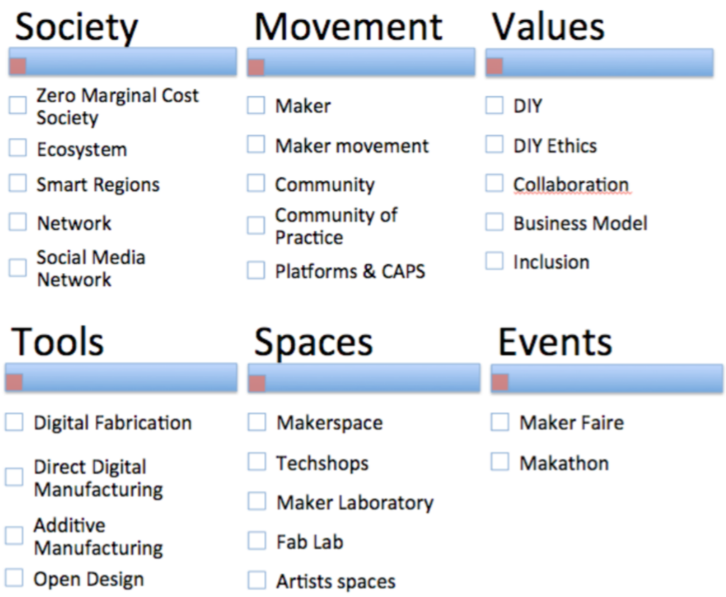


Figure 13: First round of *Make-IT* partner concepts recognition

At this stage and in line with the definition of a typology this grouping needs to pass a face value check only, a more thorough examination of the concepts as well as their grouping would result from reflecting today's understanding against our improved understanding as a result from our first case studies.

4.3.3. Folksonomies: Concepts from social media

A 'folksonomy' is a combination of the words 'folk' and 'taxonomy' and refers to the user-generated nature of a taxonomy based on social tagging, the public labelling or categorization of online recourses (Trant, 2009). Folksonomies are likely to have flatter hierarchies than their scientific counterparts and have shown to converge towards a narrower meaning over time, despite their decentralised and informal usage.

A taxonomy for the Maker movement could also be rebuilt from content produced by different stakeholders. In order to do this and create a data-driven taxonomy, we focus on three directions:

- Communication within the Maker Community (Source: Twitter, Wikipedia)
- Communication about the Maker Community (Source: The Guardian)
- Communication from the 'academic' Maker Community (Source: Scopus, Web of Science, Google Scholar)

These sources have been selected as they either have application programming interfaces (APIs), that allow harvesting historical data or because they provide open data, allowing the analysis of larger chunks of information. Other sources such as the MakeZine[19] Blog would also be a very informative source, but the lack of a dedicated access channel to MakeZien postings would make an analysis rather difficult.

4.3.3.1. The maker community on Wikipedia

We analysed a specific set of Wikipedia pages, in terms of visitor statistics and in terms of discussion and conflict in their editing process with the Contropedia platform (Borra et al. 2015). With Wikipedia being one of the 'go to' sources for people who seek a first idea what a concept means, we took daily visitor statistics over the last 8 years as proxy indicators for how interest in a given topic varied over the years (see Figure 14). The following 6 sites have been included:

- Digital modelling: https://en.wikipedia.org/wiki/Digital_modeling_and_fabrication
- 3D printing: https://en.wikipedia.org/wiki/3D_printing
- Fab Lab: https://en.wikipedia.org/wiki/Fab_lab
- DIY: https://en.wikipedia.org/wiki/Do_it_yourself
- Hackerspace: https://en.wikipedia.org/wiki/Hackerspace
- Make culture: https://en.wikipedia.org/wiki/Maker_culture

19. MakeZine is a Magazine for the Maker Community. (http://makezine.com/blog/). It focuses on DIY practices and reflects latest developments in the community.

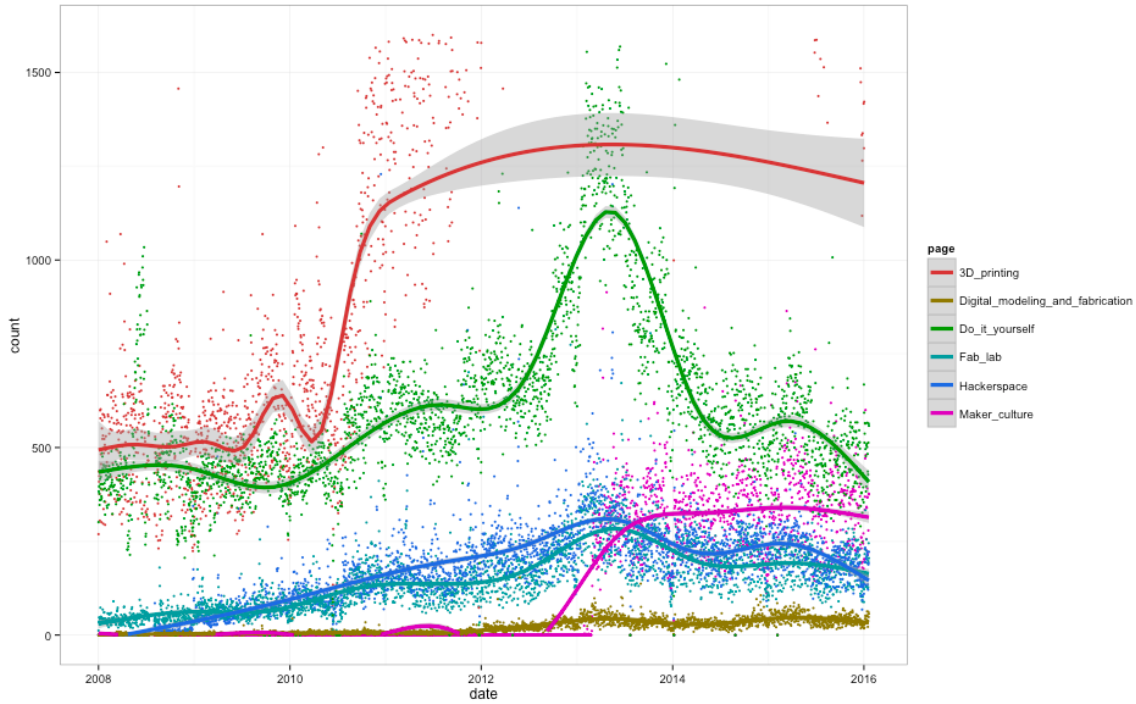


Figure 14: Daily access rates to selected Wikipedia pages

These graphs become more interesting if seen in combination with coinciding events or key publications, such as when the cover from the Economist (February, 2011) said "Print me a Stradivarius" which overlaps with spike in '3d Printing' or Chris Anderson's (2012) publication of Makers: The New Industrial Revolution which coincides with the increase in 'Maker culture' and 'FabLabs'.

For a more qualitative insight into how Wikipedia pages are discussed, revealing potentially interesting controversies, we submitted a number of pages to Contropedia[20], a service that visualises an article's revision history including content and nature of an edit.

20. *http://www.contropedia.net* The site is part of an FP7 research project 'contropedia', which was so kind to include a suggested set of pages in a 'Make section' on http://contropedia.net/#demo.

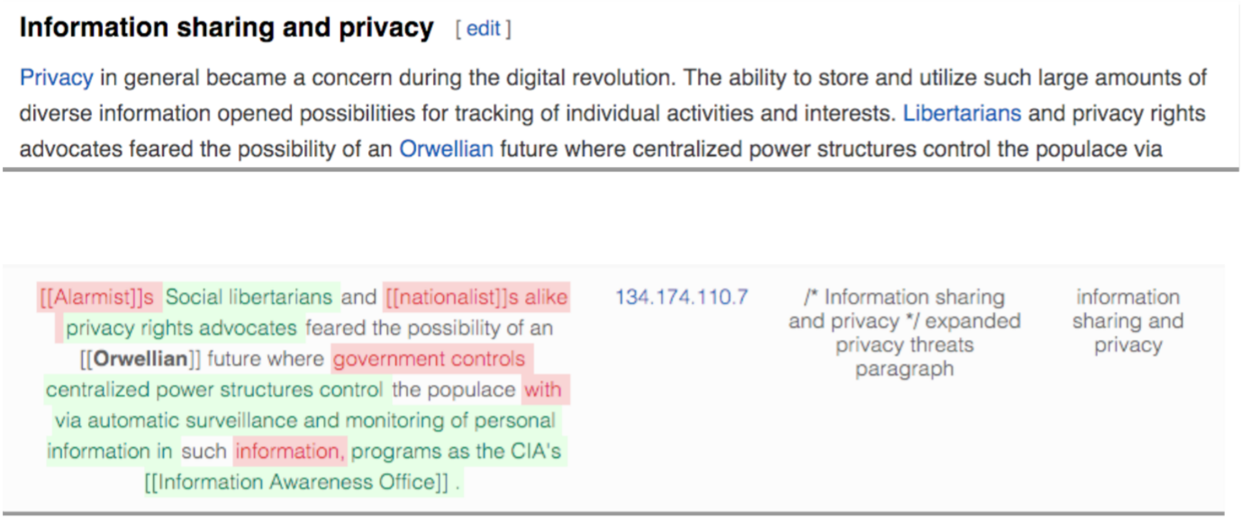
Wiki Page	Total revisions	Editors	Links to page	Edits per year
3D printing	3795	1618	1241	340
Do it yourself	1115	658	959	80
Open-source hardware	962	445	251	68
Fab lab	428	234	65	39
Hackerspace[21]	620	314	184	81
Maker culture Maker	270	122	105	48

Table 4: Selected pages associated with the Maker movement

Figure 15 shows an example of the Contropedia Analysis of the 'Digital Revolution / The third industrial Revolution' Wikipedia entry[22]. The analysis has multiple levels of information, for one it indicates the sections where most changes (reverts) happened - showing point of major interest. Furthermore we can see how changes in formulations attempt to strike a balance between neutral formulations and expressing a concern (Reagle, 2010). Below the example of Wikipedia editors discuss the description of privacy violations as one of the more negative consequences of the 'digital revolution' which is affecting increasing parts of people's lives.

21. Interestingly makerspace redirects to hackerspace.

22. https://en.wikipedia.org/wiki/Digital_Revolution


Information sharing and privacy [edit]

Privacy in general became a concern during the digital revolution. The ability to store and utilize such large amounts of diverse information opened possibilities for tracking of individual activities and interests. Libertarians and privacy rights advocates feared the possibility of an Orwellian future where centralized power structures control the populace via

[[Alarmist]]s Social libertarians and [[nationalist]]s alike privacy rights advocates feared the possibility of an [[**Orwellian**]] future where government controls centralized power structures control the populace with via automatic surveillance and monitoring of personal information in such information, programs as the CIA's [[Information Awareness Office]] .	134.174.110.7	/* Information sharing and privacy */ expanded privacy threats paragraph	information sharing and privacy

Figure 15: Wikipedia edits, red highlights indicates deletions (Source: http://go.shr.lc/1Y1cSlH)

4.3.3.2. The maker community on Twitter

The amount of historical data that can be obtained depends on the Twitter API through which data can be requested. Inquiring about a specific hashtag we obtained 15.000 Tweets from one request. The point at this stage was not a comprehensive social media study, but a first glance at high frequency co-occurrences of key words. Figure 16 shows two word clouds, describing tweets containing the hastags #maker and #makerspace. Maker's most frequent accompanying words include '3dprinting', 'diy', 'iot', 'fablab', 'robot' as well as 'coffee' or 'fun' indicating the social nature of many tweets. Makerspace's most frequent accompanying words include 'schools', 'libraries', 'resources' or 'creativity'.

Figure 16: Word-clouds generated from hashtags #maker and

#makerspaces

Each word in the cloud of keyword can finally be associated with a set of tweets which upon closer inspection might reveal further insights into the dimensions of given concepts. For example, makerspaces are strongly linked to educational initiatives, which in turn are linked to stories about communities around open hardware and open design, which constitute resources for people who want to learn but do not plan to go to a university again or cannot afford to go to a university at all.

4.3.3.3. Communication from and about the Maker Community

Communication from the maker community in form of academic references is currently under examination and was gathered through manual search and export (Scopus, Web of Science) or through Google Scholar (1000 items per term) with the Publish or Perish software (Harzing 2007). The challenge here is the normalisation of data in such a way, that the different data sources can be combined. Future work includes co-citation analysis. Similar to the most prominent Wikipedia pages or social tags, we could then hint at central publications that have a proven influence on the academic writing about the Maker Movement.

Communication about the Maker community includes so far 'The Guardian' as a resource, since they provide full access to their articles. For example, during 2014 and 2015 we identified 22 articles referring to 3D printing, featuring this activity in sections as diverse as fashion, law, business, music or art:

- Fashion (2015-07-28) Are we ready to 3D print our own clothes? - http://www.theguardian.com/fashion/2015/jul/28/are-we-ready-to-print-our-own-3d-clothes
- Technology (2015-04-30) Revamping the violin " courtesy of a 3D printer - http://www.theguardian.com/technology/2015/apr/30/revamping-violin-3d-printer
- Technology (2015-07-15) Artist 3D prints Donald Trump butt plug in protest at immigration rhetoric - http://www.theguardian.com/technology/2015/jul/15/donald-trump-butt-plug-3d-printing
- Law (2015-05-07) 3D-gun creator's lawsuit a battle to protect free speech, says legal team - http://www.theguardian.com/law/2015/may/07/cody-wilson-3d-gun-lawsuit-state-department-free-speech
- Guardian Sustainable Business (2015-02-06) Meet the robot giving hospitalised children superpowers - http://www.theguardian.com/sustainable-business/2015/feb/06/robots-for-good-hospitalised-children-superpowers
- Music (2015-03-20) The week in music: 3D-printed Paul McCartney, Kanye at Glasto and more - http://www.theguardian.com/music/2015/mar/20/paul-mccartney-3d-printed-kanye-glastonbury-adele-21-biggest-selling-album-week-in-music
- Art and design (2015-03-09) Let's all move to Mars! The space architects shaping our future - http://www.theguardian.com/artanddesign/2015/mar/09/space-architects-shaping-plans-for-life-on-moon-and-mars

4.4. Implications of the taxonomy for Make-IT

Since the case research process is still in its preparatory stage, we did not expect much debate yet. Still a few useful debates had been triggered already.

- A first debate concerned a shared notion of the platform concept. Should it include offline platforms? This decision had far reaching consequences as it would influence the scope of our case studies. The debate showed the need to be more precise by what is meant with platform, especially in combination with 'awareness platform' and 'digital fabrication'. Figure 2 was created to clarify the intersections that define the Make-IT focus. This also related to debate about the concept of a maker, which is still fairly broad. Or to use Dougherty's words 'if you prepare a cake you are a maker'. Such a broad definition can only be maintained if we are more restrictive when it comes to the maker's context.
- Other points of brief discussion included the role of TechShops for the Maker movement. Even though they are primarily found in the US, it was decided to keep them as a reference concept.
- A last point was the conceptualisation of maker spaces as inclusive spaces. It was highlighted that concepts like "vulnerability" or "marginalised" imply that a person has a "deficit", instead of directing our attention to a non-suitable environment. In that sense maker spaces are not per se inclusive, but have the tools and the mindset to create conditions that match people's needs and strengths.

See Annex 2 in Section 8 below for an initial set of definitions.

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6. List of Acronyms and Abbreviations

CAPs	Community Awareness Platforms
DoA	Description of Activities
WP	Work-package
AM	Additive Manufacturing
CAD	Computer-Aided Design
CNC	Computer Numerical Control
CSR	Corporate Social Responsibility
DIWO	Do-It-With-Others
DIY	Do-It-Yourself
DLP	Digital Light Processing
FDM	Fused Deposition Modelling
SI	Social Innovation
SLA	Stereo-Lithography
SLS	Selective Laser Sintering
SME	Small or Medium Enterprise
WYSIWYB	What You See Is What You Build

7. Annex I: Initial selection of MAKE-IT case studies

The following ten cases are presented in the DoA as likely candidates for study in WPs 3, 4 and 5. As mentioned in section 3, these will be subject to review early in WP3 in light of this conceptual framework and other considerations. These ten cases are also referenced in section 3 both by number and sometimes name for illustrative purposes.

7.1. The smart city makers ecosystem in Copenhagen (Denmark)

The DTI FabLab, located at DTI's HQ in Copenhagen, is at the centre of a thriving and growing maker ecosystem across the city as is a crucial element in Copenhagen's smart city strategies. Other important nodes in this ecosystem include the NTS centre of FabSchools, DTU (the Danish Technical University), BluePrinter (3D printer manufacturer), Copenhagen Fabrication/Cotter, etc. This case is positioned at the ecosystem level of the vertical axis in Figure 6, and on the horizontal axis is already achieving societal impacts with a view to promoting systemic change through its smart city work and supporting fundamental changes in manufacturing and ways of working.

7.2. Fab Lab Barcelona: a city and regional hub, but also hubbing a growing global network (Spain)

Fab Lab Barcelona is a leading organisation in the worldwide network of FabLabs. And the global coordinator the Fab Academy, a digitally distributed educational platform where students develop knowledge about the principles, applications and implications of digital manufacturing technologies. The case is positioned at the network level of the vertical axis in Figure 6, and on the horizontal axis is already achieving societal impacts with a view to promoting systemic change by exploring the relationship between the digital and physical worlds through integrating digital technologies into research projects focusing on fabrication and the empowerment of individuals to build on their knowledge to create everyday objects. As an internationally recognised player Fab Lab Barcelona is also hubbing a growing global network.

7.3. Raspberry Pi providing open source hardware (United Kingdom)

The Raspberry Pi is a low cost, credit-card sized open-source software computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. The Raspberry Pi Foundation is a registered educational charity in the UK with the goal of advancing the education of adults and children, particularly in the field of computers, computer science and related subjects. The Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. Given its role in a UK and increasingly global ecosystem around open source hardware, the case is positioned at the ecosystem level of the vertical axis in Figure 6, and on the horizontal axis it is solving specific educational and basic computing problems and moving towards contributing to meeting wider societal challenges in these areas.

7.4. Smart Bending Factory (Netherlands)

Although there is a high demand for customized products, the price difference with standardized products is too big. Smart Bending Factory is tackling this problem by integrating non-strategic processing of several manufacturers into one smart manufacturing process and at the same time automating this entire process from quotation to delivery. The expected outcome is a Smart Bending Factory in which manufacturers can benefit from massive increases in efficiency and reduced costs will allow for the manufacturing of affordable and high quality customized products in the European Union, as the first of many smart local factories. This case thus establishes the link between bottom-up maker communities and established smart industry parties and is positioned at the ecosystem level of the vertical axis in Figure 6, and on the horizontal axis it is solving specific educational and basic computing problems and moving towards contributing to meeting wider societal challenges in these areas.

7.5. The Mini Makers Faire Tartu (Estonia)

This is the very first Maker Faire of the region in Tartu as part of the Researchers' Night Festival 2014 (the event was called Tartu Mini Maker Faire). The Mini Maker Faire attracted over 150 makers and over 1000 visitors and included activities encouraging grass root experimenting (such as the constructing of DIY solar panels or extracting DNA). The Mini Maker Faire's success encouraged it to organize it again in 2015. promoting self-produced solar panels. Maker activities in Estonia are led mainly by the community-driven organisations and groups such as the MakerLab in Tallinn or the Tartu Centre for Creative Industries in Tartu, but the Mini Maker Fare reaches out to ordinary citizens and small enterprises collaborating with these other actors. The case is positioned at the collaboration level of the vertical axis in Error: Reference source not found, and on the horizontal axis it is solving a wide range of social and other needs and moving towards contributing to meeting wider societal challenges in these areas.

7.6.Happylab in Vienna (Austria)

This is Austria's first FabLab and currently has about 1,500 regular users and a growth rate of 1 to 2 users daily the demand in the metropolitan region of Vienna is clearly visible. Key to this development is the combination of professional equipment and low-threshold access. A goal of Happylab is to provide FabLab infrastructure throughout Austria in the medium term. In order to survive economically aside from large cities such as Vienna new approaches are needed to address a larger target group. Therefore Happylab has developed special offers for children and teenagers as well as people without technical knowledge. The Happylab is an interdisciplinary entry point for all who have creative and/or technological project ideas. The case is positioned at the community level of the vertical axis in Figure 6 given that it is embedded within a framework of universities, business incubators, funding agencies, specialised SMEs, as well as industries to provide the lab users with services when their idea grows beyond the scope of the lab. On the horizontal axis it is solving a wide range of social and other needs and moving towards contributing to meeting wider societal challenges in these areas.

7.7.Dezentrale Dortmund (Germany)

This FabLab has a strong focus on urban neighbourhood re-generation. It is run by Fraunhofer UMSICHT institute (private), as well as the local civil community (non-profit informal). Although the project is organisationally driven, it aims at promoting the democratization of innovation and production. Thus, the Dezentrale tries to involve citizens in the neighbourhood. It is open once a week for all interested citizens to suggest ideas and maybe start their own technological project. The Dezentrale's aim is to overcome the rigid trisection of research and development inventing, companies producing and citizens consuming goods. In order to initiate diffusion, in fall of 2014 the Dezentrale and Fraunhofer UMSICHT were involved in the "Innovative Citizen Festival" in Dortmund, a one-week event dealing with all aspects of maker culture, technology consequences, decentralization, degrowth and entrepreneurship. By getting involved in such events, the Dezentrale puts a focus on the empowerment of citizens when it comes to democratizing innovation and production. The case is thus positioned at the collaboration level of the vertical axis in Figure 6, but between societal challenges and helping to create systemic change on the horizontal axis.

7.8.HRW FabLab (Germany)

The HRW FabLab – FabLab of the University of Applied Science "Hochschule Ruhr West" is a maker space and network in the Ruhr region of Germany run by a university focusing on the pedagogical, social and empowerment needs of participants. It works as a catalyst and collector for issues and problems, collected by non-university people. The FabLab adds an "applied" learning dimension to higher education and brings together students and different social groups from outside the university universe. In this perspective the publicly founded university strives to provide solutions to social issues in the local/regional environment of the institution. The case is thus positioned at the community level of the vertical axis in Figure 6, but between societal challenges and helping to create systemic change on the horizontal axis as it addresses a systemic change in higher education, as well as the single limited needs of end users (inhabitants of the social environment).

7.9. Create it REAL, Aalborg (Denmark)

Create it REAL is a manufacturer of maker technology components located in the most remote Danish periphery. It produces 3D printing technology, solving the barriers of adoption through technology innovation and making it available to the maker ecosystem in Denmark and internationally. It focuses on increasing 3D printing technology adoption like through increasing speed, quality, ease of use, system interoperability and standards. The case is positioned between the community and the ecosystem level of the vertical axis in Figure 6 by creating key partnerships with all the actors of the industry to solve general barriers of technology adoption. On the horizontal axis, the case is located between social demand and societal challenge, by acting on the core technology level it aims to empower an entire industry and this way boost innovation of individuals and organisations.

7.10. FabLab Zagreb: small but active NGO FabLab as the first in the country (Croatia)

FabLab Zagreb is the first FabLab in Croatia, registered as an NGO and with good relations with the Faculty of Architecture at Zagreb University, which also undertakes teaching. FabLab Zagreb is based on the Fab Charter and its main focus is to promote digital fabrication to general public in cooperation with similar organisations on local level and internationally. FabLab Zagreb has experience in local maker workshops and strongly believes that value aided generated in these can significantly contribute to the local economy, but also to well-being of modern society. The case is positioned between the collaboration and community level of the vertical axis in Figure 6 and on the horizontal axis it is solving a wide range of social and other needs and moving towards contributing to meeting wider societal challenges in these areas. It specially focuses on children, the unemployed, disabled, artists and students, and works with the Faculty of Architecture at Zagreb University for teaching purposes.

8. Annex II: Taxonomy definitions

8.1. Society

8.1.1. Zero Marginal Cost Society

In the field of economics, the term 'marginal cost' refers to the added monetary cost of producing a single unit of a product, given that the infrastructure (e.g. factory) for production already exists. The concept of the 'Zero Marginal Cost Society' was introduced by the writer and futurologist Jeremy Rifkin (2014), to indicate a possible future state whereby the infrastructure for producing products is pervasive and free to use. In this state, individuals can make use of digital designs and production facilities to produce desired products at zero cost. An additional assumption of this idea is that solar energy will have reached the efficiency and infrastructural maturity whereby that too is free. The implications of this future state is that the cornerstone of the dominant capitalist economy will fail, leading to wholly new economics.

***MAKE-IT* focus**: Part of Rifkin's future scenario is the extensive availability of maker technology. However, as far as the project is concerned, the current state of maker infrastructure, as well as the price of raw materials and energy, is a long way from fulfilling the idea of the zero marginal cost society. Nevertheless, on a political level, the potentially disruptive nature of the maker movement for our dominant economic processes is so great that vested interests may attempt to either speed-up or block the maker movement's progress. It is important for the project that we are aware of this high level political dimension.

8.1.2. Ecosystem

Bloom and Dees (2008) identify two main sections to look at when analysing social ecosystems: players and environmental conditions. Similar to these categories, we suggest the usage of the terms actors and spaces, as this links to MAKE-IT's analytical framework. Actors is a commonly used term in e.g. sociology or political science and can be used to describe individuals as well as organisations or institutions. Based on an actor-centric view it is also possible to analyse environmental conditions that are linked to the decisions or practices of actors. Spaces, on the other hands, appears to be a broader term in order to cover physical and virtual spaces (including communities, those connected by ICT means or networks of people who know each other personally, as also used in MAKE-IT's analytical framework). Hence, it is possible to refer to physical spaces such as rooms as well as to countries or regions (also referred to as «place») that might also show a specific setting of environmental conditions.

A second strand of discussions concerning the Social Innovation (SI) ecosystem deals with the notion of what counts as an "ecosystem"; does it only comprise supporting factors of a SI – this is the notion introduced by the "incubator scene" or linked to the "fertilising" idea – or will hindering factors also be included in the understanding of ecosystem? This definition aims for a holistic perspective, including hindering factors also in the notion of "ecosystem".

Gobble (2014) states that the terms ecosystem and value network are not the same, and she stresses the complexity of the ecosystem dynamics: "An ecosystem, in contrast [to a value network], is a complex, dynamic, emergent system that constantly adapts, sometimes in unexpected ways" (Gobble, 2014, p. 55).

Perhaps the most useful definition for our purposes comes from Willis (1997, p. 270): "The definition of ecosystem can be refined as a unit comprising a community (or communities) of organisms and their physical and chemical environment, at any scale, desirably specified, in which there are continuous fluxes of matter and energy in an interactive open system." Willis' emphasis on the scale of the ecosystem is because this is frequently not specified in studies of ecosystems. Ecosystems can be as small as a patch of soil supporting plants and microbes; or as large as the entire biosphere of the Earth. However, all instances of ecosystems have an explicit spatial extent, which researchers must specify (Likens 1992; Odum 1993).

In conclusion, we propose a clarified definition of the business ecosystem in which SMEs reside, and the innovation ecosystem as a subsystem of the business ecosystem as follows: The business ecosystem is a unit comprising a community (or communities) of organizations and their physical, market and regulatory environment, at a specified scale, in which there are continuous fluxes of knowledge, finance and value in an interactive open system. An innovation ecosystem is a business ecosystem wherein organizations interact with an explicit focus on developing, and implementing new products, services or processes.

***MAKE-IT* focus:** ecosystem in our *MAKE-IT* mapping tends to be smaller scale but manifests as a well-functioning collaboration between actors typically with different types of actors with different and complementary roles and interests. This is a type from Dougherty's third group, 'maker to market': "From the workshops and the digital communities, a new wave of invention and innovation springs forth. Knowledge flows and concentrates. Some of the inventions and creations will appeal to a broader audience than the original makers. Some may even find commercial appeal. However, even if only a few makers pursue market opportunities, the impact may be huge."

8.1.3. Smart Regions

Smart regions tend to be extensions of smart cities and spread across an urbanised area, which may include a network of different sized cities or a metropolitan region. A recent definition of Smart City or Region stresses the social aspect, by describing it as: "a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of wellbeing, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development." (McPhee et al. 2015). From a more economic point of view, smart regions are associated with the concept of "smart specialization", which is defined as "an industrial and innovation framework for regional economies that aims to illustrate how public policies, framework conditions, but especially R&D and innovation investment policies can influence economic, scientific and technological specialisation of a region and consequently its productivity, competitiveness and economic growth path" (Perianez-Forte & Cervantes 2013)

***MAKE-IT* focus**: Both aspects, the social and the economic point of view are relevant in the context of *MAKE-IT*. For example, the Copenhagen case will be looking into the smart cities strategies and its connection to the maker movement.

8.1.4. Network

The term "Network" is a broad expression for an interconnected group of entities. In computer science, in which the network concept has become highly developed, network theory studies the relationships within graphs, whereby objects are connected by edges (West, 2001). This concept has been highly influential in the study of social networks, where the objects in a graph are social entities, such as people or organizations. The network concept is helpful as it aids researchers in understanding the structure and dynamics of groups. For example, simple centrality metrics can identify important entities, subgroups or relationships. These include degree (the number of edges incident on an entity), closeness (the average shortest path to all other entities), and betweenness (the number of times an entity lies on the shortest path between two other nodes).

***MAKE-IT* focus**: There is a relationship between what we understand as a network and as a community. This is an ongoing discussion in the project. Community is a subset of network, whereby there is a feeling of togetherness or 'sense of community' (McMillan & Chavis, 1986). A network as we understand it in *MAKE-IT* tends to be larger scale well-functioning collaboration between actors with relationships built on common needs and interests. This is also a type of Dougherty's third group 'maker to market' classification.

8.1.5. Social Media Network

Social media networks are computer-mediated tools that allow for users to create unique user profiles; access digital content through search mechanisms; articulate a list of other users with whom they share a relational connection; and view and traverse their connections (Kane, et al., 2012).

***MAKE-IT* focus**: There is a strong link between the concept of social media networks and that of collective awareness platforms (CAPS). Due to the focus of the Horizon2020 call from which the *MAKE-IT* project emerged, the use of the term CAPS is preferred. A clarification is needed: do these two concepts describe the same tools?

8.2. Movement

8.2.1. MAKER

A maker is an individual who makes or manufacture something, based on own creative ideas and designs (or shared by others). Makers can be DIY hobbyist as well as professionals, such as engineers, artist, and programmers. The created artefacts from makers can be mechanical, electrical, musical, visual, etc. According to Dougherty's classification of three groups of makers, the first is 'zero to maker' where "every maker has a different starting point. However, the common thread begins with an inspiration to invent, the spark that turns an individual from purely consuming products to having a hand in actually making them. To go from zero to maker, the two most important aspects are the ability to learn the requisite skills and access to the necessary means of production." According to Chris Anderson, Makers are defined by three features: (1) they use digital desktop tools to create designs for new products and prototype them ("digital DIY"); (2) they adopt a cultural norm to share those designs and collaborate with others in online communities; (3) they use common design file standards that allow anyone to manufacture them (Anderson, 2012).

***MAKE-IT* focus**: Makers are the main subject of the *MAKE-IT* project and any support infrastructures we create or modify are intended for them. The definition of maker is however very broad, so there will be probably a need for readjusting or improving the definition according to the specific stakeholders that will interact with the project.

8.2.2. Maker movement

The Maker movement includes all individuals (in Doughtery's (2012) words hobbyists, builders, hackers and other enthusiasts) and organizations (e.g. maker spaces) that pursue and advocate a maker culture (i.e. self-production and fabrication). The word movement in maker movement refers to social movements, which are *"collectivities acting with some degree of organization and continuity outside of institutional or organizational channels for the purpose of challenging or defending extant authority…"* (Snow et al., 2004, p. 11). Traditionally, there are large-scale ideological movements in society, such as the labour rights, environmental and peace movement. As a social movement, the maker movement strives for social change, which is the overcoming consumerism and mass production by promoting *a Maker culture*. Hence, words like 'industrial revolution' often accompany discourse regarding the Maker movement to emphasize the social goals of the movement. To achieve social change, social movements organize collective action outside the conventional channels to change markets, such as politics or lobbying (Hargrave & Van de Ven, 2006; Schneiberg & Lounsbury, 2008). Collective action may include protests, influence via government or watchdog organizations or promoting alternative practices and starting new organizational forms (King & Pearce, 2011). The Maker movement advocates a Maker culture by means of the latter: promoting maker activities (e.g. in education) and starting new organizational forms that challenge incumbent production-consumption patterns.

8.2.3. Community

A community is generally understood as a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings. McMillian & Chavis (1986) stresses the sense of community as core for a community; it is a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together (McMillan, 1976, in McMillan & Chavis, 1986). Their proposed definition is based in the elements of membership (feeling of belonging or of sharing a sense of personal relatedness), influence (a sense of mattering, of making a difference to a group and of the group mattering to its members), reinforcement (integration and fulfilment of needs met by the resources received through their membership in the group) and shared emotional connection (the commitment and belief that members have shared and will share history, common places, time or similar experiences) (ibid).

***MAKE-IT* focus**: When referring to communities in *MAKE-IT* we also refer to relatively intense collaboration between actors, though typically on a small scale with relationships built around common characteristics, common values and shared understanding. This is also a type from Dougherty's second group 'maker to maker'.

8.2.4. Community of Practice

A community of practice is generally defined as a group of people engaging in a collective learning process around a shared domain. The term was coined by Lave & Wenger (1991), and later further elaborated by Wenger (1998). The concept actually refers to long established practices of sharing experiences and mutual learning amongst people with shared interests, but gained attention with the advent of the Internet and related ICT, which allows communities of practice to interact in physical and virtual spaces. Three elements are core: the commitment to a domain, the development of shared practice and the establishing of relationships (Wenger-Trayner, 2011).

***MAKE-IT* focus**: In Dougherty's classification of three groups of makers communities of practice are clearly reflected in the second group "maker to maker". On platforms such as Thingiverse [23]we find groups that share a specific maker's interest, exchange design and practice, and create relationships. What makes up these virtual and physical platforms can be described as "people who share a passion for something they do and learn how to do it better" (Wenger-Trayner, 2011). Communities of practice are also relevant for *MAKE-IT* as they can potentially build links to CAPS.

23. https://www.thingiverse.com/

Arniani et al (2014) speak of communities around a common interest as being core to the CAPS development. Communities of practice can be seen as a specific type of communities of interest and their implication for CAPS is relevant for *MAKE-IT*.

8.2.5. Platforms & CAPS

By “platform” we mean the space (including virtual, physical and social spaces) where individuals and communities step into discourses. Platforms could be offline spaces (like FabLabs), online fora (like download repositories), events (like Maker Fairs) or publications (if they allow a discourse, for example a maker magazine). We closely link to the notion of "Collective Awareness Platforms for Sustainability and Social Innovation"[24] (CAPS). CAPS include online sites that create awareness of sustainability problems and offering collaborative solutions based on networks (of people, of ideas, of sensors), enabling new forms of social innovation. CAPS are expected to support environmentally aware, grassroots processes and practices to share knowledge, to achieve changes in lifestyle, production and consumption patterns, and to set up more participatory democratic processes.

8.3. Values

8.3.1. DIY

DIY or the do-it-yourself philosophy can stand for many messages, including critical making as a form of political participation (Ratto and Boler, 2014), DIY as civic learning (Meyer and Fourie, 2015) and DIY as a form of participatory design (Hamidi et al., 2015).

DIY originates from a critique of existing production systems, with their inherent lock-in mechanisms by closed hardware, proprietary innovations and authoritarian approaches to define what is best for consumers. The underlying argument is that affordable production machineries such as desktop 3D printers in combination with open source computer aided design and freely available construction files open up completely new choices for citizens who want to engage differently with the production and consumption of every day products (Ratto, 2011). However, looking at the technology landscape, different production systems are nothing new (e.g. Windows versus Android or in the hardware area, Makerbot versus RapRap 3D printers). Other concepts, closely linked with DIY, include 'open source', 'open innovation' or 'peer production' (Lindtner, 2013). At a larger scale DIY (and implicitly the maker movement) has

24. http://ec.europa.eu/digital-agenda/en/collectiveawareness

the potential to change economic orientations, such as the case of the Chinese government funding the creation of 100 'innovation houses' (Lindtner, 2013). By altering means of production, citizens could eventually co-create and change the structure of a society (Benkler, 2006).

Beside producing, it is claimed that DIY is a distinct change in how we learn. Whereas software has become increasingly more accessible to a broader audience (usability, user experience are the common key words here) this is not the case for hardware, where complexity and high costs for materials have been considerable barriers to learning. This changed with the advent of Arduino in 2005 (Mohomed and Dutta, 2015). Arduino made a crucial technology (i.e. microcontrollers) open, low-cost and comparatively easy to use. Bringing microcontrollers to users is having far reaching implications, not only in the technology sector but also in health care or innovations around smart fabrics, changing the world of fashion shows and textile production (Dias, 2015).

***MAKE-IT* focus:** An interesting question emerged while analysing different DIY accounts: 'What value proposition is linked to DIY?'. Certainly also a point that needs to be discussed in the *MAKE-IT* context. Linked to the value-proposition in general, we can consider the S in CAPS standing for 'social innovation'. It's a well-known challenge to tech activism, that under-served or in any way marginalised people may well have different ideas about the benefits of hacking and making. Considering the learning aspect, *MAKE-IT* could explore the extent to which DIY helps bridging the digital and physical world by creating materials such as e-textiles.

8.3.2. DIY Ethics

The term "'Do it yourself" (DIY) ethics' or 'DIY culture' expresses the attitude to fabricate and repair on our own without the help of professionals or paid experts. This attitude is meant to empower people since it implies that everybody has the capabilities to produce artefacts and to repair and accommodate existing products. The culture originally evolved in the 40ies and 50ies in the US simply for economic reasons. Nowadays, the DIY culture meets other needs (Lupton, 2006) and stands critically against trends such as mass-production, waste, and conspicuous consumerism. In the age of information society with a high percentage of white-collar jobs, people express increasingly the desire to manually do something, to customise products according to their needs and to personalise them (Spencer, 2008).

***MAKE-IT* focus:** The attitude of DIY and the respective empowerment are considered also as a core value in the digital maker movement. The hurdles of using 3D printers, laser cutters and other digital fabrication machines have been lowered to a high extent since their operation does not require professional knowledge and the usage is affordable for most people. In the framework of the *MAKE-IT* projects, it will be interesting to analyse the motivations of the users of FabLabs in the different case studies.

8.3.3. Collaboration

Collaboration is generally understood as working together to achieve or produce something. While collaboration and co-operation are often used together or synonymously the distinction lies in the fact that co-operation implies a shared/agreed aim, but the actual work can be done in a coordinated setting, while collaboration is the purpose of shared creation. "Collaboration is the act of working together to produce a piece of work, especially a book or some research (...) A collaboration is a piece of work that has been produced as the result of people or groups working together..." (Sinclair et al. 1995, p. 307).

***MAKE-IT* focus**: We see collaboration between actors as activities without forming a community or network. This is a type from Dougherty's second group, 'maker to maker': "The distinction in this stage is that makers begin to collaborate and access the expertise of others. At this stage, makers also contribute to existing platforms. Powerful undercurrents are at work, both from technological revolution as well as unleashing the innate desire for self-expression and creation. The desire to improve and share with others catalyzes the move to "maker to maker".

8.3.4. Business Model

A business model describes the rationale of how an organization creates, delivers, and captures value whether economic value, social value, cultural value or other contexts. The construction of a business model is an integral part of a business strategy.

The term is widely used in theory and practice for a broad range of informal and formal descriptions to represent core aspects of a business, including purpose, business process, target customers, product offerings, strategies, infrastructure, organizational structures, sourcing etc.

There is a range of business models frameworks. Probably the most well-known is the recent development of Osterwalder & Pigneur from 2010 in "The Business Model Canvas".

8.3.5. Inclusion

Inclusion constitutes one of the core values in the maker and FabLab movement as one of the aims was to make machines for digital fabrication accessible to anyone, in terms of economic affordability and in terms of education (Krannich, Robben & Wilske, 2012). "Inclusion" is referred to as the way that society changes towards the needs of people. The UN charta on rights of people with disabilities[25] changes the perspective that people with disabilities are seen as: It is important to understand that concepts like "vulnerability" or "marginalised" are not linked to a person (meaning that a person has a "deficit"), but rather to a non-suitable environment. Modern understanding of "inclusion" points very much to the conditions of environments: Do they meet the needs of everybody? Which are barriers? People on the other side are rather regarded as rich of potentials, only hindered by environments. The operation of these machines in maker spaces does not require a high level of technological expertise but makers claim that with a little help anyone can realise their own ideas. Furthermore, the maker community mostly relies on open source software. FabLabs have spread around the world, in rural areas as well as developing countries (Gershenfeld, 2008; Lassiter, 2009). However, Herrera and Juarez (2013) point out that the associated costs with installing a FabLab in African or South-American countries are between 3 to 8 times higher. Although there are initiatives that support diversity in the maker communities (e.g. Justice & Markus, 2010; Smith et al., 2013), there is still the image of the domain of „white male nerd dominance“ (Grenzfurthner & Schneider, 2009).

***MAKE-IT* focus:** We understand FabLabs as places that are accessible and appreciative and aware of the needs of different target groups. Interesting questions will be: Do the FabLabs meet the needs of everybody? Can barriers be identified (e.g. in terms of economic, educational, ethnic, regional barriers, people with disabilities, gender, etc.)?

8.4.Tools

8.4.1. Digital Fabrication

Digital fabrication refers to a manufacturing process where the fabrication machinery used are controlled by computers through the use of 3D modelling software or computer-aided design (CAD). There is a huge range of digital fabrication techniques. The important aspect that unifies them is that the machines can be programmed to make consistent products from digital designs. The most common forms of digital fabrication are:

- CNC Machining: where shapes are cut out of sheets of hard materials, such as wood, composites, aluminium, steel, plastics, and foams.
- 3D Printing: in which successive layers of material (plastic and metals) are laid down under computer control. These objects can be of almost any shape or geometry, and are produced from a 3D model
- Laser Cutting: where materials like acrylic, veneer, leather etc. are cut or engraved by a laser beam
- Vinyl cutting: refers to the process where a computer controls the movement of a sharp blade. This blade is used to cut out shapes and letters from sheets of thin self-adhesive plastic (vinyl).

25. http://www.un.org/disabilities/default.asp?id=259

Most advanced digital fabrication is now taking place in biotechnology. Organ printing or human tissue printing refers to the application of the principles of rapid prototyping technology (i.e. layer by layer deposition of cells or matrix) and is evolving into a promising approach for engineering new tissues or organs. 3D bioprinting has already been used for the generation and transplantation of several tissues, including multi-layered skin, bone, vascular grafts, tracheal splints, heart tissue and cartilaginous structures. Other applications include developing high-throughput 3D-bioprinted tissue models for research, drug discovery and toxicology.

8.4.2. Direct Digital Manufacturing

Direct Digital Manufacturing is a new manufacturing paradigm characterised by the combination of additive / subtractive manufacturing equipment and supporting 3D computer-aided design tools (Gibson, Rosen, & Stucker, 2014). Digital manufacturing holds the promise to produce ever smaller batches of products in cost-effective and sustainable ways. Smaller batches in turn allow for greater variety and hence customisation of products. Digital manufacturing allows us to skip phases of the traditional value chain, at least partially, such as identifying dedicated production sites and handling logistics and assembling the final product. All these steps can be executed close to the consumer's location.

***MAKE-IT* focus:** What changes with digital manufacturing is the origin of designs and product ideas. Whereas in traditional manufacturing craftsman and designers were leading the process, now consumers can take a more active role and can become product designers themselves (Chen et al., 2015). By empowering consumers, digital manufacturing is often labelled as a disruptive technology (Gibson et al., 2014). The product development cycle is considerably shortened and 3D models can be built seamlessly, much in the sense of What You See Is What You Build (WYSIWYB). Additionally, through the use of 3D printing and other CNC (Computerized Numerical Control) machines, there are less skills required to produce the final product, when prior to digital manufacturing prototyping included a wide range of activities such as carving, molding and forming (ibid.).

8.4.3. Additive Manufacturing

Additive manufacturing (AM) includes rapid prototyping technologies such as stereo-lithography, laser powder forming or selective laser sintering. The aim is to reduce costs and get an idea of the suitability of a design early on (e.g. for prototyping) or to directly fabricate a product based on a 3D CAD model (Chen et al., 2015).

There are three types of additive manufacturing: powder based, liquid based and solid based (Kruth, Leu, & Nakagawa, 1998). The manufacturing process builds the final product by constructing layer upon layer, whereas the thickness of the layer determines the resolution of the product, having implications for surface quality and details that can be shown by the 3D printed object. Possible materials range from wax, paper, plastics or metals, to nutritional materials such as chocolate or pasta. Extensive material combinations are still rare for desktop 3D printers.

***MAKE-IT* focus:** An important development within the context of the *MAKE-IT* project are advances for relatively low-cost 3D printing machines for consumers' desks. One of the earlier developments is the RepRap (self-replicating rapid prototyping) project, initiated by Bowyer in 2011 (cf. Jones et al., 2011). RepRap is based on open source hardware, open source design and open source programming, and resembles a robot that can partially replicate itself by printing its own parts. Current consumer 3D printing still lacks robustness and the ease of use consumers are used to from laser printers for example. However, this is poised to change in the future and 3D printers could become part of household equipment.

8.4.4. Open Design

The philosophy, tools and methods of the Open Source communities have been applied to many fields beside software development, including the design and manufacturing of physical objects. There have been many different kind of Open Source applied to the Design practice (i.e. Open Design): in fashion design, in typography, in architecture, in product design. Not all of them are, therefore, related only to physical objects; there are also approaches dedicated to the open design of design processes and of community-based services. Within the Maker movement Open Design (together with Open Source Software and Open Hardware) is one of the possible approaches to the sharing of information and to the development of collaborative projects among Makers.

***MAKE-IT* focus:** Many projects developed by Makers are examples of Open Design, and several CAPs for Makers work in this direction (Thingiverse, Instructable, …). It is important to consider these dynamics, methods and tools when focusing on the organization of collaborative projects among makers.

8.5. Spaces

8.5.1. Maker Laboratory

Makers tend to gather in online communities but also in physical places, and both can be considered as CAPs for the Maker movement. There are many different kind of physical places where makers gather: temporary places like Maker Faires or stable places like workshops or laboratories where they can access infrastructure, tools, machines, materials, components, resources, communities. These laboratories can be labelled with several terms: Makerspaces, Hackerspaces, Fab Labs, TechShops, Sewing Cafes, Repair Cafes and so on (and there are even laboratories that cannot be clearly labelled). Since most of these laboratories have been developed in a bottom-up and distributed way, the differences among them (and among the main formats or labels) are sometimes difficult to tell (some laboratories even define themselves as both one format and another: a Fab Lab/Makerspace) and sometimes are used to identify a laboratory as opposite to another (a Makerspace, not a Fab Lab). A data-driven research suggested that, for example, these laboratories might be polarized around Fab Labs on one side and Makerspaces, Hackerspaces and TechShops on another side, as depicted in Figure 17. (Menichinelli, 2016). The Makerspace term is sometimes used as a generic term for all these laboratories, but this data-driven exploratory research shows that it could work only for half of these laboratories. The Maker Laboratory term therefore is introduced as a generic term for all these laboratories.

***MAKE-IT* focus:** Our research and improvements should be available for all the Maker sub-communities and the format of laboratories, trying to avoid at the same time terms that might suggest we are working only on one format of laboratory. Tools, platforms and contents from one format of laboratory should be available to other formats as well (for example: fablabs.io is open source and can be rebranded for Hackerspaces, Makerspaces, ….).

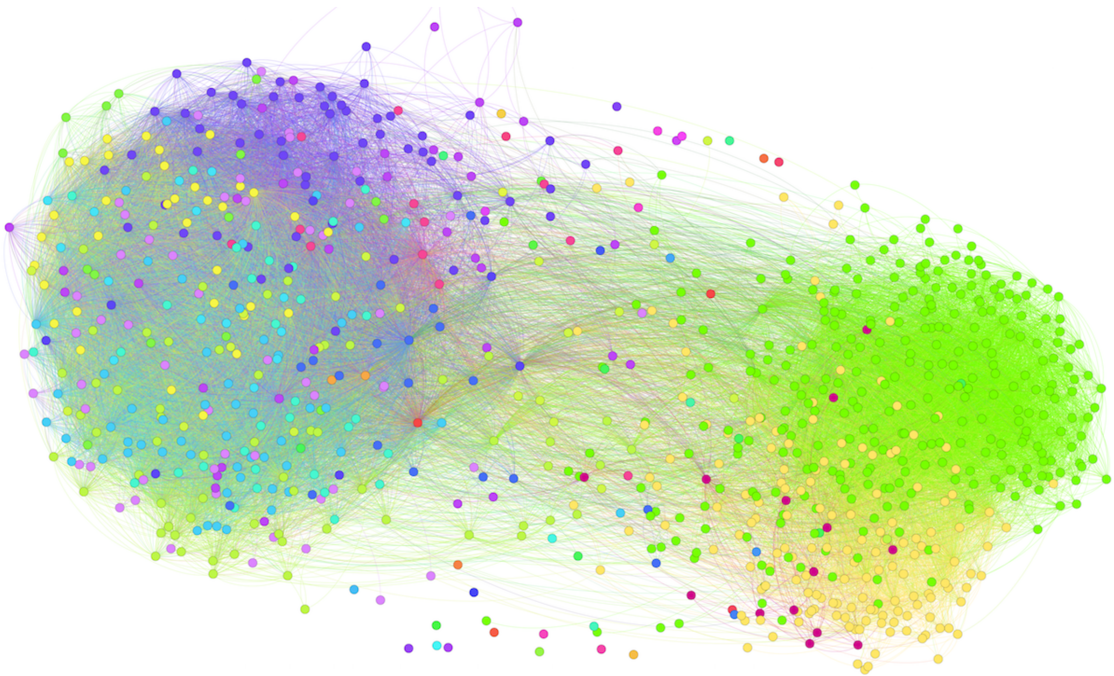

Figure 17: Polarized Maker Laboratories communities on Twitter: Fab Labs on the left, Makerspaces and Hackerspaces on the right (Menichinelli, 2016).

8.5.2. Makerspace

A *makerspace*, or hackerspace, is a shared working/hobby space in which *makers* with common interests share a physical space, materials, self-production tools, such as 3D printing technologies, knowledge, and other resources that are required for self-production (Toombs, Bardzell & Bardzell, 2014). Examples of makerspace initiatives are the Fab Lab or TechShop chains. See below for an extensive typology of these different chains of makerspaces.

8.5.3. Fab Lab

A Fab Lab is a kind of maker laboratory where anybody can have access to knowledge, communities and machines related to making and especially to digital fabrication. Fab Labs have emerged as a global network almost by accident as a consequence of the popularity of the educational outreach component of MIT's Center for Bits and Atoms (CBA), an extension of its research into digital fabrication and computation. All Fab Labs share common traits (even if to a different level in each lab) and therefore are part of a global network of distributed laboratories for research and invention (Fab Foundation, 2013a). These common traits are generally considered to be the main four criteria a laboratory needs to follow in order to be defined a Fab Lab, which must (1) provide a public access; (02) support and subscribe to the Fab Charter, the manifesto of Fab Labs (CBA, 2012); (03) share a common set of tools and processes; (04) participate in the larger, global Fab Lab network (Fab Foundation, 2013b). The global network is mapped on the fablabs.io platform, it meets every year in a global conference / festival (FAB10, FAB11, FAB12, …) and has a global and distributed educational format called Fab Academy which enable people to learn digital fabrication and how to participate in the global network. The US and global network is facilitated by the Fab Foundation, but there are many networks and organizations at several levels, from city to regions to countries to continents.

***MAKE-IT* focus:** Some partners in the consortium are Fab Labs, and the Fab Lab global network (but also the many regional networks) are interesting cases of how to organize maker communities. Furthermore, the online platform for the Fab Lab community, fablabs.io, is developed at Fab Lab Barcelona and it is released as open source online, therefore it could be easily adopted by many other Maker Laboratory communities.

8.6. Artists spaces

Artist spaces are to a high extent similar to maker spaces as both allow for and support creative process and fabrication of design and art objects and as they merge in many locations. FabLabs, for instance, are often used for prototyping objects before mass production in the design and prototyping phase, they are used for customised and personalised products that differ from objects from mass-production and are thus an expression of individual creativity (c.f. Walter-Herrmann & Büching, 2014). Objects range from printed jewellery (Yap & Yeong, 2014) to e-textiles (Kafai et al., 2014), to name but a few. Furthermore, maker spaces and FabLabs are typically used by architects and architecture and design students to build models of their ideas and constructions. There are many examples that make a distinction between maker and artists spaces difficult to draw. Also, maker spaces are increasingly used as artists spaces as they often include an exhibition area (e.g. in Ars Electronica Museum (Posch, Ogawa, Lindinger, Haring, & Hörtner, 2010)) and the other way around. Art and architecture universities often have installed a maker space for their students to craft their ideas.

***MAKE-IT* focus:** It will be interesting to see in our case studies where maker spaces and artists spaces merge or overlap or where there is a clear delineation between the two. *MAKE-IT* will further analyse the perceived self-image of the users, whether they see themselves as makers or rather as artists and how their use culture differs.

8.6.1. Techshops

Techshops started in 2006 in the United States. Functioning based on membership fees, the Techshop is the for-profit version of makerspaces, where users are viewed as customers. The geographical scope of the Techshop as a trademark is confined to the US, yet its business model sometimes inspires Fab Labs running on membership fees.

***MAKE-IT* focus:** Incorporating TechShops into the list of concepts enables us to perceive the singularities of for-profit models for makerspaces and raises questions in the debate regarding business models: can for-profit business models be conciliated with a community of makers or are those two elements antithetical?

8.7.Events

8.7.1. Makathon

A *Makathon* is a combination of the words Makers and Marathon. A Makathon is specific version of a hackathon (combination of hackers and marathon) intended for makers. A makerthon is an event to jointly innovate and develop prototypes that typically lasts a few days (Raatikainen et al, 2013). Instead of professionals working on innovation, makathons are intended for amateurs that volunteer to participate (Austen, 2013). The host of the makathon often provides a reward for the best prototype and resources for during the event (e.g. food, materials and music).

8.7.2. Maker Faire

Maker Faire is an event created by Make magazine to celebrate arts, crafts, engineering, science, DIY projects from and for the Maker movement. Since its launch in 2006, it has expanded worldwide to more than 150 faires in 2015. There are now two flagship events (Bay Area and New York); twenty larger-scale, independently produced, "featured" Maker Faires (Atlanta, Detroit, Kansas City, Milwaukee, Orlando, Pittsburgh, Silver Spring, San Diego, Paris, Rome, Oslo, Newcastle (UK), Berlin, Hannover, Trondheim, Seoul, Taipei, Tokyo, Singapore, and Shenzhen); a large number of Mini Maker Faires that took place in communities around the world (Maker Media, 2015). Since 2013, Maker Faire Rome has been the main edition for Europe. The organization of independent faires (Maker Faires and Mini Maker Faires) is linked to a successful application to the use of the official license and agreement with Maker Media.

***MAKE-IT* focus:** Maker Faires are one of the many formats of events where makers meet, and it is especially interesting because it is distributed all over the world with events of different size and that take place during the whole year (and not just in a specific part of the year). They represent therefore a very useful strategy for contacting local maker communities all over Europe, be it in the main European Faire (Rome) or in the many Faires or Mini Faires.

8.8.References

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