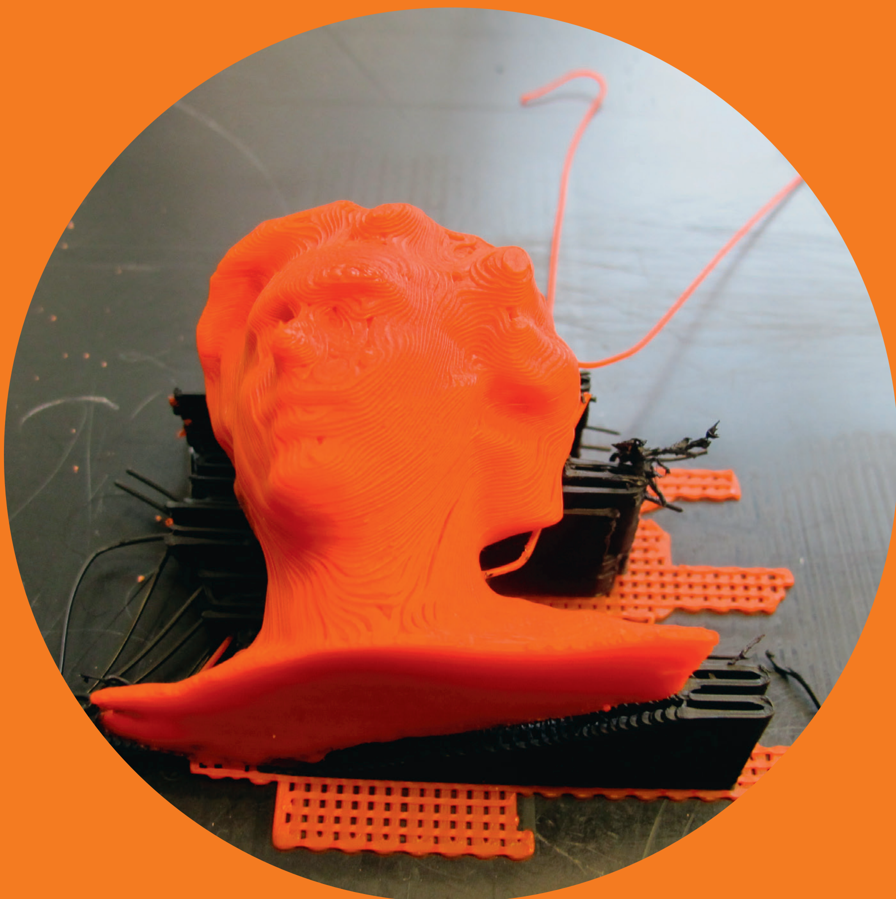
Department of Media, Aalto Media Lab

Open and collaborative design processes

Meta-Design, ontologies and platforms within the Maker Movement

Massimo Menichinelli



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DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 165/2020

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Massimo Menichinelli

Aalto University
School of Arts, Design and Architecture
Department of Media, Aalto Media Lab

Supervising professor
Professor Lily Diaz-Kommonen, Aalto University, Finland

Thesis advisor
Professor Ramon Sangüesa Sole, Polytechnic University of Catalonia, Spain

Preliminary examiners
Professor Mithra Zahedi, University of Montreal, Canada
Professor Elisa Giaccardi, Delft University of Technology, The Netherlands

Opponent
Professor Elisa Giaccardi, Delft University of Technology, The Netherlands

Aalto University publication series
DOCTORAL DISSERTATIONS 165/2020

ISBN 978-952-64-0090-7 (printed)
ISBN 978-952-64-0091-4 (pdf)
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-64-0091-4

Unigrafia Oy
Helsinki 2020

Finland

Printed matter
4041-0619

Aalto University

Abstract

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Author
Massimo Menichinelli

Name of the doctoral dissertation
Open and collaborative design processes

Publisher School of Arts, Design and Architecture

Unit Department of Media, Aalto Media Lab

Series Aalto University publication series DOCTORAL DISSERTATIONS 165/2020

Field of research New Media

Date of the defence 11 November 2020

Language English

☐ **Monograph** ☒ **Article dissertation** ☐ **Essay dissertation**

Abstract

The emergence of the Maker Movement has taken place in the context of a design practice and research that is now open, peer-to-peer, diffuse, distributed, decentralized; activity-based; meta-designed; ontologically-defined and defining; locally-bounded but globally-networked and community-centered. For many years the author participated and worked in the Maker Movement, with a special focus on its usage of digital platforms and digital fabrication tools for collaboratively designing and manufacturing digital and physical artifacts as Open Design projects. The author's main focus in practice and research as a meta-designer was in understanding how can participants in distributed systems collaboratively work together through tools and platforms for the designing and managing of collaborative processes. The main research question of this dissertation is: How can we support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems?

The focus evolved and changed with three main phases: from facilitating collaborative design processes with 1) guidelines for a generic design approach, process and tools, to the use of 2) design tools and workshops that encode the methodology to developing 3) a digital ontology and the related digital platform. In the latter, the ontology for describing, documenting, sharing and designing collaborative design processes was developed as part of a broader conceptual framework, OpenMetaDesign, that builds the ontology on top of concepts describing design processes, and encodes it in a digital platform. The role of the ontology is to support the practice and research with a Research through Design approach that works not just on understanding the practice but also informing it, navigating it and continuously redesigning it. This dissertation is an exploration of the possible role, practice and profile of meta-designers that work in facilitating distributed, open and collaborative design and making processes in the Maker Movement. As a result, it provides insights on the practice and artifacts of the author and also a strategy and tools for applying the same exploration to other meta-designers. Following a Research through Design framework for bridging practice and research, the dissertation redefines Meta-Design in the Maker Movement as the design of digital ontologies of design processes as design material. Ultimately, the practice of designing a Metadata Ontology for Ontological Design through the design of bits (digital environments) and atoms (physical artifacts) with and for Open, Peer-to-Peer, Diffuse, Distributed and Decentralized Systems. Finally, it redefines meta-designers as designers, facilitators, participants, developers and researchers embedded in social networks that define their activities, profiles and boundaries for the ontologies they design.

Keywords meta-design, maker movement, platforms, ontology, design processes, collaborative design, open design

ISBN (printed) 978-952-64-0090-7 **ISBN (pdf)** 978-952-64-0091-4

ISSN (printed) 1799-4934 **ISSN (pdf)** 1799-4942

Location of publisher Helsinki **Location of printing** Helsinki **Year** 2020

Pages 318 **urn** http://urn.fi/URN:ISBN:978-952-64-0091-4

Aalto-yliopisto
Aalto-yliopisto, PL 11000, 00076 Aalto www.aalto.fi

Tiivistelmä

Tekijä
Massimo Menichinelli

Väitöskirjan nimi
Open and collaborative design processes

Julkaisija Taiteiden ja suunnittelun korkeakoulu

Yksikkö Median laitos, Aalto Media Lab

Sarja Aalto University publication series DOCTORAL DISSERTATIONS 165/2020

Tutkimusala Uusi media

Väitöspäivä 11.11.2020

Kieli Englanti

☐ **Monografia** ☒ **Artikkeliväitöskirja** ☐ **Esseeväitöskirja**

Tiivistelmä

Maker-liike on syntynyt suunnittelukäytänteiden ja tutkimuksen kontekstissa, joka on avoin, vertaisuuteen perustuva ja hajautettu, toimintaan perustuva, metasuunniteltu, ontologisesti määritelty, paikallisesti rajattu mutta globaalisti verkottunut ja yhteisökeskeinen. Tutkija osallistui vuosien ajan maker-liikkeen toimintaan ja keskittyi siihen, miten liike käyttää digitaalisia alustoja ja digitaalisen valmistamisen työkaluja yhteissuunnitteluun ja sekä digitaalisten että fyysisten esineiden valmistamiseen avoimen suunnittelun projekteissa. Tutkijan käytännön työn ja tutkimuksen painopiste metasuunnittelijana oli ymmärtää, miten osallistujat voivat tehdä yhteistyötä hajautetuissa järjestelmissä yhteistyöhön perustuvien prosessien suunnitteluun ja hallintaan tarkoitettujen työkalujen ja alustojen avulla. Tämän väitöstyön keskeinen tutkimuskysymys on, miten voimme tukea ja integroida metasuunnittelijoiden tutkimusta ja käytännön työtä avoimen ja yhteissuunnittelun prosessien analysoinnissa, suunnittelussa ja jakamisessa avoimissa, vertais- ja hajautetuissa järjestelmissä. Työn painopiste muotoutui kolmessa päävaiheessa: yhteissuunnittelun prosessien helpottamiseksi laadittiin 1) yleistä suunnitteluperiaatetta, prosesseja ja työkaluja koskevat ohjeet, joita on tarkoitus käyttää 2) suunnittelutyökaluilla ja -työpajoissa, joissa koodataan menetelmiä 3) digitaalisen ontologian ja siihen liittyvän digitaalisen alustan kehittämiseen. Viimeisessä vaiheessa kehitettiin ontologiaa yhteissuunnittelun prosessien kuvaamiseen, dokumentoimiseen, jakamiseen ja suunnitteluun osana laajempaa konseptuaalista viitekehystä OpenMetaDesignia, joka rakentaa ontologian kehittämisprosesseja kuvaavien konseptien päälle ja koodaa sen digitaaliselle alustalle. Ontologian tehtävä on tukea käytännön työtä ja tutkimusta Research through Design -periaatteen kautta, joka ei auta vain käytännön työn ymmärtämisessä, vaan myös ruokkii, ohjaa ja uudistaa sitä. Tässä väitöstyössä tutkitaan sellaisen metasuunnittelijan mahdollista roolia, työtä ja profiilia, joka työskentelee helpottaakseen hajautettuja, avoimia ja yhteistyöhön perustuvia suunnittelu- ja toteutusprosesseja maker-liikkeessä. Näin väitöstyö antaa käsityksen tutkijan työstä sekä strategian ja työkaluja, joilla voidaan tarkastella toisten metasuunnittelijoiden työtä samaan tapaan. Tutkimus käyttää Research through Design -kehystä yhdistämään työn ja tutkimuksen sekä uudelleen määrittelee metasuunnittelun maker-liikkeessä suunnittelumateriaalina toimivien suunnitteluprosessien digitaalisten ontologioiden suunnitteluksi. Pohjimmiltaan se on metadataontologian suunnittelua ontologista suunnittelua varten kehittelemällä bittejä (digitaalisia ympäristöjä) ja atomeja (fyysisiä esineitä) sekä avoimille, vertais- ja hajautetuille järjestelmille että niiden kanssa. Lopulta se uudelleen määrittelee metasuunnittelijat suunnittelijoiksi, mahdollistajiksi, osallistujiksi, kehittäjiksi ja tutkijoiksi, jotka toimivat tiiviinä osana sosiaalisia verkostoja, jotka määrittävät heidän toimintansa ja profiilinsa sekä rajoitukset heidän

Avainsanat metasuunnittelu, maker-liike, alustat, ontologia, suunnitteluprosessit, yhteissuunnittelu, avoin suunnittelu

ISBN (painettu) 978-952-64-0090-7 **ISBN (pdf)** 978-952-64-0091-4

ISSN (painettu) 1799-4934 **ISSN (pdf)** 1799-4942

Julkaisupaikka Helsinki **Painopaikka** Helsinki **Vuosi** 2020

Sivumäärä 318 **urn** http://urn.fi/URN:ISBN:978-952-64-0091-4

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ART. 2. Menichinelli, Massimo. 2015. ‘Open Meta-Design: Tools for Designing Collaborative Processes’. In *Empowering Users through Design: Interdisciplinary Studies and Combined Approaches for Technological Products and Services*, edited by David Bihanic, 193–212. New York, NY: Springer. https://doi.org/10.1007/978-3-319-13018-7_11.

ART. 3. Menichinelli, Massimo. 2017. ‘A Data-Driven Approach for Understanding Open Design. Mapping Social Interactions in Collaborative Processes on GitHub’. *The Design Journal* 20 (sup1): S3643–58. https://doi.org/10.1080/14606925.2017.1352869.

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ART. 5. Menichinelli, Massimo. 2018. ‘A Shared Data Format for Describing Collaborative Design Processes’. In *Cumulus Conference Proceedings Paris 2018 – To Get There: Designing Together*, Cumulus Conference Proceedings Series 03/2018 Paris:190–215. Cumulus. https://www.cumulusassociation.org/cumulus-conference-proceedings-paris-2018-to-get-there-designing-together/.

ART. 6. Menichinelli, Massimo. 2018. ‘Service Design and Activity Theory for the Meta-Design of Collaborative Design Processes’. In *ServDes2018. Service Design Proof of Concept, Proceedings of the ServDes.2018 Conference, 18-20 June, Milano, Italy*, 994–1008. Linköping, Sweden: Linköping University Electronic Press, Linköpings universitet. http://www.ep.liu.se/ecp/article.asp?issue=150&article=083&volume=#.

ART. 7. Menichinelli, Massimo. 2019. 'A Research through Design Framework from the Evaluation of a Meta-Design Platform for Open and Collaborative Design and Making Processes'. *Proceedings of the Design Society: International Conference on Engineering Design* 1 (1): 21–30. https://doi.org/10.1017/dsi.2019.5.

List of Abbreviations

ART.	article
CONTRIB.	contribution
DDD	diffuse, distributed, decentralized
MDPI	Meta-Designer Profile Index
METH.	research method
Open/P2P/DDD Systems	Open, Peer-to-Peer, Diffuse, Distributed, Decentralized Systems
RQ	Research question
SIA	Social Impact Assessment

Whenever possible, the abbreviations of this dissertation follow the indications of the Oxford English Dictionary (Oxford University Press 2020).

Glossary

Activity Theory	Cultural Historical Activity Theory (CHAT) or Activity Theory is a framework for orienting researchers in understanding complex socio-technical phenomena by focusing on the co-evolution of individual mind and collaborative work and the dialectic contradictions they generate in the continuous development of individual contributions to collaborative initiatives. Activity Theory considers human activities with a systemic perspective by taking into consideration all the elements that mediate all the activities and their contexts (Yamagata-Lynch 2010; Kaptelinin and Nardi 2009; Gay and Hembrooke 2004; Engeström 1987).
collaborative design	While the term “collaboration” expresses the generic idea of working together with others or with an agency or instrumentality with which one is not immediately connected with (Merriam-Webster 2020b), the “collaborative” design terms refers to design activities performed by distributed actors with a shared objective (Kock 2009). The focus is not on traditional studio or school teamwork but on how ICT have enabled distributed teams to work at larger scale: collaborative design could be intended as a shorter term for Computer Supported Collaborative Design (CSCD), which “is carried out not only among multidisciplinary product development teams within the same company, but also across the boundaries of companies and time zones, with increased numbers of customers and suppliers involved in the process” (Shen, Hao, and Li 2008, 855). The focus of collaborative design is thus on the technological and organizational dimension of collaborative design processes.
co-design	The term “co-design” is associated with disciplines interested in product/technology design and development framed not as value creation and capture (as in co-creation) but as the relationships between designers and users, between formal and informal, professional and non-professional actors (Marttila and Botero 2013). The focus of co-design is thus on the relationship, formal/informal and culture building dimensions of collaborative design processes.
Maker Movement	The Maker Movement is a global community of distributed individuals, makers, who share the same attitudes towards designing and making with digital tools. Makers are both formally and informally trained individuals who develop design projects with a) the use of digital desktop tools for designing and prototyping artifacts; 2) the adoption of common cultural practices and collaborative processes of sharing these designs with their communities; 3) the production of artifacts with the use of digital manufacturing technologies, spaces and services (Anderson 2012). Makers often gather in laboratories where they can design collaboratively, prototype and manufacture their projects thanks to the digital fabrication technologies that these laboratories offer: Fab Labs, Makerspaces, Hackerspaces, DIY Bio Labs, Sewing Cafes, and local events like Maker Faires.

mass-participation	Mass-participation has always been one of the main general expectations of Internet-based initiatives and platforms, especially following the phenomenon of Web 2.0 (Shirky 2008; 2011; Surowiecki 2005; Tapscott and Williams 2006; 2010). The scale of the Internet and of the World Wide Web enabled several initiatives with different organizational formats that reached different formats of mass-participation, from the low-coordination, low-cost, low-risk online activism of slacktivism (Lee and Hsieh 2013; Christensen 2011) to more organized, still distributed and wide activism such as Anonymous (Coleman 2014); from collaborative writing and editing of content on Wikipedia by human actors (Rijshouwer 2019) and non-human actors as well (Tsvetkova et al. 2017; Zheng et al. 2019); from the large-scale effort of the development of the Linux kernel (Kuwabara 2000; Corbet, Kroah-Hartman, and McPherson 2015) to the large-scale of small individual open source projects (Lima, Rossi, and Musolesi 2014; Rastogi et al. 2018). In the context of this dissertation, mass-participation intends those efforts that, albeit often informally organized, can be considered community-based as the efforts in community-building and managing are central to the culture of participants.
Meta-design	Meta-design is an emerging design culture that focuses on how designers can design their own design processes, tools, media, environments, organizations, spaces and flows of participation in a self-transformative way while also allowing users to act as designers. Meta-design extends design after the traditional design process ends, extends the design infrastructure to all designers by focusing the design of evolvable systems that enable designing artifacts, instead of focusing directly on the artifacts (Giaccardi 2003; Giaccardi and Fischer 2008; Ehn 2008; Wood 2011; Fischer 2003).
Open Design	Open Design is one of the most popular approaches to integrating Open/P2P/DDD Systems with design as the intersection of design (product, fashion, typographic design and so on) with open source (these approaches are documented in ART. 1). It is commonly credited that the first proposal of Open Design was developed by the designer Ronen Kadushin (Troxler 2011). According to Ronen Kadushin, open design projects are digitally shared CAD information published online under a Creative Commons license that can be downloaded, produced, copied, modified, and produced directly from file by CNC machines (Kadushin 2010). An ongoing, open source and collaborative effort for defining Open Design (to which the author has been part of – documented in ART. 3) elaborated a long document that starts with this concise definition (Menichinelli et al. 2016): > Open Design is a design artifact project whose source documentation is made publicly available so that anyone can study, modify, distribute, make, prototype and sell the artifact based on that design. The artifact's source, the design documentation from which it is made, is available in the preferred format for making modifications to it. Ideally (but not exclusively necessary), Open Design uses readily available components and materials, standard processes, open infrastructure, unrestricted content, and open-source design tools to maximize the ability of individuals to make and use hardware.
Open P2P Design	A set of design guidelines and concepts for supporting communities in developing open and peer-to-peer organizational forms and collaborative activities through a design process itself based on such forms and activities.
Open/P2P/DDD	Web-based initiatives and technologies based or inspired on open source and peer-to-peer principles, practices and tools that have become inter-

Systems	esting for their ability to exploit the possibility of scaling to hundreds or thousands of people. Beside the technological dimension, they are considered for the collaborative networks they can enable as diffuse, distributed and decentralized systems. Diffuse systems consist of agents that are spread and not connected or coordinated (if not at the local level then within a very short range) and where activities and assets are not homogeneously present in all the agents. Distributed systems connect of activities and assets that are shared and coordinated among the agents, and where control and influence is spread as much as possible among the agents and locally optimized at short range. Decentralized systems comprise activities and assets that are shared and coordinated among the agents, and where control and influence is concentrated among few nodes instead of a single one. Open and P2P systems, coupled with general Diffuse, Distributed, Decentralized Systems are within this dissertation the main technological and organizational perspectives for understanding and supporting phenomena of mass-participation with a design approach.
OpenMetaDesign	*Framework:* An evolution of Open P2P Design, it is a program that informs Research through Design initiatives for design practice, research and education for the meta-design of open, collaborative and distributed processes. This framework is based on four dimensions: conceptual (the philosophy and its context), data (an ontology of design processes), design (the visualization and design of designing processes) and software (the connection between the ontology and the visualization, the data and design). *Software:* A digital platform that enables multiple actors to collaboratively design and discuss collaborative design processes in real-time. A free/open source software written in JavaScript, it represents one of the four dimensions of the OpenMetaDesign framework and it encodes all of them into a working artifact that is openly available and already configured for deployment at https://github.com/openp2pdesign/OpenMetaDesign
Research through Design	Research through Design is a recent approach for design research, proposed at the beginning of the 90s and still considered in its formative stage. It is a design research approach with original methods, tools and skills proper to design culture and practice that generates knowledge on and from the practice. Research through Design is one of the three main approaches to design research together with the more established Research on Design (with methods from disciplines with a consolidated research tradition) and Research for Design or Design through Research (with methods from disciplines with a consolidated research tradition and adapted to design-specific requirements).

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Acknowledgements

This dissertation is about how research can be done through practice, learning from my experience of integrating them while being part of a global community. In the Introduction I propose two metaphors for understanding how I approached the facilitation of distributed collaborative processes: the Tower of Babel and the battlefield. These two metaphors are not fortuitous, as participation in such global community often feels as ranging between navigating through the multiple languages and perspectives while taking decisions in complex network of interactions that often features opaque conflicts. The dissertation focuses on how understanding the local dimensions and worldviews in global digital networks can be strategic in coping with conflicts and confusion that are endemic of global complex systems. Submitted a month before COVID-19 became a global emergency, it contributes to the now ever stronger vision that more than a single global digital frontier we are constantly navigating a network of local agencies that constitute a global and complex architecture.

This dissertation is thus the result of years of negotiation and conflict management through travels between many cities and countries. And such travels were not just a learning experience, but also a training experience in endurance in times of adversity while going beyond expectations. From my first time in Helsinki in 2009, to a round-the-world trip to Melbourne in 2019: from Finnish *sisu* or “the ability to surpass one’s preconceived limitations” (Lahti 2019, 61) to Melbourne’s motto "Vires acquirit eundo", quoted from Vergil's Aeneid (IV, 175) and that can be translated here as “he gathers strength as he goes” (“Vires acquirit eundo” 2017). I wish here to briefly thank all who, during all these years, supported me on gathering strength for this dissertation.

Firstly, I’d like to thank Prof. Lily Diaz-Kommonen, my supervisor, and Prof. Ramon Sangüesa, my advisor, not just for their great support and supervision of my doctorate, but also for believing in the potentialities of this research at a time when very few considered it and for encouraging me to pursue it. Many thanks also to the pre-examiners, Prof. Elisa Giaccardi and Prof. Mithra Zahedi, for taking the time for reading the manuscript and for suggesting not only improvements but also issues that have already become new possibilities of future research. The predecessor of this dissertation can be tracked back to my master’s degree thesis: many thanks to Prof. Ezio Manzini for encouraging me in exploring the experimental topic of Open P2P Design in 2005-2006, and for the many ongoing discussions these last years in Barcelona about design, social innovation and communities.

I'd thank next who directly supported this research. Together with Prof. Francesca Valsecchi we wrote our first conference paper back in 2006; ten years later, we wrote another one, ART. 4. I also have to thank Francesca for hosting my lecture at Tongji University – College of Design and Innovation in Shanghai: this provided the opportunity of a comprehensive reorganization of the narrative behind this dissertation and the addition of a link to future research to it. More than ten years ago, Roger Pitiot invited me to give an Open P2P Design workshop with him at IDAS in Seoul, and right after it another one also with Fabrizio Galli at NTU in Singapore. I have to thank Roger and Fabrizio because these workshops and travels expanded my own map of explorations and opened several doors for new paths, not only in research. Andrew Paterson offered me the opportunity to organize an Open P2P Design workshop at Pixelversity (Pixelache) in Helsinki in 2011 which was documented together with the IDAS and NTU workshops in ART. 2. Dr. Massimo Bianchini and Prof. Stefano Maffei supported me in testing the OpenMetaDesign platform at Polifactory (Politecnico di Milano), documented in ART.7; Enrico Bassi offered support for another test at Opendot, which could not take place unfortunately. Many thanks to them also for all the great discussions about the state of the Maker Movement. Many thanks to all the participants of the three workshops and of the research study as well.

Many other people supported actively my doctoral research and I wish to thank them as well. Priscilla Ferronato, for the long discussions on metadesign and decentralization in design, for the articles written together, for volunteering to test the platform and support to the dissertation: an example that great collaboration that is distributed between far away continents is indeed possible. Dr. Silvia Puglisi, for the support in the software development of the platform and for the discussions about the evolution of the hacking and making communities. Prof. Peter McGrory, for the opportunity of teaching in the "Designing Open Innovation" course at Aalto University, where I could test the design canvases. Prof. Alessandro Deserti and Prof. Francesca Rizzo for encouraging me in using my OpenMetaDesign ontology for the development of the toolkit in the Horizon 2020 SISCODE project. Dr. Massimo Botta and Dr. Serena Cangiano for the opportunity of teaching Open P2P Design as part of courses in the Master of Advanced Studies in Interaction Design at SUPSI (documented in ART. 3). Prof. Oscar Tomico for inviting me to present my research at Elisava in Spring 2019, which was a great opportunity for reorganizing all the ideas while writing the dissertation. Prof. Anne-Laure Mention from RMIT University and Dr. Marta Fernandez Bertos and Boaz Kogon from RMIT Europe for supporting the dissertation.

Many thanks to several friends who were not directly involved in the dissertation, but who always encouraged it and especially for their great discussions that informed it – here's a non-exhaustive list: Dr. Cindy Kohtala (sustainability, organization and conflicts in maker communities); Prof. Daniel

Charny (distributed design, making and education); Prof. David Cuartielles (communities, open hardware, Maker Movement and research); Prof. Paolo Ciuccarelli (data visualization and research); Miska Knapek (data visualization); Paul Khan (data visualization); Alessandra Gerson Saltiel Schmidt (social entrepreneurship, impact, models of the Maker Movement); André Rocha (maker communities, open design and Research through Design); Emilio Velis (ontologies for open design and hardware, and for being a great example of a meta-designer of ontologies within the Maker Movement); Ivano Gorzanelli (ontologies and ontological design).

Many thanks to my parents Mario and Ornella, who always encouraged and supported me in this difficult path. Many thanks to Laura for the years during which she supported me. Many thanks also to all friends everywhere, current and past co-workers and to the members of the Maker Movement, who I hope will find this dissertation useful for building its open, collaborative and distributed processes.

Massimo Menichinelli

Barcelona, 10 October 2020

Part I: Overview

1. Introduction

1.1. An emerging practice and research of open and distributed processes

Several changes have emerged in the design practice and research since the turn of the last century; among them, the discipline of design has increasingly focused its attention on the importance of the local dimension and of the evolution of ICT, becoming concerned with projects and groups of users on a larger scale than what was traditionally done. Moving from local to online communities is an important step towards including more users in design processes, especially through digital platforms, shifting the focus from single users to local and online communities, from isolated projects to whole complex systems. This dissertation explores the potentialities that Open/P2P/DDD Systems can bring to design in this direction. These systems are web-based initiatives and technologies based or inspired on open source and peer-to-peer principles, practices and tools that have become interesting for their ability to exploit the possibility of scaling to hundreds or thousands of people. Design within and for such systems can be a strategy for understanding and supporting phenomena of mass-participation with a design approach through collaborative networks that might be diffuse (systems that are made of spread and not connected or not coordinated agents), distributed (systems that are made of shared and coordinated activities and assets among agents, locally optimized at short range) and decentralized (systems that are made of shared and coordinated activities and assets among agents concentrated among few agents instead of a single one).

A key context for the evolution of Open/P2P/DDD Systems and their integrations with the design discipline has been the Maker Movement, especially for its connection with localities and materiality, with technologies and processes that by translating between bits and atoms enable diffuse, distributed and decentralized networks of design and production. The Maker Movement is a global community of distributed individuals, makers, who share the same attitudes towards designing and making with digital tools: an emerging practice of open and distributed collaborative designing and making processes (Hatch 2014; Anderson 2012; Dougherty, O'Reilly, and Conrad 2016; Gershenfeld 2005; Menichinelli et al. 2015; Menichinelli 2016b). The Maker Movement is also where Open Design, as the sharing and collaborative development of digital design files into physical artifacts, has become a reality through the everyday practice of designers. Of all the possible types of projects that can be organized by integrating Design with Open/P2P/DDD Systems, thanks to the Maker Movement Open Design has been the most popular so far, considering the popularity of dedicated platforms like Thingiverse (Moilanen et al. 2015; Flath et al. 2017; Voigt 2018), the quality and quantity of available projects (Menichinelli 2015b; Recession Design 2013) and the proposed analyses (Raasch, Herstatt, and Balka 2009; Abel et al. 2011; Menichinelli 2014; Gasparotto 2019; Bakırlıoğlu and Kohtala 2019; Boisseau, Omhover, and Bouchard 2018; Ciuccarelli 2008). There might be several reasons for this: it is the simplest application and Open Source is now widely understood and probably more easily than the other approaches (1). Open Design has also found in Maker Movement the main context for expanding from the first few scattered pioneers to a real practice that now can be experienced everywhere (2). Open Design, at least with physical artifacts, would have never been real without digital fabrication technologies, which enabled the prototyping and manufacturing of digital files shared and edited globally into local artifacts (3).

If Open Design is the model of a practice, the general trend and a broad philosophy of work, Makers are its practitioners. Who are makers and what is their identity are complicated topics, since the term was invented for marketing purposes with the launch of the MAKE Magazine (The Blueprint 2014) and is broad enough to attract a wide audience, but too little defined to provide directions for building a clearly defined community and its practices. Working on refining the definition of who is a maker is a social and political act that contributes to the maintenance of the community (Menichinelli 2017a). Among the more popular narratives, in the opinion of the author Chris Anderson's[1] definition (2012) still provides the simpler starting point: a) the use of digital desktop tools for designing and prototyping artifacts; 2) the adoption of common cultural practices and collaborative processes of sharing these designs with their communities; 3) the production of artifacts with the use of digital manufacturing technologies, spaces and services. Adopting the practice might be a way for defining makers, who can be non-professional or non-professionally trained designers, but increasingly also professional and traditional designers are joining the Maker Movement, especially when working independently as Indie Designers (Bianchini and Maffei 2012). The identity of makers is still a rather open issue, with vague definitions, multiple meanings and a strategic area for discussion (Menichinelli 2017a). Makers often gather in laboratories where they can design collaboratively and prototype and manufacture their projects thanks to the digital fabrication technologies that these laboratories offer. Places like Fab Labs, Makerspaces, Hackerspaces, DIY Bio Labs, Sewing Cafes, and local events like Maker Faires are where the practice of makers is really tangible, and where communities grow.

[1] Chris Anderson was the editor-in-chief of Wired magazine between 2001 and 2012. In his work at Wired he contributed to the popularization of several topics, among which the Maker Movement is one of the key ones. Because of his passion in the Maker Movement, Chris Anderson even founded 3D Robotics, a drone manufacturing company.

The Maker Movement is often depicted as one of the most relevant recent cases of a distributed socio-technical system, of human actors (makers) and non-human actors (hardware, software, labs, manufacturing facilities, events) dedicated to open and distributed design and making processes. Because of this distributed nature, its evolution as a global phenomenon of a community of makers has been an experience of like-minded individuals finding each other and discovering that together they might collaborate and even form a community. The evolution of local and global communities, initiatives, labs and events has been supported by digital platforms in both promotion, media (MAKE Magazine, for example) and design and making (Instructables, Thingiverse, Shapeways, ...). The role of digital platforms has been of a key actor in supporting such a distributed local and global community building, with different formats of labs, events and processes.

When labs, projects and processes span multiple countries and cultures, how can they be inclusive, supportive and appropriate for each of them? When different local and discipline cultures coexist, how can makers design and make together? While often platforms have tended to replicate similar and simple models for design and making processes, the richness in diversity of local efforts might often require custom processes, artifacts and platforms. This dissertation represents a first exploratory examination of the role, practice and profile of the author as meta-designer facilitating distributed, open and collaborative design processes in the Maker Movement through the author's personal practice and research through artifacts.

1.2. Overview of the Research Approach, Process and Outcomes

The general objective of this research is to investigate if and how design, new media, software and data visualization can have a role in facilitating distributed systems and enabling new collaborative networks especially in the context of the Maker Movement and of Open Design projects. Within such an emerging and fluid practice, the Research through Design approach was adopted for strengthening the practice itself towards a self-aware reflection and improvement: Research through Design can be considered as a design practice and research that generates knowledge on and from the practice. With such approach, the research was informed by a design hypothesis:

DESIGN HYPOTHESIS: makers can be facilitated in collaborating, organizing and coordinating their work, and this facilitation can be supported with the design of digital languages and maps as a kind of new media design that defines collaborative processes with the ontology of a data format as a shared language and its related platform.

Through the research and articles developed, the hypothesis was addressed with a research question unfolded in a set of sub-questions:

RQ0. How can we support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems?

RQ1. **DESIGN.** How can collaborative design processes be designed, documented and shared with meta-design research and practice on digital platforms?

RQ2. **ANALYSIS.** How can collaborative design processes be understood, analyzed and shared with meta-design research and practice on digital platforms?

RQ3. **PRACTICE AND RESEARCH.** How can we connect the research and practice of meta-designers in open and collaborative design and making processes?

RQ4. **CONTEXT.** What is the overall context of the meta-design practice and research regarding design and open, peer-to-peer and collaborative processes?

As the doctoral research proceeded with a Research through Design approach for improving the practice of the author while answering to the research questions, it has also explored the role of artifacts in understanding and improving it. Practice and research and their underlying artifacts have evolved and changed along three main phases: from facilitating collaborative design processes with a methodology (PHASE 1), to the use of design tools and workshops that encode the methodology (PHASE 2) to developing a digital ontology and the related digital platform and software components (PHASE 3).

While PHASE 1 worked on the concept of Open P2P Design as intangible methodology, PHASE 2 translated it into OpenMetaDesign via two design tools (toolkits of design canvases). OpenMetaDesign was then fully developed into a framework and digital platform in PHASE 3, where the development moved from a desktop software to a digital ontology and then to a platform based on the ontology, as a starting point for further elaboration. OpenMetaDesign builds the ontology on top of concepts describing design processes, and encode it in a digital platform that consists of three dimensions: data (the data format encoding the ontology), design (the visualization layer that communicates the ontology) and software (the agent that binds the data format, the visualization and the interactions users have with it and among them). PHASE 3 also presented the development of a related software for social network analysis of online software (and design and hardware) collaborative development platforms such as GitHub.

The three phases represent the transition from a digital open source design methodology, to a platform for the organizing of open and collaborative design and making processes to a broader focus on Meta-Design, ontologies and platforms within the Maker Movement for open and collaborative design processes. Seven articles documented this process and its artifacts, especially the development of the OpenMetaDesign framework and its first test (Figure 1). ART. 1 proposes a preliminary framework for understanding and working with the integration of design with Open/P2P/DDD Systems. ART. 2 describes the previous practice and research of the author with the Open P2P Design approach, documenting as it was tested and slowly transformed into the OpenMetaDesign framework. Designing collaborative design processes also entails assessing how the collaboration unfolds along a process, and ART. 3 documents the experience of the author in three collaborative projects as both participant and researcher analyzing their social interactions. The article proposes a software library that extracts data of interactions with a social network analysis approach from Git and GitHub projects, a highly popular tool/platform ecosystem for software development that is also used for both Maker and Open Design projects.

ART. 4 presents a first elaboration of the OpenMetaDesign framework, structured for designing open, collaborative and distributed processes. The article positions the framework among current meta-design and design approaches and develops its features of modelling, analysis, management and visualization of processes. ART. 5 elaborates the data and software dimension of the OpenMetaDesign framework: a shared data format for describing collaborative design processes, built on existing literature and cases and the development of the experimental digital platform for the co-design of collaborative processes. ART. 6 elaborates the conceptual and design dimension of the OpenMetaDesign framework by explaining how the approach, logic and tools of Service Design and Activity Theory and Meta-Design could support as concept and tools the development of the digital platform.

Finally, ART. 7 documents the research study organized for testing the OpenMetaDesign digital platform with users and the researcher as meta-designer: the results provide insights for improving the platform but also for building a comprehensive research through design framework that connects meta-design research and practice. Many more artifacts and publications were developed during the doctoral research, and the dissertation documents them as well.

Four methodologies were applied to reply to the research questions in the seven articles (Figure 2):

- **METH. 1.** **literature review** for mapping the state of the art and related contributions to each research question and article;
- **METH. 2.** **design/development** of the design of the digital platform;
- **METH. 3.** **user testing** of the artifacts developed in each phase;
- **METH. 4.** **social network analysis** for the networks of interactions in Open Design projects the author participated to.

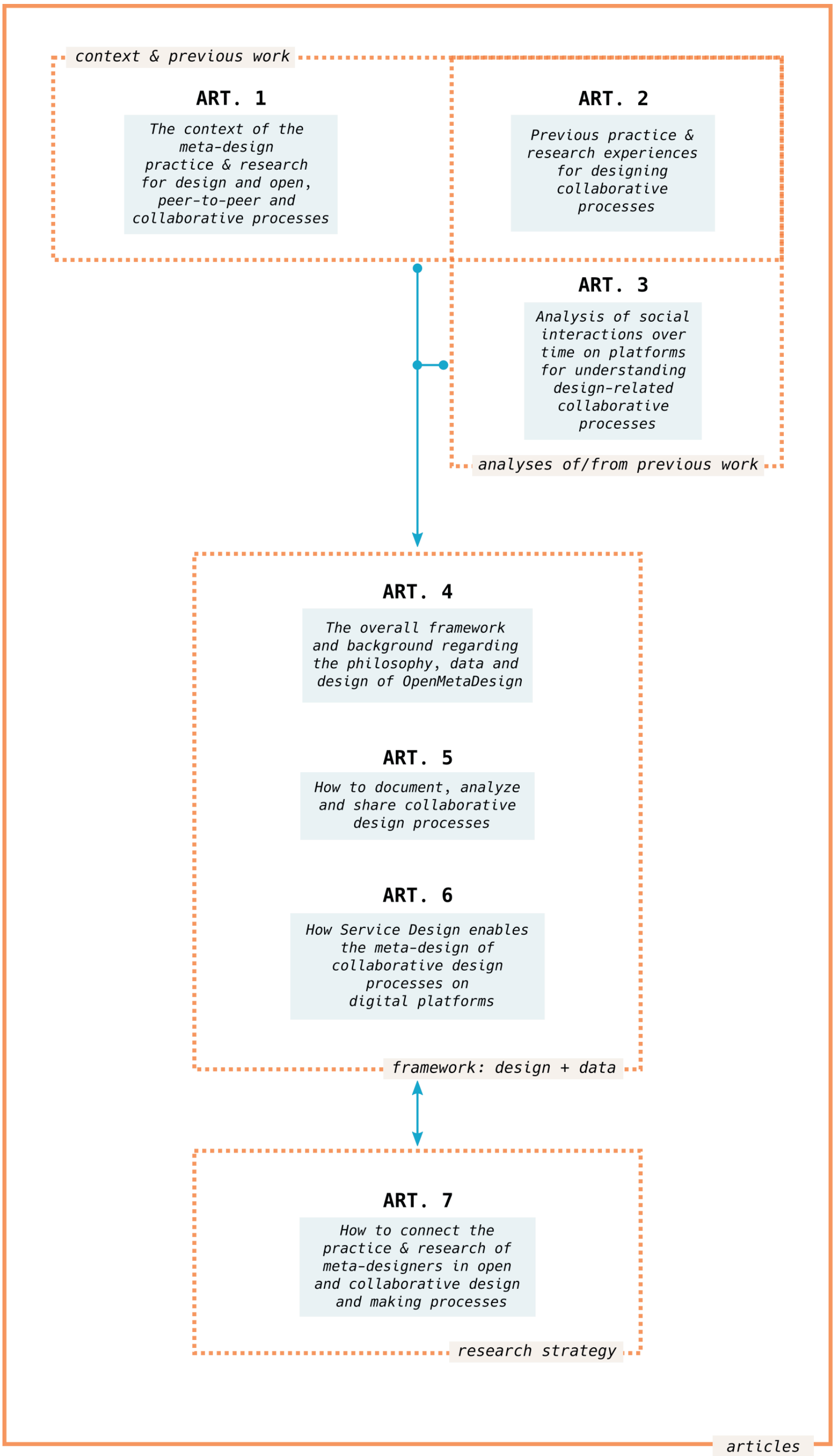

Figure 1. Research questions, roles and connections of the articles included in this dissertation

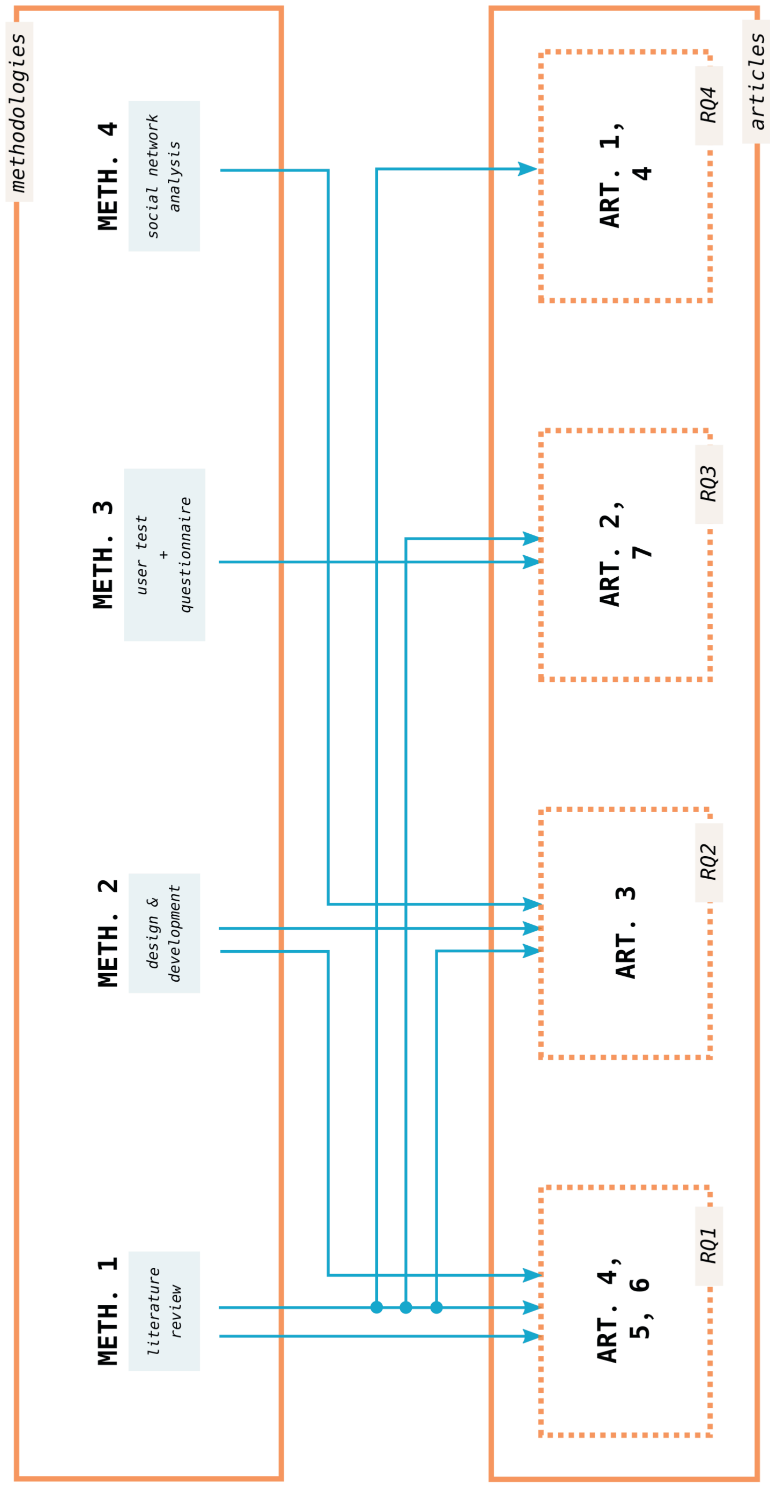

Figure 2. The connections between research questions, methodologies and articles

1.3. Structure of the Dissertation

Part I of this dissertation presents an overview of the doctoral research. This introduction, Chapter 1, provides a starting point for the navigation of the dissertation. Chapter 2 introduces the overall context of the research and practice within the evolution of digital technologies and their emerging critical issues, while identifying the gaps and motivations that represented the foundations of the doctoral research. Chapter 3 focuses on the design context, detailing the key design concepts and approaches that informed the practice and research of the author. Chapter 4 outlines the methodology adopted: the Research through Design approach, process, questions and outcomes, which are more than just the dissertation and a digital platform, but a set of related tools and publications.

The doctoral research was elaborated into seven articles of different type, and Chapter 5 presents an overview of the articles included in this dissertation (Figures 1, 3). From the articles and work of the doctoral years, four Contributions to the practice and research of meta-designers are described in Chapter 6, and the overall perspective is described in Chapter 7 within the Conclusions. Both Chapters 6 and 7 therefore represent not just the end of the doctoral studies, but a strategy for proceeding with practice and research afterwards. Finally, all references are listed in the last chapter.

Original articles are included in Part II, together with the software code describing the OpenMetaDesign ontology of design processes developed in PHASE 3 and first design tools developed in PHASE 2.

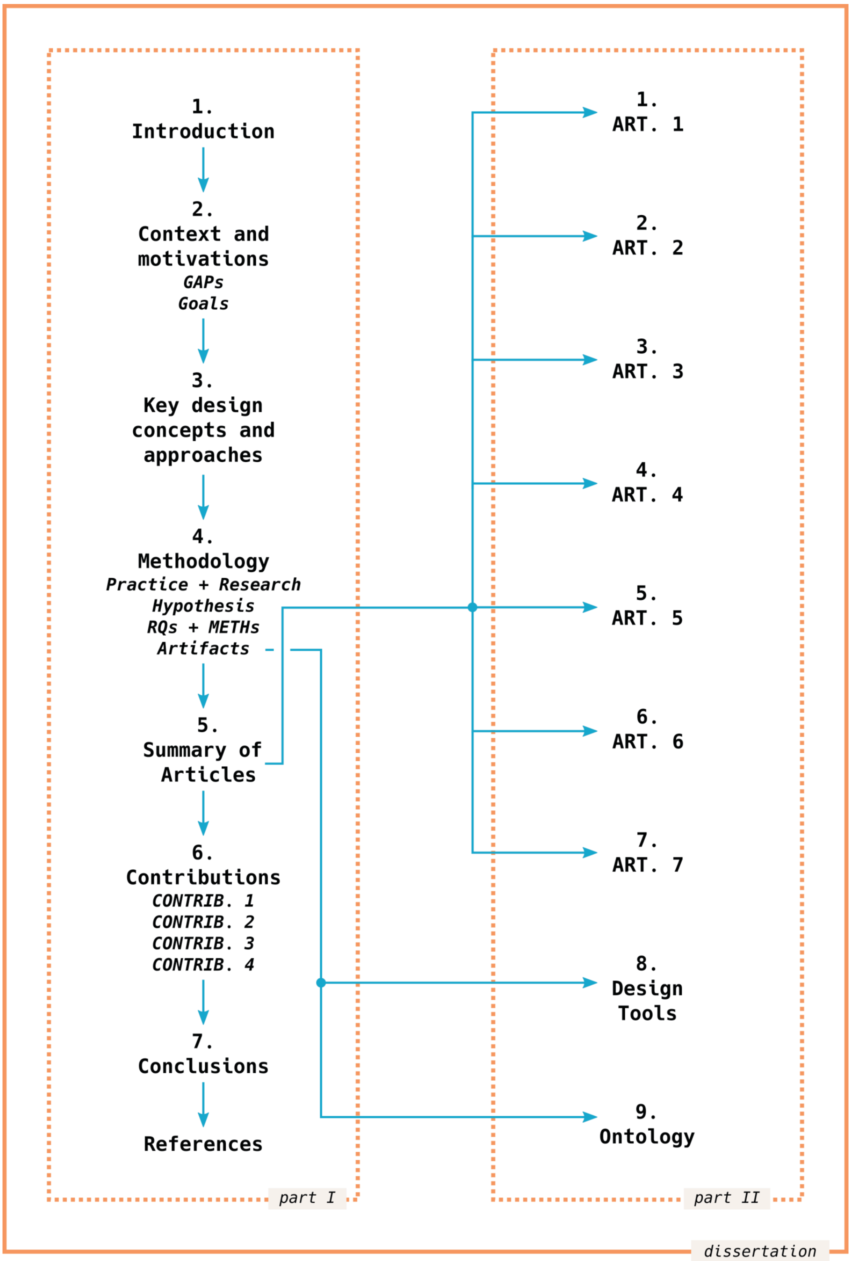

Figure 3. Structure of the dissertation

2. Context and Motivations

2.1. Digitalization/Datafication and Collaboration/Conflict

The introduction of digital technology has enabled innumerable digitalization processes that convert analog (continuously variable) phenomena into digital (discrete, approximated) records. This simplification enables a much easier storage, processing and elaboration of the information about phenomena that in turn renders thinking, making and decision-making activities cheaper, faster and thus more numerous, distributed and accessible. The digitalization of phenomena into computer-readable formats has begotten datafication processes that extend this trend by converting human behavior and processes directly into data that can be analyzed and utilized to extract value. The representation of continuous and fuzzy processes into digital representations makes easier to organize and implement both individual and social activities, especially expanding communication and coordination technologies and initiatives. When the global storage computing infrastructure of Internet and the global system of documents and applications of the World Wide Web reached the maturity milestone of the Web 2.0, the initial promises of a democratized digital world accessible to anyone seemed fulfilled. Users are no longer only passive receivers but also active producers, and global collaboration is finally at reach for everybody.

This was exemplified by the decision taken by TIME Magazine to declare literally everybody on the Web 2.0 as TIME's Person of the Year for 2006 (Grossman 2006). The title went to "you" and the cover of the magazine embedded a reflective mirror surface inside the illustration of a desktop computer, so that any reader could identify herself in it. The decision was explained as a clear shift from focusing on conflict and great men as the key agents in history, to recognizing the role of community and collaboration on a mass and global scale. Furthermore, this decision also shown the design and meta-design dimension of the social dimension of the Web 2.0 through "the many wresting power from the few and helping one another for nothing and how that will not only change the world, but also change the way the world changes" (Grossman 2006). The tools, practices, values and infrastructures built and adopted by open source and peer-to-peer initiatives seemed a very promising alternative to traditional practices in any field (Goetz 2003; Mulgan, Steinberg, and Salem 2005) towards building a new society (Bauwens

2005; Bauwens, Kostakis, and Pazaitis 2019), creating a vast number of initiatives by practitioners and body of literature by researchers about global and mass collaboration thanks to digital technologies (Shirky 2008; 2011) and therefore also mass innovation (Leadbeater 2009). Even when not explicitly coordinated, online mass efforts seemed to bring positive results thanks to their scale and complex nature (Surowiecki 2005).

Fast-forward ten years, and while some of the promises have been kept or have provided vast directions for practice and research, many worrying shortcomings have emerged in this scenario. The same TIME magazine acknowledged on another cover that we are now losing the Internet to a culture of hate enabled by online anonymity, invisibility, a lack of authority and asynchronous communication: technologies that bring people together but by making the social dimension of this act invisible (Stein 2016). The techno-determinism and techno-solutionism of Silicon Valley companies and their global imitations have been also widely criticized (Morozov 2014), together with the epistemological challenges of information technology which bring greater knowledge but not necessarily greater understanding (Lynch 2016).

The (often just potential or limited) mass-collaboration brought by the Internet and the World Wide Web is one of the main reasons of the success of Open Source software (Weber 2005), especially the ability of leveraging the contributions of multiple distributed actors with much less organizational structures, processes and costs than traditionally considered, especially with the high numbers of participants. With enough participants all problems to be solved become trivial ones: this belief is what Eric S. Raymond called the Linus's Law in his essay The Cathedral and the Bazaar (1999) ("given enough eyeballs, all bugs are shallow"). This idea was later elaborated by Kuwabara in more general terms and with a complex systems approach: “given enough participants, any complex problem is easily solvable” (Kuwabara 2000), suggesting that only complex social systems can design complex projects.

More participants (and their eyeballs) on online platforms may mean more collaboration, but more eyeballs (attention) also mean that more revenue can be made through targeted advertising. More heated discussions and online hate means more eyeballs, and online conflicts became a structural part of the Web 2.0 and digital platforms business models (Facchini 2014; Phillips 2015). And more eyeballs means more surveillance, since devices “that gives you a world of information also gives the world huge amounts of information about you” (Lynch 2016, 4), which is the underlying core business model of digital platforms forming what is now called surveillance capitalism, based on the datafication of human behaviors from surveillance of users and value extraction from it (Zuboff 2019). Designing platforms should then consider how supporting a high number of participants can enable collaboration and not conflicts and surveillance.

Historically, the Web 2.0 and digital platforms emerged after the dotcom bubble, and the surveillance capitalism model as well, as a reaction to the loss of investors and lack of resources. As Shoshana Zuboff concisely describes in her book on surveillance capitalism (2019), "Once we searched Google, but now Google searches us. Once we thought of digital services as free, but now surveillance capitalists think of us as free." (Naughton 2019). Once we believed that online mass-participation would have brought only collaboration, now we start realizing that it's about managing conflicts that enable, foster and maintain such collaboration initiatives. Once we believed that a focus on technology alone would have solved all problems, now we realize that technology is not the only element and that its embedded social, economic and political values cannot be overlooked. The expectations of what the Internet and the Web could bring to society went from the hope in a naturally emerging collaboration, to designing and meta-designing for mediation and negotiation of conflicts.

In the experience of the author, the Maker Movement itself and its distributed collaborative processes have gone through the same experience and witnessed the same issues. Several conflicts have emerged in the Maker Movement, of which only some of them were acknowledged and documented: from the internal struggles and decline of the 3D printer company MakerBot (Zaleski 2016) to the internal struggles[2] and resurgence of the microcontroller Arduino team members and companies (Benchoff 2016; Williams 2016); from to the difficulties in engaging citizens in the implementation of a public Fab Lab in a poor neighborhood in Barcelona (Greenfield 2017; Redacción La Vanguardia 2013) to the controversies around Naomi Wu's work and identity (Emerson 2018; Ferreira 2017; Wu 2018). Several reasons might be behind these conflicts, from poor engagement strategies to sexism and prejudices, from the difficulty of keeping up with the promises of a revolution (Greenfield 2017; Zaleski 2016) to the overconfidence on the organizational power of structurelessness in creating collaboration while ignoring its limitations and dark side already found in social movements decades ago (Freeman 1972).

A data-driven evidence of some of such conflicts can be found in the polarization between Fab Labs on one side and Makerspaces and Hackerspaces on another side, a phenomenon well-known by the members of the Maker Movement but that only a social network analysis of Twitter accounts provided proofs and insights about (Menichinelli 2016c). This case shows how digital platforms and tools and the datafication of trust and willingness to participate in conversations can be explored in order to uncover the hidden communities of the Maker Movement and the complexity of their structures: Fab Labs and Makerspaces/Hackerspaces are two polarizations in the global network of Maker laboratories, with Fab Labs showing a more articulated structure of sub-communities while Hackerspaces and Makerspaces are more well-defined with clearer boundaries (Figure 4).

[2] A list of blog posts published on the Hackaday blog documenting the unfolding of the so-called "Arduino Wars" can be accessed here: http://hackaday.com/tag/arduino-vs-arduino/

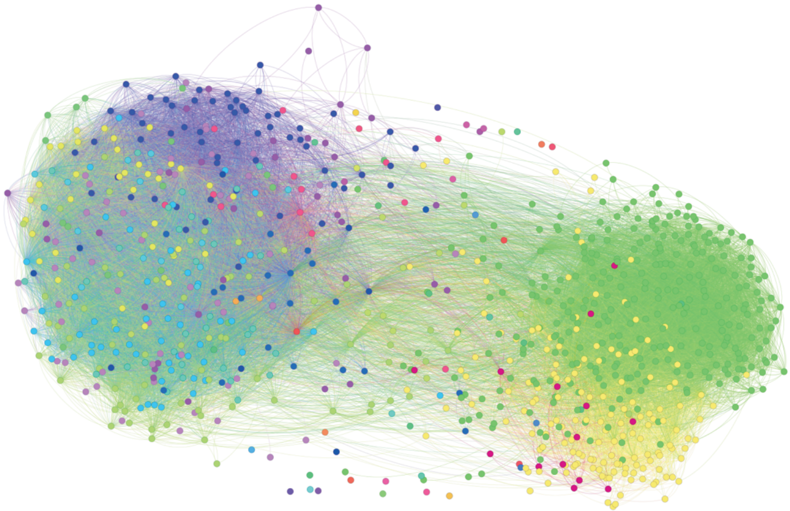

Figure 4. Communities identified in the global network of Maker laboratories (Fab Labs, Makerspaces, Hackerspaces and so on) over Twitter (Menichinelli 2016c)

2.2. Languages and Maps for Collaboration and Conflicts in Complex Projects

In order to explain the emergence of the Linux project and of open source software as a different way of organizing design and work in software development, Raymond (1999) used an architectural metaphor for talking about social processes and especially their organization of work, a tangible image for understanding immaterial systems: the cathedral as the monolithic and pre-planned traditional project, and the bazaar as the emergent and bottom-up project. Such metaphors and other storytelling devices are useful for unpacking the innumerable dimensions of complex social processes, and there are two more metaphors that might be useful for introducing the doctoral research described in this dissertation: the Tower of Babel and the battlefield. These are somehow similar to Raymond's metaphors of the Cathedral and the Bazaar and merely an introduction to the importance of some of the core elements of social processes and therefore also of design processes, which are at the core of this dissertation: language, information, discussion, maps and decision-making.

Very briefly recounted in the Genesis (11:1–9), the story of the Tower of Babel is a typical example of how, in complex and ambitious projects, communication failure in the management of design and its maps can collapse completely (Blayney 1769). The common interpretation, with a negative overtone, is that the introduction of confusion and multiple languages by God is an act of punishment to contain humanity, who was able to imagine that Heaven could be reached by designing and manufacturing just one tower. Such an effort was possible because all humanity spoke the same language, and God introduced multiple languages so that with the ensuing confusion the execution of the blueprint would result impossible, and consequently also the unity of humanity, who scattered over the whole Earth speaking different languages. But more than a punishment of hubris, this story can also be read as a kind of suggestion: we cannot reach peace, solutions, success with just a simple project and focusing on strength in its execution, but through diversity, discussion, distributed efforts and explorations and getting together (again). There is no understanding and design without an appreciation of diversity and discussion, and both must be experienced, and the difficulty of collaboration managed if we want to achieve such impossible goals. If the chaos of the bazaar enables self-organization in a project, too much chaos can render communication and therefore self-organization impossible.

Scattered, with different languages and in conflict, we then had to start using maps for finding each other but different languages caused more conflicts, often ending with violent discussions and then even battles and wars. And communication, coordination (language) and maps are also crucial in the battlefield but are not enough. In *War and Peace* Tolstoy points out that generals do not calmly elaborates plans of campaign and battles while accurately checking a map in a comfortable room, and especially they are almost never in the position of observing, considering and planning everything from the beginning. Instead, they are always acting in the action, *in media res,* in the midst of a chain of distributed events where the whole picture is hard to get (Tolstoy, Pevear, and Volokhonsky 2011). In this sense, Carl von Clausewitz spoke of fog as a metaphor for the ambiguities, uncertainties and dynamic nature of war (Clausewitz 1980) and General Dwight D. Eisenhower famously said that plans are useless in the battlefield, but planning is an unavoidable core strategic element (Quote Investigator 2017; Blair 1957).

Collaboration in complex projects cannot exist without a shared language, otherwise we end in division and conflicts that cannot be engaged without maps; maps and a shared language are key elements in the decision-making processes of the management of conflicts. There are many types of maps and languages for supporting collaboration and conflict management in complex projects, and this dissertation focuses on the role of language and maps in facilitating the design of collaborative design processes, and on the role of the designers working on the languages and maps they need for the task. The changes that digitalization and datafication have brought to languages and maps have also affected how they mediate individual and social activities in the collaboration and conflict management of complex projects. New technologies remediate the role of languages and maps, creating needs and opportunities for the design of new media, in both practice and research.

This doctoral research has been largely about mapping and the mediating nature of the design activity, especially with languages designed for them and their implementation in many other digital tools. Because of this, this path has been an experience in both the practice and research of Meta-Design, and consequently several design schema (Nelson and Stolterman 2012) were designed for it and included in this dissertation. Maps and language not just as mediating artifacts in the practice and in the research over the practice, but also in their communication and navigation. But since acting and deciding in the battlefield is not just a matter of calmly beholding a map but instead of acting in the fog of research and practice, these are more an account of the first battlefield and a strategy for the future ones.

2.3. The Research and Practice Dimensions of this Dissertation

Within this dissertation collaboration is considered not as an outcome, but as a process: digital languages and maps can mediate this process in order to support discussion about projects. The focus of this dissertation is on collaborative design processes, on making them possible, on designing them and the conditions that enable them, thus with a Meta-Design approach. As Friedman and Stolterman note, the practice of design predates professions and therefore the formal definition and practice of designers (2017). They note that the term Design was first conceived as a verb than a noun, with the first written citation of the verb occurring in year 1548 and the first cited use of the noun in 1588. It could be argued that half a century separates the awareness of the existing of a type of process from the awareness of its results. Considering the design of digital languages and maps as a kind of new media design, this doctoral research worked on developing, testing and reflecting upon an ontology for describing, documenting, sharing and designing collaborative design processes as the basis for a data format as a shared language.

But the ontology, its implication and reflection are not the only focus of the doctoral research: it emerged as the (digital) artifact that enabled the elaboration of the main contributions together with other tools and experiences of the years of doctoral research. The focus of the doctoral research and of this dissertation has been the personal path of practitioner and researcher of the author; practice and research are here so interconnected that most of the times they will be indicated as practice and research. The research documented here is both personal but also historical as part of the emergence of the Maker Movement. It’s not an analysis done by an external participant, but the constant effort of navigation by a participant of a community; it’s not a practice and research done in a controlled, organized and contained lab and within specific time frames, but a travel that unfolded through years and several different cities and countries. The role of the ontology and the languages and maps that build it was to support the practice and its research, with a Research through Design approach that worked not just on understanding the author's practice but also informing it, navigating it and continuously redesigning it. As the specific context of the practice and research, it emerged around 2008 as the Maker Movement, which was just emerging back then in Europe: the author considers himself lucky for the opportunity to observe its growth, learn from it and hopefully positively contribute to it. And being part of a movement, a community, and working in it for years also meant something else for this research: while the initial goal was on working with one specific Maker community with an Action Research approach, during these years many communities the author participated in started, developed and died. Even by maintaining a common and coherent path, the author also moved between different cities, countries and jobs. Through years of work in both academic, professional and non-profit contexts the author has been working as a researcher, lecturer, consultant, and project manager working on the integration of design with technology, especially digital ones. Participation in the Maker Movement has happened with many roles, starting with the ones of researcher, student, designer, facilitator, participant (Figure 5). Taking all these different roles has been a complex task, but also has brought a rich view, experience and understanding of the movement, integrating different perspectives. Identifying a single role or single term has been difficult and this dissertation contributes towards improving the definition of these roles.

The author's focus has been on developing the conditions for other makers and designers to collaborate by designing and making together while distributed. This practice and research have unfolded especially by developing shared places, tools and processes with a design approach: hence the preference of the term meta-designer over the term facilitator. Furthermore, the focus has been on exploring the possibilities generated by prototypes, workshops and experiments, not on deploying a complete tool and assess its efficiency or usability: hence the preference of Research through Design over Research on Design or Research for Design approaches. Furthermore, this dissertation is about the integration of practice and research and not about User Experience or Interaction Design. It is an exploration of such practice and role, of designing the conditions, environments and dynamics for collaborative design processes.

However, such practice and role are not well-established, taught, defined, supported: an evolving practice of meta-design in the emerging phenomenon of the Maker Movement. The dissertation is therefore not an in-depth reflection upon an established practice, but the broad exploration of the experience that concurred in defining and supporting it, as the practice emerged together and during the doctoral research. This dissertation is therefore an exploratory analysis that aims not at describing a snapshot in time, but at creating the infrastructure for future design-driven, research-driven and data-driven strategies for building an established and coherent practice and the research that will keep supporting it. It is an exploration of the possible role of meta-designers within the Maker Movement through the research, practice and artifacts of the author, providing not just insights from this specific case, but also tools and strategies for applying the same exploration to other meta-designers.

Beside literature review, in such exploration of how platforms supports and influences makers' processes the author collected data from both platforms and from makers: in the first case by analyzing interactions on social media platforms such as GitHub and Twitter through their API, in the second case with questionnaires and surveys. It is therefore an exploration of the social and data dimension of the role of meta-designers within the Maker Movement, between platforms and communities, structures and processes that are both digital and social.

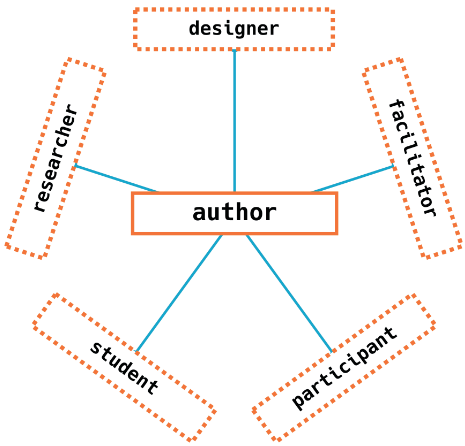

Figure 5. The author's practice and research profile at the start of the doctoral studies

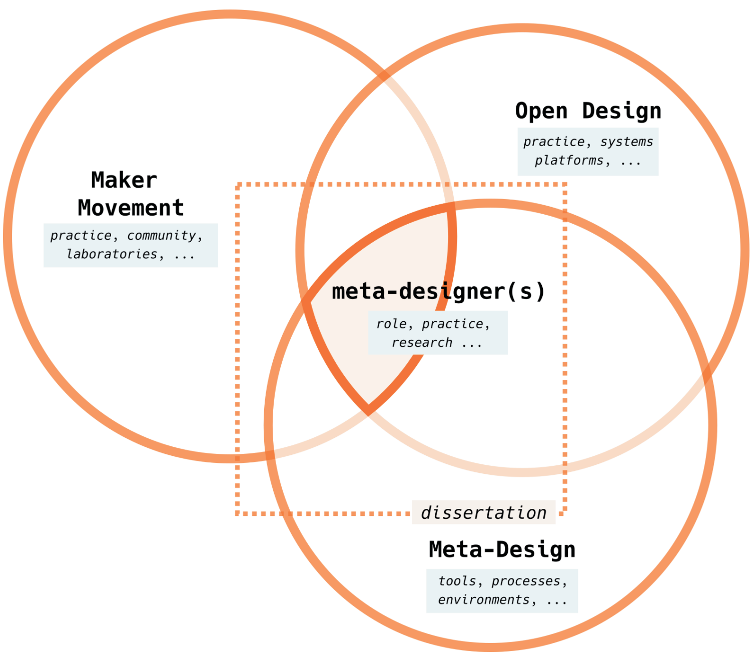

Figure 6. The domain of the dissertation, between the Maker Movement, Open Design and Meta-design

2.4. Gaps, Research and Audience

Through the years, the author's practice moved from a traditional design profession focused on artifacts, to the fluid practice of facilitating collaborative design processes in communities through artifacts while being also part of such communities. A meta-design practice with many roles and places, that promoted the adoption of 3D printing and other digital fabrication technologies not for the geometrical and industrial complexity they can manufacture, but for the social complexity they indirectly generate. A meta-design practice for fostering dialogue, collaboration, conflict management and translation. A practice and research that lay at the intersections among Design, Making, Software Development, Social Research and Data Science, with Data at the center bridging the two polarities of Design and Making and of Software Development and Social Research (Figure 7).

These dimensions define the domains of action of both research and practice that informs the author's professional profile, but also inform the goals of the doctoral studies as a practitioner and a researcher, and therefore also as a maker and a meta-designer. As a maker, the main question that the author developed has been "How can we design and make projects together as a community and in a collaborative way?". As a meta-designer, the question for the author is reformulated as "How can we enable collaborative design and making processes for communities?". The goal of both practice and research has been to answer to these two broad questions, and this dissertation elaborates such questions further. Now that we can connect and communicate with everybody, how do we design collaboratively? Now that with digital fabrication and sharing and communication platforms we can make anything in a distributed and collaborative way, how do we organize for doing it collaboratively? How can we design processes that support and facilitate collaborative design and making in a distributed way?

This practice is supported by a vast body of literature and offer of services, but there are several gaps in them and therefore also the need for an effort that inform it and make it coherent. Collaboration has been analyzed from several dimensions; digital platforms have been developed and studied; the Maker Movement has become a fruitful phenomenon for studying grassroots innovation, democratization of digital tools and practices, active and multidisciplinary education and more. Most of the times platforms have been researched and developed much less with a design approach (Cuartielles Ruiz 2018; Avram et al. 2019; Carroll and Beck 2019) and activist approach (Scholz and Schneider 2016; Lanier 2010; Morozov 2014) than with an engineering and business one (Codagnone, Matthews, and Karatzogianni 2018; Cusumano, Gawer, and Yoffie 2019; McAfee and Brynjolfsson 2017; Evans and Schmalensee 2016; Yoffie, Gawer, and Cusumano 2019). In order to focus on platforms with the perspective of a meta-designer, the author decided to consider the following as the most relevant gaps to address:

GAP 1. **Supporting the makers' collaborative practices with project documentation and organization.** The work of makers is mostly addressed in terms of technology adopted and its innovation and education potentialities. A consequence of the democratization of tools and approaches is that often the design practices seem to be considered as naturally positive and well established, while this is hardly true for any emerging phenomena. If it is true that makers collaborate in their design projects and document them, there should be more focus on how these activities unfold and how to improve them.

GAP 2. **Research for and through Design in the Maker Movement.** Most of the research in this context, even design research, is on the Maker Movement, not for or through it: the goal is in understanding the Maker Movement, not at supporting it or acting in it or through it. This is an understandable approach with an emergent phenomenon, but its design dimension is poorly understood and fostered, its potentialities only addressed as a future blurry direction and not as a concrete roadmap to take.

GAP 3. **Role of Meta-Design and meta-designers for the Maker Movement.** One key element of the Maker Movement is the interest of makers in building their own tools and approaches, a sign of the importance of the agency[3] of each actor and the consequent social reputation. The Meta-Design approach is here crucial, since it is already partially de-facto adopted by makers and could be scaled, extended and democratized. There is, however, not so much focus on how it could be adopted and the awareness of it by makers, beside the design of tools. There is a particular gap in understanding the role of meta-designers within the Maker Movement, what are the skills, needs and processes of this practice.

GAP 4. **Design with open, peer-to-peer, distributed and decentralized systems.** The possibilities generated by ICT technologies of building ad-hoc collaborative networks and the practice of sharing content have been often proposed, but rarely addressed in terms of the strategies they enable and their implications. Sharing and collaboration seem often to be naturally emerging practices with simple and established formats. However, the impact on design practice and research has been addressed mostly in terms of technologies, intellectual property and business models, and much less on the fundamental

[3] This dissertation mentions the term “agency” several times, considering its meaning of “the capacity, condition, or state of acting or of exerting power” (Merriam-Webster 2020a). Such term has a crucial role in the redefinition of Design in the Posthuman, which is the background future perspective of the design practice and research detailed in this dissertation. Within this context such term has a complex meaning that is not fully developed here as it is not the main focus of the dissertation; it is kept as a reference of the background future perspective.

changes that can be found in the re-organization and re-orientation of design projects.

For makers that want to design and make projects together as a community and in a collaborative way, and for the meta-designers that want to support these processes, this dissertation addresses such gaps by formulating this main research question: How can we support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems? This dissertation is less a research on an established practice and more a research for and through an emerging one. Chapter 4 explains how this research unfolded and Chapter 3 within which design context, developed into seven articles that are summarized in Chapter 5. By elaborating these articles, Chapter 6 presents four main contributions for answering to the research question in a strategic way for future paths: the definition of a Research through Design approach for bridging practice and research in the Maker Movement (CONTRIB. 1); the definition of how design processes can be designed as digital ontologies with communities (CONTRIB. 2); the redefinition of Meta-Design (CONTRIB. 3) and the practice and profile of meta-designers in supporting the Maker Movement (CONTRIB. 4).

The focus of this dissertation has never been only about improving the author's individual path, but also about how it can be part of a social movement and shared with the other participants. Or better said: how the tacit, often only partially understood and codified ideas and practices could be redesigned into a shared strategy for the Maker Movement, as one of the author's contributions towards its evolution. For designers and makers, the contributions here presented can offer further ways for organizing their practice while being more aware of the social implications and infrastructures. Such awareness is tied with the understanding that countless formats, approaches and organizations can be designed by taking into account the local context, and that they can be creative also in the organization and management of collaboration, not just on its objects and outcomes. Up until few years ago writing software and designing hardware was not considered the work of designers, but with Processing, Arduino and similar projects it is now increasingly common. In a similar way, designing processes and their organizations through digital ontologies and platforms might thus become a common practice for designers and makers.

The author hopes that this dissertation can provide researchers with a strategy and maps for studying all the aspects of collaborative processes and especially how digital technologies can impact them, and how to design such impact, moving from just research on these phenomena to research for and through them. This, in turn, could be applied to design education as well, since it is one of the main contexts where the practice is shaped and research can improve it: the contributions can be discussed with the future designers and makers, and improved by them as well as they become more aware of the possibilities brought by the Meta-Design approach. Overall, the author hopes that the approach and strategy outlined here can provide a strategy for studying how data, design and social dimensions can be integrated in research and practice in order to improve distributed agency in collaborative processes.

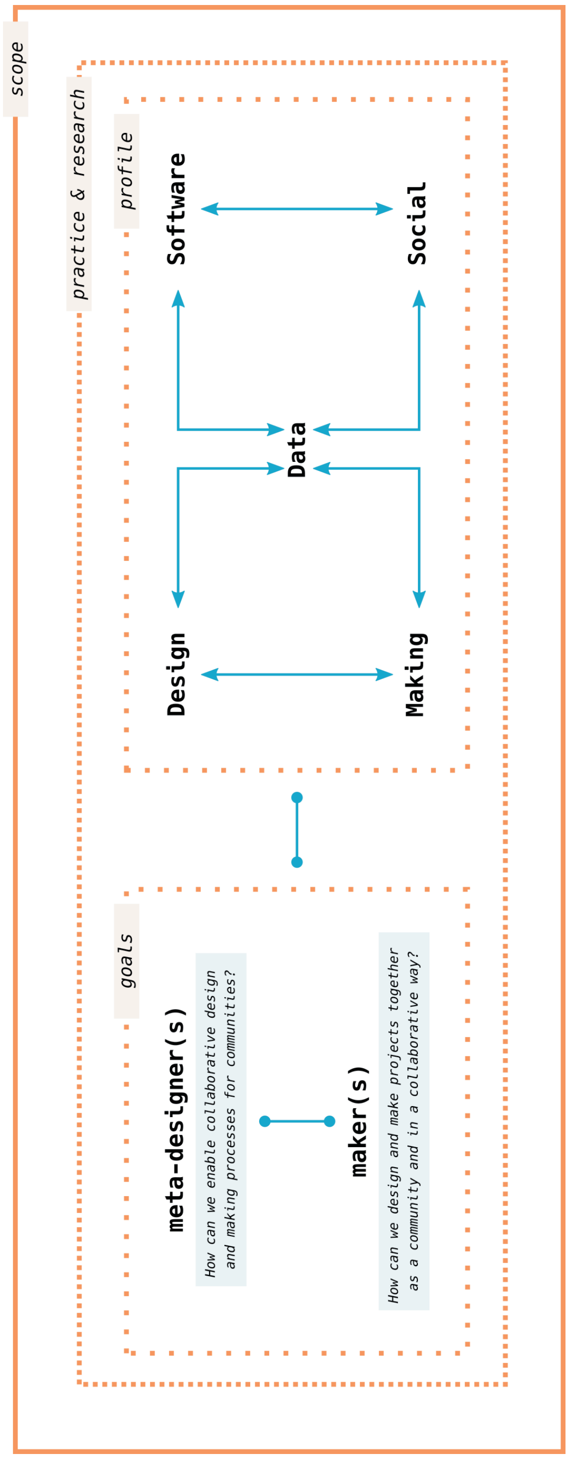

Figure 7. Scope of the dissertation and author's profile in his practice and research

3. Key design concepts and approaches

The previous chapter introduced the broader context where the dissertation can be located, pointing out the main gaps it addresses and how they are related to the overall structure of the dissertation. This chapter focuses on the design context of the dissertation, and how it informed the research methodology and artifacts for the specific development of the author's practice and research. The doctoral research followed the Design approach to inquiry, considered as a third way distinct from the Art and Science (Nelson and Stolterman 2012). More precisely, the Research through Design approach adopted connects design research and design practice through several artifacts, a digital platform and other related software and tools. This Design approach is contextualized in the recent trends of a design practice and research that is increasingly 1) open, peer-to-peer, diffuse, distributed, decentralized; 2) activity-centered; 3) meta-designed; 4) ontologically-defined and defining; 5) locally-bounded but globally-networked and community-based.

3.1. The Design Context of the Practice and Research

Within the context of this dissertation, designers and makers work increasingly often in a collaborative way, with a strong attention to the social dimension, upon and within networks as conceptual and technological infrastructure. In this context, design is becoming a practice and research that works within Open/P2P/DDD Systems developed along the social and local dimensions with a focus on processes and their structure. Beside the design as a general approach to inquiry as the overall perspective (Nelson and Stolterman 2012), such landscape of design practice (and to a lesser extent, research) defines which kind of design approaches merge and contribute to the development of the meta-design approach of OpenMetaDesign. Design as a practice and research that is increasingly 1) open, peer-to-peer, diffuse, distributed, decentralized; 2) activity-centered; 3) meta-designed; 4) ontologically-defined and defining; 5) locally-bounded but globally-networked and community-based (Figure 8). These design approaches are defined by the core elements of social/local dimensions and based on and oriented towards process/structure. Both the context and goal of such 3) Meta-Design (ART. 2, 4, 5, 6) is to learn from in order to design and design in order to replicate 1) open, peer-to-peer, diffuse, distributed, decentralized (Open/P2P/DDD) systems (ART. 1).

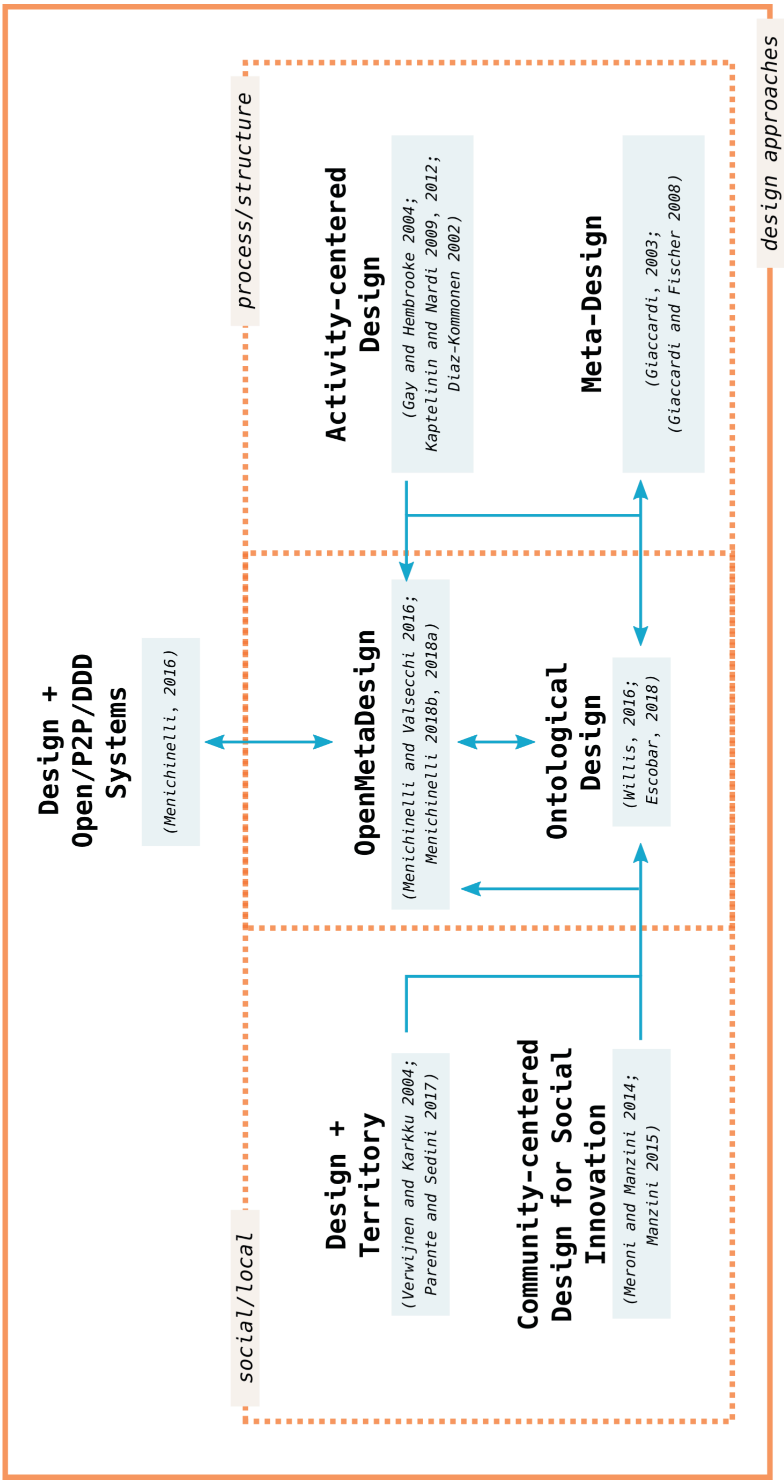

Figure 8. The approaches to design practice and research as the design context of the dissertation

The approaches of design for territory defines that this context is 5) locally-bounded but globally-networked and community-based (ART. 3), with the goal of designing for social innovations. It is a design that is 4) ontologically-defined and defining, which means that it works on designing ontologies (as a design material) and is itself defined by and designed by design ontologies (as worldviews). As a design material, ontologies are 2) activity-centered as they are conceived in terms of network of activities (ART. 4, 5, 6). As worldviews, they are found in the locally-bounded but globally-networked and community-based context.

As all these approaches provide a way for understanding and categorizing design initiatives, they can be considered theoretical perspectives that contribute concepts to OpenMetaDesign. Activity-centered Design is instead adopted here 'operatively', as a methodological approach, inside the OpenMetaDesign platform (ART. 4, 5, 6).

3.1.1. An Open, Peer-to-Peer, Diffuse, Distributed, Decentralized Design Practice and Research

Amongst the many different approaches and researches on managing knowledge and networks that emerged with ICT networks, the experience of the Free Software/Open Source and P2P communities represents a promising direction for investigating and implementing new organizational forms based more on fluid communities and self-organization processes rather than on predefined hierarchical structures and tasks. These initiatives have been considered interesting approaches for generating new and distributed community-based digital organizations with the potential of being applied in fields other than their original one of software development including biotechnology, pharmaceutical drug research, education, public services, micro-credit financial services amongst many other existing cases (Benkler 2002; Goetz 2003; Gormley 2009; Howe 2006; Lathrop and Ruma 2010; Tapscott and Williams 2006). This phenomenon has expanded to so many fields and contexts that often it has been called as Open Everything (Steele 2012) or a P2P society (Bauwens, Kostakis, and Pazaitis 2019; Bauwens 2005). In such organizations, openness defines the access to content and activities and peer-to-peer defines the goal of horizontal and equalitarian interactions between participants.

In the culture and practice behind these organizations there is often an interest on the distributed and decentralized nature of these organizations, at least partially as an inheritance of Paul Baran's famous description of a potential architecture of the Internet (Baran 1964). Baran's work proposed that a distributed architecture could make the Internet more resilient in case of attacks and failures; more recently, this architecture has become firstly an established practice for computing systems (van Steen and Tanenbaum 2016) and later an idealized image of a democratized infrastructure of open content accessed, created and shared by peers. This idealization emerged especially with the rise of Web 2.0 and then with its transformation into surveillance and platform capitalism: the former promoted the idea that a user-generated web can be developed through co-creation processes and platforms by multiple distributed actors (Shirky 2008; Tapscott and Williams 2006); the latter sparked critiques that saw distributed architectures as a strategy for limiting the excessive concentration of power and control of current platforms and systems (Srnicek 2016; Zuboff 2019). Designers that work with platforms are caught in this tension between idealized open participatory systems and opaque value-extraction walled-gardens: in the opinion of the author a way forward could be found in putting communities at the center of the action, not of the surveillance. The contributions of this dissertation aim at enabling meta-designers in 1) designing the platforms communities need by getting them involved and 2) adopting existing platforms in a critical way by analyzing their impact over communities and the role of meta-designers: from accepting platforms as given environments to co-designing them with all the engaged and affected actors, as the platform cooperativism movement is promoting (Scholz and Schneider 2016).

Baran's popular set of network architectures still influences how collaborative networks could be organized, but these are rather ideal and simplified models, elaborated decades before the emergence of Network Science (Barabasi 2003). Technically speaking, a distributed system is a collection of autonomous nodes that appears as a single coherent system while sharing resources and concurring to the same objectives (van Steen and Tanenbaum 2016). However, a system of nodes that can be all potentially connected to each other can take the shape, in real life, of different network structures, especially when taking into consideration the local conditions.

Furthermore, it is the opinion of the author that this set of ideal network architectures should be extended by adding also diffuse systems, since they represent a different layer of organization and participation, that can be often identified with grassroots initiatives defined as diffuse design (Manzini 2015). A simple and preliminary simulation based on Network Science can provide an updated image and explanation of such architectures (Figure 9 and ART. 1)[4]. Centralized networks have one main node collecting all the edges; decentralized networks have several central nodes that collect edges from the closest nodes, creating thus local centers; in distributed networks, all nodes are connected to each other, and in diffuse networks nodes are connected only locally at short range.

These are all ideal and generic forms of organization, that can be grouped together and defined as Open, P2P and Diffuse, Distributed and Decentralized (Open/P2P/DDD) Systems: they explain how local interactions can be networked at a larger scale through sharing and collaboration, strengthening diffuse actors into distributed movements. Such systems can then be considered a preliminary broad framework for understanding several different formats of mass-participation that have emerged in the past years thanks to the emergence of the Internet and the World Wide Web. For designers and

[4] A software simulation of the DDD systems of Figure 9 can be found here: https://gist.github.com/openp2pdesign/9ccc0f6d00e9a0bec9a0d196f5f5e78f

researchers, the shift from local to online communities has been an important move towards amplifying impact and including more users in design processes: digital platforms enabled reaching potentially large numbers of participants, and open and peer-to-peer organizations enabled the active contribution of participants, thus actively engaging larger groups of people distributed in several localities.

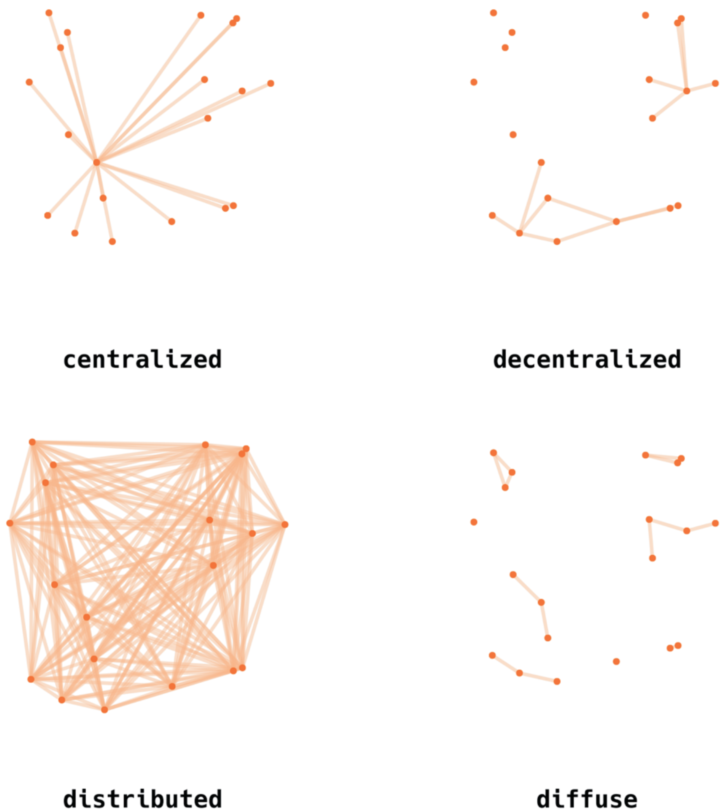

Figure 9. A simulation of centralized and diffuse, decentralized and distributed networks

Therefore, designers can adopt and introduce everywhere several tools, principles, processes and organizations: but how can this be done? Within design and research, several initiatives and approaches appeared. One main examples is Open Design, that started with the first open distribution by Ronen Kadushin of downloadable Creative Commons-licensed CAD files of lamps, tableware and furniture that could be digitally fabricated (Kadushin 2010; Troxler 2011) to *Thinkcycle*, the first open and collaborative design platforms that connected designers, users and stakeholders in the development of complex artifacts (Sawhney 2003; Sawhney, Griffith, et al. 2002; Sawhney, Prestero, et al. 2002).

After few years and the success of Open Source Software (Weber 2005) and Open Hardware (Thompson 2008; Torrone 2010), the idea of adopting the Open Source practice into the Design field became widely understood and adopted in many interesting cases (Menichinelli, 2011d, 2011e, 2011f). Important companies such as Ford and Autodesk acquired or established partnerships with Open Source, Open Hardware and Open Design companies (Bilton 2011; Torrone 2011; Wauters 2011); important design associations started promoting the idea of Open Design (Abel et al. 2011; Trautenberger, Dax, and Hirsch 2011) and science-fiction writers published novels about Open Design and Digital Fabrication (Doctorow 2010).

Around the end of the 00s the first contributions about design processes with open source and p2p dynamics appeared (Abel et al. 2011; Bauwens 2009; Ciuccarelli 2008; Cottam and Leadbeater 2004; Balka, Raasch, and Herstatt 2009; Raasch, Herstatt, and Balka 2009), explaining the phenomenon and proposing guidelines for adoption between Maker laboratories, knowledge management, physical production and citizen participation. The body of literature and cases expanded so much that researchers started developing meta-analyses of these phenomena (Bakırlıoğlu and Kohtala 2019; Gasparotto 2019; Boisseau, Omhover, and Bouchard 2018).

One of the addressed gaps in this dissertation is the still limited exploration of how these cases could be approached and designed, and more generally how design can inhabit Open/P2P/DDD Systems beyond the mere file sharing which constitutes the most known approach. With this objective in mind, the author listed and categorized the main projects and literature that represent all the current possible intersections of the design practice and research with Open/P2P/DDD Systems in ART. 1. The author proposed two main directions for these intersections: on one side, designers can integrate Open/P2P/DDD Systems in their practice by embracing them with a design approach. On another side, they can apply their design practices in order to improve and implement them, with a meta-design approach. Designers can thus both learn from such systems but also improve them. Understanding all the potential formats enable designers to develop more diverse and custom approaches, while learning and promoting these systems at the same time.

3.1.2. An Activity-Centered Design Practice and Research

Among the many redefinitions brought by Open/P2P/DDD Systems, the concept of authorship is probably the most controversial and well-known for designers: the popularized but rarely real romantic view of the single author is challenged by emerging processes based on non-professional or non-professionally trained designers or by collective and community projects where processes and outcomes are complex and individual contributions might be hard to identify. The issue of authorship has implications not only in terms of intellectual property and economic value, but it has also the deeper effect of redefining the agency in design. Open/P2P/DDD Systems have contributed to redefining who are the actors and also the target or stakeholders of design projects. A new perspective of agency and participants in design projects also redefines how we design and who we design with and for: the shift from User-centered Design to Activity-centered Design is part of the larger emerging trend towards Posthuman Design or More-than-Human Design (Forlano 2017; Giaccardi and Redström 2020). In a Posthumanist perspective, agency and responsiveness are not a trait of human actors only but of non-human actors and matter too (Carranza 2018) and in general of "actants" since agencies are continuously debated (Latour 2007). Agency thus becomes distributed across a wide range of entities, structures, and processes within assemblages: and a focus on activities rather than users (or generally speaking, only human actors) in design thus enables designers to design within and for such assemblages.

The shift of focus towards activities in Design was generated by several evolutions, for example by the introduction of ubiquitous computing that required a move to context-based design for designing context-aware computing artifacts (Genco and Sorce 2010; Greenfield 2006). In parallel, this is also a shift from the individual user to group of users, from thinking about the needs to exploring the activities behind them, from fictitious personas to real and complex groups of interacting actors: "If it is so critical to understand the particular users of a product, then what happens when a product is designed to be used by almost anyone in the world?" (Norman 2005). This is a shift from individual users to their activities, and most importantly to their local context, to which activities are a systemic part of: from user-centered to user involved, from laboratory to context, from rigid to emergent design practices, from individual to groups, from bounded and defined tasks to cross-boundary and systemic activities (Gay and Hembrooke 2004). The rationale for this change is the need for focusing on more complex dimensions of life by adding reasons, motivations, meanings to analyses and design, and ultimately it aims at understanding more the context, and context is about agency as well: it's not static, it's systemic and based on processes and groups. Processes are at the center now, but this does not obliterate people, it actually expands the focus in order to improve their participation. Activities and processes, as immaterial entities that can be described intuitively, can mean different things to different people, and Activity Theory offers a rigorous approach for informing their description with a shared language that can support the development of artifacts by analyzing design, art and other types of activities (Diaz-Kommonen 2002).

The introduction of Activity Theory in Interaction Design has also changed the perspective and role of technology, from a static artifact to an active element that mediates activities in their context, from being designed as logical and sophisticated interventions to being designed as the supporting system for meaningful human activities. Ultimately, from being the goal of design processes to being part of a system of the "social, emotional, cultural, and creative dimensions of human actors in shared contexts" (Kaptelinin and Nardi 2009, 6). Activity Theory has changed Interaction Design in its two different meanings of "all efforts to understand human engagement with digital technology and all efforts to use that knowledge to design more useful and pleasing artifacts" (Kaptelinin and Nardi 2009, 5) or as the design of spaces for human communication and interaction (Winograd 1997). Activity Theory has also been adopted in Service Design in order to extend it beyond individual digital artefacts to the analysis and design of services "from a service (and communication) design to what we call the design of activity systems" (Maffei and Sangiorgi 2006, 2). Overall, Kaptelinin and Nardi (2012) identify three ways Activity Theory has been integrated into Human-Computer Interaction and Interaction Design:

1. **As a theoretical re-framing of concepts.** A computer is not an object, but a mediating tool, from individual to groups, from artifacts to processes.
2. **As a provider of conceptual tools for design and evaluation.** When utilized as a design tool, Activity Theory supports designers in identifying the problems and contradictions in a context; they can thus adopt it to supporting the framing of the problems for then deciding their actions.
3. **As a theoretical lens in empirical studies.** As a qualitative analytical framework, the contribution of Activity Theory is mostly valued during or after a project completion to study the design team's process, choices or different variables that may have affected the design outcome.

Beside these ways, this research contributes to one more possibility:

4. **As a design material.** Activity Theory can be adopted as a design tool not just for understanding the context and therefore informing the projects aimed at it, but also for designing activities directly. It can be thus used reflexively in combination with a Meta-Design approach, especially when such activities are part of a design process. This direction is elaborated in ART. 2, 4, 5, 6 and in CONTRIB. 2 (section 6.2).

Activity Theory has played a role in expanding the role of agency and context in designing artifacts, in the trajectory from Computer-centered Design to Human-centered Design by focusing on "consciousness as the product of an individual's interactions with people and artifacts in the context of everyday practical activity" (Kaptelinin and Nardi 2009, 8). This research adopts it mainly as a design material, and by developing an ontology and digital platform for its designing and management, includes algorithms in the design process, contributing thus to moving a step forward to a Post-Human-centered Design / More-than-Human Design of human and non-human actors (Forlano 2017; Giaccardi and Redström 2020). Here such Activity-centered Design approach is not just for designing mediating tools or objects, but increasingly also for defining subjects, rules and divisions of labor and their enabling conditions in collaborative and distributed processes.

3.1.3. A Meta-Designed Design Practice and Research

Theory can be applied at any scale, and works at any human activity, including itself: "Activity theory is self-reflexive, and we are encouraged to find ways to inform our own development" (Kaptelinin and Nardi 2009, 13). With such a self-reflexive approach, the activity of design has also been analyzed with Activity Theory in the development of new media artifacts for multidisciplinary contexts (Diaz-Kommonen 2002); in collaborative design processes in order to understand teams' interactions and relative collaborative evolution and its dynamics (Zahedi, Tessier, and Hawey 2017); in the design of social innovation initiatives (Tjahja, Yee, and Aftab 2017) and communities (Barab, Schatz, and Scheckler 2004). When applied to understanding and designing design processes, becomes a reflexive approach to design, a Meta-Design approach.

Giaccardi and Fischer highlighted that User-Centered Design (with users in a reactive role) and Participatory Design (PD) (with users as co-designers) approaches have considered primarily activities and processes taking place at design time; Meta-design deals also with the use time, especially by considering projects as living entities that can evolve over time (2008). Their Meta-Design approach, instead, focuses on the democratization of the creative process by avoiding designing complete solutions by opening up solution spaces where users can act as designers and be creative:

> *Metadesign* is an emerging conceptual framework aimed at defining and creating social and technical infrastructures in which new forms of *collaborative design* can take place by redistributing design activities at different times and levels of interaction with the environment." (Giaccardi and Fischer 2008, 4)

According to Fischer, such social and technical infrastructures are open systems that can be modified by their users and evolve at use time, shifting a part of control from designers to users, and based on these principles (2000):

- Software systems must evolve; they cannot be completely designed prior to use.
- Systems must be designed for evolution.
- Systems must evolve at the hands of the users.
- Evolution of systems must take place in a distributed manner.

Giaccardi's definition of Meta-Design (2003), elaborated by crossing etymological facts with extensive literature review of approaches, proposes three dimensions for Meta-Design:

- **Behind (or designing design):** "Design of Design processes" / "Design of the generative principle of forms" / "Design of the Design tools".
- **With (or designing together):** "Design of media and environments that allow users to act as designers" / "Design of the organization of flows".

- **Between/among (or designing the "in- between"):** "Designing the spaces of participation" / "Design of relational settings and affective bodies".

In Meta-Design, the *behind* dimension "supports the modifiability of computational structures and the malleability of social infrastructures"; the *with* dimension "defines the way in which meta-designers and users can participate together in the design activity"; the *between/among* dimension "defines how people can experience and negotiate their relationships and socially engage in meaningful activities" (Giaccardi and Fischer 2008, 22).

Meta-Design has always the nature of a reflexive, self-aware and collaborative process, and works in at least two directions: enabling designers inform their own practice and in enabling the active role of non-designers in design processes. Meta-Design can be applied to the development of digital environments, social dynamics and tools but also to the development of a new design research environment (Tham et al. 2016) and as a dynamic approach for responding to uncertainty in socially-responsive design initiatives (H. Jones and Lundebye 2012). Design always works at achieving the desired impact in the future as a static outcome while Meta-Design aims at developing the conditions that, through open systems, enable future designing in achieving an impact in a dynamic way by evolving through time and multiple actors (Wood 2011).

Meta-Design can be particularly interesting for the design of digital environments, the design of design processes, the enabling power towards users and its application and perspective is explained in ART. 4, 5 and 6. It has to be noted how, regarding processes, Meta-Design has been applied also to Management and Engineering approaches such Business Process Modeling (Brown, Recker, and West 2011; Q. Chen and Hsu 2001; Erol 2012; Erol, Mödritscher, and Neumann 2010). ART. 4 recollects and analyzes these approaches, suggesting that such tools and processes are developed for engineers and not for designers/makers, and their complexity and codified nature makes them of difficult application in the context of this research. Within its boundaries and constraints, the author preferred to work with Activity Theory as the main framework for designing and describing design processes.

Meta-Design is also promising because it extends the benefits of Design while avoiding its predictive expectations: from 'design as planning' to 'design as a seeding process', and therefore also from 'designers as master creators' to 'meta-designers as systems integrators' in order to create synergies in many processes on many levels (Wood 2011). The roles and profiles of meta-designers has also been analyzed within End-User Development (EUD) studies, which focus on how to empower end users in modifying software systems. Some of these studies proposed classifications of the possible roles of actors in Meta-Design initiatives, showing that not only end users and meta-designers can be present, and that several knowledges and expertise might be necessary (Cabitza, Fogli, and Piccinno 2014):

- **End users.** Passive users of a system of artifacts and services in a domain-specific activity.
- **Domain developer.** A domain expert actively involved in the meta-task of improving the system used in the domain-specific activity by developing her own tools.
- **Meta-designer.** An actor that designs the infrastructure, environment, tools by which domain developers can build their own system of artifacts and services. Meta-designers aim at designing the infrastructure, its usability and modeling.
- **Maieuta-designer.** An actor that facilitates the evolution of single users from being passive end users to domain developers. Maieuta-designers focus on motivation strategies, the proper training of the domain developers, and on managing the risk and the impact of the system.

Within Open/P2P/DDD Systems, Meta-Design has a particularly important role not just for the adoption Open/P2P/DDD Systems, but also for designing them and supporting their activities; ART. 1 explores these possibilities.

3.1.4. An Ontologically-Defined and Defining Design Practice and Research

Furthermore, Meta-Design presents some connections and implications with ontologies, both at philosophical and operative level, which are relevant for the context of Open/P2P/DDD Systems and this research. Meta-Design can be regarded as 1) design of ontologies (ontologies considered as a design material) and as 2) Ontological Design (ontologies considered as worldviews which are designed by actors in a context and which designs them). Pomerantz clearly expresses this duality of ontology in the context of metadata:

> In philosophy, ontology is the study of the nature of reality and the categories of things that exist. In information science, an ontology is a formal representation of the universe of things that exist in a specific domain. What these two approaches to ontology share in common is that they both articulate a universe of entities and relationships between entities. (2015, 46–47)

In design of ontologies (1), the adopted meaning of ontology is the one from information science and about the technical infrastructure (Gruber 2009; 1995; 1992); in Ontological Design (2) the adopted meaning is from philosophy and about the human condition (Fry 2012; Willis 2006; Escobar 2018). Designing an ontology is “a way of characterizing the world and its entities through language” (Diaz-Kommonen 2002, 146) creating thus a vocabulary and classification system that provide the conditions for collaborative activities to emerge. Creating an ontology also moves the work of designers to the ontological dimensions by virtue of knowing how it is generated, by whom, and the boundaries of the activities that generate it (Diaz-Kommonen 2002).

In information and computer science, the role of ontologies to enable the sharing, reuse and analysis of common understanding of the structure of information among people or software agents (Noy and McGuinness 2001).

Gruber's work on ontologies is among the most cited, and his definitions can be considered the main reference for the context of this research; an ontology

> defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). The definitions of the representational primitives include information about their meaning and constraints on their logically consistent application. (Gruber 2009, 1963–65)

Ontologies are also designed with a purpose: "formal ontologies are designed artifacts, formulated for specific purposes and evaluated against objective design criteria" (1995, 907) and are shared among agents and sustain their agency: "an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents" and "a specification used for making ontological commitments" (Gruber 1992) by defining "the vocabulary with which queries and assertions are exchanged among agents" (Gruber 1995, 909). In a database, an ontology is the semantic level of abstraction of data models, and enables the integration of heterogeneous data sources, enabling interoperability and specifying interfaces (Gruber 2009). Every time a database, a data structure or an algorithm that manages data are designed, an ontology is designed, redesigned, shared or adopted.

The design of ontologies (1) is thus a common activity in New Media, Meta-Design and Open/P2P/DDD Systems. Jos de Mul suggested that in Open Design the role of designers is to become meta-designers by being database and interface designers that create multidimensional design spaces based on a database ontology in order to enable users to become co-designers, and more specifically by creating pathways through such spaces (de Mul 2016). Here the database is described using a metaphor as described by Manovich (2001): databases as ontological machines that render anything an object for digital manipulation and that therefore shape both our world and our worldview thanks to the pervasiveness of computing devices and processes. Ontologies are designed within new media artifacts, and through them the ontology of digital technologies contributes to the computerization of culture. Any process is reduced to an algorithm, and any object is modeled as a data structure: together they constitute the world ontology according to a computer. Designers thus are affected by the ontology of digital technology, and by creating new media artifacts they design algorithms and data structures. Designers are affected by a digital ontology, and design digital ontologies, and the two actions reinforce each other, reflexively. ART. 4 and 5 elaborate an ontology of design processes with a Meta-Design approach.

Therefore, such ontological dimension of digital ontologies is not only an example of Meta-Design, but also of the Ontological Design perspective (2). These two design approaches overlap on the philosophical dimension: here *ontology* refers to enquiry of 'what is' and *design* refers to how such enquiry feeds back to design, changing it; indeed, some philosophers consider ontology and metaphysics as synonyms (Harman 2018). For the context of this research, Ontological Design is important in terms of how it affects the meaning of agency in design (1), and the promising application towards empowering local communities (2) thanks to its focus on a plurality of worldviews and therefore of designs. Willis defines Ontological Designing as

> (i) a hermeneutics of design concerned with the nature and of the agency of design, which understands design as a subject-decentered practice, acknowledging that things as well as people design, and following on from this, (ii) an argument for particular ways of going about design activity, especially in the contemporary context of unsustainability. (2006, 81)

The dimension of redefining agency is clear from the simple definition of Ontological Design, which “stems from a seemingly simple observation: that in designing tools (objects, structures, policies, expert systems, discourses, even narratives) we are creating ways of being. That we design our world, and our world designs us back— in short, design designs.” (Escobar 2018, 4).

The main message of Ontological Design is that designing is fundamental to being human, and in turn we are designed by our designing, and in this aspects Ontological Design mainly works on the philosophical level of Meta-Design. And more broadly, with a conscious Ontological Designing we design not just artifacts but rather a new way of being, since they embed culturally specific intentions (functions) and therefore participate in agency. We are thus engaging in a philosophical discourse about the self in a posthuman way, contributing thus to Posthuman Design / More-than-Human Design not just by engaging with non-human actors (Forlano 2017; Giaccardi and Redström 2020), but by redesigning human actors as well (Fry 2012).

In the Ontological Design perspective, the enquiry of ‘what is’ is always indirect and mediated: knowing is not just a matter of description or reflections but also of activities where the object of knowing is embedded in the practice. Design is not only limited to artifacts, but also inseparable from interpretation and the agency of artifacts and of their culturally specific embedded knowing. And being part of an ontological cycle, this knowing is directly part of a way of being, which is connected to a multiplicity of worldviews which are circumscribed, situated but never individualized: there is no Cartesian divide between observer and observed: “human beings occupy space through their embodiment and mental activity, but the two cannot be separated, in fact ‘space’ could be considered as the product of an embodied mentality” (Willis 2006, 86).

An embedded and embodied knowing that is not only an expression of multiple local worldviews, but because of this dual direction of Ontological Designing, is part of what is designed and what designs. According to Escobar, the potentialities of design for enacting social change can be found here, considering social change as an ontological endeavor, especially for transitioning towards a more sustainable dimension, since ecological crisis requires new way(s) of thinking and understanding, new culture(s), a multiplicity of worlds, a pluriverse (2018). This transition is with a design that is not objectivist, dualist, and detached understandings of world that is based on a new ontology, “described in the North as being postgrowth, postmaterialist, posteconomic, postcapitalist, and posthuman, for the South it is expressed in terms of being postdevelopment, nonliberal, postcapitalist/noncapitalist, biocentric, and postextractivist” (2018, 140).

Here Ontological Design becomes a way for thinking the transition from the modernity’s one-world ontology to a pluriverse of socionatural ontologies that can regenerate local worlds; each community could thus practice the design of itself. As a practice, Ontological Design can bring social change because by showing the possibility of multiple and complex worldviews not just for the design of artifacts, but also of material and immaterial infrastructure (management systems, communication systems, …) and systems of thought (Willis 2006).

3.1.5. A Locally-Bounded but Globally-Networked and Community-Based Design Practice and Research

Ontological Design has several connections with Design for Social Innovation and Sustainability by focusing on how a plural change of worldviews could pave the way for a transition to a more sustainable society. Within this dissertation, it is the opinion of the author that worldviews should be considered as always situated and limited, tied to a context, and this interest on the local and social dimension of action is the key dimension for designing sustainable societies. Societies that are a pluriverse of cultures where each community practices the design of itself (Escobar 2018). This centrality of the context and the local conditions is also one of the key elements of Activity-Centered Design, especially through its social and historical dimensions that are inseparable from it (Gay and Hembrooke 2004). The work of Escobar further extends and integrates two decades of practice and research on Design for Territories on one side, and on Design for Sustainability and Social Innovation on one side, adding the ontological layer that influences the local and social dimension of posthuman activities (Escobar 2018). The practice and research of these two directions emerged with the objective of expanding the focus of Design facing emerging global issues by tackling them at local level by defining at which geographical and social dimension to move.

The change of scale and scope of the Design practice and research since the end of the 90s has shifted from single users to local and online communities, from isolated projects to complex system of solutions, from artifacts to networks of local and global actors. Such interests crossed their path with the importance of new strategic approaches such as territorial marketing, cultural marketing and the experience economy, and this led to an increasing focus on localities and their traditions, production systems and communities. Two pioneering projects can be highlighted: at European level the *Spark!* project developed and tested a new approach of community design education (Verwijnen and Karkku 2004); at country level in Italy the *Me.design* project elaborated products, events reflections and the exploitation of resource in the

Mediterranean area through the valorization of territorial capital of localities (Fagnoni, Gambaro, and Vannicola 2004). Parente and Sedini (2017) analyzed the different approaches of Design practice and research with territories, and systematized them in three categories that represent three different stages of evolution of the relationship between design and the territory; this doctoral research operates in the last stage of design for the territory:

1. **Design in the territory.** This approach investigates the territorial distribution of design industries, their strengths and specificities.
2. **Design of the territory.** This approach concentrates on how design could enhance local cultural products, environmental historical and cultural resources.
3. **Design for the territory.** This approach is dedicated instead to the role of communities in their territories and their processes with stakeholders.

The evolution between the three approaches shifts the perspective on the territory: from the context of design activities – a design context (with a focus on the physical dimension of manufacturing and distributing products), to as an object of intervention – a design object (with a focus on how the idea of a territory influences design projects), and then to a relational system (with a focus on designing the relationships within and around the communities, and being designed by them). Especially in the last two approaches, the design practice and research has worked on different kind of projects, from traditional and tangible types to more intangible and strategic ones: from products and communication to place identity and experience; from cultural events, heritage and local development to social innovation initiatives and policies. Among the many approaches that can be found, Community-Centered Design is particularly interesting for this doctoral research. Its focus on the relationships between Design and local resources, communities, identities and economies is also often tied to exploring how design can work within the path-dependency of territories, influence it and being influenced by it (Maffei and Villari 2004) and therefore being entangled with the local traditions, values and thus worldviews, becoming one of the relevant approaches for Ontological Design. Furthermore, working at local level, within communities and territories put designers/researchers directly in contact with the challenges and opportunities of render them self-sustainable and able to learn from other communities and territories on a peer-to-peer level (Magnaghi 2000).

Design for Territories is strictly connected with communities and Design for Social Innovation, and this is a relevant phase in the evolution of Design for Sustainability, expanding from single products to complex systems: from an insular technical and product-centric perspective towards large scale system level people-centered process-based changes; reaching sustainability has moved from a static goal to a dynamic socio-technical challenge based on the understanding of the interdependencies between social and ecological systems (Ceschin and Gaziulusoy 2016). This evolution is due to the increasing awareness that improving single products does not achieve sustainability, since improvements are generally counterbalanced by increased consumption levels, and thus social changes are necessary in order to reconfigure production and consumption systems, coupling technological innovations with social ones. The technological and social dimension are thus the two main directions of Design for Sustainability, which has undergone through four stages so far: 1) Product (focus on improving existing products or new ones with a reduced environmental impact over their life-cycle); 2) Product-Service System (focus on extending products with the integration of services and business models); 3) Spatio-Social (focus on improving the conditions of communities with a positive social impact); 4) Socio-Technical System (focus on promoting radical changes to societal needs) (Ceschin and Gaziulusoy 2016). Design for Social Innovation falls into the latter two stages: its main traits are the focus on people with the goal of improving their conditions through iterative prototyping/piloting (Villari and Mortati 2014). Design for Social Innovation aims at addressing social demands not addressed by the market or institutions, societal challenges and systemic initiatives reshaping society. Social innovations are driven by a social mission to create social and economic value through positive transformations for people, places and organizations empowering society:

> The connection between design and social innovation is deepening the practices and tools for citizen empowerment and engagement, upscaling the solutions for re-thinking the traditional relationship with industry, outreaching to examine the impact, replicability, and viability of solutions on a larger systemic scale. (Villari and Mortati 2014, 82)

An important element of Design for Social Innovation for the context of this research is that the "social" dimension applies to both the "how" (the process) and the "why" (the social, societal and systemic goals). Among the many contributions of Ezio Manzini's work (2015), there are three directions through which Design for Social Innovation addresses social, societal and systemic goals that are especially important for this doctoral research: 1) the design of more sustainable lifestyles for improving the wellbeing of communities; 2) diffuse design and distributed systems; 3) cosmopolitan localism: the connections about local communities but at global scale. Design for Social Innovation can provide contributions to local conditions and to societal and systemic challenges by developing the conditions for sustainable behaviors towards more sustainable lifestyles (1). By listening to local communities, their knowledge, expertise and worldview enabling solutions can be designed in order to improve their local conditions through place making for the redefinition of new ideas of wellbeing in a multiplicity of cultures of resilience. Such endeavors are developed (2) by both expert designers and systems of diffuse design where everybody has knowledge and expertise, especially within distributed systems which represent more resilient infrastructures and collaborative organizations in continuous collaboration: "today, in a networked society, all design processes tend to become co-design processes" (Manzini 2015, 48). Such diffuse design often emerges not individually but in communities and grassroots initiatives (Meroni 2007; Manzini 2015). The previous directions take place in a design scenario built on a cosmopolitan localism culture that joins the local: places are “nodes in both short- and long-distance networks, where the short networks generate and regenerate the local socio-economic fabric and the long ones connect a particular community to the rest of the world” (Manzini 2015, 25).

With the strategy of working at a larger, systemic scale and not only at individual, insular project, designers can work with a Community-Centered Design approach by focusing on understanding values and behaviors, the worldview and needs of local creative communities and collaborative organizations in order to develop solutions for their scale-up, from prototypes of sustainable ways of living towards distributed systems (Meroni and Manzini 2014). Community-Centered Design extends User-Centered Design “to the complexity of the community, in order to understand its behaviors, needs and network of relationships” (Meroni and Manzini 2014, 370). A further extension of this approach can be found in the concept of “massive codesign”, that deals with the collaboration of multiple and/or numerous participants in design processes (Meroni, Selloni, and Rossi 2018).

The scaling of such initiatives is often enabled by digital technologies and especially platforms with a specific social nature, called Digital Social Innovations initiatives (Bria et al. 2015; Stokes, Baeck, and Baker 2017). Furthermore, platforms are interesting not only for facilitating, scaling and networking such social initiatives, but also for the possibilities they provide for assessing the social impact of such initiatives at several levels, from local to global, while recognizing and valorizing their distributed nature (Menichinelli and Gerson Saltiel Schmidt 2019). Assessing the social impact of such initiatives is a strategic and complex effort that has already generated several initiatives (Grieco, Michelini, and Iasevoli 2015; Maas and Grieco 2017), and in this context it is thus important to anchor the assessment to local cultures and practices in order to evaluate how they influence the design, implementation and evaluation of Design for Social Innovation projects (Hill and Vaughan 2017). All these contributions add further elements that support the task of scaling participation and collaboration in design processes, providing the social dimension for a design approach that works for a territory and within Open/P2P/DDD Systems.

4. Methodology

The previous chapter introduced the design context of the dissertation, for both practice and research. This chapter focuses on the design research methodology and artifacts of the author's research during this dissertation. A special attention is given to Research through Design as the research approach adopted. The focus of the dissertation evolved and changed with three main phases, following the evolution of the practice and research of the author in facilitating collaborative design processes from the implementation of 1) guidelines for a generic design approach, process and tools, to the use of 2) custom design tools and workshops that encode the methodology to developing 3) a digital ontology and the related digital platform that enable users to adopt the methodology. This chapter documents the design hypothesis, research questions, methodologies and artifacts of the author's research and how they evolved during the three phases.

4.1. Understanding Practice and Research with Research Through Design

This dissertation adopts a Design approach, following the definition elaborated by Nelson and Stolterman (2012) which establishes Design as a method of inquiry separated from the scientific and the artistic ones, which is not a mix or intermediate approach between the two but a culture of its own:

> Design is a tertium quid— a third way — distinct from the arts and sciences. In support of this argument we make a case for the reconstitution of sophia— the integration of thought and action through design. We make a case for design as its own tradition, one that reintegrates sophia rather than following the historical Western split between science and craft or, more recently, between science and the humanities. (2012, 11)

With this definition and approach, practice and research are never separated but their connection is a foundational element: the objective is to reflect for future development rather than to analyze existing conditions. According to Nelson and Stolterman, one key element for distinguishing design from science is the difference and confusion between what is true and what is real. Science deals only with what is true (therefore, general and universal), and has no approach for creating the real (the particular). Design, instead, deals with the particular, as well as with that which is real and the ideal (what is considered to be a desirable outcome): "design is a process of moving from the universal, general, and particular to the ultimate particular — the specific design" (2012, 31). Furthermore, what distinguish the design approach from the scientific but also the artistic ones, is service as its defining element:

> all design activities are animated through dynamic relationships between those being served — clients, surrogate clients (those who act on behalf of clients), customers, and consumers or end users — and those in service, including the designers. Design ideally is about service on behalf of the other — not merely about changing someone's behavior for their own good or convincing them to buy products and services. (2012, 41)

Science and art are self-serving cultures of inquiry, while design is an other-serving culture. Furthermore, for Nelson and Stolterman design is a common human ability, not just a professional activity, positioning this view in the evolution process that has brought the design practice and research from a focus on technology, markets or products to a user-centered approach, then to co-design (Sanders and Stappers 2008), then to design for social innovation and diffuse design (Manzini 2015) then to design with and for Open/P2P/DDD Systems. Design is a tradition of enquiry that reintegrates science and craft, and this connection can take more than one form of intersection between practice and research (Frayling 1993; Manzini 2015; Findeli et al. 2008):

1. **Research on Design** (with methods from disciplines with a consolidated research tradition). Research that helps to understand the nature of Design itself: designers and their practice as the object of research studies. This approach aims at helping, guiding and developing a design practice. Normally performed by researchers from various disciplines, it can present a relative lack of relevance for Design if carried out to advance such disciplines and not Design.
2. **Research for Design or Design through Research** (with methods from disciplines with a consolidated research tradition and adapted to design-specific requirements). Research that produces better conceptual and operational tools for helping and developing a design practice: designers and their practice as the goal of research studies. This approach aims at properly and responsibly informing design projects.
3. **Research through Design** (with original methods, tools and skills proper to design culture and practice). Design practice and research that generates knowledge on and from the practice. This approach aims at providing a research culture to the actual design practice with methods of enquiry and an epistemology of its own.

Within the scope of this dissertation the practice is an emerging and fluid one, and therefore the Research through Design approach was adopted for strengthening the practice itself towards a self-aware improvement and understanding through artifacts[5]. The practice and its artifacts are the way through for understanding the role of meta-designers within the Maker

[5] The doctoral research spanned three phases, and the first one started some years before it: during PHASE 1 the adopted approach was Research for Design; during PHASE 2 the approach shifted towards Research through Design; see section 4.3.1 for more details.

Movement from the first-person perspective of the author, who investigated 1) the nature and role of meta-design through the OpenMetaDesign ontology and platforms for supporting distributed collaborative processes (ART. 2, 4, 5, 6, 7), 2) his own position and role in several Open Design-related collaborative initiatives (ART. 3) and 3) the role and position of Open Design and OpenMetaDesign within Open/P2P/DDD Systems.

Albeit a more recent approach, after being proposed at the beginning of the 90s, Research through Design emerged in the 00s (Bang et al. 2012) and as of the latter years of the 2010s it can still be considered in its formative stage. Research through Design has only recently become popular after research activities became a recognized part of designing artifacts and after design has been accepted as an established way for generating and communicating knowledge (Stappers and Giaccardi 2017). One of the more interesting promises of Research through Design is that it could be more relevant to the end user of the research: the design research community (interested in "fundamental" or "theoretical" knowledge), the design practice community (interested in "applied" and "useful" knowledge), and the design education community (interested in "teachable" and "applicable" knowledge) (Findeli et al. 2008). Together with the design communities, Research through Design also takes place in three of their contexts: the lab, the field and the showroom (Koskinen et al. 2011). The lab de-contextualizes research; the field contextualizes research; the showroom enables research by building on art and design rather than on science or on the social sciences.

Research through Design is typically practice-based due to the centrality of artifacts for the generation of knowledge, rather than of the centrality of practice:

> For practice-based researchers, making an artifact is pivotal, and the insights from making, reflecting and evaluating may be fed back directly into the artifact itself. Practice-led research, on the other hand, does not depend upon the creation of an artifact but is nevertheless founded in practice. (Candy and Edmonds 2017, 65)

Artifacts have a central role in the knowledge-generating process because they embed the tacit and explicit knowledge that generates them and therefore provides an access to it. Artifacts informs research by embedding research questions and at the same time by being the means for answering them, for testing the hypotheses, for gathering and assessing data, for enabling designers/researchers to reflect on their activities (evaluative role) and for exploring new design spaces (generative role) (Stappers and Giaccardi 2017).

But the specific research dimension of Research through Design implies that artifacts are not the goal of Research through Design: knowledge and understanding are instead the goal and emerges from the making of an artifact and are embodied in it (Godin and Zahedi 2014a). According to Zimmerman and Forlizzi, in Research through Design:

> researchers make prototypes, products, and models to codify their own understanding of a particular situation and to provide a concrete framing of the problem and a description of a proposed, preferred state [...] By practicing research through design, design researchers can explore new materials and actively participate in intentionally constructing the future, in the form of disciplined imagination, instead of limiting their research to an analysis of the present and the past. (2008, 42)

In Research through Design knowledge can be considered as an understanding of the world, a worldview, that can be shared (Stappers and Giaccardi 2017), reinforcing the importance of Ontological Design for both practice and research. Artifacts generates knowledge in their designing and when being adopted, when they are developed and tested in experiments, which can be considered initiative of controlled hypothesis-testing research or more generally, explorative initiatives. Experiments can be exploratory when they initiate, drive and frame the research at the beginning of a research program; they can be testing experiments when they reframe or consolidate a research program; they can be closing experiments when they position and contextualize the research program (Redström 2011; Stappers and Giaccardi 2017).

In Research through Design the generation of artifacts and the overall structure of research is based on motivations more than on theories. Zimmerman and Forlizzi propose two motivational contexts for Research through Design: a research question is 1) formulated out of an existing theory or philosophy and investigated with an artifact (the "philosophical approach") or 2) it emerges from the focus on real-world problems and the artifacts designed towards them (the "grounded approach") (Zimmerman and Forlizzi 2008). Bang et al. further elaborates this by investigating the interactions among hypothesis, research questions, motivations and experiments in Research through Design (2012). According to their model, motivations shape hypothesis making as the foundational element that support a continuous experimentation process and a consequential continuous reformulation of the research:

> The hypothesis articulates the premise(s) under which any research work must be read and understood. It articulates and de-limits the validity of the studies and frames the methodological landscape. Following this, the research questions are more detailed accounts of what is subject to study, and point out appropriate research techniques and even possible outcomes. Preceding these the motivation of the research contains both the internal and external relevance of the research. The actual concrete research activities are in this model described as experiments. Experimental work is not limited to be the construction of prototypes or artefacts but also means the evaluation or exposure of these in the context they are developed for. (2012, 7)

However, some clarifications are necessary in order to adopt the concept of hypothesis in Research through Design. The trial and error process of cycles of hypothesis, prediction, experiments and analysis could support validity of the Research through Design; however, the adoption of such process in Research through Design is still primitive as it is lacking proper literature (Godin and Zahedi 2014b). One of the possible main obstacles in this direction might be found in the fact that design problems are generally considered "wicked" (ill-defined, never solved) in contrast with typical "tame" problems (definable, separable, with findable solutions) of Science and Engineering (Buchanan 1992; Rittel and Webber 1973). Wicked problems are defined by indeterminacy (there are no definitive conditions or limits) (Buchanan 1992) and are typical of open societal systems and are the results of three traits of them: 1) finitude (of cognitive capacity); 2) complexity (of systems, actions and other co-occurring interactions); 3) normativity (that is intertwined with problems formulation and problem resolution) (Farrell and Hooker 2013). As a result, "the classical paradigm of science and engineering – the paradigm that has underlain modern professionalism-- is not applicable to the problems of open societal systems" (Rittel and Webber 1973, 160); furthermore,

> Design problems are "indeterminate" and "wicked" because design has no special subject matter of its own apart from what a designer conceives it to be. The subject matter of design is potentially *universal* in scope, because design thinking may be applied to any area of human experience. But in the process of application, the designer must discover or invent a *particular* subject out of the problems and issues of specific circumstances. This sharply contrasts with the disciplines of science, which are concerned with understanding the principles, laws, rules, or structures that are necessarily embodied in existing subject matters. (Buchanan 1992, 16)

Wicked problems are unique and their solutions cannot be true or false but evaluated as good or bad through a "one shot" operation that therefore cannot be part of a trial and error process. Wicked problems can also have more than one possible explanation. Therefore, when adopting Design as a method of inquiry, the adoption of the concepts of hypothesis and experiments should be redefined because while science adopts them to move from the ultimate particulars to universal principles and laws, in Design they would enable the moving from the universal to the ultimate particular:

> In science, we strive to reason from ultimate particulars to universal principles and laws. This is done by the method of induction. Through science, we can also explain something quite particular with the help of the universal, by the method of deduction. But, the process for creating the ultimate particular is not based on scientific induction or scientific deduction. There is no scientific approach for creating an ultimate particular because science is a process of discerning abstractions that apply across categories or taxonomies of phenomena, while the ultimate particular is a singular and unique composition or assembly. Creating that which is unique and thus particular, therefore, cannot be accomplished using a scientific approach. (Nelson and Stolterman 2012, 30–31)

However, Design as a method of inquiry is not completely disconnected from Science; it is instead "an emergent, compound form of inquiry that is inclusive of the real, the true, and the ideal" (Nelson and Stolterman 2012, 37); an approach to gaining knowledge through "evoking, or creating, the ideal in the real. But design has to be grounded in what is already real, as well as what is actually true." (Nelson and Stolterman 2012, 39). While Science tends to provide an explanation, Design tends to realize an intention:

> This means we will never be able to ground design on the idea that the "right" design is out there, embedded in reality, just waiting to be discovered. To the

> contrary, design will always be about creating something that does not yet exist. It is not about finding something already in existence. Science can help us in our design process by providing knowledge about structures, laws, and processes that reveal the natural world. But the primary thing this kind of knowledge gives us is a description, or explanation, of already existing things. Science cannot provide insight into what should be brought into existence, through intention, imagination, and innovation. It can only confirm potentiality and assist realization. (Nelson and Stolterman 2012, 28–29)

Furthermore, the rigid distinction between tame problems for Science and Engineering and wicked problems for Design has been criticized: for example, Farrell and Hooker argue that both Design and Science contain various problems that to varying degrees are wicked or tame (2013). Design and Science are not two completely different traditions, and both present hypothesis and experiments:

> This phenomenon of hypothesis-testing and possible refutation avoidance is therefore common to both design and science. Moreover, the ultimate source of this phenomenon derives from both the cognitive finitude of human beings and from resource finitude. We cannot, in science, perform all possible experiments, all at the same time, in order to clearly assign fault to one of the many sub-systems potentially causing an unsuccessful experiment. Similarly, we cannot, in design, implement all possible designs, all at the same time, in order to see which one is optimal and which ones not. (2013, 699)

Therefore, hypothesis and experiment can still be considered in Research through Design: in this context, they are not about finding an explanation of what is real and already existing, but rather about developing an explanation of how to bring something to existence and achieving a change: “a designer forms an idea or a working hypothesis about the nature of products or the nature of the human made in the world. This is the designer's view of what is meant, for example, by the "artificial" in relation to the "natural." (Buchanan 1992, 16); “the working hypothesis that will lead to a particular product is the principle of relevance, guiding the efforts of designers to gather all available knowledge bearing on how a product is finally planned” (Buchanan 1992, 18). In order to make a distinction from the science tradition, the author uses here the expression of “a design hypothesis”: a proposition or supposition about the relevance of the artificial nature of a design intervention towards creating the ideal in the real while being grounded in real and true.

New knowledge can be formulated after the research meets the desired criteria for evaluation, tied to at least six motivational contexts: 1) a practice based/artistically inclined approach, 2) an ethical, 3) political, 4) empirical or 5) technological provoked approach and finally a 6) theoretically informed approach (Bang et al. 2012). The whole process is based on abductive reasoning: “knowledge, empirical findings, concepts and ideas are combined as a form of abstract prototypes to be tested and debated according to their relevance to practice, academia, and practicability or feasibility of the experiment” (Bang et al. 2012, 7). Hypothesis, research questions, motivations and experiments generate knowledge, which is the foundation for building theories. Generally, theories are elaborated on a high level of abstraction, so that they can be generalized and applied to many different contexts. The role of research is often to establish connections between the conceptual and the concrete, the general and the particular. But the Design approach is not concerned with the "true" but with the "real", it is not past-based but future-oriented, and therefore also design research (Stappers and Giaccardi 2017; Nelson and Stolterman 2012; Redström 2017; Godin and Zahedi 2014a). Design theories in Research through Design should be elaborated so that they emerge from the coevolution of design practice and research and should be easily understood in a comparable way as a design artifact should be easy to use (Godin and Zahedi 2014a).

Redström (2017) proposes that Research through Design can elaborate transitional "design theory of something". Such theories are not theories of design, that would take design and designing as their subject, but rather design theories that are developed in and through design and that "refers to what we use to conceptualize, understand, and articulate design and designing" (2017, 135). They are inherently transitional (dynamic, unstable and constantly changing) because of their nature of being future-oriented: "Theory is used not only to account for existing things but also importantly to imagine things not yet seen." (2017, 136). According to Redström theory and practice in design research are typically approached with two incomplete tactics. The *parallel* tactic keeps theory and practice parallel and separated by adopting existing research frameworks as a reflective layer on top of the practice. The *sequencing* tactic join theory and practice together only with an iterative research process; here again by applying theories external to design and generally without contributing any new theory to design. Redström suggests a third tactic for overcoming such limitations: the *intermediaries* tactic, which focuses instead on the tension between the general and the particular by articulating intermediate and dynamic theories at different levels of abstraction between theory and practice.

Two main elements can be identified here as the foundation of design theories: design definitions (as definitions made through the design practice) and how these can be organized in a spectrum that comprises the tension between the general and the particular. Part of the human nature is to connect things and words, and Design has a role in this by creating and recreating definitions not just of objects but of the human existence through its practice: "Consider how a chair defines the act of sitting, and how, therefore, designing a chair in a certain sense is a matter of defining what sitting is." (2017, 31). This can be considered a continuous process of Ontological Design that lays the foundations for design theories: "when we aim to redefine what some *thing* is, what we offer is not a new description but a concrete design that *sounds differently*." (2017, 34).

Such definitions and the activities generating them are a way for addressing the tension between the general and the particular, from addressing what a design is (product) to what designing is (paradigm), at a different level of focus in developing definitions through design. Between the two extremes, from products to paradigms, we encounter projects (efforts with an objective and with given limitations in both time and resources), programs (overall frameworks defining scope and purpose for different but related projects), practice (human activities organized around shared practical understanding). Such spectrum "is not about the distinction between design as a thing versus design as an activity, but rather about the continuity between a distinct outcome and the overall effort producing such outcomes." (2017, 83). Within this spectrum, Redström considers programs as the key element that enables Research through Design to contribute to design because they have the function of connecting theory with the practice by informing the latter and influencing all the definitions in the spectrum. Along this direction, programs have a key role in Ontological Design, allowing designers/researchers to deal with worldviews by making them explicit in the practice.

The reflections on how Research through Design can generate knowledge in a rigorous and structured way are increasingly generating proposals on how to proceed in connecting and enriching design practice and research, which are similar but still not completely integrated:

> designers often confuse practice with research. Instead of developing theory from practice through articulation and inductive inquiry, some designers simply argue that practice is research and practice-based research is, in itself, a form of theory construction. Design theory is not identical with the tacit knowledge of design practice. (Friedman 2003, 519)

It has to be noted how Research through Design is not necessarily limited to design skills, professionals, and communities but also to other contexts such as social sciences, and especially it can be applied to Action Research because of its focus on improving a specific context while understanding the generated impact (Stappers and Giaccardi 2017). As in Action Research, contexts are always different and design/designing as well, so validity in Research through Design cannot be evaluated by the reproducibility of the results, but rather through recoverability, making sure that the practice and research process is well documented and recoverable; validation of practice and research can be also elaborated from the quality, acceptance and outcomes of the artifact (Godin and Zahedi 2014a).

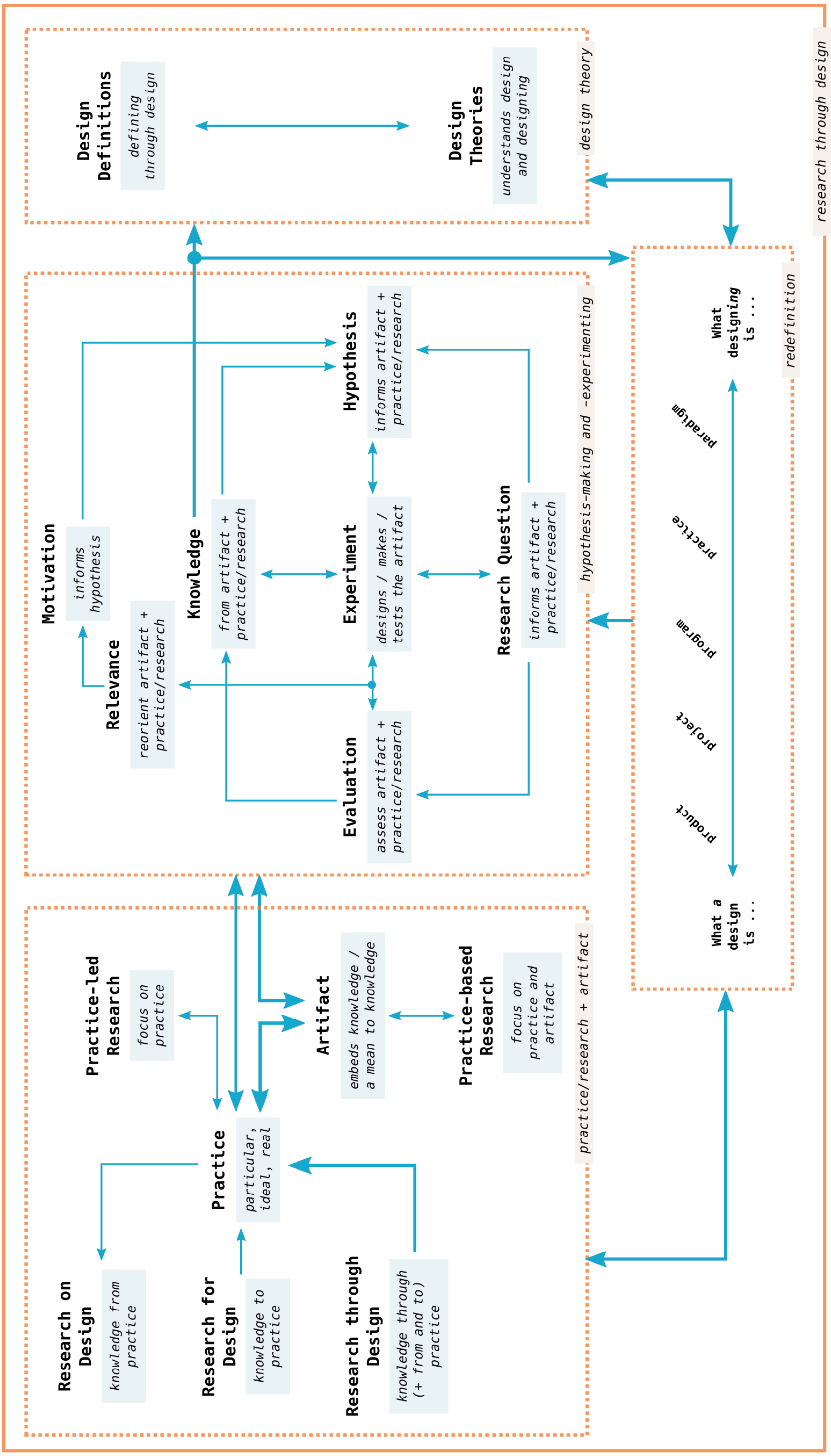

Figure 10. An overview of Research through Design (based on Frayling 1993; Bang et al. 2012; Redström 2017)

4.2. Practice Through Time, Space and Social Dimensions

The focus of this dissertation is on understanding how participants in distributed systems can collaboratively work together, and what is the possible role of design approaches, tools and research in facilitating them with digital tools and platforms. This perspective emerged from the evolution of both the practice and the social dimensions of the author: the Research through Design approach here adopted works on both improving and understanding the practice through artifacts.

For these reasons the practice and research focused on 1) exploring the intersections of openness and peer-to-peer systems within design research and practice; 2) extending these intersections through new media by focusing on the software, digital and distributed dimensions that 3) tools and platform have in facilitating the designing and managing of collaborative processes. Open source and peer-to-peer initiatives have been often considered interesting for their replicability in many different contexts, and the application of this research and practice is not an exception. Therefore, rather than replicability, and more than recoverability, the practice that is the context of this research is described in order to move towards adaptability of results into other contexts. Design practice and research works with the real (the particular) and describing and understanding the context (the author's practice here) is a key step towards the recoverability of Research through Design and adaptability of results to other contexts.

For historical, social and professional reasons the context of this dissertation is the Maker Movement and especially the Fab Lab community. In this context the author participated, worked and researched as maker/designer, facilitator, researcher, lecturer, consultant and project manager in it: a complicated but rich approach that wasn't originally planned but that enabled the acquiring of a multi-dimension understanding of the phenomenon. Beside participating in an emerging community and learning about it and from it at the same time, the author's focus has been on the practice of the Maker Movement of using digital platforms and digital fabrication tools for collaboratively designing and manufacturing digital and physical artifacts as Open Design projects. The Maker Movement has provided professional and non-professional, professionally-trained and non-professionally-trained designers an easier access to digital fabrication tools and systems, and more importantly, a social dimension for collaboration and sharing, with social roles and processes still largely undefined; the design of tools and media can therefore influence them, while being influenced by them.

The experience of the author in being part of this community and because of his work in establishing labs was extensively documented in books together with an overview of the technology, spaces, business, organization and relationship with design of the Maker Movement and especially of the Fab Lab network (Menichinelli 2016b; Menichinelli et al. 2015; Bianchini et al. 2015; Menichinelli and Ustarroz Molina 2018). The main element that should be highlighted in this section is that here in this context communities can be found on three levels and a cross-cutting socio-technical dimension (Figure 11):

1. **local communities** that form in and around local laboratories (Ghalim 2013; Maldini 2014);
2. **a global community** of local events and laboratories with a complex social structure emerging from bottom-up (Menichinelli 2016c);
3. **the communities that form around the development of projects** which are typically prototyped and manufactured locally in maker laboratories (Menichinelli 2015b; Gershenfeld 2005).
4. **digital platforms as a cross-cutting dimension** that connect the previous three scales, for example for sharing projects openly as Open Design, which then become community-based initiatives; ART. 3 is a contribution towards this direction (Menichinelli 2017c).

The starting point of the author's practice and research path can be identified with his master's thesis at School of Design, Politecnico di Milano (2005-2006), which explored how open source and peer-to-peer principles and practices could be applied to the design of collaborative processes with communities in a master degree thesis (Menichinelli 2006). Developed when the first research initiatives about design for territories were ending, and open source, peer-to-peer and other online systems were beginning to expand beyond just software, it created the opportunity for thinking guidelines for moving from designing services to designing collaborative distributed and localized networks as services.

In 2006 such work was considered too experimental, vague, conceptual, and still detached from practice. To complicate things further, open source and peer-to-peer were still considered as too controversial, and even more in the design community, in both practice and research. This situation immediately led to an independent and informal research, that started in 2007 with the launch of openp2pdesign.org, a website developed for disseminating the master's degree thesis and for open discussions. This dissemination effort led to several workshops and events, which were then fed into the doctoral research at Aalto University that started in January 2011, with the aim of making it more rigorous.

While in Finland for the first years of the doctoral studies (2011-2012), the author also worked in project management as producer at Aalto Media Factory, where he taught Digital Fabrication Studio course for Media Lab Helsinki (now Aalto Media Lab) and he was one of the core organizers of the first Open Knowledge Festival[6] in Helsinki (2012). During this period, he also collaborated at the development of the Aalto Fab Lab[7], while at the same time attending

[6] https://2012.okfestival.org/

[7] https://fablab.aalto.fi/

there as a student the Fab Academy[8], the distributed educational format on Digital Fabrication of the global Fab Lab network[9].

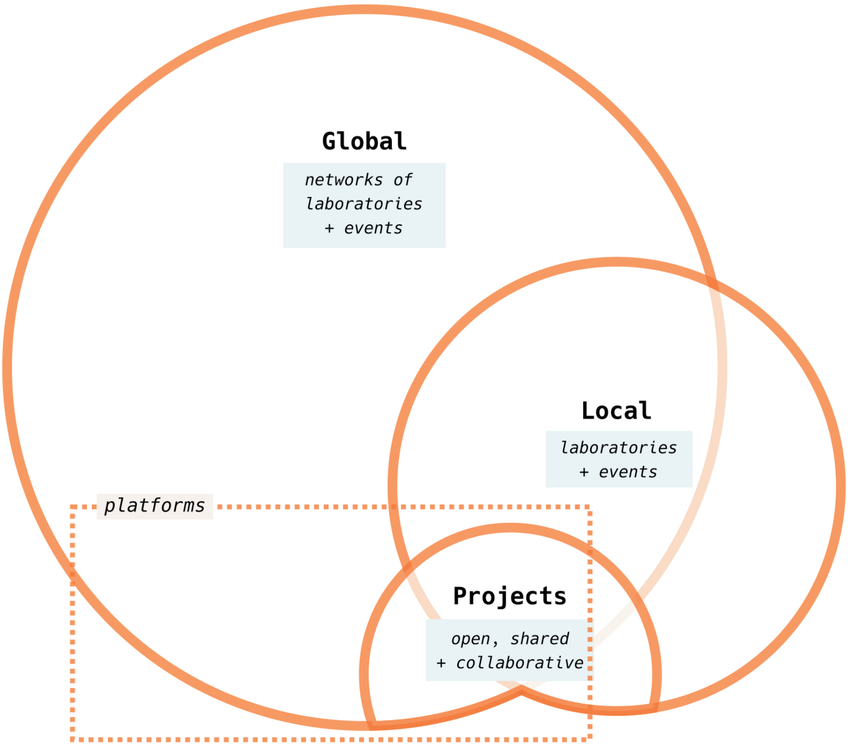

Figure 11. The dimensions of the Maker Movement in the context of this dissertation

After two years in Finland, the author moved back to Italy, bringing there the knowledge and expertise for developing Fab Labs. In Italy the author worked as a consultant, building labs with service design tools and a Human-centered approach, developing labs around the people who would spend time in them rather than the technology in them, such as MUSE Fab Lab[10] and Opendot[11], participated in other initiatives for launching labs and gave workshops for sharing this approach to other initiatives. The author also worked as director of a foundation, in the Make in Italy CDB Foundation (Italy), analyzing the emergent Maker and Fab Lab Italian community (Menichinelli and Ranellucci 2015; Bianchini et al. 2015), promoting it and supporting their projects

[8] http://fabacademy.org/

[9] The development of the concept of Fab Lab and the global network that connects them happened by accident as an unexpected positive outcome of the success of the "How To Make Almost Anything" course taught at MIT by Neil Gershenfeld since 1998 (Gershenfeld 2005). The success of this course, especially among artists and designers, led to the creation of the Fab Lab network and later, from 2009, to the creation of the Fab Academy. This initiative replicates the "How To Make Almost Anything" course but for students outside MIT, and located in several Fab Labs. The focus in the Fab Academy is on providing the basic knowledge needed in order to be able to develop a project with Digital Fabrication technologies in a Fab Lab, and the experience of working in such kind of lab while in a global network.

[10] http://fablab.muse.it/

[11] http://opendotlab.it/

and the launch of new labs. Meanwhile the author continued lecturing the Digital Fabrication Studio course at Media Lab Helsinki, acted as instructor in the Fab Academy done at Opendot and WeMake[12], lectured the Open and Collaborative Design in the “Design with the user” course in the Master for Advanced Studies in Interaction Design[13] at SUPSI (Lugano, Switzerland).

At the end of 2015, the author moved from Italy to Spain and had the opportunity of focusing only on research by making it the professional practice with the role of project manager and researcher in European research project. Between January 2016 and December 2018, the author worked as project manager and researcher in Horizon 2020 and Creative Europe projects in the Fab Lab Barcelona[14] / Fab City Research Lab at the Institute of Advanced Architecture of Catalonia (IAAC)[15] in Barcelona. The objective of such work was to improve the impact of the Maker Movement by connecting it with more stakeholders and organizations, creating opportunities for research and connection with industry and policy making, measuring the impact of digital fabrication technologies and Maker products, places and initiatives.

The author had the opportunity to research on: the dynamics and impact of the Maker Movement (MAKE-IT[16]); a European network of co-creation laboratories for extending Responsible Research and Innovation (RRI) to citizens thanks to a network of Fab Labs, Science Museums and Living Labs (SISCODE[17]); assessing Digital Social Innovation initiatives (DSISCALE[18]); promoting makers with digital platforms (DDMP[19], a Creative Europe project the author wrote and coordinated). Furthermore, at IAAC the author worked during October 2016 – December 2018 also as project manager of Fablabs.io[20], the online platform that connects all the Fab Labs worldwide.

The interest in understanding how to connect and facilitate the collaboration between different kind of stakeholders brought the author to join RMIT in January 2019 in its European hub in Barcelona as a Research Fellow, working on the coordination of the MSCA-RISE-2018 (Research and Innovation Staff Exchange) Horizon 2020 project OpenInnoTrain[21], a global network of researchers and industry practitioners across Europe and Australia for promoting the translation of research between university-industry through cooperation and Open Innovation.

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12 http://wemake.cc/

13 https://www.maind.supsi.ch/

14 https://fablabbcn.org/

15 http://iaac.net/

16 https://cordis.europa.eu/project/rcn/200424_en.html – http://make-it.io/

17 https://cordis.europa.eu/project/rcn/214915_en.html – https://siscodeproject.eu/

18 https://cordis.europa.eu/project/rcn/213142_en.html – https://digitalsocial.eu/

19 http://distributeddesign.eu/

20 https://www.fablabs.io/

21 https://cordis.europa.eu/project/id/823971 – https://openinnotrain.eu/

4.3. Research Questions, Hypotheses, Methods and Artifacts

4.3.1. Phases

As is the case with many research initiatives and doctoral studies, work on the dissertation lasted several years (2011-2019). It was influenced by the rumination of the author regarding his professional practice as well as reflections about changes of jobs, cities and countries. In the practice dimension, the interest of the author shifted increasingly from teaching digital fabrication technologies, making processes and open and collaborative design processes to facilitating them, participating and directing organizations and later managing the development of digital platforms that support them.

The focus of the research moved then from improving teaching processes to support teaching, platform development, project management, research and other activities around open and collaborative design and making processes. And even changes outside of the author's path influenced the path: new open source software frameworks for real-time platforms emerged, enabling the move from the need of learning and teaching asynchronous tools such as Subversion[22] and Git[23] to the possibility of developing custom real-time digital platform with the adoption of the Meteor[24] framework. Furthermore, moving between cities, countries and jobs made it increasingly difficult to focus on specific contexts and communities where to apply the research; at the same time, some maker initiatives emerged and disappeared, complicating things further. Initially, Participatory Action Research was considered as the main strategy for this research, with the purpose of understanding the impact of the author's research and practice in his social context. However, the continuously shifting local context proved an obstacle to this idea. Instead, the objectives evolved to into developing an understanding of how to improve the author's role and path in this continuously changing landscape.

The research hypothesis, questions, methods and activities reflected the shifting perspectives and were thus subsequently updated, reoriented and reorganized several times. Working on New Media and Design, the focus of the research has always been on digital tools, or rather on how digital tools (and the design of new digital tools) mediate the practice of the author in facilitating the design of collaborative design processes. This evolved and changed along three main phases, following also the evolution of the research and practice of the author: from facilitating collaborative design processes with 1) guidelines for a generic design approach, process and tools (PHASE 1), to the use of 2) custom design tools and workshops that encode the methodology (PHASE 2) to developing 3) a digital ontology and the related digital platform and software components (PHASE 3) (Figures 12, 13).

[22] https://subversion.apache.org/

[23] https://git-scm.com/

[24] https://www.meteor.com/

During these phases, the author changed the approach to design research, from Research for Design in PHASE 1, to a shift to Research through Design in PHASE 2, which then became fully adopted in PHASE 3 (Figure 12). This shift emerged through studying, writing and experimenting thank so the realization that a) the many changes in the evolution of Maker communities and in the practice and location of the author made more relevant a research of the foundations for future in-depth research than a research for specific projects; b) Research through Design is still relatively an emergent approach, and crucial contributions towards its adoption emerged only at a later time. When a practice is still fluid and changing quickly, so the knowledge it needs changes accordingly, and thus research as well; developing insights, approaches and tools for a less fluid future research and practice might be more relevant. The author considered thus that Research through Design was more apt for strengthening the emerging and fluid practice of meta-design within the Maker Movement towards a self-aware reflection and improvement. The shift was from design research for design practice to design research through design practice and for it: from design research to design practice and research together. During PHASE 2 and especially PHASE 3, Research through Design thus contributed a method for developing a research through the practice of meta-designing in the Maker Movement, and finally elaborated as a full strategy in CONTRIB. 1 (see section 6.1).

The doctoral research started during the last two years of PHASE 1 (2005-2012), which can be considered its antecedent: during this phase the work was on guidelines for a generic design approach with many tools and workshops for making it more accessible and applicable, developed in the master degree thesis (Menichinelli 2006). PHASE 2 (few months between 2012 and 2013) was characterized by a shift from guidelines for a generic design approach with many tools to a single toolkit made of design canvases (Part II, Chapter 8) for making it more accessible; ART. 1, 2 and 3 document the context and the first experiences in testing PHASE 1 and moving to PHASE 2. PHASE 3 (2013-2019) focused on a data visualization tool, its test with users and a final reflection about it and its broader implications. While PHASE 1 worked on the concept of Open P2P Design, PHASE 2 translated it into OpenMetaDesign, which was then fully developed into a framework in PHASE 3 with ART. 4, 5, 6, 7. Here the development moved from a desktop software to a digital ontology and then to a platform based on the ontology, as a starting point for further elaboration. See section 4.3.3 for an overview of the outcomes and how they were developed, where three different phases, albeit not completely coincident with the above phases, can be clearly seen.

The timeline of the articles shows that, beside two articles (ART. 1 and 3) which conceptually are not part of any phase since they are more general and not linked to the main artifacts of each phase, all the other ones can be assigned to phases. ART. 2 is a first test of what developed in the master's degree thesis during PHASE 1 (Menichinelli 2006). No article has been written from the work of PHASE 2 yet, and PHASE 3 has most of the articles (ART. 4, 5, 6 and 7) (Figures 12, 13). The connection between the practice and the research consequently changed: from the practice being just the context to where apply the artifacts of the research (methodology, design canvases, workshop formats, ...) at the beginning (PHASE 1 – PHASE 2), to becoming the focus of the research and intertwined with it (PHASE 3), ending the course with a reflection (this dissertation) on the connection of research and practice, the role, the general framework and tools of meta-designers, a final reflection and redefinition that itself is the end of this exploratory course and the start of a new and structured path (PHASE 3) (Figures 12, 13). The main three version of the working title of this dissertation are a clear indicator of this evolution:

v0.1. A digital open source design methodology for enabling collaborative design networks with open and p2p dynamics.

v0.2. Open Meta-Design: a platform for the organizing of Open and Collaborative Design and Making processes.

v0.3. Open and collaborative design processes. Meta-Design, ontologies and platforms within the Maker Movement.

This dissertation thus represents a first exploratory examination of the role, practice and profile of the author as meta-designer facilitating distributed, open and collaborative design processes in the Maker Movement.

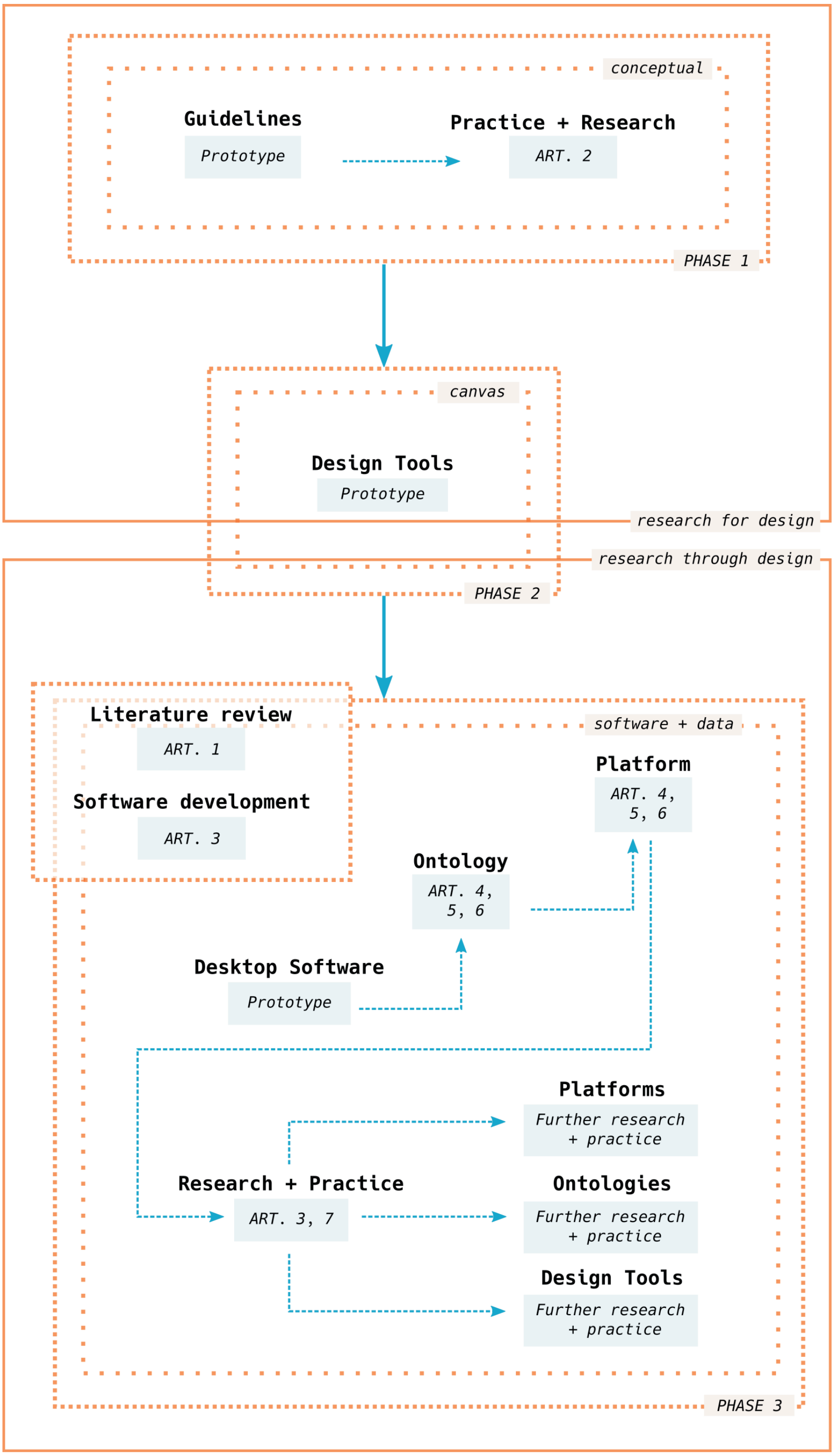

Figure 12. Path and phases of the doctoral studies leading to the dissertation

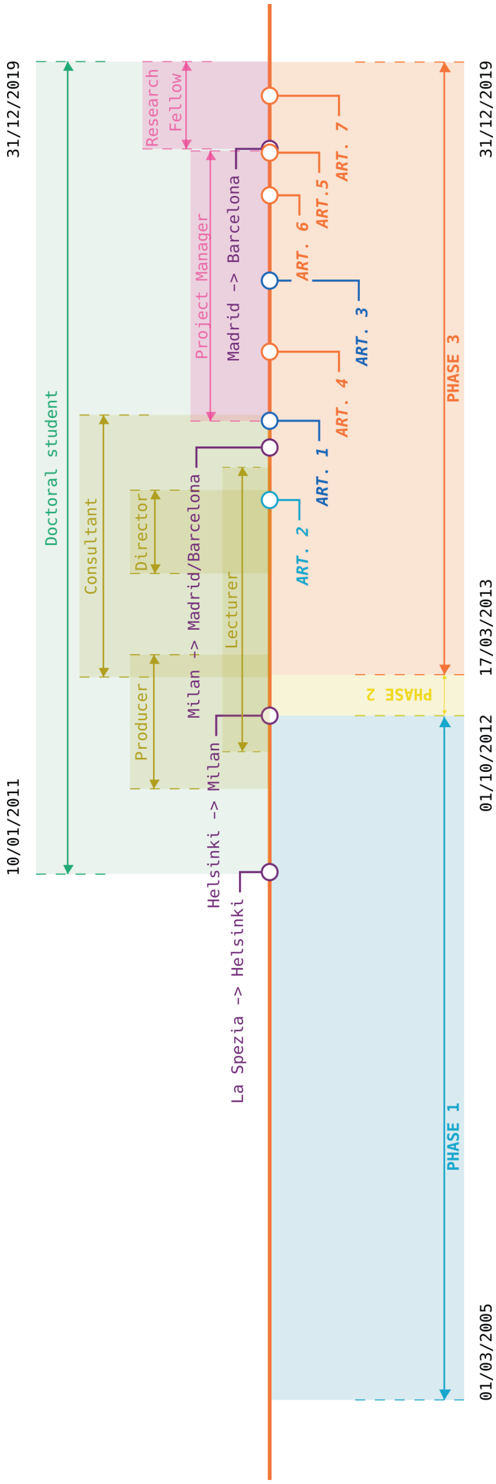

Figure 13. Timeline of the practice and research of the dissertation

4.3.2. Design Hypothesis, Research Questions and Methods

Often technology and innovation are considered more in terms expectations and how to meet them than in other aspects. Bruce Mau's *Massive Change* project famously asked for the expanding integrations of design, innovation and technology: "Now that we can do everything, what will we do?" (2004, 15). Fab Labs emerged from Neil Gershenfeld's course at MIT called "How to make (almost) anything" (2005; 2012). In the opinion of the author these are rather rhetorical affirmations, formulated to draw attention to the vast range of possible applications. With the development of additive manufacturing, other digital fabrication technologies and their democratization in maker laboratories and events, a more refined question following this direction and contextualized would be: now that we can design and make (almost) anything with digital fabrication technologies over distributed networks of maker laboratories, how will we do it collaboratively? With so much attention to the technologies, the single projects and the future potentialities, less attention has been devoted on how to make these to scale up and become collaborative, distributed and complex as they are often promised. Exploring this and its connection with the practice of the author has been the main motivation behind this doctoral research, as the author has been for many years not only a researcher and practitioner but also a member of the Maker Movement. Such exploration would be relevant not just for the author, but also for the participant of the Maker Movement and for anybody approaching it.

Following Zimmerman and Forlizzi (2008) this doctoral research has followed a motivation with a "philosophical approach" because it tried to explore applications and implications of an existing approach for designing collaborative networks (Menichinelli 2006) rather than focusing on designing for one specific context. Among the six motivational contexts identified by Bang et al. (2012), the motivation of this doctoral research resembles most the combination of two of them: a practice-based and artistically inclined approach combined with a technologically provoked approach. The reasons for this direction stem mainly from the fact that during the many years of practice and research of the author many maker initiatives emerged and declined. This doctoral research thus took the shape of Action Research but mainly of the author's practice and research within the global Maker Movement and some of its local initiatives more than of a specific maker initiative. Collaboration, organization and coordination are structural activities that enable makers to be part of a community: by supporting the emergence of collaboration, this dissertation also contributed towards a better understanding of the structure and meaning of maker communities, especially with ART. 3 and other publications (Menichinelli 2016c).

While motivation defines both the internal and external relevance of the research, the design hypothesis defines the landscape of the research and how to explore it (Bang et al. 2012). The design hypothesis of this dissertation is that a shared, common way of describing, discussing and editing collaborative processes can be useful in enabling members of the Maker Movement in understanding open, collaborative and distributed projects as complex processes and systems. The design hypothesis thus is that:

DESIGN HYPOTHESIS: makers can be facilitated in collaborating, organizing and coordinating their work, and this facilitation can be supported with the design of digital languages and maps as a kind of new media design that defines collaborative processes with the ontology of a data format as a shared language and its related platform.

The design hypothesis is in line with the general objective of this research of investigating if and how the design, new media, software and data visualization can have a role in facilitating distributed systems and enabling new collaborative networks especially in the context of the Maker Movement and of Open Design projects. The design hypothesis nevertheless changed through the three phases, mainly reflecting which artifact would support the definition and design of collaborative processes: from guidelines for a generic design approach, process and tools (PHASE 1) to custom design tools (PHASE 2) and finally to a digital ontology and its related platform (PHASE 3).

Research questions further details the design hypothesis in terms of what to study and how to do it. Research questions, more than through the phases of the doctoral research, evolved through the articles included in this dissertation, and especially crystallized during PHASE 3 (Figure 17):

RQ-ART 1. What is the overall context of the meta-design practice and research regarding design and open, peer-to-peer and collaborative processes?

RQ-ART 2. What are the previous research and practice experiences of the author for designing collaborative processes, and how could they be further researched and improved?

RQ-ART 3. How could the analysis of social interactions over time on such platforms improve the understanding of design-related collaborative processes?

RQ-ART 4. What is the overall framework and background regarding the philosophy, data and design of an OpenMetaDesign tool?

RQ-ART 5. How can be collaborative design processes documented, analyzed and shared?

RQ-ART 6. How could Service Design enable the meta-design of collaborative design processes on

RQ-ART 7. How can we connect the research and practice of meta-designers in open and collaborative design and making processes?

These research questions can then be re-elaborated as these final research questions, with RQ0 as the main research question and RQ1-4 as the research sub-questions:

RQ0. How can we support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems?

RQ1. **DESIGN.** How can collaborative design processes be designed, documented and shared with meta-design research and practice on digital platforms?

RQ2. **ANALYSIS.** How can collaborative design processes be understood, analyzed and shared with meta-design research and practice on digital platforms?

RQ3. **PRACTICE AND RESEARCH.** How can we connect the research and practice of meta-designers in open and collaborative design and making processes?

RQ4. **CONTEXT.** What is the overall context of the meta-design practice and research regarding design and open, peer-to-peer and collaborative processes?

The methodologies applied throughout this doctoral research have been part of the included articles in the dissertation and connected to specific research questions (Figure 2), and overall:

METH. 1. **Literature review.** This method was adopted in each publication, especially for mapping the state of the art and related contributions to each research question and article.

METH. 2. **Design/development.** The design of the data visualization and interface of the digital platform and its related software development has been a fundamental part of the approach of the research, and the processes and results have been detailed in ART. 4, 5 and 6.

METH. 3. **User testing.** In each phase, the artifacts were tested with users: design methodology in PHASE 1, detailed in ART. 2; design tools in PHASE 2, not documented in any publication as both the results and the artifacts proved to be ineffective and inadequate and therefore were discarded; the digital platform in PHASE 3, tested with a group of typical and potential users in the final experiment detailed in ART. 7. While in the PHASE 1 workshops included informal focus groups after the test, the final experiment in PHASE 3 adopted a well-structured questionnaire with both open and closed questions covering the needs of the participants, their expectations, their experience in using the tool and potential future directions. For this reason, the questionnaire included established questions like the System Usability Scale (SUS) (Brooke 2013) and it was shared in digital format online in order to enable verification, reproducibility and further adoption and development (Menichinelli 2019b). The research study took place as a half a day on 16th

October 2018 in Polifactory, the makerspace of the Politecnico di Milano (Italy) and consisted in a presentation of the OpenMetaDesign framework and digital platform, followed by an unstructured and autonomous test session of the OpenMetaDesign digital platform (Menichinelli 2019c) with 9 participants organized in groups of 2-3 finally followed by a questionnaire for structured in this way:

a. *You:* questions about the personal profile of the participants (age, gender, work experience, and so on).

b. *You and Making:* questions about the interest, ambition, role in the Maker Movement.

c. *You and Open Design:* questions about the interest, ambition, difficulties encountered before the research study and experience with open source software, hardware and design.

d. *Organization in your open and making practice before this research study:* questions about the coordination and organization in open and making practices before the research study (experience, metaphors for describing them, tools, experience of the whole system – actors, roles, interactions, organizations, places).

e. *Organization in your group during this research study:* questions about the coordination and organization in open and making practices during the research study (experience, metaphors for describing them, tools, experience of the whole system – actors, roles, interactions, organizations, places).

f. *Interactions in your group before the research study:* questions about the frequency, strength, quality and perception of interactions with other participants before the research study.

g. *Interactions in your group during the research study:* questions about the frequency, strength, quality and perception of interactions with other participants before the research study.

h. *You and OpenMetaDesign:* questions about the usability, usefulness, adoption, improvements for the OpenMetaDesign digital platform, and how it could contribute to the Maker Movement.

METH. 4. **Social Network Analysis.** The networks of interactions in Open Design projects of the author were analyzed with a custom open source software, *platform_analysis* (Menichinelli 2017b) in order to get insights about his practice and role; both the software and the results are described in ART. 3 (Menichinelli 2017c). A simple analysis of interactions was also included in the questionnaire of the final experiment (Menichinelli 2019b) and therefore also in ART. 7 (Menichinelli 2019d).

4.3.3. Artifacts

In the framework of the author's practice and research and in connection with the motivation, design hypothesis, research questions and motivations, several artifacts were produced during this doctoral research. Beside two design toolkits, all the other artifacts are software projects: all of these were developed as open source software on the GitHub platform, and through their analysis it is possible to see how their development unfolded in terms of work and time (Figure 14), be them design tools (in red), software scripts and modules for social network analysis (in blue) or the ontology/platform and the related questionnaire (in green).

PHASE 1 adopted guidelines for a generic design approach, process and tools from previous research (Menichinelli 2006), and therefore no artifact was produced. During PHASE 2, two design tools (toolkits of design canvases) were created: *OpenMetaDesignToolkit*[25] (19/01/2013 – 04/04/2014) (Part II, Chapter 8) and from it, the more generic *ServiceDesignToolkit*[26] (24/04/2013 – 27/04/2013). As both tools and their tests were unsatisfactory, this line of practice and research was discontinued in favor of the digital ontology and platform. Such tools proved to be too simple, too little flexible and difficult to establish as a shared language for describing collaborative processes, and the ontology/platform was considered more promising in terms of setting up standards while enabling more participation and interactions from users. Since working on an ontology as a starting point can then provide the infrastructure for more and different tools, visualizations and approaches (see CONTRIB. 2 in section 6.2), the ontology/platform served as the starting point of another toolkit of design canvases. In the SISCODE project, where the author worked, the ontology of this doctoral research was used for building the system of canvas tools of the *SISCODE Toolbox*, with the purpose of designing the co-creation process with stakeholders (Rizzo et al. 2018; Real et al. 2019). The ontology is the shared language for describing collaborative design processes (ART. 5) and the foundation for the development of the whole platform.

During PHASE 3, the artifact developed is a meta-design ontology/platform for the design and visualization of Open Design processes and systems, with open source data format and documentation. In this artifact the ontology was developed as part of a broader conceptual framework, OpenMetaDesign, that builds the ontology on top of concepts describing design processes, and encode it in a digital platform that consists of three dimensions: data (the data format encoding the ontology), design (the visualization layer that communicates the ontology) and software (the agent that binds the data format, the visualization and the interactions users have with it and among them). The focus on the development of such artifact was not on its User Experience and User Interface, but on its meta-design possibilities, an exploratory design, development and test for laying the foundation of more refined User Experi-

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[25] https://github.com/openp2pdesign/OpenMetaDesignToolkit

[26] https://github.com/openp2pdesign/ServiceDesignToolkit

ence Design in future practice and research. This fact defines that this doctoral research is not a User Experience or Human-Computer Interaction research, but a Meta-Design one that explores practice and research through and ontology/platform with a Research through Design approach. The role of the ontology/platform here is to provide the (digitally) codified and embodied dimension of the previous guidelines for a generic design approach, process and tools. The digital ontology that describes design processes, and the interface and visualization of its editing are encoded within OpenMetaDesign (Menichinelli 2019b), a free/open source digital platform for the collaborative design and discussion of collaborative design processes. A first version of this project was developed as a Python desktop software called *OpenMetaDesignApp*[27]: this proved a first context for prototyping the digital ontology, but the idea of a desktop software was discontinued because of technical issues and because it could not easily provide the functionality of real-time access, edit and discussion to multiple users, which could be easily obtained with a server-based platform instead (22/03/2013 – 20/06/2013). The final version, *OpenMetaDesign*, is a real-time JavaScript application based on the Meteor[28] framework that it is openly available and already configured for deployment[29] (20/05/2017 – 15/11/2018). The project of the digital platform has been elaborated regarding its background research, design, software and data dimensions in ART. 4, 5, 6. The digital platform was tested with users and the results from this research study are documented in ART. 7. The questionnaire files for the open source LimeSurvey[30] software and the Jupyter[31] notebook Python files for the data analyses and visualizations are openly available online[32] for assessment and reuse in future research studies (Menichinelli 2019b).

A related data analysis software was also developed: *platform_analysis* (Menichinelli 2017b), a free software/open source Python1[33] module[34] for social network analysis of online software (and design and hardware) collaborative platforms such as GitHub that adopt tools like Git, Hg, SVN for both the individual and the collaborative software development and storage (13/11/2015 – 03/02/2018). This module enables researchers to extract interactions over time in such repositories, creating thus timelines, charts and network of collaboration in open projects. ART. 3 documents the usage of this module in three Open Design-related projects: the discussion of an Open Design definition, the teaching of Open Design in an Interaction Design Master and the development of a platform for Fab Labs and Open Design projects. This project is a complete and documented module, a refactoring, reorgani-

[27] https://github.com/openp2pdesign/OpenMetaDesignApp

[28] https://www.meteor.com/

[29] https://github.com/openp2pdesign/OpenMetaDesign

[30] https://www.limesurvey.org/

[31] https://jupyter.org/

[32] https://github.com/openp2pdesign/OpenMetaDesignResearchStudy

[33] https://www.python.org/

[34] https://github.com/openp2pdesign/platform_analysis

zation and further development of two previous projects, which were simple collections of scripts: *Github-Social-Network-Analysis*[35] (10/02/2013 – 17/05/2014) and *GitHub-Organization-Analysis*[36] (15/12/2013 – 13/01/2014).

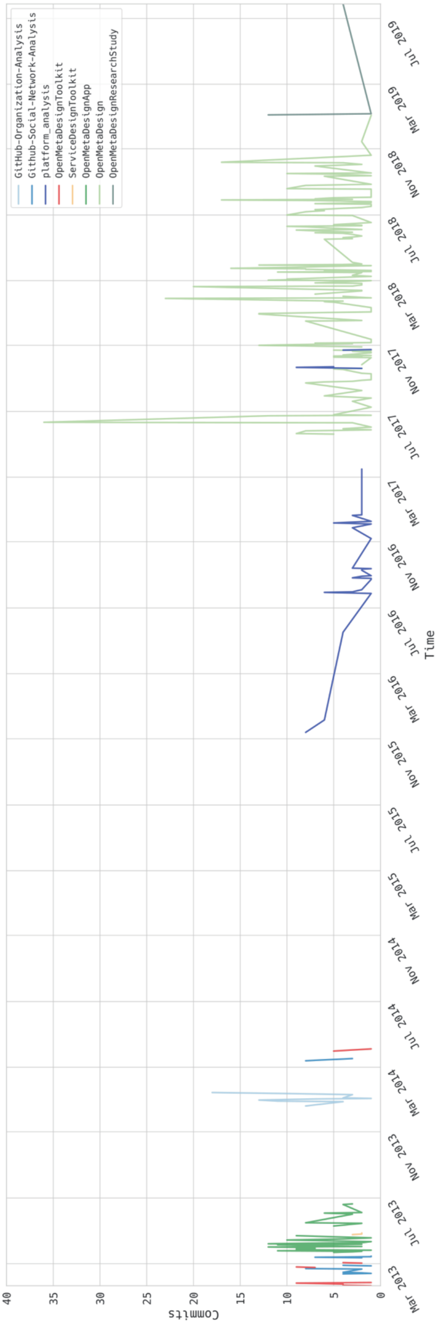

Figure 14. Development of the software of the doctoral research on GitHub over time

[35] https://github.com/openp2pdesign/Github-Social-Network-Analysis

[36] https://github.com/openp2pdesign/GitHub-Organization-Analysis

5. Summary of the Articles

This chapter presents the summary of the articles included in the dissertation as the outcomes of how such methodology was applied on artifacts over the phases. Articles are introduced together with their main research questions, their relevance to the OpenMetaDesign framework and the overall doctoral research. The full articles can be found in Part II and the main findings and contributions of this dissertation are elaborated from them in Chapter 6, and can be grouped into four themes:

1. Defining the context: ART. 1 (Menichinelli 2016a)
2. Reflecting upon the first approaches: ART. 2, 3 (Menichinelli 2015a; 2017c)
3. Building the experimentation context: ART. 4, 5, 6 (Menichinelli and Valsecchi 2016; Menichinelli 2018b; 2018a)
4. Elaborating the research through design framework from the research and practice: ART. 7 (Menichinelli 2019d)

5.1. ART. 1. A Framework for Understanding the Possible Intersections of Design with Open, P2P, Diffuse, Distributed and Decentralized Systems

Menichinelli, Massimo. 2016. 'A Framework for Understanding the Possible Intersections of Design with Open, P2P, Diffuse, Distributed and Decentralized Systems'. *Disegno – The Journal of Design Culture* III (01–02): 44–71. http://disegno.mome.hu/?page_id=136.

RQ-ART. 1: What is the overall context of the meta-design practice and research regarding design and open, peer-to-peer and collaborative processes?

Methodologies: METH. 1 (literature review)

This article proposes a preliminary framework for understanding and working with the integration of design with open, peer-to-peer, diffuse, distributed and decentralized (DDD) systems. In one direction, such Open/P2P/DDD Systems can be applied into design practice: this first intersection has many applications, from digital projects to P2P-based initiatives to physical projects designed and manufactured on global networks of distributed laboratories like Fab Labs and Makerspaces. In another direction, design practice can also have a role in enabling such systems through the analysis, visualization, and design of their collaborative tools, platforms, processes, and organizations. Designers, therefore, could learn from such systems and also improve them.

Concepts and cases of the main mass-participation phenomena were contextualized into an Open/P2P/DDD Systems framework. Then two main directions of relationships of such systems with the discipline of design were identified and structured into families of approaches. The article therefore shows that the intersection of Open/P2P/DDD Systems with design is not limited to the popular view of open 3D models that can be downloaded with P2P applications and 3D printed locally, but that there are more approaches to work on immaterial, social, and organizational levels as well.

Sole Author. *This publication gives an overview of the concepts, approaches and current studies about Open Design and P2P Design, providing a detailed description of the overall context of the OpenMetaDesign framework, while also differentiating it with the previous work around the Open P2P Design approach.*

5.2. ART. 2. Open Meta-Design: Tools for Designing Collaborative Processes

Menichinelli, Massimo. 2015. 'Open Meta-Design: Tools for Designing Collaborative Processes'. In *Empowering Users through Design: Interdisciplinary Studies and Combined Approaches for Technological Prod-ucts and Services*, edited by David Bihanic, 193–212. New York, NY: Springer. https://doi.org/10.1007/978-3-319-13018-7_11.

RQ-ART. 2: What are the previous research and practice experiences of the author for designing collaborative processes, and how could they be further researched and improved?

Methodologies: METH. 1 (literature review), METH. 3 (user test & questionnaire)

This article describes the previous research and practice of the author with the Open P2P Design approach, an open source meta-design methodology aimed at co-designing distributed systems that show open, peer-to-peer and collaborative dynamics with users and their communities, visualizing and managing their nature of complex social and technological systems. Such approach is a precursor to the OpenMetaDesign framework, which later emerged during the doctoral studies thanks to one of the workshops described in the article and thanks to the article itself. This article presents and discusses the first workshops where the concept of Open P2P Design approach, its tools and methodologies were tested in Seoul (South Korea), Singapore and Helsinki (Finland). The goal of these workshops and tests were to understand if the Open P2P Design approach is proper, understandable and easy to use by designers (and possibly even users), if it needs specific knowledge, tools and abilities (and which ones), for example whether designers could adopt the same tools that software programmers have developed in order to coordinate the mass-collaboration efforts inside the Open Source and P2P distributed systems cases. These workshops also represent some of the first tests for understanding the viability of the application of open source and p2p principles, tools and practices inside the Design discipline.

Sole Author. *This publication documents the starting point for the research and practice done during the doctoral studies, contributing to the evolution of the OpenMetaDesign framework from the previous Open P2P Design approach.*

5.3. ART. 3. A Data-Driven Approach for Understanding Open Design. Mapping Social Interactions in Collaborative Processes on GitHub

Menichinelli, Massimo. 2017. 'A Data-Driven Approach for Understanding Open Design. Mapping Social Interactions in Collaborative Processes on GitHub'. *The Design Journal* 20 (sup1): S3643–58. https://doi.org/10.1080/14606925.2017.1352869.

RQ-ART. 3: How could the analysis of social interactions over time on such platforms improve the understanding of design-related collaborative processes?

Methodologies: METH. 1 (literature review), METH. 2 (design & development), METH. 3 (social network analysis)

This article proposes a software module that extracts data of interactions from Git and GitHub projects with a social network analysis approach. GitHub is a highly popular tool/platform ecosystem for software development that is also used for both Maker and Open Design projects. The software module was tested in three cases with similar size related to Open Design where the author participated, in order to 1) advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design, 2) provide support to the activity of Maker and Design researcher and reflective practitioners. Such analyses show that this approach is useful for understanding the process of a project, the interactions that constitute it, the kind of work done in it, the influence and importance of specific actors on it, and the amount of participation in it. Furthermore, this approach can be of use to any designer/researcher or designer/maker for understanding her position in the social network as it emerges from her practice and research.

Sole Author. *The publication is important for documenting the practice done during the doctorate and the software developed for its analysis, providing a tested and structured approach for the social network analysis of open and collaborative projects.*

5.4. ART. 4. The Meta-Design of Systems: How Design, Data and Software Enable the Organizing of Open, Distributed, and Collaborative Processes

Menichinelli, Massimo, and Francesca Valsecchi. 2016. 'The Meta-Design of Systems: How Design, Data and Software Enable the Organizing of Open, Distributed, and Collaborative Processes'. In *6th IFDP - Systems & Design: Beyond*

Processes and Thinking, 518–37. Valencia: Editorial Universitat Politècnica de València. https://doi.org/10.4995/IFDP.2016.3301.

RQ-ART. 4: What is the overall framework and background regarding the philosophy, data and design of an OpenMetaDesign tool?

Methodologies: METH. 1 (literature review), METH. 2 (design & development)

This article is a first elaboration of the OpenMetaDesign framework that provides a way for designing open, collaborative and distributed processes. The article positions the framework among current meta-design and design approaches and develops its features of modeling, analysis, management and visualization of processes. This framework is based on four dimensions: conceptual (describing the philosophy, context and limitations of the approach), data (describing the ontology of design processes), design (visualizing designing processes) and software (managing the connections between the ontology and the visualization, the data and design dimensions). This article focuses on the visualization challenge of meta-design: how can we represent a system, its relationships, the complexity of social and local dimensions, and at the same time how visualization can inform the design of meaningful complexity in within organizational, productive, and information structures.

Main Author. *This publication proposes the overall concepts, roots, data design and visualization design of the OpenMetaDesign software application for designing and visualizing open and collaborative design processes and organizations. It gives also an overview of the existing literature regarding this topic, elaborating It basically propose the design project of the research and contextualizes its development. As first author the main responsibility was for the overall structure and contents of the article. The second author was mainly responsible for reviewing and editing the article.*

5.5. ART. 5. A Shared Data Format for Describing Collaborative Design Processes

Menichinelli, Massimo. 2018. 'A Shared Data Format for Describing Collaborative Design Processes'. In *Cumulus Conference Proceedings Paris 2018 – To Get There: Designing Together*, Cumulus Conference Proceedings Series 03/2018 Paris:190–215. Cumulus. https://www.cumulusassociation.org/cumulus-conference-proceedings-paris-2018-to-get-there-designing-together/.

RQ-ART. 5: How can be collaborative design processes documented, analyzed and shared?

Methodologies: METH. 1 (literature review), METH. 2 (design & development)

This article presents a shared data format for describing collaborative design processes, building on existing literature and cases and the development of an experimental digital platform for the co-design of collaborative processes. This data format is a key component of a framework for modeling, analysis, management and visualization of design processes, based on four interconnected dimensions: conceptual, data, design, software. Such a framework could potentially facilitate the design, understanding, management and participation in open, collaborative and distributed processes. Furthermore, this investigation might advance our understanding of the relations among data and design, as a possible new language and tool for working with processes and organizations. The article provides a) an overview of the existing approaches for documenting design projects and processes, b) a proposal of an ontology and data format for describing collaborative design processes and d) directions for future research and for validating the proposal.

Sole Author. *This publication proposes further improve the data design of the OpenMetaDesign platform for designing and visualizing Open Design processes and organizations and proposes research strategies for its validation. This publication is a further development of ART. 4, with a more specific focus on the data, software and design dimensions of the OpenMetaDesign framework.*

5.6. ART. 6. Service Design and Activity Theory for the Meta-Design of Collaborative Design Processes

Menichinelli, Massimo. 2018. 'Service Design and Activity Theory for the Meta-Design of Collaborative Design Processes'. In *ServDes2018. Service Design Proof of Concept, Proceedings of the ServDes.2018 Conference, 18-20 June, Milano, Italy*, 994–1008. Linköping, Sweden: Linköping University Electronic Press, Linköpings universitet. http://www.ep.liu.se/ecp/article.asp?issue=150&article=083&volume=# .

RQ-ART. 6: How could Service Design enable the meta-design of collaborative design processes on digital platforms?

Methodologies: METH. 1 (literature review), METH. 2 (design & development)

This article explores how the approach, logic and tools of Service Design could be part of the Open/P2P/DDD Systems trend by supporting the development of a digital platform that enable the collaborative design of open and collaborative design processes and therefore the management of the communities behind them. This article focuses on how the approach, logic and tools of Service Design can be adopted for visualizing, understanding, discussing and designing collaborative design processes and the communities that manage and implement them over time. This article elaborates a proposal for integrating Service Design concepts and tools into a meta-design digital platform for the design and management of collaborative design processes, by providing 1) a reflection on the theoretical connections between Service Design, Activity Theory and Meta-Design, 2) a proposal of a meta-design platform that represents a proof of concept of such connections and 3) a proposal of evaluation strategies for validating such platform. Furthermore, the role of software and digital platforms in influencing both communities, collaborative processes and service design tools and practice is another key part of this article.

Sole Author. *This publication details the visualization design of the OpenMetaDesign platform for designing and visualizing Open Design processes and or-*

ganizations and proposes research strategies for its validation. This publication is a further development of ART. 4, with a more specific focus on the design and software dimension of the OpenMetaDesign framework.

5.7. ART. 7. A Research Through Design Framework from the Evaluation of a Meta-Design Platform for Open and Collaborative Design and Making Processes

Menichinelli, Massimo. 2019. 'A Research through Design Framework from the Evaluation of a Meta-Design Platform for Open and Collaborative Design and Making Processes'. *Proceedings of the Design Society: International Conference on Engineering Design* 1 (1): 21–30. https://doi.org/10.1017/dsi.2019.5.

RQ-ART. 7: How can we connect the research and practice of meta-designers in open and collaborative design and making processes?

Methodologies: METH. 1 (literature review), METH. 4 (user test + questionnaire)

This article investigates the role of meta-design digital tools for the facilitation of distributed systems of creative agents, formally trained and informal amateurs that collaboratively design and produce artifacts. It documents a research study organized for testing a digital meta-design platform with users and with the researcher as meta-designer: the results provide insights for improving the platform and for building a comprehensive research through design framework that connects meta-design research and practice for exploring the role and nature of meta-design and meta-designers in facilitating collaborative design processes starting from their description with digital ontologies.

The approach adopted in this article is thus to elaborate the Research through Design framework on top of the practice and research of developing such a digital meta-design platform and the research of testing it with users: the importance of the Research through Design approach can be found here in the focus on the insights gathered from the platform, rather than on the development of a complete product, in order to elaborate future strategies. The Research through Design framework is therefore based on both theoretical research, meta-design practice and on the profiles and expectations of (potential) future designers and the role of the researcher/designer in this context in order to build a framework for future research and practice. This article presents a summary of a research study as well as of several years of research, on both theoretical and experimental work. The Research through Design framework is both a conclusion of this path and the strategic plan for future work.

Sole Author. *This article documents the final version of the OpenMetaDesign digital platform, the results from its first test in a research study and the related Research through Design framework emerging from it, also documented in section 6.1.*

6. Contributions to Meta-Design and Meta-designers within the Maker Movement

The previous chapter introduced the articles developed within the design context, methodology and artifacts of the dissertation. This chapter further elaborates and integrates the insights proposed in the articles into the main findings of this dissertation, organized into four contributions:

CONTRIB. 1. A Research through Design framework for the past and future research and practice of Meta-Design.

CONTRIB. 2. A design redefinition of digital ontologies of design processes as design material.

CONTRIB. 3. A design redefinition of Meta-Design for the context of the Maker Movement.

CONTRIB. 4. A design redefinition of the role of meta-designers.

These contributions are then adopted also in the discussion on future research in Chapter 7.

6.1. CONTRIB. 1. Defining a Research through Design framework for Meta-Design in the Maker Movement

This dissertation documents an effort in bridging the research and practice of facilitating collaborative design processes in the Maker Movement. By working on such processes, which are intangible and dynamic entities that take place in a fluid and emergent context, the author explored how digital artifacts can represent both a context, a product and a research strategy with a Research through Design approach. Therefore, the first and foundational contribution of this dissertation and that informs the other contributions is a Research through Design framework that integrates the practice and research of open and collaborative design processes. With this contribution, this dissertation adopts Research through Design for its development and elaborates it further for the context of the Maker Movement. The digital meta-design platform developed in ART. 4, 5 and 6 and tested in ART. 7 is the artifact that enabled the elaboration of a comprehensive Research through Design framework that connects meta-design research and practice of meta-designers in open and collaborative design and making processes (RQ3). The goal of this framework is to support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems (RQ0).

Such framework is relevant not just for improving the platform itself, but also for improving the practice (and therefore the role and profile) of the meta-designers that develop, deploy and use the platform. The ontology, platform and research study can be considered as the building blocks for future research and practice. The main relevant point is that the artifact and experiment of a Research through Design initiative can not only improve artifacts and our understanding of design, but also contribute to directly informing the research and practice strategy. Here the role and goal of the artifact (the ontology and platform system) was not of being a final product, but a first exploratory prototype for developing the Research through Design framework that can support the development of an ecosystem of more robust and stable related artifacts.

The Maker Movement is an emerging and therefore often changing context; developing an exploratory framework, artifact and strategy might contribute to more future development than efforts at improving the efficiency or user experience of artifact. When processes are still unclear and under definition, efficiency and effectiveness can be traded for an exploratory research and practice for building a strategy for such a bottom-up movement which globally connects distributed local efforts and worldviews. The framework is the main result of the evaluation of the OpenMetaDesign platform, as documented in ART. 7. Because the research approach adopted is a Research through Design one, the insights elaborated are not (or rather not only) about the platform, but through the platform, for the overall practice of meta-designers. This framework is therefore not only the summary of a research study but also of years of research, on both theoretical and experimental work: it is both a conclusion of this path and the strategic plan for its future.

The framework is the result of an effort in evaluating the digital platform, making sense of the practice and research done in the doctoral dissertation so far and the planning of future practice and research directions. Its importance can be found in showing that it is possible to develop artifacts and test them not just for their improvement but also for developing practice and research paths and also for contributing to the Research through Design approach itself. The Research through Design framework is based on the approach proposed by Redström (2017) for developing design theories and does not comprise only of artifacts and publications but extends instead to the whole spectrum of initiatives between practice and research, the specific and the universal. Following Redström's approach, such framework was organized in order to elaborate a design theory of the meta-design practice, its projects and the role of meta-designers within the Maker Movement. The spectrum ranges from a very specific view of "what Design is" (a Meta-Design digital platform that supports the collaborative design of distributed and collaborative design processes within the Maker Movement) to “what designing is” (the Meta-Design approach of supporting makers in their distributed and collaborative initiatives within the Maker Movement). Between these two polarities there are several initiatives, from the OpenMetaDesign platform as a product, to the author’s dissertation as project, to the OpenMetaDesign conceptual framework as program, to the author’s practice as meta-designer and finally to the paradigm of Open Source, Peer-to-Peer, Open and Collaborative and Meta-Design (Figure 15). More specifically, since the framework organizes and structures this dissertation and its contributions: OpenMetaDesign platform as a product is elaborated in CONTRIB. 2 in section 6.2; the project is in this case the dissertation; the program is the OpenMetaDesign conceptual framework elaborated in CONTRIB. 2 in section 6.2 and in the Conclusions in Chapter 7; the practice is the author’s practice as meta-designer, elaborated in CONTRIB. 4 in section 6.4; finally the paradigm is represented by Open Source, Peer-to-Peer, Open and Collaborative and Meta-Design, elaborated in CONTRIB. 3 in section 6.3. OpenMetaDesign as a framework can be considered as a program that informs Research through Design initiatives, and as Redström suggests the importance of programs for informing future practice, this will be extended in the conclusions towards design education, practice and research that aim at working with distributed systems. The other important aspect of this approach is that it enables the elaboration of design definitions, and in this case the dissertation includes definitions or redefinitions of ontology and meta-design platforms, Meta-Design and meta-designers. Overall, OpenMetaDesign redefines the act of collaboratively designing design processes (CONTRIB. 2), the approach behind this activity (CONTRIB. 3) and the role and profile of meta-designers working on this (CONTRIB. 4).

Beside elaborating this framework based on Redström (2017), this CONTRIB. 1 further adds another element for Research through Design: Koskinen et al. proposed that it can take place in three settings: in the lab, the field and the showroom (2011). This dissertation updates such list of settings to the emergence of the Maker Movement and digital platforms and their integration with design with three new settings: in the makerspace, in the community and in the platform. While the lab de-contextualizes research, the makerspace contextualizes it by enabling the participation of local stakeholders, organizations and initiatives through the democratization of technologies and processes. The field contextualizes research and the community further extends this by giving prominence to social structures, organizations, processes and worldviews. While the showroom enables research by building on art and design rather than on science or on the social sciences, the platform enables scaling of projects, their audience and participation of the stakeholders by connecting distributed settings at global level. These three settings take place at the different intersections of global, local, and project and platform dimensions of the Maker Movement (Figure 11). This highlights the fact that each different context, with its own community and worldview, might need and provide different settings and different frameworks for applying Research through Design, either by identifying new ones or by adapting and extending existing ones. By considering OpenMetaDesign framework as a program, it becomes a meta-model for more locally distributed Research through Design initiatives that work with meta-design platforms.

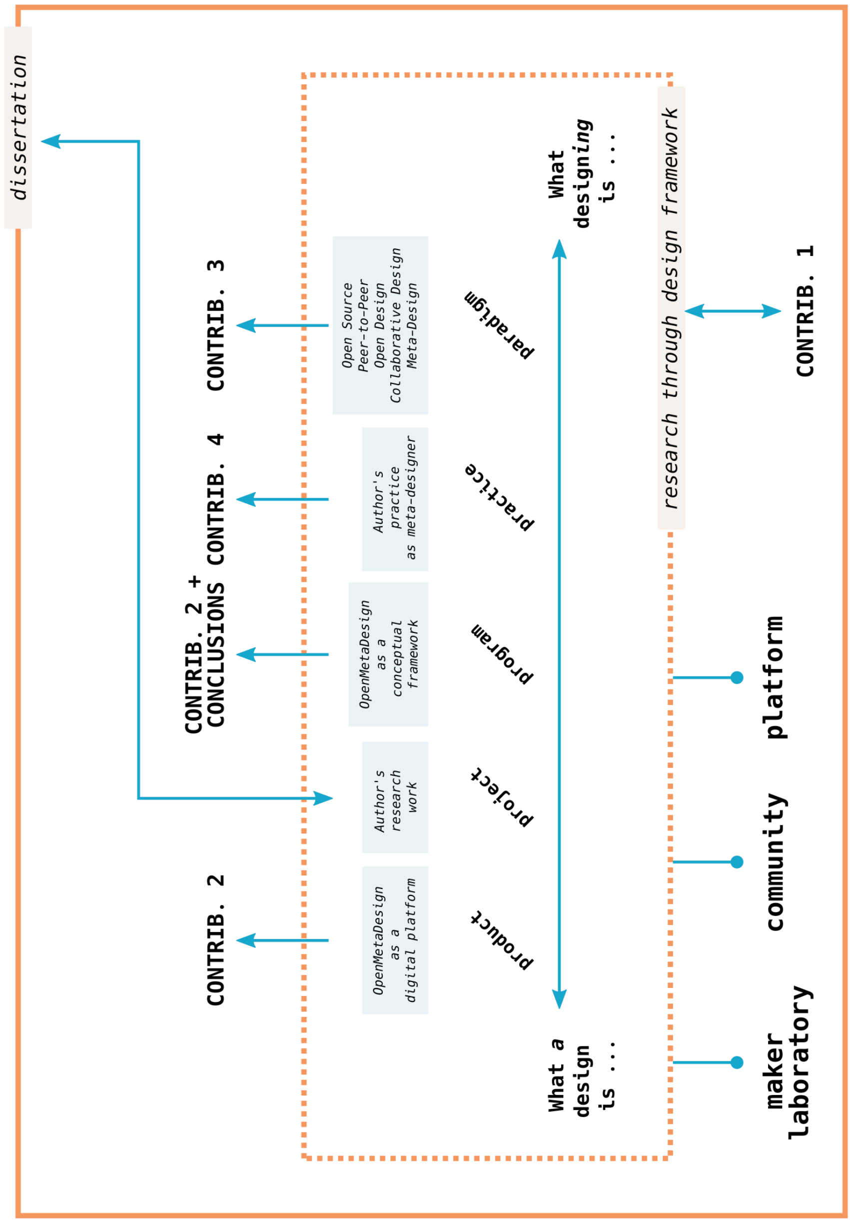

Figure 15. A Research through Design framework for connecting research and practice of meta-designers within the Maker Movement

6.2. CONTRIB. 2. Meta-Design for Defining Design Processes with Digital Ontologies as a Design Material

How to access a database through multiple interfaces is the core of new media artifacts and processes (Manovich 2001); designing data structure and tools and protocols for accessing them is therefore an established practice and research in new media. Any digital technology is a case of this, and even early meta-design digital and interactive environments were efforts of organizing data and its interfaces in order to enable users to design in and through them. Tis specific contribution (CONTRIB. 2) represents a further evolution in the application of this approach: from meta-design environments that support the design of artifact by end users, to meta-design platforms that support the collaborative meta-design of collaborative design processes by and for end users. At a deeper level, the shift is from designing data structures and their interfaces for enabling the designing of artifacts to enabling the designing of design processes that enable the designing and making of artifacts. Design of data is here extended from the digital platforms to the meta level of design itself within and around digital platforms. All media objects are basically databases: list of items without an order and logical causations, the opposite of narratives that "creates cause-and-effect trajectory of seemingly unordered items (events)" (Manovich 2001, 225). But design processes do have logical causations, narratives and cause-and-effect paths. Here the change is that the OpenMetaDesign approach makes so that the database's creator is not who establish the narrative, but are rather the users that collaboratively build, discuss and modify narratives of design processes to be stored and facilitated by databases.

This approach supports makers' collaborative practice with project documentation and organization (GAP 1) by elaborating how to design, document and share collaborative design process with meta-design practice and research on digital platforms (RQ1). In this contribution, the work on the OpenMetaDesign digital platform is elaborated not just in software code but summarized in a framework; this enables not just creating digital platforms but also the elaboration of educational, research and practice programs based on the Research through Design framework of this dissertation (CONTRIB. 1). The framework enables to design digital ontologies and their related platforms, but also enables the generation of programs later. Such programs might cover activities that support how to design such ontologies and platforms (research), how to develop, deploy and adapt in real life context (practice) and how to prepare new generations of designers in their design and adoption (education).

The OpenMetaDesign framework was developed after an extensive literature review (METH. 1) and a long process of design and development (METH. 2) and documented as a framework and first ontology with ART. 4, as a full ontology linked to design documentation and design processes in ART. 5 and linked to Service Design and Activity Theory as the theoretical and instrumental building blocks in ART. 6. The resulting platform was tested in a research study that served as the basis for analysis and further reflection in ART. 7. As a result, the framework elaborates how design, data and software encode an ontology based on theoretical concepts and elements from a community worldview into a digital platform (Figure 16). In this way theoretical concepts and approaches and worldviews contributes to the development of a model of design processes, described by an ontology: the latter constitutes the schema or data structure that represents and stores processes. Theoretical concepts and worldviews here flow into a shared language for describing collaborative design processes. Such processes can be then designed (visualized and edited) with the software that embodies the framework by connecting the design and data dimensions. This enables the definition of custom ontologies and the related platforms for creating environments where communities of participants can discuss, edit and manage design and making processes for each specific context.

Design processes becomes designable because ontologies and their data, software and design dimensions can be treated as design materials. That is, meta-designers can thus design ontologies and their platforms with and for communities in order to support the emergence and evolution of collaborative design and making processes: the OpenMetaDesign framework and program supports educational, research and practice initiative for the creation of the necessary skills, knowledge and initiatives. The ontology is at the center of the framework and it is considered a design material because it is the explicit specification of a conceptualization and that is designed in a formal way (Gruber 1995).

Furthermore, the ontology and platform are part of a bigger ecosystem in the life cycle of projects (Figure 16). Processes, their discussions, design and implementation generate networks of social interactions among meta-designers, members of the communities involved and stakeholders. Such social interactions can be then analyzed with Social Network Analysis (CONTRIB. 4, METH. 4) in order to uncover the social structures and dynamics, which are the basis for the emergence of organizations. When the processes assume a certain structure and participants have more roles and tasks, i.e. when emerging, chaotic, fuzzy collaborative efforts become more established, organizational structures come into place, which can then be studied and communicated to participants through visualizations in order to make them aware of the organization they are part of. When organizations become more complex, the need for governance arises as conflicts and tensions might emerge and must be their management and resolution must be then facilitated in order to maintain the organization healthy. Finally, concluding the cycle of this model, governance mechanisms further add or refine processes in the organization, which then flow into the processes that the framework addresses. Within this dissertation and the research behind it, the focus was mainly on the design of processes and on the social network analysis of interactions in processes, so future research should address further the issues of organization and governance (Figure 22).

Any process can then be discussed, edited and managed, from design and making processes to organizational and governance processes, which can then be added later as the project evolves. If more processes are needed in a project, beside design and making ones, they can be included in the platform and collaborative effort. The ontology becomes thus a language for discussing processes, and the platform the space where such discussions take place. Ontologies become thus a design material encoded in a digital format, processed with digital tools, captured and discussed with the participation of communities and their stakeholders. As seen in section 3.1.4, design and ontologies interact in three ways: 1) designing an ontology as a formal description of concepts their relationships as a technical infrastructure; 2) enacting and enabling an ontological impact over the human condition via design initiatives; 3) describing, designing and supporting design processes through their ontology. The OpenMetaDesign framework works thus in all three directions by enabling the collaborative definition of the ontology of design processes (3) through the participation of a community that shapes the ontology according to its worldview and for its social and sustainable purposes and needs (2) based on a digital ontology encoded, visualized and edited in a digital platform (1).

Regarding the ontology of design processes (3), there are several ways (or potential languages) for discussing the design dimension of initiatives in the Maker Movement. ART. 5 identifies at least five different forms, of which one is design as a process; here three main clusters of approaches are possible, where processes are considered as: 1) the execution of activities; 2) a dialogue between actors; 3) the reconstruction from the reverse engineering of artifacts and documents. These are all perspectives that should be considered when developing ontologies of design processes.

Regarding the digital ontology and platform (1), one of the most relevant insights elaborated is that the ontology is not just a technical artifact necessary for the development of the platform, but a fundamental tool for defining the infrastructure for action and participation. The transitions between the three phases of research represented the evolution of this insight and also the potential path for similar research initiatives: from an untested methodology (PHASE 1) to prototyped design tools (PHASE 2) and to tested digital ontology and platform (PHASE 3) (Figures 12, 13). Furthermore, the last phase also showed that once the ontology is defined, not just digital platforms but also custom paper design tools can be built on top of it (Rizzo et al. 2018; Real et al. 2019). The ontology is thus here the main artifact of the Research through Design effort and also the foundation for more practice and research.

Regarding the ontological dimension and impact of the OpenMetaDesign framework together with and towards communities (2), the emerging insight is that practice and research should get local communities involved in the definition of ontologies and the related locally understandable visualization. In order to fully take advantage of the possibilities of Ontological Design in bringing social change through multiple and complex worldviews, digital ontologies and platform must be developed by integrating them with existing theoretical and technical frameworks.

The OpenMetaDesign framework defines activity-centered process ontologies, and the workshop done in Seoul and documented in ART. 2 showed how different worldviews created huge obstacles even in adopting internationally established approaches such Activity Theory for such ontologies. Since Activity Theory is used as a design tool and not as a research analysis framework, it could be replaced or integrated with framework and concepts that are more understandable with the local worldviews. However, if we want to connect local initiatives with a cosmopolitan localism approach, such worldviews should be integrated with concepts and elements that connect them and act as a sort of conceptual APIs, and Activity Theory could be still adopted in this direction.

The practice and research efforts behind OpenMetaDesign were mainly developed by the author among several communities, and therefore the ontology and platform represent a first exploratory prototype of how they could be developed and tested within communities, considering that the author is part of these communities as well. Through the research study documented in ART. 7 the importance of community emerged also regarding the usage and understanding of the ontology and platforms, and the fact that worldviews are in any case always present in them. Therefore, the process of developing ontologies and platforms should always render the meta-designers' and communities' worldviews explicitly visible and debatable.

The practice of meta-designer adopts in this direction the idea of defining locally-bounded but globally-networked and community-based ontologies that are defined and that redefine the social dimension of projects. Research on communities and software and data prototyping become thus a strategy for creating custom ontologies for each community while understanding and improving their social dimension.

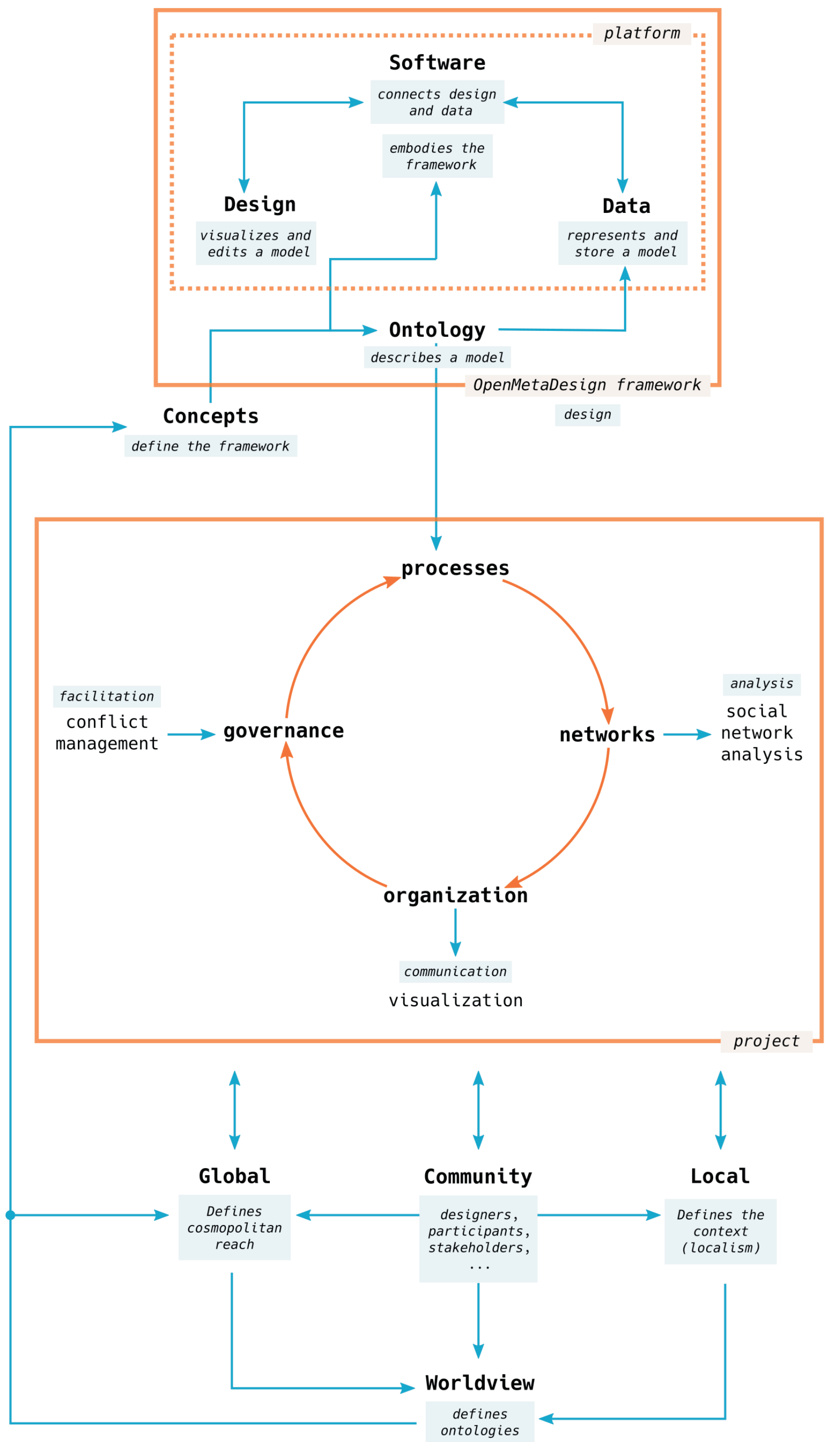

Figure 16. The OpenMetaDesign framework, its role in the life cycle of projects and the relationships with communities, worldviews and local and global dimensions

6.3. CONTRIB. 3. Redefining Meta-Design within the Maker Movement

The Maker Movement has brought new requirements and opportunities to Meta-Design, its principles and artifacts: from new technologies to the resurgence of the relevance of local space and physical production. This contribution elaborates insights about the role of Meta-Design and meta-designers within and for the Maker Movement (GAP 3) and especially how they can be contextualized in the scenario of Design with Open/P2P/DDD Systems (GAP 4). This contribution especially explores the Meta-Design context of OpenMetaDesign, or more specifically the paradigm where it is developed and it operates, how Meta-Design evolves and integrates with Design and Open, Peer-to-Peer and collaborative processes (RQ4).

The development of OpenMetaDesign has provided the experience for redefining Meta-Design after its integration with the Maker Movement as a paradigm for the actions of meta-designers working with distributed and collaborative processes within Open/P2P/DDD Systems. Such paradigm has a stronger focus on processes and their ontology, and therefore a stronger connection with Ontological Design. Furthermore, it is at the same time based on digital platforms at global level and physical meeting and making spaces at local level. Overall, within the Maker Movement, three main directions emerge:

1. Meta-Design with and for Open, Peer-to-Peer, Diffuse, Distributed and Decentralized Systems;
2. Meta-Design of bits (digital environments) and atoms (physical artifacts);
3. Meta-Design as a Metadata Ontology for Ontological Design.

6.3.1. Meta-Design of bits (digital environments) and atoms (physical artifacts)

The Maker Movement can be especially regarded as a global experiment in democratizing knowledge and access for working with digital fabrication technologies that connect bits and atoms in manufacturing and computing (Gershenfeld 2005; 2012). Within this context, digital technologies become also physical and analog ones: not only for Design, but also for Meta-Design, thanks to the focus on how the design of systems enable further processes (Gershenfeld, 2019). As the openness and DIY component of Maker culture includes the idea that makers could also design and manufacture their own technologies, the practice of meta-designing is quite diffused among makers even if often without a proper awareness of its nature or even name.

A wide range of cases and typologies exists for example with 3D printers, we can see self-made and customized machines, often starting from the RepRap project (R. Jones et al. 2011; Kostakis and Papachristou 2014) or even 3D printers adapted for working with genetically modified bacteria (Alasdair 2014). But makers often go further, for example by integrating different technologies in the same portable device (Peek and Moyer 2017), mixing virtual and analog tools in the same device (Zoran and Paradiso 2013; Zoran et al.

2014) or even by repurposing 3D Printers as custom pasta making machines (Menichinelli 2015b).

The development of cheap and easy to use prototyping electronic boards like Arduino (Banzi 2009) further supported this trend and also generated a whole ecosystem of different boards (Frauenfelder 2013). Fab Labs are increasingly interested in the development and production of their own machines as a meta-reflection of their technology development (Hobye, Padfield, and Haldrup 2016) and along this direction researchers have studied how to create reconfigurable and extensible infrastructures (Peek 2016). Finally, often makers and designers also develop and manufacture their own DIY and custom materials (Rognoli et al. 2015).

Furthermore, the practice of designing and making one's own machine is an established element of maker educational programs, and therefore OpenMetaDesign and its Research through Design strategy (CONTRIB. 1) can be integrated with such exercise and be part of a specific OpenMetaDesign educational program. As Research through Design in OpenMetaDesign takes place in maker laboratories, communities and platforms, so Meta-Design in the Maker Movement also takes place in these three settings, and not only in digital environments. Meta-Design thus not only enables social interactions and processes through digital environments, but now take places in maker laboratories with the making of physical artifacts, in the social networks constituting communities and in the digital platforms connecting communities, laboratories and projects. Just as the Maker Movement and Digital Fabrication technologies have merged bits and atoms, Meta-Design in this context works between bits and atoms.

6.3.2. Meta-Design with and for Open, Peer-to-Peer, Diffuse, Distributed and Decentralized Systems

The Maker Movement works with approaches and systems that are typically open and peer-to-peer, with the aim of establishing distributed, decentralized and diffuse interactions. ART. 1 mapped how the Design and Meta-Design practice and research adapt to this context by integrating such approaches in two directions: design projects that adopt Open/P2P/DDD Systems (design-based approaches), or design approaches that enable and replicate such systems through the analysis, visualization, and design of their tools, software, toolkits, platforms and collaborative processes and organizations (meta-design-based approaches). The second direction can be classified as Meta-Design, working at the development of tools (technical frameworks, software, toolkits) and methods and methodologies (Open/P2P-inspired Design, Custom Platforms, Open P2P Design, OpenMetaDesign) for replicating open and peer-to-peer systems.

This Meta-Design dimension is also part of a larger trend at the intersection of the evolution of Participatory Design and of several other initiatives in Design practice and research. OpenMetaDesign aims at enabling the participation of users in shaping design processes, and with its open source approach, in shaping also the software and data dimension supporting this. Therefore, it can also be considered as part of Participatory Design in at least two of the approaches that marked its evolution. Marttila and Botero identified four turns related to “co” in co-design: Usability, Sociability, Designability, and Openness (Marttila and Botero 2013). Firstly, they classify Meta-Design as one of the strategies that are part of the third turn of Designability thanks to its focus on the design needs of contributors and end-users can be empowered. Secondly, in the fourth turn of Openness they introduce Open Design into Participatory Design through the notion of open-endedness of the artifacts or the activities and practice. OpenMetaDesign represents thus two phases of the evolution of Participatory Design, and its integration with the Maker Movement could be regarded as an example of a further set of turns that decentralize several aspects of Participatory Design along eight dimensions: meta, who, what, where, how, tools, process, scale (Menichinelli and Ferronato 2019).

6.3.3. Meta-Design as a Metadata Ontology for Ontological Design

The design of ontologies is a common activity in new media, and already discussed in Open Design: Jos de Mul suggested that in Open Design the role of designers is to become meta-designers by being database and interface designers that create multidimensional design spaces based on a database ontology in order to enable users to become co-designers, and more specifically by creating pathways through such spaces (de Mul, 2016).

The practice and research of meta-designers in the Maker Movement is increasingly focused on the development of digital ontologies as a design material for enabling collaborative design processes (CONTRIB. 2). Meta-Design here unfolds along three directions: as 1) design of ontologies (ontology as a design material) and as 2) Ontological Design (ontology as worldview which is designed and which designs); and 3) ontology of design (ontology as a description of a worldview of design entities) (Figure 17). Within this context, Meta-Design becomes the practice of designing ontologies (1) as both the data and social dimension of design processes (3) in order to move towards a social impact (2). Ontologies of design as a Meta-Design practice are developed as a mix of design practice and research considering a) design as the work done by designers, with a study of the actual practice (Cross 2006), b) documentation of design practice (ART. 5) and c) approaches that avoid universal models of design processes and instead focus on their situated nature based on local worldviews in a respectful and reciprocal way (Akama, Hagen, and Whaanga-Schollum 2019).

In this respect Meta-Design is a way for implementing Ontological Design because of its enabling and redefining agency in design processes (1), its focus on a plurality of worldviews and therefore of designs (2), the promising application towards sustainability and local communities (3), the self-reflexive act of designing design processes that defines the conditions of our designing (4). Meta-Design in the Maker Movement is an example of how we can design and facilitate not just digital artifacts but the whole social and situated conditions for everybody to design (Manzini 2015). Given the importance of algorithms in defining and enacting ontologies, agency here is expanded towards the posthuman, exploring thus how data and software impacts and are influenced by situated worldviews and their social practices and structures. As a consequence, thanks to their agency in supporting human actors, non-human actors here can concur to the development and management of the meta-design ecosystem and therefore they can be considered non-human meta-designers as well. One of the main insights emerging from the Ontological Design approach is that designers are affected by digital ontologies, and this contribution proposes that they can also design such ontologies and the related ones, reflexively. With communities (and even non-human actors) involved in the meta-design and design processes, this contribution also proposes that not only everybody could be a designer (Manzini 2015; Meroni and Manzini 2014; Gerritzen and Lovink 2010), but also a meta-designer (or at least an active actor of the meta-design ecosystem). This democratization of meta-design becomes an acknowledgement of the right to being aware of and defining an individual's and a community's own ontology. This contributes to the shift from being defined by an ontology and therefore a platform (or generally speaking, a technology) to defining an ontology and its related platforms (and technologies). Such democratization is of course not naturally emerging in equal manner, as it depends on the qualitative and quantitative amount of participation of an actor in the definition of an ontology and on the requisite necessary for undertaking such activities of a meta-designer (as an example, privileges, inequality and minority capture are still issues to be addressed).

Following Giaccardi's definition of Meta-Design (2003), ART. 4 defines how OpenMetaDesign fits into the existing categories of Meta-Design:

- **behind (or designing design):** OpenMetaDesign is a framework of design tools that generate the design of processes;
- **with (or designing together):** OpenMetaDesign is a framework with an online environment and a data format that allow users to design the organization of flows;
- **between/among (or designing the "in-between"):** OpenMetaDesign is a framework for collaboratively designing the organization of participation in processes through an open discussion.

Furthermore, OpenMetaDesign adds two more layers of *meta-* to its Meta-Design approach, that can be relevant insights for other Meta-Design initiatives in the Maker Movement. On one side, OpenMetaDesign add a metadata layer about design processes to design projects. This type of metadata fits into several categories: descriptive (it provides a description of an object); administrative (it provides information about the origin and maintenance of an object); structural (it provides information about how an object is organized); use (it provides information about how an object has been used) (Pomerantz 2015). On a second side, being the digital ontology and platform open source software, they can be modified, customized and used as material for other Meta-Design approaches and initiatives.

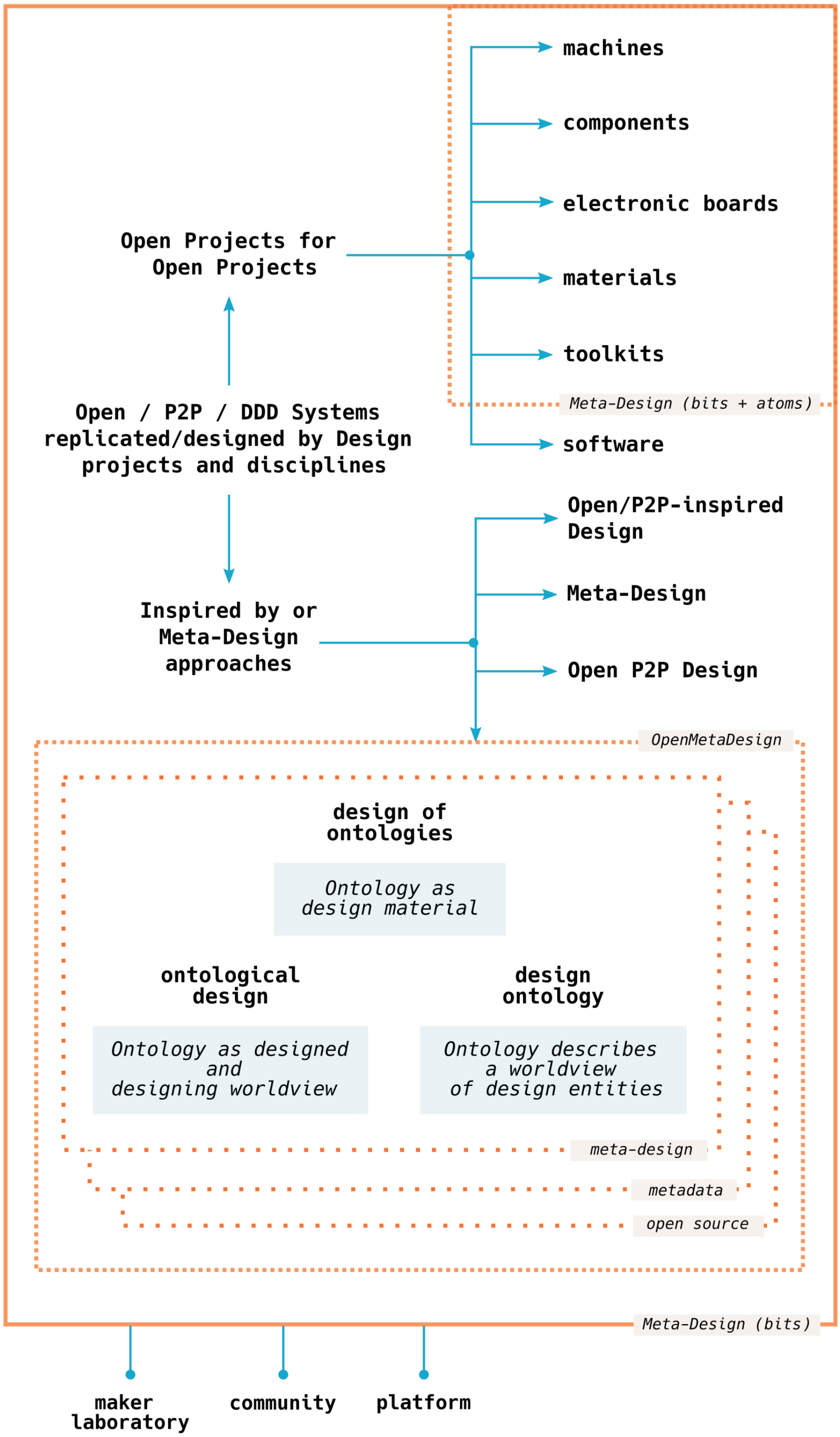

Figure 17. Redefinition of Meta-Design in the context of the Maker Movement

6.4. CONTRIB. 4. Redefining Meta-Designers within the Maker Movement

The last contribution addresses meta-designers' practice and role (GAP 3) in supporting makers' collaborative practice with project documentation and organization (GAP 1). Most of research has focused more on Meta-Design, its principles and artifacts rather than the practice, profiles, role, social organization of the meta-designers working on it, especially in the context of the Maker movement. This contribution elaborates insights about the practice of meta-designers and how to integrate it with research (RQ0-RQ3), with the idea that contributing research to the profile of meta-designers is a pragmatic way for influencing the practice. Here can be found the importance of educational programs, for example, that are based on informing the designers of the future, which will increasingly adopt meta-design. This is also a reflection on two directions: on one side on the now common idea of designers and facilitators, trying to unpack it and enriching it, and on another side as an extension of the initial considerations about the author's profile and role in practice and research (Figure 5). Both are connected through Action Research and Research through Design, as a way of getting insights from the practice of the author. Two directions emerge in this contribution: 1) from ART. 7, a redefinition of the role, knowledge and profile of meta-designers and 2) from ART. 3 how social network analysis can be used by meta-designers in order to understand the social dynamics of the collaborative processes they support and their role in them.

6.4.1. Identifying the profile of meta-designers within the Maker Movement

A redefinition of the role, knowledge and profile of meta-designers is a reflection on their identity. While this is a complex task that would require more in-depth research, this contribution might provide elements to it by examining the author's profile in his activities. Furthermore, such reflection is connected with the current redefinitions of the identity of makers, for whom the author has acted as a meta-designer for. The Maker term is very generic and universal, with quite few broad definitions elaborated more with the aim of universality for the sake of building a large audience, community and market than with the goal of crafting a clear strategy and community-driven collective effort. The Maker Movement is a global loose network of people trying to find themselves and each other while engaging in shared projects, events and discussions that meanwhile contribute to building global and local communities (Menichinelli 2017a).

The redefinition of the identity of makers is critical not just for understanding the phenomenon, but also for contributing to its development, and a further integration with the practice and research of designers might be promising. For example, makers or at least a part of them might be actually considered more as agents that instead of having only one role they operate in a spectrum between different more established roles like designers working with social innovation and social entrepreneurs (Menichinelli, Gerson Saltiel

Schmidt, and Ferronato 2019). Such perspective can also be adopted for understanding better meta-designers for makers, who can act with multiple roles or have their activity spread among different professions and roles. The research study of the OpenMetaDesign platform detailed in ART. 7 provided the starting point for elaborating insights in this direction, which were later integrated with reflections on the author's practice and research for the development of OpenMetaDesign and beyond it.

During the research study of the OpenMetaDesign platform, the last section of the questionnaire provided to the participants investigated how they had perceived the digital platform; among the several dimensions, usability was assessed with the System Usability Scale (SUS) (Brooke 2013). The platform was considered to be complex but not too difficult to use without requiring too much knowledge. However, participants felt the need of a technical person to support them in the use of the platform: this could be a consequence of the prototype nature of the platform, the limited amount of time available for testing the platform, of the complexity of collaboratively designing intangible processes and so on. But this element also provided a simple insight, that a meta-designer should always be part of the deployment and adoption of the platform, given also the fact that the Maker Movement operates in physical spaces and digital global networks, with bits and atoms, and this presence would further reinforce this connection.

Some of the few research initiatives that explored the role of meta-designers focused on defining the differences between them and other roles, for example end users, domain developers and maieuta-designers (Cabitza, Fogli, and Piccinno 2014). The author focused instead on understanding the role of meta-designers not as differentiated and separated from other roles, but rather as the sum of the knowledge and experience necessary. It has already been argued that Research through Design initiatives are typically multidisciplinary efforts where designers have less control and collaborate with sociologists, anthropologists, and computer scientists (Koskinen et al. 2011). Findeli et al. proposed a distinction between multi-disciplinarity (cohabitation of different disciplines) and multi-professionality (cohabitation of different design processes), both always present in design efforts because of their aim to improve conditions which are always complex situations (Findeli et al. 2008). Design professions distinguish themselves by their end-products, but no single end-product can be the only element of a complex situation where designers intervene, and therefore an integration of different design professions is always crucial. Different disciplines do not only enrich and provides expertise of a project, but actually contribute their embedded worldviews to it, and therefore each design team or meta-designer profile must be developed carefully by considering this aspect and how it will affect the end results and how it can be reoriented to them accordingly. This aspect is important in order to develop Research through Design efforts that reflect the local ontologies of the context of the design intervention, by defining programs that design the right mix of disciplines and participants:

> The representation the research team will construct of its phenomenon is dependent on its choice of multi-disciplinarity, and such is also the visible and intelligible part they will reach of it. Every discipline carries with it philosophical and anthropological (in the philosophical sense) prejudices and a specific Weltanschauung which influences the way it beholds the world. (2008, 79)

Given the fact that multi-disciplinarity and multi-professionality are an important aspect for planning Research through Design initiatives, this contribution elaborates further how these might affect the role of meta-designers not on general or epistemological terms, but in professional, educational and practical terms. Given also the lack of research upon the practice of meta-designers, it is important to know which disciplines and design professions they need for operating, in this case in the context of the Maker Movement. As a consequence, a single meta-designer might not be able to cover all the disciplines and design professions necessary for a determined context, so a team of meta-designers might be organized by distributing the necessary experiences and skills among more actors. This perspective might also be adopted when designing Meta-Design practice, research and also educational programs with the goal of promoting a more integrated and comprehensive set of skills and knowledge for doing Meta-Design.

The author reflected upon his experience through the OpenMetaDesign framework and platform, considering how the new media, digital and data dimension were added to profile of designer, maker, student, researcher and facilitator. The emerging profile is a consequence of the practice and research path, how they evolved in a distributed, evolving, bottom-up social and technological context. Communities emerged and disappeared, technologies that give access to developing synchronous collaboration emerged and made it possible to develop a platform like OpenMetaDesign instead of relying and adapting the usage of existing tools. The emerging profile is of a reflective practitioner that works as a meta-designer: a designer and researcher of metadata of social systems and processes for distributed and collaborative design and making processes.

Such profile of a meta-designer is based on a system of 5 roles: 1) designer, 2) facilitator, 3) participant, 4) developer, 5) researcher. Each role contains 3 professions, with a total of 15 professions: 1) designer (visualization, UX, service design), 2) facilitator (teacher, consultant, project manager), 3) participant (laboratory manager, maker, student), 4) developer (ontology, visualization, platform), 5) researcher (data, design, social) (Figure 18). These are all the professions and roles the authors adopted in the doctoral research and practice in the Maker Movement: all experiences which contributed to this dissertation. The initial profile of the author at the beginning of the doctoral research and this dissertation (Figure 5) was elaborated into a more structured and refined system after the years of practice and research. For example, the role of student became rather a subset of being a participant, while the role of developer rose to predominance.

This structure of the profile of a meta-designer can be used as a self-reporting tool for meta-designers to understand their skills, knowledge and experience, and how to complement them by either improving the missing or poor elements, or by building teams that complement them. Structured as a polar chart, this profile can be adopted as an index for assessing the multiple dimensions of a meta-designer, the Meta-Designer Profile Index (MDPI). While this specific meta-designer profile is the one emerging from the author's work, customized versions could be considered for different contexts. By keeping the same structure of 5 roles, 3 professions and 10 levels each, different profiles can be also compared. Based on an overall score of 100% (a meta-designer that completely covers the skills necessary for a specific context), then the value of each role is 20%, each profession is valued as 6.66% and each level of a profession is of 0.66%.

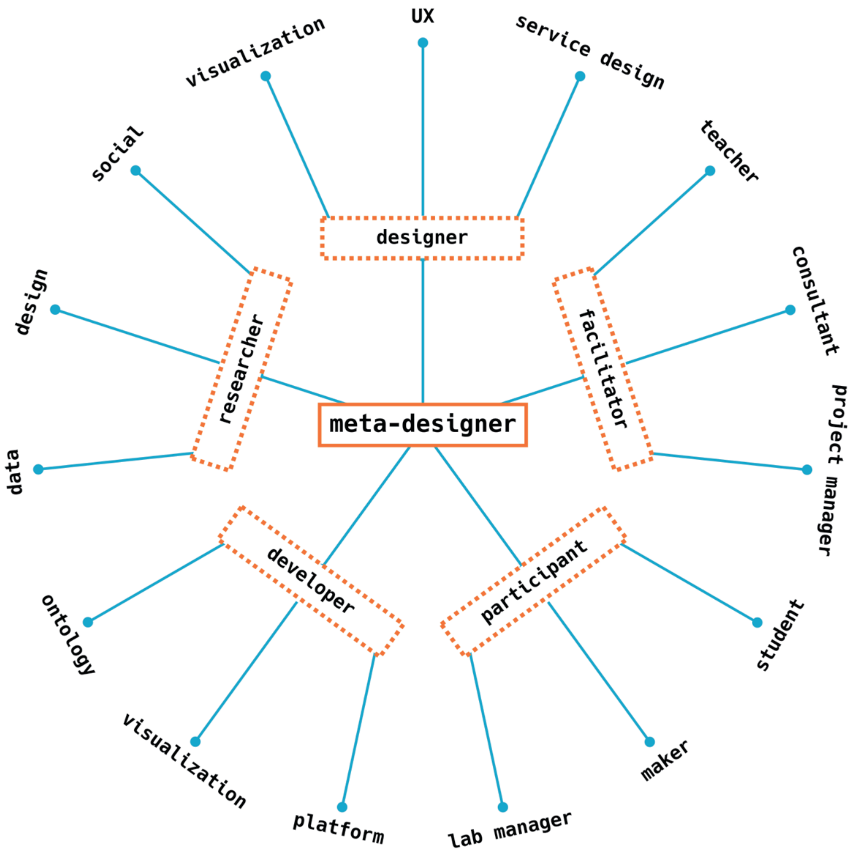

Figure 18. Redefinition of the profile of the meta-designer in the context of the Maker Movement

In the example of the author's self-reported profile in Figure 19, the MDPI value is of 66.66%: designer 10.56% (visualization 4/10, UX 4/10, service design 8/10), facilitator 16.50% (teacher 9/10, consultant 7/10, project manager 9/10), participant 13.86% (laboratory manager 7/10, maker 6/10, student 8/10), developer 11.88% (ontology 5/10, visualization 5/10, platform 8/10), researcher 13.86% (data 6/10, design 9/10, social 6/10). It is interesting to note that the researcher and participant roles have the same value, while facilitator is the most relevant role; then the role of developer follows, and the last role is of the designer. Hence an identity of meta-designer as a facilitator that operates as a researcher enabled by being a participant of the context of the intervention, through software development and then design.

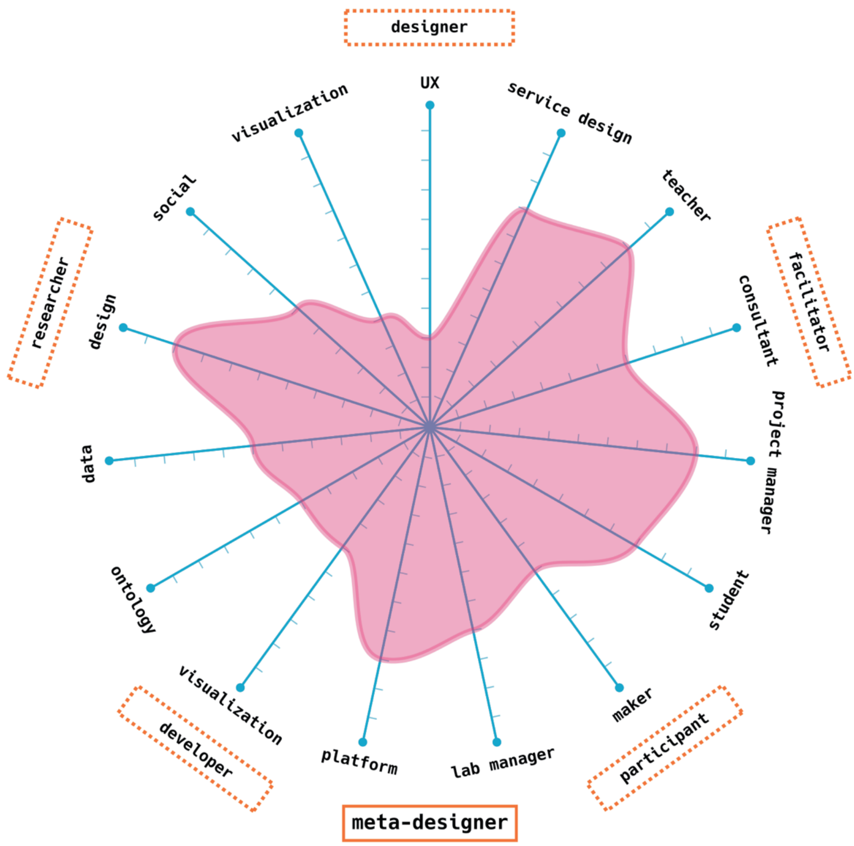

Figure 19. The author's self-reported meta-designer profile

6.4.2. Finding the position of meta-designers within the social networks of the Maker Movement

The second direction of this contribution shows that the application of Social Network Analysis (METH. 4) can be a helpful approach not just for a research detached from practice but also for meta-design practical efforts, since it enables meta-designers to understand their place and role in the context they intervene into. By analyzing their position and centrality in the social networks of interactions, meta-designers can understand their place and role in community-based initiatives and reorient their practice and the processes they support accordingly. The introduction of Network Science (Barabasi 2003; Watts 2004) has enabled to understand the systemic and social architecture of organizations and at scale, representing a strategic way for understanding the real structure of Open/P2P/DDD Systems. Social Network Analysis can be adopted to apply Network Science to the studying of social systems and in this direction enables us to understand how such system are organized beside the main idealized models that are often promoted, without considering the complexities and nuances of social systems.

Generally, Network Science has been applied to design initiatives mainly for understanding their systemic nature, and less as an engineering or design tool: three areas were identified in existing research in network-based modeling and analysis in design (W. Chen et al. 2018): 1) networks and architecture (for understanding structural dependencies within products and systems); 2) networks and design decisions (for understanding communication, cooperation and competition in design processes); 3) networks and design ecosystems (for understanding the social, economic, and institutional environment of design processes). Examples can be found in approaches for (3) uncovering how the social interactions influence design processes and projects on local creative ecosystems (Bruce, Malcolm, and O'Neill 2017), or (2-3), of the dynamics in digital platforms, for example for the design and sharing of 3D-printable files such as Thingiverse (Flath et al. 2017; Voigt 2018).

During the doctoral studies the author worked on all the three directions (METH. 4), for the analysis of: 1) a digital ontology of design process, documented in ART. 5; 2) collaboration dynamics in Open Design projects on digital platforms, documented in ART. 3; 3) the global structure of the community of maker laboratories on Twitter (Menichinelli 2016c). Digital ontologies can be explored with a network analysis approach, in order to understand the role and centrality of each of their element, and therefore uncover their internal organization, weights and influences (1). Open Design projects (not just design projects, but also educational activities, platforms and definitions related to Open Design) often use version control systems like Git and platforms like GitHub for file storage, management, discussions and collaborations. All of these can be analyzed by meta-designers in order to uncover the architecture of the social interactions on the adopted platforms and facilitate them (2). Furthermore, if meta-designers participate actively in the discussion and development, their activities can be also assessed: they can thus understand their impact on the collaborative processes and their position, centrality and influence in the social networks of the supported community. Thus, they can then extract and analyze metadata of social interactions from design projects and through that operate and understand their place in the community. At larger scale, the global network of maker laboratories can be explored in its social structure thanks to their connections on Twitter, adopted as a proxy of their interactions of multiple natures (3). With this approach, not only singular node (participants) can be analyzed, but also sub-communities can be identified with several different algorithms (Coscia 2019), and in this way meta-designers could define the social boundaries for the definition of ontologies of specific communities.

Furthermore, these maps can be also elaborated in order to present the position of meta-designers inside the community structure of their context of work; in the case of the author, this possibility can be represented for example by extending a previous research on the structure of the global community of maker laboratories (Menichinelli 2016c) with search functionalities of Twitter accounts by relevant keywords in their profiles (Massimo Menichinelli 2020). The position of the author in the global community of maker laboratories on Twitter can be then found within Fab Labs and close to the border with Maker Faires and Hackerspaces (Figure 20). Such position not only provides more insight to the author about his role and identity within the Maker Movement, but also contextualizes his practice and research, and point thus to which directions are still not explored in the movement for his work. Social network analysis can thus contribute to identifying existing and potential conflicts in the Maker Movement (Figure 4) and how they evolve through the years and the role and position of meta-designers in them (Figure 20).

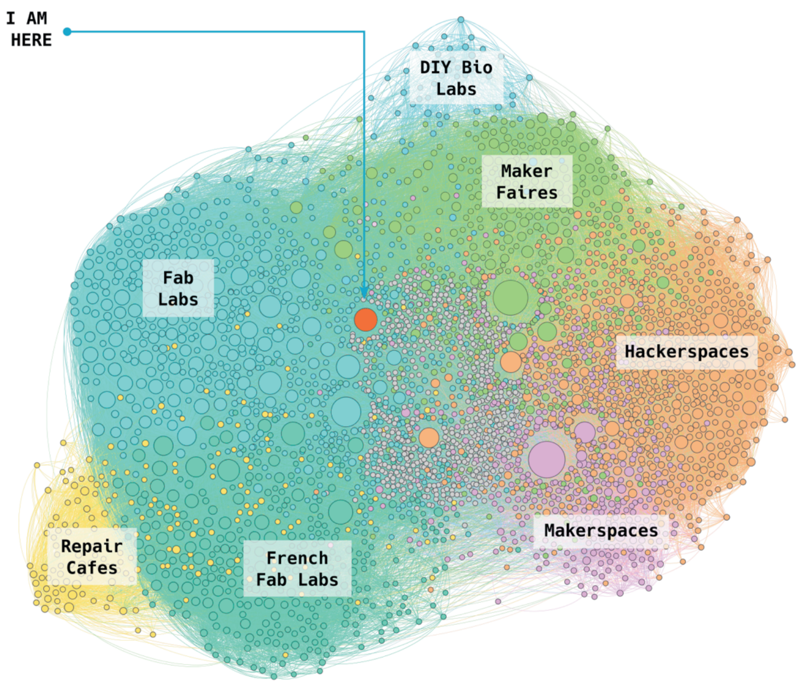

Figure 20. Position of the author in the social network of Maker Laboratories accounts on Twitter (node size: degree; node color: modularity class / community identified at resolution 1.0)

The identification of the social position enables meta-designers a qualitative self-assessment of their role within the social network they operate in. This is the approach taken in the research documented in this dissertation (in this section and in ART. 3), and while it is enough for preliminary analyses, Social Network Analysis provides several other more refined and quantitative options for uncovering a role, based on the position but also on other features. Within sociology, position and role in social networks are differentiated so that position is defined as a place in a social structure based on patterns of connection with other actors (similar patterns for different actors mean they have the same position); a role instead is defined as a set of expectations attached to specific positions (similar roles for different actors mean they share the same specific behaviors and interactions) (Forestier et al. 2012). Roles can then be found within a network (and therefore also for a meta-designer in a network) by analyzing positions and the behaviors and interactions associated to them, or through features found in such behaviors: in this direction, roles can be explicit (Forestier et al. 2012; Doran 2015). Furthermore, if we consider roles as based on behaviors more than on structural position, they assume a more dynamic nature: they can be identified from sequences of activities done by actors in a network (Brendel and Krawczyk 2011) or from sequences of communication or communication in online discussions (Welser et al. 2007; Gleave et al. 2009). The adoption of such approaches would provide further possibilities for understanding Open/P2P/DDD Systems as collaborative processes generated by distributed activities of multiple actors with different roles rather than only the technical infrastructure for the sharing of files.

7. Conclusions

The previous chapter proposed the main findings of this dissertation, organized into four contributions, by further elaborating the articles here included. This chapter concludes by contextualizing such contributions in the overall OpenMetaDesign framework and the Design community, highlighting how they also constitute strategies for a future design research, practice and education. These strategies provide a framework for further explorations on how data, design and social dimensions influence and support distributed agency in collaborative processes towards a redefinition of the relationship between places, localities and digital media.

The introduction of digital technology opened up innumerable new possibilities through digitalization and datafication; this unleashed a wave of energy and initiatives especially in its development in the storage and computing infrastructure of Internet and the global system of documents and applications of the World Wide Web. But understanding which are the real concrete possibilities, their implications, requirements, value and impact can be a difficult effort in such euphoria, and the Dotcom stock bubble was a global earthquake that reminded everybody of this (Geier 2015).

The aftermath of this bubble saw many efforts that tried to still explore and promote digital technologies while avoiding the pitfalls of not properly considering that the digital frontier cannot be separated from its entanglement with the physical world. This awareness reoriented efforts and investments in both business and research and coupled the digital world of bits with the local and material world of atoms, and both the advancement in digital fabrication and the emergence of the Maker Movement can be seen as a consequence of this.

These new directions have been promoted with the narrative that by mixing bits and atoms with digital technologies, processes and materials we can make (almost) anything. We can then bring a revolution not just on screens but on objects and factories as well, from the digitalization of traditional manufacturing to their miniaturization to nanotechnologies as both materials and machines (Gershenfeld 2012; 2005), and even to biological materials (Ginsberg et al. 2014; Myers and Antonelli 2012; Hockfield 2019).

As these technologies have been developed, implemented and offered in more and more spaces, services, organizations, initiatives, debates and so on, they have become more democratized and therefore more accessible. We can thus increasingly make (almost) anything in (almost) easier ways in (almost) distributed and collaborative initiatives (almost) everywhere. Understanding how this revolution of bits and atoms can be pushed has been an issue of exploring through practice and research, first by focusing on how to technically and pragmatically make (almost) anything and then by focusing on how to do it collaboratively in ways that are socially innovative, sustainable and accepted.

The main question of makers went from “How can we design and make projects with digital fabrication and in distributed maker laboratories?” to “How can we design and make projects together as a community and in a collaborative way?”. And for makers that focus more on supporting other makers instead of making things, that can thus be considered a type of meta-designers, the question has been rather “How can we enable collaborative design and making processes for communities?” or “How can we enable collaborative design and making processes within communities while managing conflicts?”.

This dissertation tries to reply to such question by providing a framework for studying how data, design and social dimensions can be integrated in research and practice in order to improve distributed agency in collaborative processes. The dissertation and the framework can be considered as exploratory, since they are the results of experimentations in a fluid and emerging context with the aim of preparing the foundation for a more stable and organized future context. Here the Research through Design approach provided a way for an Action Research of the author’s own practice and participation in several communities, both local and global. And in order to network so many distributed social networks the artifact of the research process became necessarily a platform.

The artifact in such a Research through Design effort went through three phases: from the proposal of a methodology (PHASE 1), to physical and digital design tools (PHASE 2) to ultimately a software platform (PHASE 3). The shifts between phases were determined by reflecting upon the practice and the results supported by the artifact, and interestingly such a sequence could be also considered also as a design process: initially with the elaboration of a concept, then with its prototyping and experimentation through canvases and workshops, and then with the development of a complete software system. The popular case of the Business Model Canvas is a similar example of how starting with the definition of an ontology can facilitate the development of design artifacts later: elaborated as an ontology in a doctoral dissertation at first (Osterwalder 2004), it was then transformed into a design tool (Osterwalder and Pigneur 2010).

This dissertation is thus the result and the documentation of a research effort taking place through such a design process, its artifacts, contexts and articles. The contributions presented here are a systematization of the main insights into a Research through Design Framework (CONTRIB. 1) for designing ontologies of design processes and their platforms (CONTRIB. 2) in a redefinition of Meta-Design (CONTRIB. 3) and of the profile and role of meta-designers (CONTRIB. 4) within the Maker Movement. Gaps, research questions, articles and contributions can be clustered together in four categories: design, analysis, practice & research, and context (Figure 21).

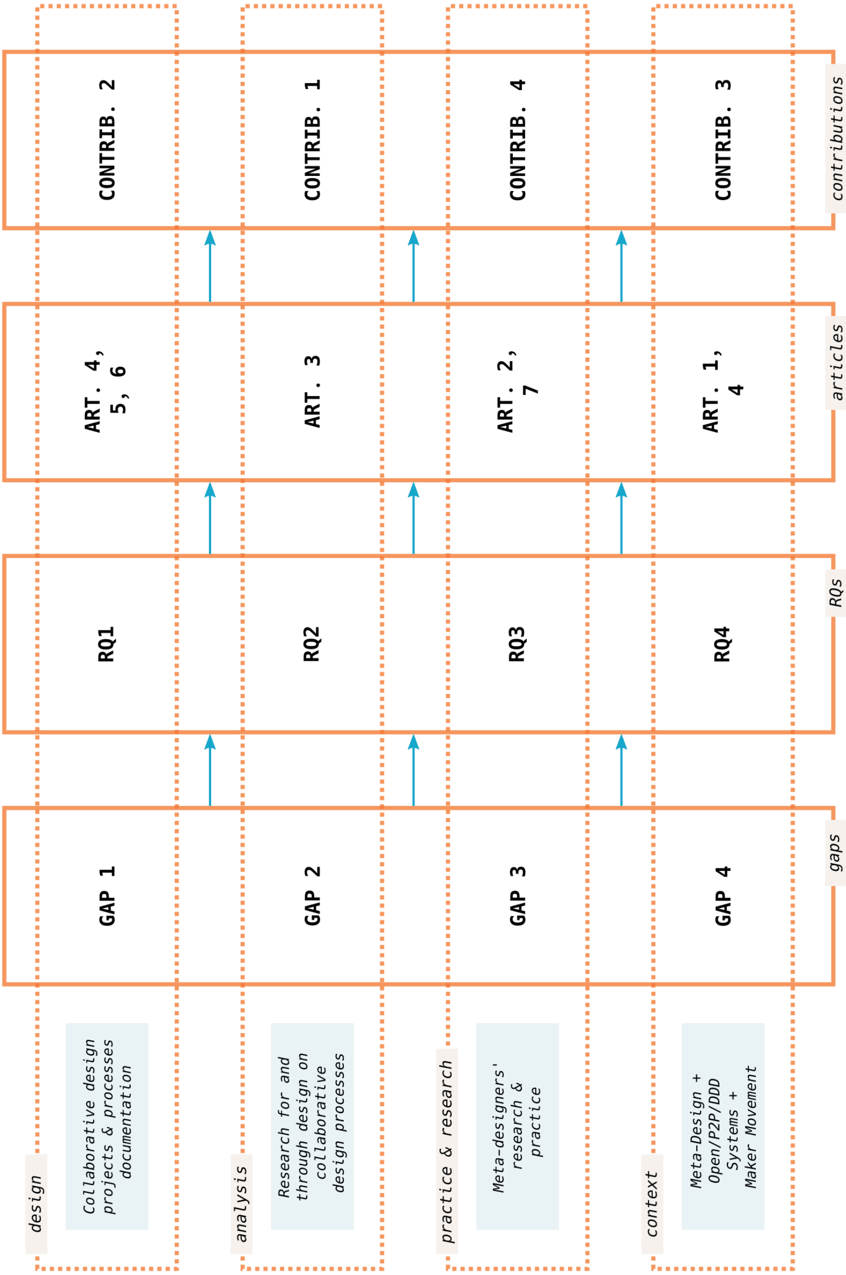

Figure 21. The organization of gaps, research questions, articles and contributions along design, analysis, practice & research and context

Through developing and testing a digital platform, CONTRIB. 1 presents a comprehensive Research through Design framework that connects meta-design research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems. Developing and testing an artifact is here not just a way for improving its effectiveness, usability and experience, but rather for planning its development between research and practice. The result of an exploratory research, it represents the foundation for future research and practice, and therefore its validation and improvement should come from evaluating its implementation in research, professional and educational programs with meta-designers and the profiles that can be found in the Maker Movement: makers, designers working with social innovation initiatives, social entrepreneurs (Menichinelli, Gerson Saltiel Schmidt, and Ferronato 2019). Mapping these profiles, their geographical distribution and impact is also becoming part of the practice and research of the author; ART. 3 addressed the impact of the development of Open Design projects on the social dynamics and structure of communities. Further research has been published on assessing the social impact of Maker initiatives through SIA (Social Impact Assessment) frameworks implemented on digital platforms (Menichinelli and Gerson Saltiel Schmidt 2019). Impact evaluation, especially with composite indicators, is in parallel becoming part of the OpenMetaDesign framework (Figure 22), which the doctoral research explored only in the aspects of processes and networks, opening thus doors to many practice and research future initiatives also for the dimensions of organization, governance and impact of collaborative processes.

At the core of the Research through Design framework proposed (CONTRIB. 1), the OpenMetaDesign conceptual framework (CONTRIB. 2) is the program that connects all the efforts in the spectrum between practice and research. For example, the OpenMetaDesign digital platform is the artifact at the center of the research documented in this dissertation, and its importance is not as a tool per se but as the encoding of the conceptual framework into a prototype that supports both the design of collaborative processes and the redefinition of the conceptual framework itself. As a program, the OpenMetaDesign conceptual framework enables the elaboration of educational, research and practice initiatives. It should be therefore evaluated through such programs and especially centering them in developing and testing with communities their specific ontologies of design processes. A further refinement would be to understand which kind of platform and visualization can be designed for each ontology and community.

The OpenMetaDesign conceptual framework and its artifacts and activities has provided the experience for redefining Meta-Design (CONTRIB. 3) after its integration with the Maker Movement. With a strong focus on meta-designers facilitating distributed and collaborative processes within Open/P2P/DDD Systems, it especially connected Meta-Design with Ontological Design. The centrality of ontologies here add a further self-reflection of a practice that 1) design processes as ontologies that 2) embed the ontology of design processes as seen by 3) the worldview (ontology) of a specific community thus 4) constituting an ontology as a shared language and map that enable such community to navigate collaborative design processes. Furthermore, here the adoption of a Research through Design approach in investigating Meta-Design further highlighted the self-reflective and self-aware possibilities of design. As the redefinition of Meta-Design here presented was based on an artifact and the practice of the author, it should be expanded with reflections on multiple contemporary experiences and more theoretical contributions.

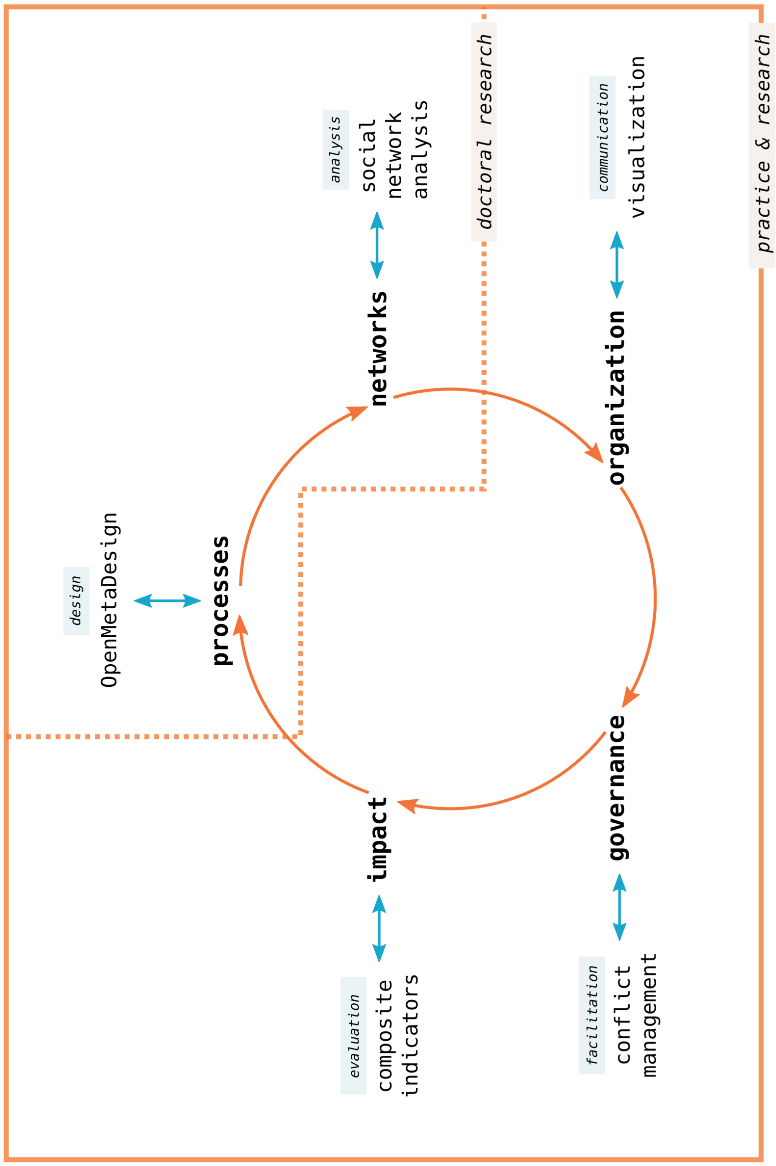

Figure 22. OpenMetaDesign framework: doctoral research within the emerging future practice and research

An overall theoretical redefinition of Meta-Design (CONTRIB. 3) emerges from the reflection upon artifacts, practice and context of meta-designers; consequently, a redefinition of who are meta-designers is the last contribution of this dissertation (CONTRIB. 4). A redefinition of the possible role, knowledge and profile of meta-designers emerges from the analysis of the skills and expertises necessary for the author in the development of the artifacts and their implementation in practice. Furthermore, the analysis of the context where the author as meta-designer has worked highlights how social network analysis can be used by meta-designers in order to understand their position in social networks and influence in social dynamics of the collaborative processes they support. Further development of this contribution might be granted by an analysis of a plural system of meta-designers that operate in different contexts and with different approaches.

Based on the Research through Design framework (CONTRIB. 1) and the design definitions elaborated (CONTRIB. 2, 3, 4), the dissertation thus proposes a first temporary, contextualized and transitional design theory (Redström 2017) of Meta-Design within the Maker Movement.

A TRANSITIONAL DESIGN THEORY OF META-DESIGN WITHIN THE MAKER MOVEMENT.

1. Meta-Design in the Maker Movement is a practice and research with and for Open, Peer-to-Peer, Diffuse, Distributed and Decentralized Systems done in makerspaces, communities and platforms and through the design of bits (digital environments) and atoms (physical artifacts) for supporting distributed collaborative processes (CONTRIB. 3);
2. Meta-Design in the Maker Movement is the development of a Meta-Data Ontology for Ontological Design as the collaborative definition of the ontology of design processes through the participation of a community that shapes the ontology according to its worldview and for its social and sustainable purposes and needs based on a digital ontology encoded, visualized and edited in a digital platform (CONTRIB. 2, 3);
3. Meta-Design in the Maker Movement is the multi-disciplinary and multi-professional practice of meta-designers that are designers, facilitators, participants, developers and researchers embedded in social networks that define their activities and profiles while at the same time providing the boundaries for defining the ontologies they design (CONTRIB. 4).

The contributions of this dissertation can be grouped by the design community they might be more interesting to. Following Findeli et al. (2008), the three main “end-users” of design research are communities are of design research, practice and education, and this consideration shows the weight and relevance of each contribution to take into account when defining programs based on OpenMetaDesign:

1. **the design research community:** interested in “fundamental” or “theoretical” knowledge (CONTRIB. 1, 2, 3);
2. **the design practice community:** interested in “applied” and “useful” knowledge (CONTRIB. 2, 4);
3. **the design education community:** interested in “teachable” and “applicable” knowledge (CONTRIB. 1, 2, 4).

As the contributions might interest and affect the different members of the design community, they can also be extended further for them. In Redström’s approach to Research through Design (2017) the program is the focal point of all the initiatives between practice and research, given its centrality in balancing them. Here the program is represented by the OpenMetaDesign framework, and it represents thus the starting point for supporting all the members of the design community by creating design research, practice and educational programs.

The OpenMetaDesign framework is still more a conceptual model for orienting practice, research and education, while a program for Redström is rather an assemblage of material resources, institutional contexts, infrastructures, economic conditions; not a model but a planned set of events or actions. The OpenMetaDesign framework is thus not a complete program but a model for building programs with further practice and research. Furthermore, for Redström programs are characterized by being informed by a certain worldview: OpenMetaDesign has its own embedded values and worldview, but it has been developed for further understanding its underlying worldview and the one of the localities where it is adopted, and therefore this feature operates towards an awareness and design of the embedded worldview of programs.

At the core of the OpenMetaDesign framework is the ontology, and how design can influence it and being influenced by it. Here ontology has always a dual nature: it is a media and a community, a technology and a worldview, a global technical infrastructure and a set of local initiatives. In OpenMetaDesign ontology unfolds as data and social elements, as software and cultural elements, and design supports their connection by enabling their discussion and editing by groups of people. OpenMetaDesign is thus a set of practice, research and educational data/social design efforts that work in and support collaborative distributed systems. Furthermore, the data/social/design elements are also present in the redefinition of the profile of meta-designers as the structural element of the researcher dimension (CONTRIB. 3, Figure 19), providing thus also a direction for the author’s further research.

Programs developed on top of the OpenMetaDesign framework might thus cover activities that support how to design such ontologies and platforms (research), how to develop, deploy and adapt them in real life contexts (practice) and how to prepare new generations of designers in their design and adoption (education). The Research through Design framework (CONTRIB. 1) here presented is not just a document of the process behind the dissertation, but also the research strategy for evaluating all of these programs.

Through a research on the practice of meta-designers and educational programs for meta-designers, the framework establishes the foundations for understanding which might be the different disciplines and professions necessary for Meta-Design in each specific context, and how they can be connected to the local worldview and its social processes and systems. The hope is that with the OpenMetaDesign framework and its future evolution the practice and research of future designers will increasingly be also about a data/social/design approach to designing ontologies, not just as databases of digital artifacts but also as social processes. Through the Maker Movement both formally trained or formally employed designers and informal and amateur makers have popularized the idea that the design culture comprises also software and hardware; hopefully with programs based on the OpenMetaDesign framework the design of ontologies will be popularized in a similar way.

In the Research through Design process of this dissertation the artifact started as a conceptual methodology and then became a platform, and ultimately ended as a reflection on ontologies as both digital technologies and cultural worldviews. The emerging framework supports the definition of new possible practical approaches, conceptual directions and educational and research initiatives for meta-designers. At the core of both there is another approach to design and making efforts and platforms that emerges and that turns how digital movements are organized upside down. This dissertation argues that in order to enable collaborative networks through digital platforms it might be more promising to network distributed local initiatives and their plural worldviews into global processes and organizations instead of building one single global worldview that is then distributed to and through local efforts.

The Maker Movement integrate bits and atoms, digital and analogue, local and global, traditions and contemporary practices. Beside the impact over manufacturing and collaborative practices, it can provide a setting for exploring how to balance these opposites by transferring knowledge from one context to another for implementing digital social innovations but by balancing the role of global digital technology and visions with local worldviews and needs.

The concept of ontology is central in the OpenMetaDesign framework, both as a design material and as the design context. The connection between the two meanings is a core element here, since often they are disconnected in new media artifacts and especially in web initiatives, where a global community with a single ontology is often the main worldview pursued. The workshop organized in South Korea and the research study organized in Milan showed how users should not just be engaged in testing methods and tools, but also for understanding how their worldview might affect their usage and redesign: not just usability or user experience but the worldview that defines the data and its visualization.

The framework and its practice, research and educational programs are also about redefining not just the meta-designers in the Maker Movement, but how new media create interfaces between the physical and the digital, and especially between the local and the global. The approach however is different from the common practice, it is what Loukissas defines as an emerging reaction towards the conventional digital universalism through a place agnosticism attitude to digital media (2019), of which Negroponte is one of the clearest and historical examples: "Digital living will include less and less dependence upon being in a specific place at a specific time, and the transmission of place itself will start to become possible." (1996, 163). This is a vision of the Web as a "global community that works for everyone", that reached its widest implementation in Facebook (Zuckerberg 2017), but that influenced even the development and adoption of such technologies and efforts that are more localized, such as digital fabrication and Fab Labs, with Neil Gershenfeld urging to "think globally, fabricate locally" (2012, 46). According to Loukissas digital universalists adopt such place agnosticism in order to avoid questioning the free market ideology: "If you are not influenced by your setting, you are a more independent and economically rational individual" (2019, 10).

The place agnosticism is thus also present in the Maker Movement, but here as well there are signs for potential changes in the connections between design and distributed systems. An example of similar but different perspectives of this can be found in two apparently similar approaches for design and distributed systems and making and social innovation. Both approaches have a similar name, but with an important difference that distinguish between them: Cosmo-localism and Cosmopolitan Localism.

Cosmo-localism emerges from the integration of a global open design community with the digital fabrication technologies that enable the distribution of its projects. It is based on the idea that humanity is a single world community, and therefore access and participation to the global design commons should be treated as a human right (Ramos 2017; Bauwens, Kostakis, and Pazaitis 2019). On the other side, Cosmopolitan Localism is connected to design through distributed systems of social innovation for the resilience of a sustainable society: "while centralized systems can be developed without considering the social fabric in which they will be implemented [...] no distributed systems can be implemented (and therefore, no resilient systems can be realized) without social innovation." (Manzini and M'Rithaa 2016, 278). This approach connects design with a vision of a new sense of place and a new idea of locality as a node in a variety of networks instead of one single and homogeneous global community. This is the Cosmopolitan Localism vision as described by Wolfgang Sachs, where local differences become more valued as a reaction to a global homogenization:

> the fear that modern humans will encounter nobody else but themselves on the globe is about to revolutionize contemporary perceptions. The pursuit of space-centered unity is turning into the search for place-centered diversity. After all, it is only from places that variety crops up, because it is in places that people weave the present into their particular thread of history. Thus native languages are beginning to be revaluated, traditional knowledge systems rediscovered, and local economies revitalized. [...] The globe is not any longer imagined as a homogeneous space where contrasts ought to be levelled out, but as a discontinuous space where differences flourish in a multiplicity of places. (1999, 105).

The contrast between a single globally connected and global community and a complex assemblage of uneven and overlapping social systems has been at the center of web technologies. The traditional utopian vision of the web as a universal space feared balkanization as the ultimate menace (Mueller 2017). But despite global connectivity, groups self-organize at multiple scales but in fragmented ways, with clear geographical borders that are consistent between physical and virtual spaces that reinforce the diversity of individuals and groups (Hedayatifar et al. 2019). The author's analysis of maker laboratories on Twitter also shows that indeed what is supposed to be one global community, the Maker Movement, is polarized into two factions with different structures and overlaps of localized networks and more global ones (Menichinelli 2016c). There are already many communities, more fragmented and nuanced: we are indeed after the fall of the Tower of Babel, with multiple languages for addressing the same shared project.

In designing for distributed systems, Cosmo-localism aims at a universal community, while Cosmopolitan Localism aims at valorizing local diversities and connecting them globally. The OpenMetaDesign ontology was at first developed with established approaches and tools such as Activity Theory and Service Design, but workshops and research studies proved how these are still far from being always understood and accepted everywhere and pointed out how local worldviews should be rather addressed when designing digital ontologies, platforms and visualizations. Here again the now old approach of a global standard, a digital platform and visualizations slowly gives place to a Cosmopolitan Localism of digital platforms, ontologies and visualizations. Understanding how design and worldviews are connected when working with communities and distributed systems might augment the impact, for example by changing how complex and wicked problems like climate change are framed, communicated and addressed (Yoder 2018) or with a specific approach for specific communities (Goldberg et al. 2019). Mass-collaboration becomes less about global initiatives that are adopted locally and more local initiatives that are scaled by being localized in a distributed way.

The valorization of local diversities as opposed to a universal community brings another question: how many different local ontologies should there be in an Open/P2P/DDD System? Here again the equilibrium of the Tower of Babel: only one ontology would be too ambitious and would collapse, too many ontologies would be noise and no collaboration. The identification of communities with social network analysis (CONTRIB. 4) could be a strategy for fine-tuning the number of ontologies and their similarities and differences, by contextualizing them within the social structure, its path-dependency and community governance mechanisms. Coupled with this social-driven strategy, a data-driven strategy could be based on the customization of the ontologies or of their visualizations and interfaces: practitioners expect that with emerging implementation of artificial intelligence in website and platforms more customization could follow, adapting to people's usages and to the communities' local dynamics (Zasada 2020).

We are now increasingly realizing that data and localities are entangled in more complex ways than previous considered, and especially in contrast with the common practice of current digital platforms. To sum this new approach, all data are local (Loukissas 2019); data can represent local knowledge (Ezoji and Matta 2019); algorithms are socially-bounded and diffuse artifacts (Seaver 2017); new media technologies should be designed following the worldviews of an increasingly diverse community of users (Srinivasan 2013). Data are always entangled with the local context, knowledge, community and algorithms, and they should be referred to as data settings instead of data sets: "data are cultural artifacts created by people, and their dutiful machines, at a time, in a place, and with the instruments at hand for audiences that are conditioned to receive them" (Loukissas 2019, 1–2) and algorithms are entangled with them in situated and multiple ways. Furthermore, researchers have developed ontologies that identify tangible and intangible resources of geographical, human, economic, political capital in a local territory; the purpose of such ontologies is to represent the territorial knowledge on and for sustainability to enhance the knowledge and agency of actors within local industries (Ezoji and Matta 2019).

As more non-Western users are increasingly adopting new media technologies, these should be designed according to their values, priorities, and ontologies in order to empower them. Such effort might be done by analyzing their experiences and the processes they represent through a community-based ontological approach that comprehend not just one ontology but a set of networks of multiple ontologies (Srinivasan 2013). Finally, algorithms are heterogeneous and diffuse socio-technical systems, and should be considered "as" culture. They are determined by social engagements rather than by technological or material constraints and are tied to social (group) boundaries: between who shares the same definition and understanding and who does not. They should be explored through ethnography using fieldwork to discover what they are in a practice that sits at the boundaries of diverse communities of practice (Seaver 2017). Following a Posthuman / More-than-Human perspective in design (Forlano 2017), because of their agency platforms and algorithms (and in general, non-human actors) should be also explored in their ethical know-how, co-performance and responsiveness with human actors (Giaccardi and Redström 2020) for example with Actor-Network Theory (Latour 2007). As part of the meta-design ecosystems and processes, non-human actors can be considered meta-designers, and future research should explore the features and dynamics of such meta-designers.

Overall, this dissertation is also a reflection about the traditional digital universalism of the Maker Movement, its limitations and that a way forward might be by rebuilding the movement from the practice with research, platforms and a focus on ontologies. OpenMetaDesign redefines the act of collaboratively deciding design processes, the understanding of design processes, the role and profile of meta-designers and a comprehensive strategy for bridging research and practice with a Research through Design approach. Such strategy enables the creation of practice, research and educational programs for designing with distributed social collaborative networks. In this emerging context of the Maker Movement, this dissertation is not strictly speaking a reflection upon a practice: here practice is the context for Research through Design. Not reflection on practice, but through practice; not a generalization of a single practice, but insights, tools and strategies from one practice shared to be adopted and modified by other practices.

Ontology is here the new link between data and local, bits and atoms, for enabling distributed agency while respecting local differences: we design digital culture and technology for understanding (local) ontologies and connect them globally for enabling collaborative and distributed design and making processes. Ontology has here a dual nature of media/community, bringing thus forward two directions for future practice and research: data/social design. With social systems defining the worldview and the design efforts, social network analysis can be useful then for finding the social position, dynamics and impact of meta-designers but also the boundaries of the worldviews they have to work with. In Design for Social Innovation the “social” dimension applies to both the “how” (the process) and the “why” (the social, societal and systemic goals). OpenMetaDesign thus adds the “what” to them by supporting the design of social processes.

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Part II: Original Articles, Canvases and Ontology

1. ART. 1

Menichinelli, Massimo. 2016. 'A Framework for Understanding the Possible Intersections of Design with Open, P2P, Diffuse, Distributed and Decentralized Systems'. *Disegno – The Journal of Design Culture* III (01–02): 44–71. http://disegno.mome.hu/?page_id=136.

A framework for understanding the possible intersections of Design with Open, P2P, Diffuse, Distributed and Decentralized Systems

Massimo Menichinelli

Aalto University, School of Art, Design and Architecture, Department of Media, Media Lab

IAAC | Fab Lab Barcelona

massimo.menichinelli@aalto.fi

Abstract

Since the turn of the century, the discipline of design has increasingly focused its attention on its application to projects and groups of users at a larger scale. Researchers and practitioners have tried to understand how design could shift its focus from single users to local and online communities, from isolated projects to whole complex systems. These new perspectives consequently brought the interest of designers to the tools and strategies that can enable their interactions with larger groups of people distributed in several localities. More specifically, designers and researchers started adopting many approaches coming from software development and web-based technologies, like open source, P2P, diffuse, distributed and decentralized systems. This article proposes a preliminary framework for understanding and working with the integration of design with open, P2P, diffuse, distributed and decentralized systems. In one direction, such open, P2P, DDD systems can be applied into design practice: this first intersection has many applica-

tions, from digital projects to P2P-based initiatives to physical projects designed and manufactured on global networks of distributed laboratories like Fab Labs and Makerspaces. In another direction, design practice can also have a role in enabling such systems through the analysis, visualization, and design of their collaborative tools, platforms, processes, and organizations. Design, therefore, could learn from such systems and also improve them. This second intersection falls into the meta-design domain, where designers can have a role in building environments for the collaborative design of open processes and their resulting organizations.

The article therefore addresses this phenomenon by providing both an analysis of the concepts and the history of both directions and, in order to understand the phenomena with a broader overview, it proposes a preliminary framework for understanding the possible intersections of design with open, P2P, diffuse, distributed and decentralized systems through both literature and case studies. As the framework is still preliminary, the article provides as a conclusion some possible strategies for validating or improving the framework.

Keywords

Open design, peer-to-peer, distributed systems, meta-design, mass-participation

1. Introduction

Since the turn of last of the century, the discipline of design[1] has increasingly focused its attention on its application to projects and groups of users on a larger scale than in the previous decades. Several approaches have addressed the participation of users inside design processes, from participatory design to user-centered design, from user experience design to co-design (Rizzo 2009). Even in the art world, participation has been relevant in the past decades, especially with new media art, net art[2] and activism (Bazzichelli 2008; Dezeuze 2012) where it has grown on a larger scale. More recently, design researchers have worked on co-designing with communities instead of single users (David, Sabiescu, and Cantoni 2013), and even with online communities using both online and offline tools (Näkki and Antikainen 2008). The shift from local to online communities is important in the path towards including more users in the design processes, potentially even a large number of them thanks to the scaling and enabling features of social media and online plat-

[1] The design term has several meanings in the English language and it is adopted by several disciplines. Within this paper, we consider design any project or approach developed by the professional and research community of designers, in all its kinds (industrial design, graphic design, interaction design, and so on), and therefore it could refer to both digital and physical artifacts, material and immaterial projects.

[2] Within this paper, we refer to net art broadly as artworks and approaches developed with the support of Internet for their development, fruition, interaction and participation by users.

forms. Researchers and practitioners have tried therefore to understand how design could shift its focus from single users to local and online communities, from isolated projects to whole complex systems. The social, economic and technological changes of the past decades have created new scenarios that are strongly influenced by the phenomena of globalization, the quest for sustainability and recurring economic crises. All these phenomena have brought to the attention of a considerable number of researchers and practitioners in many fields the emerging role of territories and of the communities that live in them for shaping the future of society. Even the design discipline itself—which traditionally focused only on artifacts (be they material or immaterial), but much less on territories and communities—has, since the first years of this century, started to focus on how it could address and foster local resources, communities, and initiatives. Some research projects, workshops, and exhibitions were developed, especially in Europe and Italy, with the focus on the relationships between Design and local resources, communities, identities and economies (Verwijnen and Karkku 2004; Fagnoni, Gambaro, and Vannicola 2004; Cristallo et al. 2006). Some of this research also focused on how design could interact with the local dimension and the local community (Villari 2013; Maffei and Villari 2006; Menichinelli 2006). These new perspectives have consequently brought the interest of designers and design researchers to the tools and strategies that can enable their interactions with larger groups of people distributed in several localities. More specifically, designers and researchers started adopting many approaches coming from software development and web-based initiatives and technologies, like *open source, P2P, diffuse, distributed and decentralized systems* [Figure 4]. All these web-based initiatives and technologies have become interesting for their ability to exploit the possibility of scaling to hundreds or thousands of people. This new scale for participation and for projects also brought more interest to the dimension of complexity, which is one of the frontiers for the discipline of design, both for visualizing it and for embracing it in many directions. The complexity of the local dimension and of the collective intelligence emerging from potentially high scale participation are redefining many design approaches.

In this direction, we might find relevant and useful all the possible projects, approaches and tools that may be generated from the intersections of the design discipline with open, P2P, DDD systems. One of the most popular approaches is open design, intended as the intersection of design with open source, which is an approach commonly credited to the designer Ronen Kadushin (Troxler 2011). According to Ronen Kadushin, open design projects are strictly CAD information published online under a Creative Commons license that can be downloaded, produced, copied, modified, and produced directly from file by CNC machines (Kadushin 2010). Further research has investigated the dimension of the open design phenomenon by addressing open source physical objects (Balka, Raasch, and Herstatt 2009; Raasch, Herstatt, and Balka 2009). This article argues that there might be many more approaches generated from the intersections of the discipline of design with open, P2P, DDD systems and that they are not necessarily restricted to tangible goods, since many design projects are immaterial or digital. In order to explore this landscape, a search for possible publications was done in several databases like Scopus, Web of Science, JSTOR, Google Scholar [Table 1]:

Search term	Scopus	Web of Science	JSTOR	Gooogle Scholar
“open design”	636	754	36	400
“p2p design”	23	8	0	22
“distributed design”	817	557	26	985
“diffuse design”	6	6	0	0
“decentralized design”	232	111	11	144

Table 1. Number of possible publications about the intersections of Design with Open, P2P, DDD Systems in the databases of Scopus, Web of Science, JSTOR, Google Scholar. The terms were searched in title, keywords, abstracts except for Google Scholars, where they were searched in title only.

The results from the databases generally fall in the same scale. The data gathered from Scopus was further investigated, since it provided additional metadata regarding the subject areas and time of the publications. We can generally observe that the publications mostly cover distributed, open and then decentralized design, and very little P2P and diffuse design [Figure 1]. The publications were mainly produced in the subject areas of engineering and computer science; medicine and mathematics followed [Figure 2]. Arts and humanities, and subject areas related to design and net art are poorly represented, showing that the publications in the such disciplines of design are either few, not mapped by Scopus, or that the size of the phenomenon is still small. Furthermore, data about the date of publication shows how the topics were not really addressed in the 1960s and 1970s, but they mostly grew in popularity the 1990s and have experienced an high growth since the 2000s [Figure 3].

The gathered publications could be therefore only partially related to the discipline of design, only very recently for their majority, and unevenly among open, P2P and DDD systems; questioning the ability of such literature or of such databases to explain the phenomenon, or suggesting that more extensive research could provide more insight. Therefore, the thesis of this paper is that there might be many more approaches generated from the intersections of the discipline of design with open, P2P, DDD systems, that they are not necessarily restricted to tangible goods, that existing literature might be insufficient for understanding them, and that a preliminary framework could be proposed here by analyzing both literature and practical cases. Such a framework is intended for future literature and case analysis in order to enable design researchers to both understand the phenomenon and improve or reject the framework, and design practitioners to know which possible formats, approaches, tools and projects could be adopted in designing projects in their work and how many combinations are possible at the moment, for designing new approaches and tools. A preliminary framework needs validation, rejection, or modifications, and possible strategies for this evolution are outlined in the conclusions of this article.

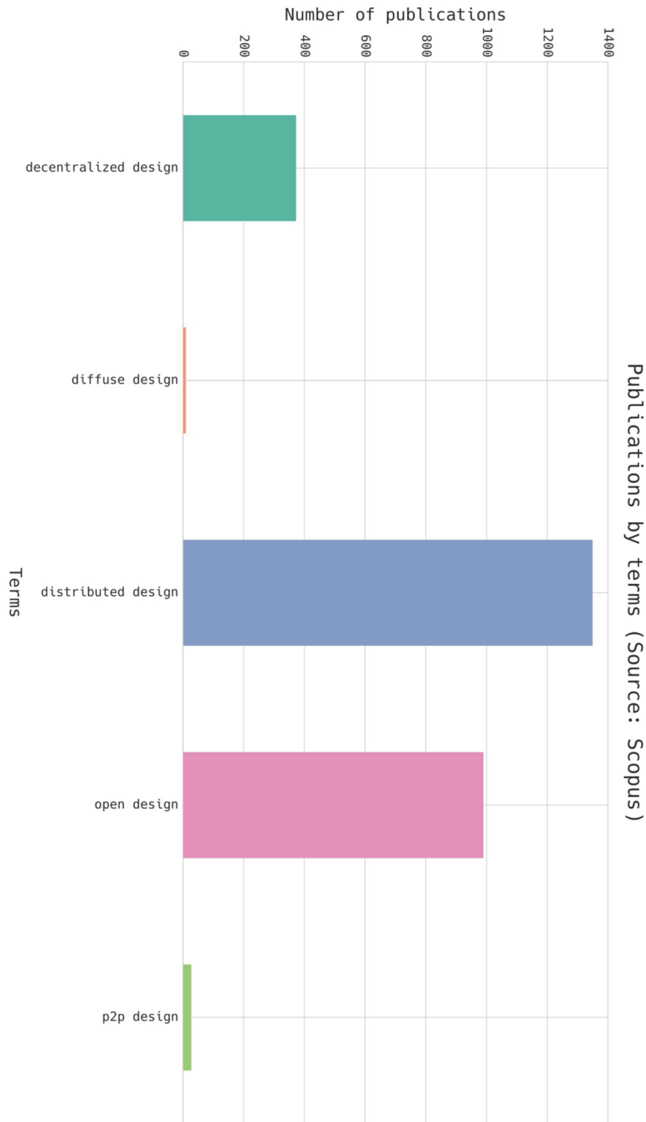

Figure 1. Number of publications by search terms found in the Scopus database.

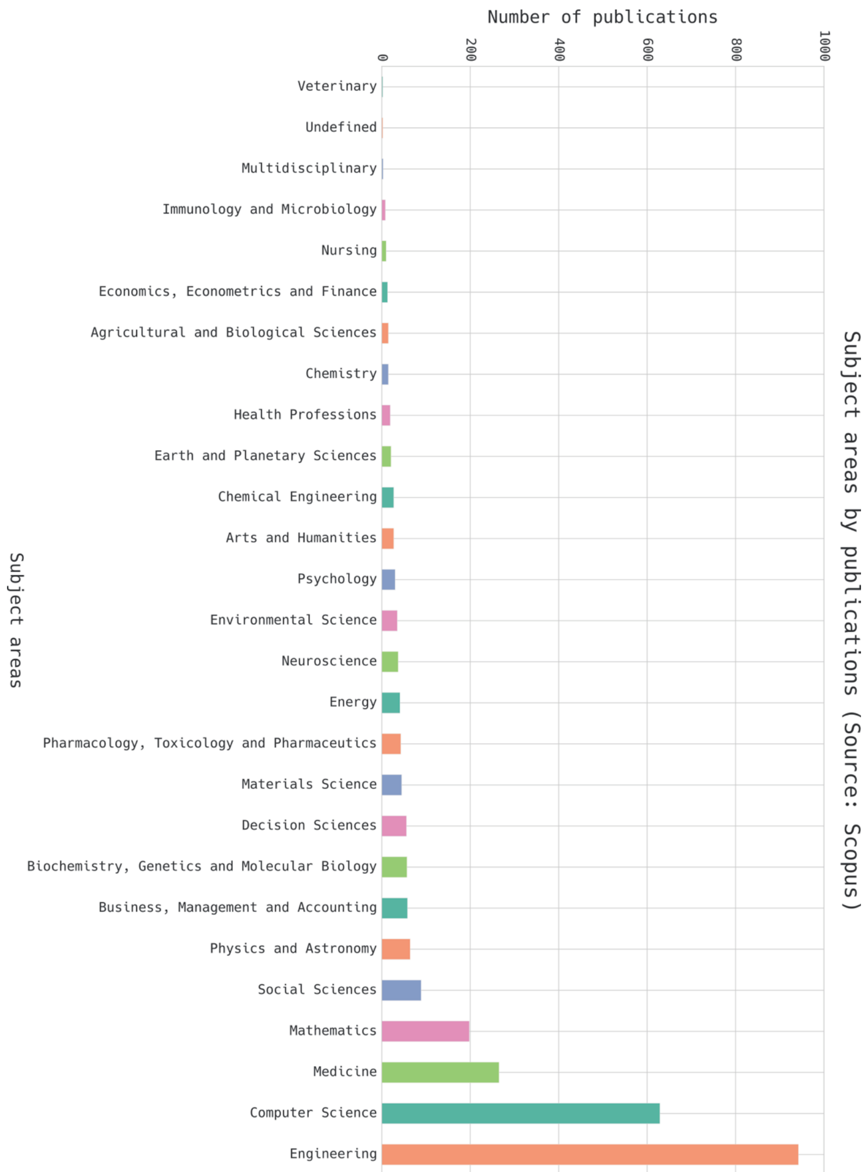

Figure 2. Number of subject areas covered by the publications foundin the Scopus database.

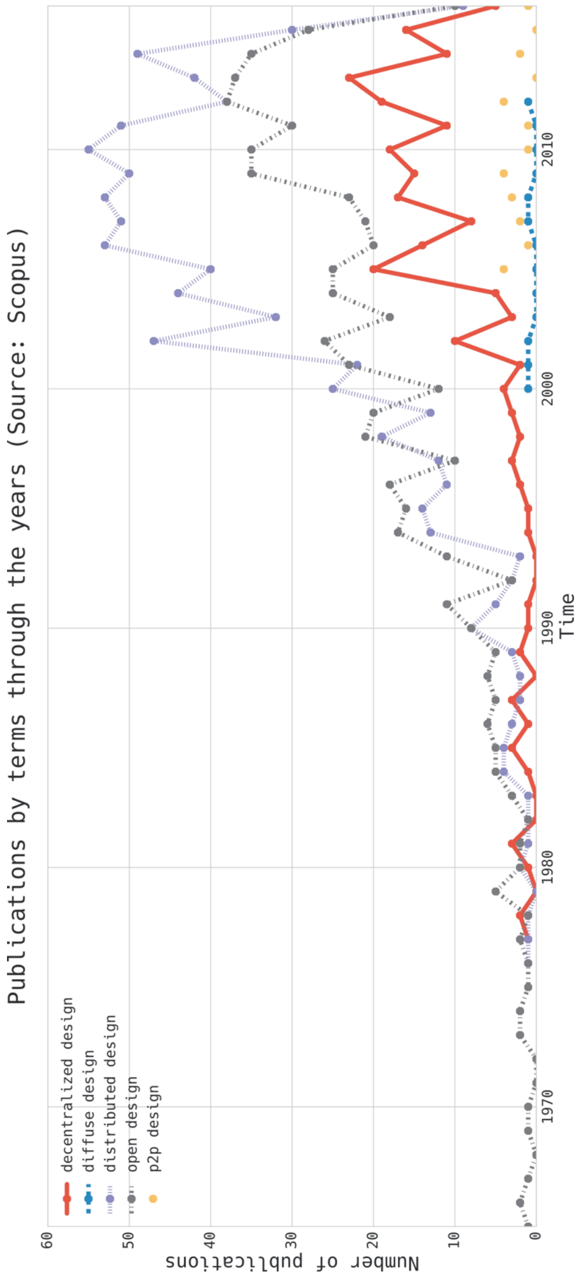

Figure 3. Time plot of the number of publications by search terms found in the Scopus database.

In order to build this preliminary framework, relevant literature and cases regarding the intersections of design with open, P2P, DDD systems were analyzed by trying to understand how they integrate, especially with regard to three questions: 1) is the case/publication inspired by open, P2P, DDD systems? 2) is the case/publication based on the adoption of open, P2P, DDD systems? 3) is the case/publication aimed at designing open, P2P, DDD systems? After analyzing the cases and publications, the position of this article is that design could interact with open source, P2P, diffuse, distributed and decentralized systems in two directions: 1) by embracing them in its practices or 2) by applying its practices in order to improve and implement them [Figure 6]. Many projects and publications have been produced in both directions, but generally with more focus on how design could adopt open source practices and tools inside its practice. Both directions could be therefore explored more by design practitioners and researchers. The article therefore addresses this phenomena by providing both an analysis of the concepts and the history of both directions and, in order to understand the phenomena with a broader overview, it proposes a framework for understanding current possible intersections of design with open, P2P, diffuse, distributed and decentralized systems through literature review and case studies. In conclusion, it points to possible strategies for validation and evolution of the framework.

2. Promising approaches for designing at a larger scale: Open, P2P, Diffuse, Distributed and Decentralized Systems

The introduction of digital technologies in the past decades has either enabled new forms of organization and new forms of distribution of resources, or it has modified or rendered obsolete old forms, especially thanks to infrastructures such global network of devices and technologies (the Internet) or information and documents (the World Wide Web). These technologies have shaped new ways of working and participating in projects, which in turn have contributed to shaping these technologies. These new technologies and their related organizational forms have been experimented with not only in software and web projects, but also in projects related to music, biotechnology, movies, science, art, design and so on (Goetz 2003). There are, however, different formats, terms, and approaches for understanding and therefore designing with and for these web-enabled technologies and organizational forms. In order to understand the possible relationships between design and them, this section provides a brief overview of them through a literature review and some cases. This overview intends to establish a starting point for a connection between open, P2P, DDD systems and their integration with design in the next two sections.

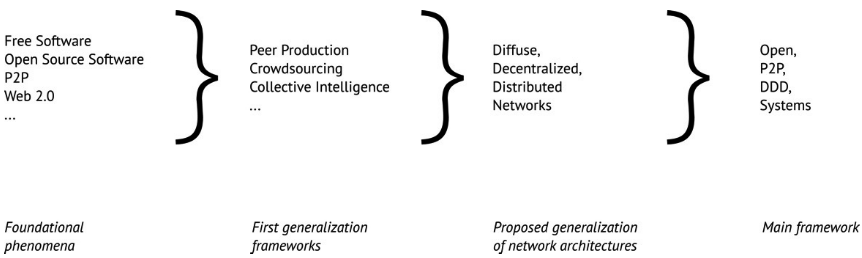

Figure 4. Frameworks for under- standing mass-participation phenomena.

These technologies and organizational forms have become interesting for their ability to enable participation, collaboration, and sharing on a mass level. Historically, their origin can be traced back to the first years of computer science and software development, when it took place in many academic institutions, and from where it also took the ethic of sharing and participation which would later become the Hacker ethic (Himanen 2001). At the beginning of the 1980s, however, the software industry started changing its business models with the introduction of personal computers, and the development of software was less based on sharing and more on closed strategies based on proprietary rather than common licenses. In 1985, Richard Stallman founded an initiative that would be the starting point for renewed interest in sharing and collaboration: for him, being able to access the source code of a software is a requirement for personal freedom, hence the term free software (and the Free Software Foundation he established for facilitating its development) (Stallman 2002). The main components of free software were the GNU operating system and the GPL license, which are still the basis for many projects today. The free software movement, however, grew slowly because of the difficulties in finding like-minded hackers. A turning point came with the opening up of the Internet to the general public at the beginning of the 1990s, which enabled more hackers to meet and create a community, and Linus Torvalds to develop the core of the GNU operating system, the Linux kernel (hence the more formal name GNU/Linux for the commonly named Linux operating systems). Linux proved to be another foundational project, not just on the technical level, but also for proving that a complex project could be developed by an online community in a more efficient way than a traditional closed and hierarchical project: the participation of a large complex social system is the key to its success (Raymond 1999; Kuwabara 2000). The term free was controversial and less accepted by companies, and in order to promote the concepts further, a group of hackers developed the term open source and the Open Source Initiative instead (Perens 1999), shifting the focus from freedom to openness, with a stronger accent on methods and processes than on philosophy, with more focus on the design of systems and processes than on ideas and principles. Both terms and approaches overlap and have different nuances at the same time, but the term open source gained particular momentum and became an inspiration for the adoption of the same practices and principles outside the software movement, a phenomenon that was firstly witnessed at the beginning of the 2000s (Goetz 2003) and that has sometimes been called open source everything (Steele 2012). The concept has been considered not just in terms of technology, but as an organizational form and approach more suited to the knowledge society (Mulgan, Steinberg, & Salem 2005).

Like software development, the same trend is found with Web platforms which, around 2005, stopped being static or managed only by a closed team and started opening the production of content to every user. This phenomenon became associated with a further evolution of the Web and therefore of many initiatives that could be organized on the Web, thanks to the term *Web 2.0* (O'Reilly 2005). New online platforms like YouTube or Facebook emerged and at the time they were considered as both new kind of business and a social experiment of digital democracy on a mass scale, thus also representing a further evolution in the role of citizens (Grossman 2006). All these free, open and 2.0 initiatives of potential mass-collaboration were then analyzed mainly in terms of business potential (Tapscott and Williams 2006; Tapscott and Williams 2010) or in terms social and collaborative approaches which could lead to the emergence of a global *collective intelligence* (Leadbeater 2009; Shirky 2008; Shirky 2011; Surowiecki 2005). All these approaches tried to create a framework for understanding and promoting these initiatives of mass-collaboration, and slowly more differences and criticisms emerged in the approaches and in the literature and public opinion. The term *crowdsourcing*, for example, started as a generic term for mass-collaboration (Howe 2006; Howe 2008), but later became more synonymous with mass-competition where tasks are highly regimented and pre-specified in order to exploit cost reduction thanks to the outsourcing to the online crowd, rather than a free and collective exploration of creative opportunities (Benkler 2016). Web 2.0 platforms and social media are increasingly under the analysis regarding their real neutral position and influence on the social, political, and economic dimensions of society (Lovink and Rasch 2013; Morozov 2014; Morozov 2012). The increase in the size of such platforms has brought more side effects to society and welfare (Morozov 2016) and politics (Epstein 2015) than just global interactions; there are effects that work at a deeper level, affecting our relationship with knowledge by making us privilege some ways of processing information over others, with unprecedented dynamics that are not always necessarily democratic or expressions of a collective intelligence, and with more profound philosophical and epistemological implications (Lynch 2016). These critical dimensions further suggest how such formats are not only always completely positive, but also how it is important to reflect on how it would be possible to modify and design them.

Some approaches therefore have tried to find differences among all these cases of mass-participation. A relevant approach that focuses on the organizational and economic implications of such initiatives is the concept of *peer production* (Benkler 2002), which consists of a subset of cases of collective intelligence where control and activity are decentralized, where monetary and non-monetary incentives are present and where inputs and outputs are mostly governed as open commons (Benkler 2016). Peer production is important not as a technological innovation, but rather as an innovation in the organization of work thanks to technology, which shows an organization different from markets or hierarchies. In peer production, the distributed pool of users/designers participating in a project can better identify who is the best person for a task, with an improved identification and allocation of human creativity, since human knowledge, experiences and skills are highly variable and distributed. The concept of peer production has been mainly developed around the production of digital content, but it has also inspired discussion around how it could be applied to physical goods (Siefkes 2008; Bauwens 2009).

The same goal of generalizing methods and principles from mass-collaboration to the whole society is one of the aspects that has generated interesting reflections on the possible dynamics enabled by *peer-to-peer* software, where nodes in the network (devices, but also users) are directly connected without a middleman. Peer-to-peer software infamously emerged at the end of the 1990s with the file-sharing service *Napster* and are therefore commonly linked to the illegal distribution of digital content. However, such and similar cases proved to be more interesting because of their more efficient distribution for a much wider variety of content than the traditional centralized network (Benkler 2002). Furthermore, this principle for social interaction has been elaborated as a whole scenario for a sustainable future society besides mere software applications (Bauwens 2005; Kostakis and Bauwens 2014). Peer-to-peer software is indeed bringing innovative approaches to many practices, and not just in video-conference systems or file sharing. An interesting example in this direction comes from Bitcoin, a peer-to-peer based software that enables decentralized pseudonymous transactions of a digital currency which is in turn generated by the distributed data processing that users offer in order to verify and record such transactions in a distributed database, the *blockchain* (Nakamoto 2008). The blockchain is what is commonly considered as the most innovative component of *Bitcoin*, as the decentralized “trustless” proof mechanism of all the transactions on the network, that can be extended from currency to markets to organization, art and many other projects (Swan 2015). The global interest around Bitcoin and the blockchain has generated many experiments and approaches regarding their generalization, like *Dapps* (decentralized applications), *DAOs* (decentralized autonomous organizations), *DACs* (decentralized autonomous corporations), and *DASs* (decentralized autonomous societies). All these terms essentially propose peer-to-peer-based and sometimes AI-based software that can decentralize consensus without a centralized communication and control that can manage organizations, sometime in an autonomous way (Swan 2015; Raval 2016).

We have seen the main technologies and related organizational forms, principles and framework that have influenced the general awareness about the possibilities and modalities for managing participation (collaboration and competition) on a mass scale. They mostly refer to decentralized communications where each participant is a peer, where the work is based on shared assets and outcomes and agency are distributed over networks. All these initiatives start as technological innovation but also reach (or are believed to reach in the future) the economic and social dimension of society. As we have seen, there is a common stress on the distributed and decentralized nature of communication, control and agency in socio-technological networks. The distinction between centralized, decentralized and distributed networks of communication has been part of many reflections on the architecture of communication networks since the inception of the Internet, with the goal of designing a network that could withstand enemy attacks (Baran 1964). These, however, are mainly theoretical discussions about ideal types of networks, and many times there are no clear boundaries and definitions of them, or terms are adopted mainly as a reaction to traditional hierarchies, intended as centralized networks where one node control all the other nodes or the interactions among the other nodes. As a conclusion of this section, we propose to integrate open and P2P dynamics into a simple framework that tries to clarify such concepts of systems defined by network architectures as the fundamental architecture of social and technological interactions. We propose to add a *diffuse* kind of system, and we integrate diffuse, distributed and decentralized systems with open and P2P systems, extending Paul Baran's famous visualization of networks (Baran 1964) [Figure 4 – Figure 6]:

- *Diffuse systems:* the general meaning of this term could be linked to ill-organized, not concentrated or localized initiatives ("Diffuse" 2015). Therefore, they could generally refer to systems where the agents are spread and not connected or coordinated (if not at the local level then within a very short range) and where activities and assets are not homogeneously present in all the agents.
- *Distributed systems:* the general meaning of this term could be linked to computer networks in which processing and storage of information is shared among many coordinated devices ("Distributed" 2015). Therefore, they could generally refer to systems where activities and assets are shared and coordinated among the agents, and where control and influence is spread as much as possible among the agents and locally optimized at short range.
- *Decentralized systems:* the general meaning of this term could be linked to the dispersion, distribution, or delegation of functions, position and powers from a central authority or place to regional and local authorities or places ("Decentralization" 2015). Therefore, they could generally refer to systems where activities and assets are shared and coordinated among the agents, and where control and influence is concentrated among few nodes instead of a single one.

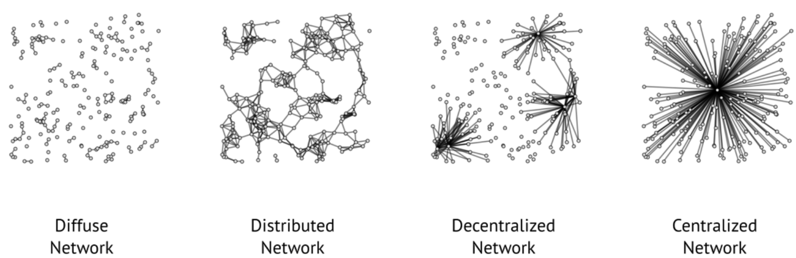

Figure 5. Network simulations for DDD Systems.

The framework of such DDD systems is a preliminary and broad one, and it would require a more complex formulation that is beyond the scope of this article, especially with approaches related to network science in order to uncover its network structure. This article proposes a simple and preliminary description, in order to build the preliminary framework of design with open, P2P, DDD systems. In this case, DDD networks were simulated by software

[Figure 6][3], providing a first rough description of such networks: 1) in diffuse systems, nodes are connected by network proximity at a very low distance, enabling only very local structures; 2) in distributed systems, nodes are connected by proximity, but at a larger distance, enabling local structures to be connected globally; 3) in decentralized systems, nodes are connected by proximity to local hubs which are more important in the networks; 4) in centralized systems, nodes are connected to one or very few hubs who completely control the whole network.

Open and P2P systems, coupled with general DDD systems can be regarded as the main framework for understanding phenomena of mass-participation. The intersections of these phenomena with the design discipline has generated several approaches and applications that will be explored in the next two sections and that will be referred by number to the main visualization of the framework proposed in this article [Figure 4 – Figure 6]. There are two main directions for the intersections we will examine here, and the following sections will address them in their interactions with design.

3. Design adopts Open, P2P, Diffuse, Distributed and Decentralized Systems

In one direction (1), such open, P2P, diffuse, distributed and decentralized systems can be applied in design practice: this first intersection has many applications, mostly with the open source practice. The open design phenomenon (1.1) has passed through a first stage of hypotheses and first attempts (1999-2005), then through a period of expansion and construction of an ecosystem between several projects (2005-2010), and finally to a stage of relevant interest from mainstream researchers, media and institutions (2010-) in which it is seen not only as a hypothesis but as a feasible proposal with many elements yet to be explored. The origin of open design is sometimes traced back to the work of Ronen Kadushin and his *Open Design Collection* of Creative Commons-licensed objects that can be manufactured digitally and that started in 2005 (Troxler 2011). However, one of the first online platforms for open and collaborative design, *Thinkcycle*, was already active in a research project at MIT during 2001-2002 (Sawhney 2003). These two origins already show different approaches: open design as digital files of projects (which is the focus of this section) or open design as an online platform for collaborative design processes (which is the focus of the next section). The following cases and publications are examples of this direction, and could be adopted in exiting projects and research or they could provide inspiration for further work along this direction.

As shared digital files of projects (1.1.1), open design has been applied to several different fields of design, and not just to product design. Among the early projects, *Openmoko* ("OpenmokoTM - Open. Mobile. Free." 2013) and then *BugLabs* ("Bug Labs" 2015) are particularly interesting for being com-

[3] https://gist.github.com/%20openp2pdesign/ecb64798f004%20bd9c7619a5445d3cbfe4

pletely open products in the software, hardware and design (encasing and interface) files. Openmoko was a smartphone project released as open source; BugLabs consists of a series of electronic devices that can be integrated in order to build complete products (furthermore, the design components of BugLabs were designed by IDEO). There have been, however, cases of open design that are not related to technology or industrial products; among the many projects, two directions are particularly interesting: fashion design and typographic design. The fashion industry is an interesting case for open design, given its peculiar IP regime with little protection and a tradition of imitation and learning from peers (Raustiala and Sprigman 2012). One of the most interesting projects of open design in fashion design, for its wide reach and completeness, was *OpenWear*, a collaborative clothing platform, open fashion collection, and brand developed between 2009 and 2012 with the goal to optimize the competitiveness of small producers through collaboration, common-based resources and community (Niessen et al. 2010; Romano 2015). Besides the reflection and the experimentation on the economic and social impact of an open design project on workers, the project made a founding contribution to the reflection on open design not just as blueprints but also as a brand. Regarding typographic design, this direction is interesting because this is an immaterial kind of design, but definitely linked to its tradition more than to technology (1.1.2). The first examples could seen in the *Gentium* font ("Gentium" 2015), the *Ubuntu Font Family* for the Ubuntu Linux operating system ("Ubuntu Font Family" 2011) but even in *Source Sans Pro* (Hunt 2012), designed by Adobe, the company that delivers a relevant part of the proprietary software used by designers (and therefore a historical step in the diffusion of open design among commercial and proprietary companies). Other interesting open design experimentations can be found also regarding the organization of spaces as in interior design like the *Instructable Restaurant* (Hendriks 2011) (1.1.3) or in architecture (1.1.4), with first experimentations in competitions like *Open Architecture Network* (TED 2006) or in academic research such as the *Open Source Building Alliance Operation* (OSBA) at MIT (Larson et al. 2004), in experiments from practitioners such as the WikiHouse online platform (TED 2013) or in recent collaborative reflections on open design in architecture as a new culture (Ratti and Claudel 2014). Recent cases of corporations and media becoming more interested in experimenting with oOpen dDesign could be considered as a sign of it entering the mainstream (Menichinelli 2011b; Menichinelli 2011c; Menichinelli 2011d). A further element that has contributed to the growth of the phenomenon is the emergence of the distributed manufacturing scenario (Bauwens 2009; Bianchini and Maffei 2013) and of the identity of Makers (Anderson 2012; Hatch 2014), which in part develop design projects in a collaborative way in a global community of many Maker laboratories with shared traditional and digital manufacturing technologies such as Fab Labs, Makerspaces, Hackerspaces etc. (Abel et al. 2011).

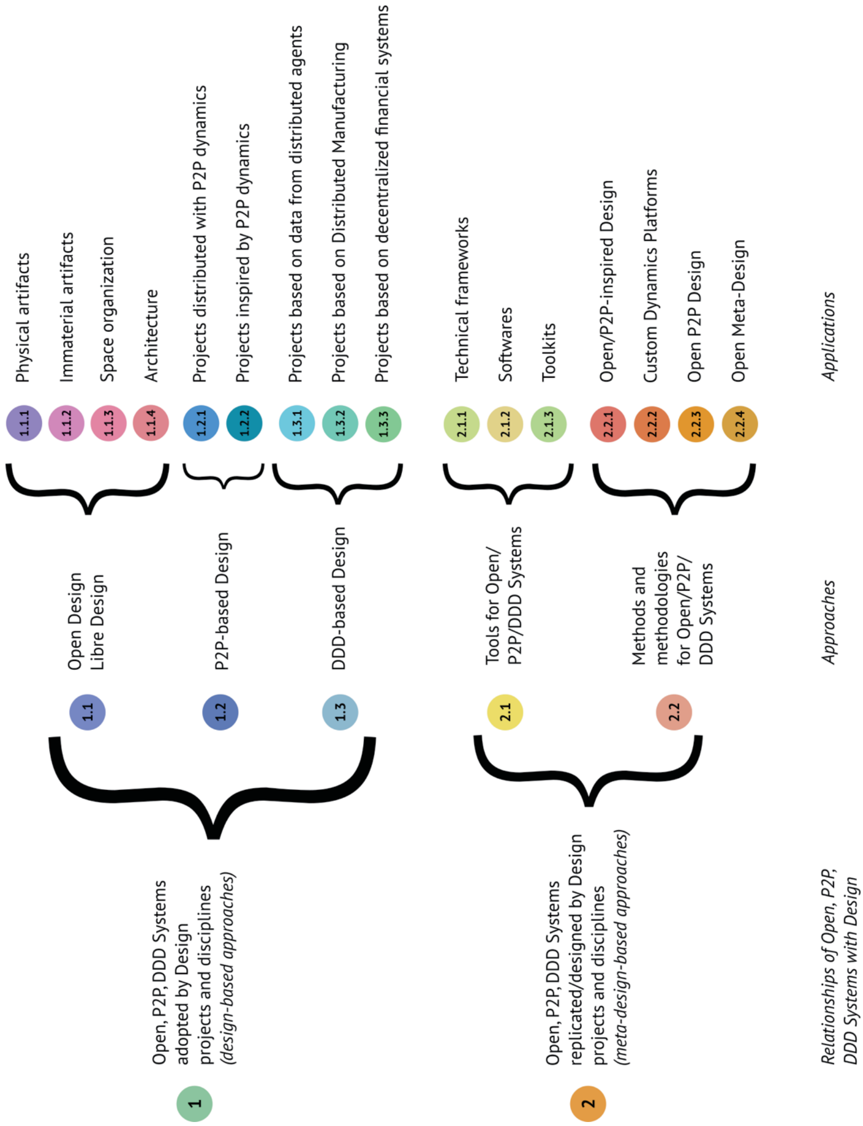

Figure 6. A framework for understanding the intersections of design with open, P2P, DDD

The main reflections regarding open design have been early attempts at understanding it as a potential framework (Ciuccarelli 2008), statistical analysis of the early cases (Balka, Raasch, and Herstatt 2009), mainstream diffusion (Abel et al. 2011), and analysis regarding its relationship with innovation and the role of designers (Cruickshank 2014). Other authors link oOpen dDesign with the evolving practices of co-design, identifying it as a fourth “turn” directed towards a further engagement of users in the design process thanks to a focus on open and peer-driven processes taking place in resources as shared commons (Marttila and Botero 2013). A common approach for understanding these collaborative phenomena is the drafting of definitions instead of manifestos (Perens 1999; Stallman 2002). As a further sign of the recent emergence of the phenomenon, there are many attempts at defining open design (Tooze et al. 2014; Aitamurto, Holland, and Hussain 2015), but at the time of writing there is no generic, common and collectively shared or developed complete definition. Furthermore, almost mirroring the split between free software and open source software (but without the same history, chronological order and dynamics) some activists, practitioners and researchers prefer to use a term closer to free software such as *libre design* or its local translation—mainly in Brazil (Instituto Faber-Ludens 2012) and France (Association Entropie 2013).

The P2P, diffuse, distributed and decentralized systems mostly refer to social dynamics and organizational formats, and therefore these are approaches that can be translated to design projects less easily, due to the complexity of the topic. Regarding P2P, although we could see a series of P2P-based design initiatives (1.2), few examples can be traced to the introduction of a category of *physibles* (i.e. digital files of physical object that could be 3D printed) on The Pirate Bay (Laird 2012), concretizing the common fears of a piracy of physical products within P2P networks. Other examples, while not directly linked to P2P, can be understood as being inspired by P2P dynamics (1.2.2): the Coca-Cola Company manufactured a few cans and bottles for its beverages that enable and foster the sharing of the beverage among its customers, almost in a P2P way (Kiefaber 2013; Monllos 2014). Regarding DDD systems and *DDD-based design initiatives* (1.3), there are three main directions of application inside design projects: (1.3.1) using data from distributed agents to build a collective project, even if it is uncoordinated (Agarwal et al. 2011); (1.3.2) the adoption of the distributed manufacturing scenario for the production and distribution of projects (Bauwens 2009; Bianchini and Maffei 2013); (1.3.3) the use of decentralized financial systems for the production and distribution of an artifact: *Plantoid* by Okhaos (okhaos 2015) is an example of a self-creating, self-propagating artwork that uses Bitcoin to gather and manage the necessary resources for funding artists to participate in its creation and distribution. Here the main concepts are therefore linked to the managing and exploiting of networks in developing, producing and distributing projects.

4. Design for the organization of Open, P2P, Diffuse, Distributed and Decentralized Systems

On another direction (2), design practice can also have a role on enabling and replicating such open, P2P and DDD systems through the analysis, visualization, and design of their tools, software, toolkits, platforms and collaborative processes and organizations. Design, therefore, could not only learn from such systems but also improve them. This second intersection can be considered more as part of the meta-design domain, where designers can have a role in the building of environments for the collaborative design of open processes and their resulting organizations. Meta-design is a broader concept with several meanings and no single definition; here we refer to Giaccardi's overview of the topic (Giaccardi 2003). Meta-design is not an established design approach and practice, but rather an emerging design culture (especially related to interaction design) that intersects with net art. The interest on the meta-level shifts the focus from objects to process, from contents to structures, from design as planning to design as seeding or emergence. Giaccardi identifies three main different meanings for meta-design, based on the different meanings of the prefix "meta-":

1. *behind* (or *designing design*): "Design of design processes" / "Design of the generative principle of forms" / "Design of the design tools";
2. *with* (or *designing together*): "Design of media and environments that allow users to act as designers" / "Design of the organization of flows";
3. *between/among* (or *designing the "in- between"*): "Designing the spaces of participation" / "Design of relational settings and affective bodies".

Open, P2P, DDD systems have many connections with meta-design: on one hand there are many meta-design approaches that enable them; on another hand, Meta-Design has historically been associated with many technologies and approaches which are now related with such systems, such as mass-customization, digital fabrication, generative design, open processes, and participation in online communities. This direction is mostly related to the concept of design for social innovation, where designers work on the social dimension and for social goals (Manzini 2015), with these approaches therefore considered (2.1) tools, components and toolkits to be applied in projects or (2.2) as a whole project or rather comprehensive approaches to projects. Both approaches could be integrated: for example, tools from (2.1) could be part of comprehensive approaches in (2.2). These approaches have different philosophies and different interest at the *meta*- level, and therefore they enable different types of projects and systems [Table 2].

Approach	Short description	Meaning of the meta-level	Focus of the meta-level
Design projects linked with Open, P2P, DDD Systems (1)	Design of a physical or immaterial artifact inspired by, based on or distributed or realized by Open, P2P, DDD Systems	-	-
Open Projects for Open Projects (2.1)	Design of a physical or immaterial artifacts that can facilitate the development of projects within Open, P2P, DDD Systems	1 (behind)	Tools
Open/P2P-inspired Design (2.2.1)	Design of an organization, service or process with dynamics inspired by Open, P2P, DDD Systems	3 (between/among)	Platforms

Custom platforms (2.2.2)	Design of a custom platform with hybrid organizational dynamics	2 (with) 3 (between/among)	Platforms
Open P2P Design (2.2.3)	Design of an Open and P2P process for the emergence of an Open and P2P process	1 (behind) 2 (with) 3 (between/among)	Platforms, processes
Open Meta-Design (2.2.4)	Meta-Design of Open, P2P, DDD Systems organizations and processes based on open platforms and data	1 (behind) 2 (with) 3 (between/among)	Platforms, organizations, processes, data

Table 2. Synthesis of main approaches and their relationships with Meta-Design.

In (2.1) we can find *tools for open, P2P, DDD systems* such as (2.1.1) technical frameworks that facilitate the collaboration in open projects, (2.1.2) software specifically design for enabling open projects, or adopted by open projects and (2.1.3) toolkits as collections of tools, technical frameworks, and software. An example of technical frameworks (2.1.1) can be found in *OpenStructures* (TEDx Talks 2012), an open grid designed in order to facilitate the integration of several open projects or several modules into larger assemblies. There are many examples of free/open source software projects that facilitates the development of open and P2P projects (2.1.2). Regarding design projects, these might be generic raster, vector or 3D design software, or more specific software for fashion design projects such as *Valentina* (Prokoudine 2013) or typographic design projects such as *Birdfont* (Prokoudine 2014), specifically designed for fostering open projects by giving more accessible and therefore democratized tools. However, many more free/open source or proprietary software projects could be helpful in replicating open and P2P projects even if this is not the primary goal or if design is not necessarily involved. Software projects like *Sourcemap* (Bonanni et al. 2010), which provide a diagnostic tool for carbon accounting through design, analysis, and visualization of supply chain management, could be adopted in the improvement of the Distribute Manufacturing scenario. Frameworks, tools, and software projects could then be packaged in custom toolkits for replicating open projects (2.1.3), thus providing a ready-made and logically constructed toolkit. An example of such toolkits could be experimentations like *P2P Design Strategies* (Bonetti 2009), a set of techniques that allow a team of graphic designers working in a peer-to-peer environment, or Frog Design's *Collective Action Toolkit*, a set of activities and methods edited in order to enable groups of people to create solutions their local communities through collaboration and organization ("Collective Action Toolkit" 2013).

Material or immaterial tools (such as frameworks and software), used alone or in collections (toolkits), are an example of meta-design (2.1). In this case, the focus is on tools; however, there are also many cases where the focus is on the process or organization of the design projects or generally on *methods and methodologies for open, P2P, DDD systems* (2.2). Among these cases, we can identify informal or less structured approaches that can be therefore named *open/P2P-inspired design* (2.2.1); environment for an active participation of users in projects which have custom dynamics platforms (2.2.2); open and P2P processes integrated with design tools and culture in order to build open and P2P organizational forms in *open P2P design* (2.2.3) and the integration and simplification of this approach into an open version of meta-design in *open meta-design* (2.2.4).

Open/P2P-inspired design (2.2.1) could be considered a category for all the cases where open, P2P, DDD systems were designed, or where their emergence and growth was facilitated as the main object of the project; usually through a platform (generally an online platform, but sometimes coupled with physical artifacts and physically-located services and activities) as the foundation for the interactions among the participants. Here there is much less interest in the meta- level, a less structured approach, or an approach that has not been developed for open, P2P, DDD systems. Early experimentations in this direction were developed by the RED unit within the UK Design Council, where reflections and projects of public services based on P2P interactions were developed (Cottam and Leadbeater 2004). Beside these first experimentations, there have been several more cases of both research and design, and production and provision of public services with P2P dynamics through co-creation (Botero, Paterson, and Saad-Sulonen 2012). These cases have been mostly developed in the context of an integration of the public sector, the third sector and citizens, but the last decade has seen an enormous amount of services designed with P2P dynamics that are mostly localized in the integration of private sector and citizens. These are mainly cases of online platforms which provide a space for P2P dynamics between users and are based more on sharing, bartering, lending, trading, renting, gifting and swapping dynamics than conventional dynamics of selling, buying or serving (which are still present, but in a minority of cases). Some of the most famous examples of these businesses are *eBay, craiglists, Zopa, Zipcar, Uber, Airbnb*. Generally, within these platforms goods and services are distributed with P2P dynamics rather than from a central point of control; there are however several possible patterns of organization and business models, which has led to several different terms for these cases (Botsman 2015): *collaborative economy* (an economic system of decentralized networks and marketplaces with p2p dynamics); *sharing economy* (an economic system based on sharing underused assets or services, for free or for a fee, directly from individuals); *collaborative consumption* (the reinvention of traditional market behaviors through technology, taking place in ways and on a scale not possible before the internet); *on-demand services* (platforms that directly match customer needs with providers to immediately deliver goods and services). Even if these seem to be mostly technology-driven initiatives, design is increasingly one of the forces driving them. One of the most famous of these cases is

Airbnb, an online platform that enables users to rent their houses or rooms to other users in an almost P2P way (admittedly, Airbnb's platform is still the central place for the interactions). Airbnb was designed, developed and managed by two designers and it is considered a relevant example of the growing phenomenon of design-led entrepreneurship (Mata Garcia 2014). The founders developed its business around the users rather than around the market or a technology, and this approach surprised Silicon Valley (Fairs 2014).

There are many business-based social media or free and open source online platforms that open, P2P, DDD systems could adopt for their organization and processes; however there are interesting cases in *custom dynamics platforms* (2.2.2), that is, online platforms that are specifically designed with uncommon organization and processes as a goal. One of the best examples in this direction can be found in *OpenIDEO*, an online platform (coupled with a toolkit) for the development of solution of social challenges by a global community of designers. Launched by IDEO in 2010, it was specifically design around IDEO's design methodology. Each social issue is addressed via a challenge, a three- to five-month collaborative process within an online community where members can contribute and build off each other. OpenIDEO could be also considered as part crowdsourcing, part Web 2.0, and part open design. This experience could be connected to the idea that there are several different formats of social (or organizational) dynamics and that, at least at this stage where these phenomena are still recent and under development, custom organizations and processes could be a promising strategy instead of relying on ready-made platforms, and therefore organizations and processes.

These considerations share a common idea with another approach called *open P2P design* (2.2.3) which tries to develop custom organizations and processes for each community (Menichinelli 2006). This approach was developed within the context of exploring the relationships between design and localities and therefore local communities (Verwijnen and Karkku 2004; Fagnoni, Gambaro, and Vannicola 2004): given the extreme diversity of each locality and its communities regarding culture, history, geography, economy, and many more dimensions, the basic concept of this approach is that specific organizations and processes are needed for each community and locality. Inspired by the idea that the key to the success of many open source projects is the complexity of a community that can therefore tackle a complex challenge and project (Kuwabara 2000), the open P2P design approach tries to build open, P2P, DDD systems through organizations and processes where both designers and communities work together in the designing of open, P2P, DDD systems that can be helpful for the future self-organization of the communities. The approach is based on the idea that collaborative processes can be modeled as activities and it is therefore linked to activity-centered design approaches (Kaptelinin and Nardi 2009; Gay and Hembrooke 2004); it further extends the concept of platform for collaborative communities from an online place, to a set of artifacts, rules, and roles that must be shared within the social network of the participants, thus giving a network-based architecture to platforms. The approach first started as a generic methodology

(Menichinelli 2006), which was then extended with a set of tools from service design, participatory urbanism, sociology, and other disciplines (Menichinelli 2011a). The approach was experimented with in a series of workshops where it was applied to Maker communities and Maker laboratories, after which it was simplified and transformed into the more recent *open meta-design* approach (2.2.4) (Menichinelli 2015; FAD Barcelona 2013). The workshops proved that the open P2P design approach is too complex and suggested the development of a simpler approach which could be understood more clearly by users, and which could be considered as a broader class of open P2P design. While open P2P design could be framed as “open design of open P2P processes”, open meta-design reframes it as “open design of design processes”: the approach tries to present a simpler way for generating different formats of processes and organizations instead of generic open and P2P processes. The approach focuses on processes made as networks of activities in an ecosystem of actors and on the organizations emerging from such networks of interactions. Such processes and organizations are approached through a combination of 1) a specific visualization format (instead of relying on separate tools and toolkits); 2) a software platform for their management and on 3) a specific ontology and related data format.

5. Conclusions

Open, P2P and diffuse, distributed and decentralized systems can be considered a preliminary broad framework for understanding several different formats of mass-participation that have emerged in the past years thanks to the emergence of the Internet and the World Wide Web. This framework refers to several terms, frameworks and experiments that are a still recent phenomenon, and have recently been the subject of discussion and criticism, after the initial phase of general optimism. This article addressed how this phenomenon has encountered the design discipline by providing both an analysis of the concepts and the history of the phenomenon, and by providing a general and preliminary framework for understanding it. As a first step, concepts and cases of the main mass-participation phenomena have been contextualized into an open, P2P, DDD systems framework. As a second step, two main directions of relationships of such systems with the discipline of design were identified and structured into families of approaches. The article therefore tried to show that the intersection of open, P2P and DDD systems with design is not limited to the popular view of open 3D models that can be downloaded with P2P applications and 3D printed locally, but that there are approaches to working on immaterial, social, and organizational levels as well. The broader and more comprehensive overview of the phenomenon could be a starting point not only for understanding it, but for further experimenting with it, by both researchers and practitioners.

The framework presented, however, is still preliminary. DDD systems are mostly abstract and ideal types of networks and therefore activities, and a more rigorous formulation according to network science is suggested. The network structures presented in the article are just simple descriptions that explain the DDD framework in very generic terms, and further development of such network structures is suggested, by adopting several centrality measuresement and real life cases. The proposed framework is still theoretical and represents a first proposal for categorizing the possible cases of intersections between design and open, P2P and DDD systems. Further research is required in order to understand the validity of such framework, for modifying and improving it; we suggest three possible directions for this here, by rebuilding the framework from: data (*a data-driven approach*), the experience of makers, hackers, designers (*a bottom-up approach*), or from the experience of experts like researchers, relevant designers and so on (*an expert-driven approach*). In the first direction, the framework could be tested or even rebuilt with a data-driven approach (1), by analyzing literature and cases. Several approaches might be adopted according to the available data and its structure: co-authorship networks could show the social dimension of the cases; if only textual data is available, the text could be analyzed with natural language processing. Machine-learning algorithms could then be useful for clustering the analyzed cases and literatures in groups that could later be labeled. A second direction could bring the experience and knowledge of practitioners working with design and open, P2P, DDD systems such as makers, hackers, designers: surveys or interviews could uncover their perception of all the possibilities. A third direction would instead focus on the experience and knowledge of experts (researchers, authors, journalists) about such possibilities. This triangulation would open up the framework proposed here, and mix it with a global overview (1), an overview from the practice (2) and an overview from experts (3). Furthermore, as the integration of design with open, P2P and DDD systems could be seen as a relatively recent, emerging, and unstable phenomenon, such frameworks should take this into consideration and any research should also focus on the evolution of the phenomenon in order to understand the real scale and also therefore the possible adoption of any frameworks. We suggest that such a recent phenomenon could be understood and improved not just with research but also with experimentation with communities and other organizations. As a conclusion, further quantitative research on the dimension of the phenomena and of its applications would be strategic in order to understand its real impact and the value of any framework that tries to describe it.

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2. ART. 2

Menichinelli, Massimo. 2015. ‘Open Meta-Design: Tools for Designing Collaborative Processes’. In *Empowering Users through Design: Interdisciplinary Studies and Combined Approaches for Technological Prod-ucts and Services*, edited by David Bihanic, 193–212. New York, NY: Springer. https://doi.org/10.1007/978-3-319-13018-7_11.

Empowering Users through Design: Interdisciplinary Studies and Combined Approaches for Technological Products and Services

Massimo Menichinelli

Doctoral Candidate, Aalto University, School of Art, Design and Architecture, Department of Media, Media Lab

massimo.menichinelli@aalto.fi

Abstract

The experience of the Open Source and P2P distributed systems represent a promising direction for the organization of collaborative networks, since their processes and organizational forms have been applied in fields other than the software development industry including biotechnology, pharmaceutical drug research, education, micro-credit financial services and also design. Until now, almost all of these cases have been designed and brought to the users focusing more on the technologies than on the users' needs and their possible active role, and almost none of them has analyzed in depth the methodologies that could be used. There is a strong opportunity for the design discipline to have an important role in designing such distributed systems with open, collaborative and peer-to-peer dynamics starting from users, their communities and localities. This article focuses on an open source meta-design methodology aimed at co-designing distributed systems that show open, peer-to-peer and collaborative dynamics with users and their commu-

nities, visualizing and managing their nature of complex social and technological systems. In order to organize collaborative design processes between multiple and distributed actors, an activity-centered meta-design approach is introduced in the discussion, thus further advancing the possibilities of organizing open and peer-to-peer design systems and networks. This article reports the experiences of planning and facilitating three workshops in Seoul (South Korea), Singapore, Helsinki (Finland), for the experimentation of such meta-design approach.

1. Open Source and P2P Distributed Systems everywhere: the Open Everything phenomenon

Thanks to the evolution of ICT technologies in the past decades, our society now heavily relies on the production and distribution of knowledge over networks of actors.

These network-based knowledge management activities are being implemented in business models, government practices, research and education institutions, and non-profit organizations and activism initiatives. Many authors note that in the present social and economic context it is strategic to have the capability of enabling and participating into global and local networks where all the actors have an active role, in order to keep the whole society socially, financially and environmentally sustainable (1–6). Therefore the ability of designing and enabling collaborative networks of distributed actors is becoming not just an opportunity but even a strategic asset.

Amongst the many different approaches and researches for the management of knowledge and networks, the experience of the Free Software / Open Source communities represent a promising direction for investigating and implementing new and more appropriate organizational forms. These communities consist of collaborative networks and are enabled by specific software platforms and specific principles and practices (7,8); the adoption of these principles, practices and platforms has made possible their wide diffusion in many different contexts. These initiatives are proving to be an interesting way to generate new community-based digital organizations fit enough to generate considerable economic wealth in terms of labor (9). In fact, such initiatives are considered propitious enough to spark growing interest in collaboration strategies over competitive ones. The influence of Free Software / Open Source and P2P software communities can be traced back to the Web 2.0 evolution of the World Wide Web, where new forms of services, sharing and outsourcing are being experimented on a mass-collaboration level. Furthermore, these Open Source and P2P distributed systems are also proving that their new organizational forms and practices can be applied in fields other than the software development industry including biotechnology, pharmaceutical drug research, education, public services, micro-credit financial services and finally even design amongst many other existing cases (5,6,10–15). Such Open Source and P2P distributed systems are considered promising for the successful involvement of active users in the development of complex and sustainable projects (16–19).

This article is divided in four parts. The first part will describe the theoretical background that supports the experiments. It describes what is Open Design, how collaborative networks could be designed and the open meta-design approach that the author has developed over the years. The second part is the experimental part and it will describe three experimental open meta-design workshops based on the Open P2P Design approach held in Seoul (South Korea), Singapore and Helsinki (Finland). The third part will discuss the results of the workshops and the implications of the findings as well as the limitations of the research and possible future developments. Finally, the fourth part will present the conclusions.

2. The promising perspective of Open Design

Open Source and P2P distributed systems are having an impact on the design discipline, in at least two ways: on one hand, with the adoption of open source and p2p principles, practices and organizational forms inside the design discipline; on the other hand on the use of design knowledge, tools and practices for replicating these initiatives.

In the first level, the change is more evident in the emergence of Open design projects (or DIY design), publishing the documentation of the projects as open source and by involving the collaboration of many designers and users in the development of such projects. The revolution brought by digital technologies and networked systems has influenced the landscape of design bringing new processes, business models and initiatives, and manufacturing models as well (17,18,20–27). After the first experimentations (19,28,29), the idea of adopting the Open Source practices into the Design field is now becoming mainstream (30–32). After witnessing the success of Open Source Software (8) and Open Hardware (33,34) now many initiatives are linked to Open or DIY Design. For example, nowadays important companies are acquiring or doing partnerships with Open Source, Open Hardware and Open Design companies (35–37); important design associations are promoting the idea of Open Design (17,38) and science-fiction writers are publishing novels about Open Design and digital fabrication (39).

Furthermore, places like FabLabs (23,40) where people can design collaboratively and manufacture their projects with easy access to digital fabrication technologies, are widely successful (40,41) both in the quantity of places and in the number of countries where they have started up. In this way, a whole ecosystem of places, services, technologies, professionals and communities is developing around the concept of Open Design and DIY Design. It is therefore becoming more and more possible and common to share the documentation of design projects openly, to develop such design projects with collaborative networks of designers, manufacturers and users, to solve complex problems quickly and to redefine supply chains towards more local and distributed systems with a more sustainable ecological footprint (16–18). This direction has proved to be very fruitful for research and application (17,18,22,42,43). This phenomenon is therefore evolving from an hypothesis to a promising solution, and it is important to further investigate it in order to understand if, how and when it can be adopted, whether its adoption would need to follow an adaptation, and which tools and processes could help implement this adoption. It is important then to understand also how design could have a role in replicating and adopting the Open Source and P2P principles, practices and organizational forms, building therefore more open source and p2p collaborative networks.

3. Designing Open and Collaborative Networks

On the second level, then, it could be possible to adopt design tools, practices and processes to apply Open Source and P2P distributed systems in many different contexts.

However, in order to do so, more research is needed in order to develop specific design processes and social systems that would allow for their successful application. Currently this direction is being developed by fewer researchers and practitioners (15,44,45). Current research on Open Source and P2P distributed systems has focused more in technologies, intellectual property (19) and on the business strategies and even specific case studies (5,6). Until now, almost all Open Design projects were designed and delivered to the users with a big emphasis on the technological aspects rather than on the users' needs and their possible active role in co-designing those products or services. Therefore, almost none of them has discussed in depth the design methodologies that could be used for this task.

The design discipline traditionally fosters a culture of mediation between the different actors involved in a project, and its role in the economy is currently shifting from the development of physical goods to the development of services, systems and strategies. Thus, there is a strong opportunity for the design discipline, to have an important role in designing such distributed systems with open, collaborative and p2p dynamics starting from users, their communities and localities. Rather than focusing only in developing better interfaces or user experiences for collaborative and social services (46), the design discipline could have an important role in developing and implementing services, tools and strategies for enabling distributed systems together with the end users and their social networks (15,45).

Existing design literature has approached this issue in the past ten years, starting from the researches about design for localities (47,48) and about design research as a strategy for discovering and valorizing user-driven innovation for sustainability (49). Design research has been also evolving from a user-centered approach to a co-design approach since a user-centered design approach alone cannot address the scale or the complexity of the challenges we face today (50,51). however, co-design approaches are ongoing development and still need further refinement (52). A few researches about designing public services with p2p dynamics (44) and Collaborative Services (4,53) have appeared in the past years, explaining the phenomenon and proposing guidelines for adoption. Nevertheless, they don't address the complexity of such systems or a community-centered approach that addresses the complexity of the social networks that constitutes Open Source and P2P distributed systems.

The author has specifically researched the phenomenon of design for distributed systems with open and p2p dynamics (15,45,54) and has tried to fill this gap, by involving the communities and their social networks inside the organization of the design process. This article reports the results of the first testings of the methodologies and techniques proposed in this research. However, it is necessary to explain the metadesign approach used in the development of the methodology used in the workshops.

4. An Open Meta-design approach: Open P2P Design

Within this phenomenon of Open Source and P2P distributed systems, the new role of users (and therefore also of designers) and the scale of their participation, which may potentially reach very large social networks, brings the need to redefine the relationship between users and designers, the design process in which they are involved and the project that is the outcome of this process.

Recently, design practitioners and researchers have researched and tested many different approaches that involve the users in the design process, starting with Participatory Design. Ehn (55) defines Participatory Design as a way to try to solve the challenge of forecasting how a design project will be used, before it is even designed. One possible solution to this design challenge is meta-design. This means to leave space for user participation in the design process even including after the design process, otherwise considered completed, creating therefore the conditions also for a ‘design-after-design’ (55).

As in Participatory Design, professional designers and potential users are both considered equally valuable contributors to the design process, but the whole idea of design process changes. Rather than focusing on involving users in a design process that ends with manufacturing or distribution, the focus shifts now towards considering even everyday use situations as potential design interventions by the users, who could alter and change features of the design to fit their personal needs or tastes. This potentially makes the design process open and never ending.

As a consequence, it becomes crucial to plan design processes accordingly, throughout the whole lifespan of a project, even after the traditional design phases are over. The active involvement of users in redefining the design when using it should be considered and facilitated since the beginning of the design process in the “identifying, designing and supporting social, technical and spatial infrastructures that are configurable and potentially supportive” of future design practices in everyday use (55). The support of user redesign at use time is part of the tasks of professional designers, and it has to be taken into consideration since the beginning of a design project. This concept of meta-design is in line with other researchers like Fischer and Scharff, that see meta-design as an activity that extends the traditional notion of design with the development of a system that include an ongoing process in which stakeholders become co-designers, not only at design time, but throughout the whole existence of such system (56). According to them, a meta-design project consists of objectives, techniques, and processes for creating new media and environments that allow those people who want to solve a problem with a project to act as a designer (whether she/he is a professional designer or a user). According to Fischer (57), meta-design is a more advanced version of user-centered design (where the users have mainly a reactive role) and participatory design because the control of the design process has shifted from designers to users. Meta-design can be intended also as 'designing the design process', meaning that "creating the technical and social conditions for broad participation in design activities is as important as creating the artifact itself" (56). The concept of meta-design embraced by the author is that a design project is not something that is developed in a void, but rather, it is the result of a collaborative activity within a process between different stakeholders with rules, roles, tools, networks and practices, and that the design discipline could have a role in facilitating this collaborative process (15). Designers could have a role in creating the environment that enable users to co-design with them. While meta-design for Ehn and Fischer is something that happens after the design of a project, here it is intended as a collateral project that starts from the beginning, and that enables the work on the design project.

Open Source software projects are one possible application of meta-design, together with learning communities and interactive art (57). We can then understand how this concept of meta-design can be seen at place in open source communities, where the design and the use time and spaces are not separated bur rather take place continuously and at a faster pace; the "release early, release often" principle of open source (58) clearly show this concept: design, distribution and use happens in a compressed time and space scenario and always coexist. The purpose of the line of research at the basis of this article is to investigate how this meta-design approach can be applied to the design discipline, along with open source principles and practices. If we want to introduce Open Source and P2P practices inside the design discipline, meta-design projects can have an important role in creating the environment that enables a relevant user participation inside the design process; that is, meta-design projects will be what makes the design processes really open source and p2p. If we want to use design tools and practices for replicating Open Source and P2P distributed systems, we can then use them for setting up meta-design projects that enable the users, their communities and social networks to participate in the co-design of such Open Source and P2P distributed system.

As a concept, meta-design is a promising direction for involving both professional designers and potential users along all the life cycle of an Open

Source project, in order to continuously adapt the project to the most recent needs and the context. However, we still need to clarify the role of designers in crafting the socio-technical environment that constitutes a meta-design project: why should a meta-design project be developed by a designer and not by an engineer or a software developer, for example? What can a designer develop inside a meta-design project?

As Fischer noted, software systems are necessary in meta-design projects, in order to enable the users to work together on the same project, along the life cycle of the design project; however, to design such software systems is not the totality of a meta-design project, which is also constituted by design components like the design process, design tools, social rewards and so on.

It then becomes important to reflect upon the nature of the other design components. While different kind of design components may be useful in each project (whether it's graphic design, interior design, and so on), it is important to focus on those design components that enable social interactions. Because of this, service design can be especially interesting, because of its capacity to orchestrate interactions through time and space among many actors (15,45). Software systems may help orchestrating and facilitating certain behaviors and interactions through the creation of a common platform in the meta-design project, but the specific role of a designer in this project is to develop these interactions through space and time thanks to service design tools and techniques (59).

More specifically, some service design approaches that try to design human and social activities as complex entities are promising for enabling social networks-based projects like the Open Source and P2P distributed systems. Such approaches try to bring the tools, techniques and knowledge of Activity Theory inside the development of service design projects (60,61): in this way we can design complex activities as services, thus, a set of interactions between multiple agents (15). The adoption of Activity Theory and of an Activity-centered approach has already started with the expansion of user-centered design: we now consider the multiplicity of groups and individuals engaged in the use of technology, we focus more on human interactions mediated by technology in context rather than human-computer interaction, and we start with understanding what people already do instead of focusing on what a user should do (62,63). An activity centered approach focus also more on how tools mediate activities among multiple actors, and is therefore more apt to the need of meta-design a process where multiple actors interact. Since with these approaches we can analyze, design and redesign activities using the Activity System, the model that visualize the complexity of an activity (64), we can adopt them for crafting meta-design projects that enable collaborative activities and that consists of an Activity System (15). Within the line of research of this article, the Activity System is the model for the analysis and visualization of activities and also for the design of activities: we can therefore use it for designing collaborative activities such as the Open Source and P2P distributed systems.

We have seen that a service design project with an activity-centered approach may be suitable for designing the shared conditions that enable and support the creation of collaborative activities and networks and as a way to create the meta-design spaces for designing and replicating Open Source and P2P distributed systems. One further step could be taken in order to render these collaborative networks self-organizing: to publish the meta-design project as an open source project and get the users and their social networks involved in its co-design and management throughout its life cycle (15). In Open Source and P2P distributed systems, the meta-design phase and the use design phase are never separated in time nor in space: the meta-design starts first, by creating the conditions for the co-design process with the users, yet it never ends. And in order to have a real open source governance inside the designed Open Source and P2P distributed system, the meta-design part should always be co-designed and co-managed by both the professional designers and the users, even if with different level of participation for each step in the design process (15,45). A further confirmation of the social importance of this approach comes from Manzini and Rizzo (51), who state that when aiming at large-scale transformations (on the scale of cities, regions or complex organizations), the notion of participatory design must be redefined as a constellation of design initiatives aiming at the construction of socio-material assemblies where social innovation and open and participated processes can take place.

The concept of an open source meta-design approach, based on the intersection between Service Design and Activity Theory (60,61), with open source and p2p interactions part of it and a focus on the social networks of the users and the designers is called Open P2P Design (15,45). Open P2P Design is an approach that tries to develop Open Source and P2P distributed systems by generating a meta-design project that describe the design process. The design process is considered as a collaborative activity, and thus analyzed and designed with Service Design and Activity Theory. Since both the design process and the Open Source and P2P distributed systems designed are collaborative activities, both are designed with the same tools. Open P2P Design does so by bringing open source and p2p principles and practices both in the development of the meta-design project and inside the design project. Activity Theory is used both for analyzing an existing community of users to be involved in the collaborative process, and also for designing the collaborative activity with open source and p2p principles and practices that would solve the community's identified problems and its meta-design. This paper reports the first tests of this approach in three workshops: one in Seoul (South Korea), one in Singapore, and one in Helsinki (Finland).

5. Three Open P2P Design workshops

5.1 Purposes of the workshops

This Open P2P Design approach needed to be tested in order to understand if it is proper, understandable and easy to use in order to be adopted by designers (and possibly even users) and if it needs specific knowledge, tools and abilities (and which ones).

A test for this approach would also shed light on the application of open source and p2p principles, tools and practices inside the design discipline, and if it is a promising direction for future research and adoption by practitioners. Since this approach was developed during the early years of introduction of Open Source and P2P distributed systems inside the design discipline, a test would also clarify if it is still a valid approach after years of testing and adoption of such systems. More practically, there was also the need to test whether designers could adopt the same tools that software programmers have developed in order to coordinate the mass-collaboration efforts inside the Open Source and P2P distributed systems cases.

5.2 IDAS, Seoul (South Korea)

The first workshop was co-organized and co-delivered by Massimo Menichinelli and Roger Pitiot at the International Design school for Advanced Studies (IDAS) in Seoul, South Korea, during November 20th-23rd 2009.

The title of the workshop was "Open P2P Design: Enabling Design 2.0 through Open Processes, Systems" and lasted 4 days. The workshop audience consisted of 36 students organized in 7 groups, mainly Korean students with a few Chinese students, however only half of them completed it (the workshop took place during the weekend). The workshop aimed at explaining and applying the Open P2P Design methodology to an Open Design project, whether it was product design or service design. Students were asked to develop an Open Design project that could solve a common problem for all the students at IDAS (which was identified by the participants as having lunch inside the university building). The workshop was structured with theoretical lectures in the morning and the afternoon was dedicated to the practical side of the workshop. The content of the lectures included the concept and history of Open Design, the theory and practice of Open P2P Design, technologies and techniques for working collaboratively and distributing the shared project, the Distributed Manufacturing scenario and its related digital fabrication technologies, and principles and techniques for dealing with intellectual property in an Open Design project.

The workshop was based on the idea that the open meta-design project should have been included inside the design project, and that both would have been developed using the same tools that developers use to work on Open Source software. The workshop therefore was also a testbed for the adoption of open source mass-collaboration tools inside the design process by designers who are not developers and who are not familiar with these tools. After examining the existing softwares for such task, we decided to use Subversion[1], which is an open source version control system founded in 2000 by CollabNet, Inc., and now developed as a project of the Apache Software Foundation. A version control system manages files and directories, and the changes mad to them, over time in a central database called repository. This allows users to recover old versions of the data or examine the history and the changes of the data. Subversion can operate across networks, which allows it to be used by people on different computers, fostering collaboration between distributed users (65). Subversion was chosen as the common tool for the workshop thanks to its wide adoption, its stable status of development and its easiness to use. Ideally, however, open meta-design project and Open Design project can be developed with other version control systems as well; the development of collaborative and open source project is not linked to a single specific software. The project repository, that is the database that keeps track of all the versions of the files and therefore the history of the collaborative development, was hosted at Codesion[2], and the collaborative discussion between all the users was managed with the open source platform Trac[3]. Trac is an open source, Web-based project management and bug tracking system, that allows hyperlinking information between a bug database, revision control and wiki content. This kind of software are one of the main places for discussion in the development of Open Source software projects, along with mailing list (7). Since the workshop was limited to a 4 days time period and since all interactions were happening in the same room the mailing list was not used, and instead we relied on face-to-face communication. The repository was a temporal installation, therefore the content of the repository was exported after the workshop and it can be accessed now at a permanent address[4]. The content of the Trac installation could not be exported, so it is not accessible any longer: this poses the critical issue of being able to access, export and store personal data, a common and still unresolved issue regarding online platforms. Since Subversion is a terminal application, we used instead a visual client with a graphical user interface, in order to make it more accessible to students. We considered different options but then adopted a Mac application called Versions[5] as the main application, since it was voted as the most accessible one by the organizers of the workshop.

The process of the workshop started with focusing on an existing community: the workshop was used to develop an Open Source community that could solve a problem of the existing community through collaborative networks. The participants of the workshop identified the community of the students at IDAS as the main existing community to design for (and with, in the future), and the problems encountered in having lunch inside the university build-

[1] http://subversion.apache.org/

[2] http://cloudforge.com/codesion

[3] http://trac.edgewall.org/

[4] http://workshop.openp2pdesign.org/01seoul09/

[5] http://versionsapp.com/

ings as the main problem to be solved through collaborative networks. The workshop then proceeded with a collective analysis, done by the organizers with the students, of the activity of having lunch inside the university through Activity Theory (62–64) in order to understand which were the contradictions inside the activity that could be solved later. The next step consisted in the collective organization of the whole process with the use of the participation matrix, a tool that can be used to design the levels of participation inside a design process (66). The workshop then continued with the design of the flows of physical goods, information and financial resources inside the Open Source community, with a tool used in Service Design and called system map (67,68). These steps were performed by the workshop organizers together with the students. After these steps, the students worked in teams in order to develop specific project proposals. These project proposals regarded the specific Activity System and a poster for its promotion of an Open Source and P2P distributed system. That is, the meta-design of the design process where the participants and the future users would work together were developed by the workshops organizers together with all the students, while the specific collaborative activities that would have been offered to the users were designed by the students alone. In this way, the students would have had a common example for understanding how to design an activity, before designing an activity themselves.

The students were able to use the tools and deliver projects in the time available, however there were relevant cultural problem with the concepts of Activity Theory. The workshop was held in English, and since the students had some problems in understanding Activity Theory, we asked one student, who previously had studied Activity Theory, to explain the concepts to them in Korean. However, even after an explanation in Korean, Activity Theory proved to be based on concepts such as subject and object of an activity that are common in Western countries (Activity Theory was developed in Russia and Finland above all) but were reported to be different in Korea. This may be caused by the difficulty of differentiating subject and object of a sentence in informal spoken Korean (69).

Furthermore, the Activity System was considered too complicated by the students, who preferred to express the analysis and the design of an activity through a mindmap (everybody used Xmind, an open source mindmapping and multiplatform software[6]). Over 7 groups, only 3 then adopted the concepts of Activity Theory in the mindmap, and another 1 was not complete. The specific design projects of each group turned out to be all services.

5.3 NTU, Singapore

The second workshop was co-organized and co-delivered by Massimo Menichinelli and Roger Pitiot at the School for Art, Design & Media of the

[6] http://www.xmind.net/

Nanyang Technological University (NTU) in Singapore, during November 25th -27th 2009.

The Singapore workshop took place as one of the event of the Singapore Design Festival 2009. The title of the workshop was “Open P2P Design: Enabling Design 2.0 through Open Processes, Systems” and lasted 3 days. The contents of the lectures, the process of the practice and the tools used were the same adopted in the first workshop, which worked also as a test for the workshop format. The participants were 11 at the start of the workshop, and 7 at the end of the workshop (which ended on a public holiday day). Here as well the community to be analyzed and designed for was the community of the students at the university, and its problem was the lack of possibilities for resting inside the university building. Instead of services, here all the projects developed were product design projects.

There were, however, some small differences that accounted as improvements from the first workshop: Xmind was used directly also for designing collaboratively the system map, instead of relying on a whiteboard drawing to be later digitalized. This digitalization from the start enabled a better collective discussion on the system map, which proved to be one of the most valuable and promising tools in the development of Open Source and P2P distributed systems. During the collaborative design of the system map enabled by the use of Subversion, the students were able to understand clearly the meta-design project and introduce changes and discuss them. In particular, the students were able to visualize and understand the flows of money, and introduced modifications in order to have a more balanced revenue for all the actors. Furthermore, also the poster worked well in communicating and designing the concept of the projects, which in this workshop were all products, and which were also modified collaboratively between different groups. And, lastly, in this case the workshop did not encounter any problem at all in explaining the concepts of Activity Theory, which the students adopted with success; a mindmap was again used in this context, for the sake of simplicity in designing the Activity System.

5.4 Pixelache, Helsinki (Finland)

The third workshop was organized and delivered by Massimo Menichinelli at Pixelversity[7], in Helsinki (Finland) during September 16th-17th and 23-24 2011.

The workshop was structured with two open lectures (September 16th and 23rd) and two full days of lectures and practice (September 17th and 24th). For this workshop, a toolkit to be printed and consulted was also developed (70). The contents of the lectures reflected the same contents of the previous workshops, even if they were briefly updated and reduced in time. Here the participants addressed the coworking community in Helsinki, and the activity they wanted to analyze and improve with an open source and collaborative

[7] http://www.pixelache.ac/pixelversity/

project was brainstorming. The participants wanted to design a collaborative service as a design project.

The third workshop tried to address also technical questions raised in the previous workshop, like the availability of multiplatform software. This time the Trac instance was self-hosted and therefore preserved for further studies[8]. Instead of Versions, which run only on Mac Osx systems, we adopted the open source software RapidSVN[9] which runs on Windows, Mac and Linux. We also used Perforce P4Merge[10] for comparing images: the file comparison is a serious obstacle to the adoption of version control systems by designers, since these softwares can only compare text files, because they were developed for working with software and not with images or other design files. This is a problem that was encountered during the first two workshops, and it was fixed in the third workshop with the adoption of P4Merge, a freeware and multiplatform software; however, this issue poses critical obstacles to the adoption of tools designed for the development of open source projects.

Furthermore, also the dynamics of the workshop changed this time, since the workshop had only 7 students. This time, the meta-design of the design process ,where the participants and the future users would work together, and the specific collaborative activity that were offered to the users were both developed by the workshops organizers together with all the students.

The use of the Activity System was further improved through the use of a ready-made template (to be used with Xmind, since it proved to be a very easy to use and accessible software) that was delivered to the students. Like in the second workshop, there were no problems in understanding and adopting the Activity System and Activity Theory as frameworks for analyzing and designing collaborative activities. Activity Theory was used successfully but proved to need further studies by the students for a full adoption.

During the workshop, a storyboard was developed thanks to the use of StripThis![11], an open source software that transform the script of a story into a graphic storyboard. However, the tool should be improved and be part of an integrated system. The third workshop also introduced the use of the business model canvas (71) for the analysis and development of a business model for the Open Source and P2P distributed system to be developed. There were problems, however, in understanding how the structure of the business model canvas could fit in the networked nature of the project: the business model canvas is clearly more proper for a project whose organization has clear boundaries. The problem of clearly defining boundaries was also present during the drafting of the system map: it is therefore an issue that has to be addressed further, wether with a clarification of the boundaries or with the development of tools that work with fuzzy and more distributed boundaries. The system map, together with the participation matrix, proved again to be

[8] http://workshop.openp2pdesign.org/03helsinki11-trac/

[9] http://www.rapidsvn.org/

[10] http://www.perforce.com/product/components/perforce-visual-merge-and-diff-tools

[11] http://www.kesiev.com/stripthis/

very flexible design tools that can be used successfully for designing the meta-design project for a collaborative activity. Most of the time of the two days workshop was spent for drafting the meta-design project, therefore there was little time left for the design project, which in this case was a service design project, and was brainstormed and developed with the use of a poster, again a useful design tool for designing and documenting a project.

6. Discussion

According to the direct feedback of the participants and an analysis of the work produced during the workshops, the meta-design approach proved to be useful while at the same time some weak points were discovered, and future research may address them.

For example, Activity Theory is a powerful framework for understanding and designing complex activities, yet it turned out that not all the cultures can understand it and that there is a considerable learning curve before an inexperienced user can use it. In the future, professional designers may study it and acquire the needed knowledge, but most likely most of the users won't be able to understand it and master it. It is therefore important to further research how to simplify and visualize these concepts and tools, in order to have a real open source and p2p participation inside the distributed systems that the Open P2P Design methodology was designed to address.

On the other side, service design tools were adopted without any problems by the participants, and proved to be a promising direction for the development of collaborative activities. The system map is a promising tool, but the students pointed out that it clearly lacks the time dimension; further research could also try to integrate the system map with the participation matrix, towards simplifying the design work for a meta-design project by reducing the number of documents to be analyzed and designed.

The workshops tried also to introduce the business model canvas as a tool for understanding and designing the business models for Open Source and P2P distributed systems. The participants found some limitations for this tool, when used for a distributed system: specifically, the business model canvas was built around the concept of a single business unit with clear boundaries, while often Open Source and P2P distributed systems have fuzzier boundaries and more units. For Open Source and P2P initiatives, when the business unit is a single and well defined structure, the business model canvas works well; otherwise we need to take into account the distributed and fuzzy nature of the systems. A more promising approach for the future may be the adoption of the business model canvas at a network level, following the structure of the network and the roles and actors involved (72), rather than just applying it to the whole distributed system as if it were a unique system. In this way, we would first identify single and defined units and then use the business model canvas, building the business model canvas of the whole system as a network instead of a single document. However, we should find a clear and fast way of communicating the business model of the whole system.

7. Limitations and future research

The results from the workshops indicated that at least 2-3 days are necessary for understanding and learning the concepts and the tools for designing the meta-design project, while an additional day would be welcomed for the design of the design project.

Therefore, these past experiences suggest to organize future workshops with 4-5 days, in order to fully explain, experience and test the meta-design process, and in order to work on the design project as well, be it a service design project or a product design project. In this last case, the adoption of digital fabrication technologies inside FabLabs or similar spaces would make the participants experience and test how a whole Open Source process would apply to product design, with also the manufacturing of physical prototypes or working objects, as the normal practice of Open Design take places in FabLabs (17).

The purpose of the workshops was also to test whether designers could adopt not only principles and practices from Open Source and P2P distributed systems, but also the tools that enable the mass-collaboration in these systems. The practice of the workshops proved that these tools can be adopted, after a proper training, but there are still limitations since these softwares were developed for the collaborative development of software (i.e. text files) and not of design files. With complementary software, images may be compared, but not technical drawings and 3D models unless they are saved also as images. At the moment, these softwares may be integrated with other softwares for improving the collaborative development of design files, but a common and unique tool is still missing. Furthermore, in the meanwhile other softwares for development of collaborative projects in the Open Source communities have been developed, and softwares like Mercurial and Git represents the future of these softwares. Platforms like GitHub are improving the user experience and the tools for working with design files, therefore the use of more advanced tools like Git and GitHub could be the subject of further research.

Service design tools and Activity Theory proved to be useful tools, with some cultural limitations sometimes, and with the big limitation of consisting of a set of unrelated tools for the design of the same project, a collaborative activity. There may be further research that integrates service design tools and Activity Theory, or a possible visualization and standardization or creation of toolkit, in order to simplify the work of single designers and their collaboration on the same files. During the workshop, the poster worked well as a quick tool for designing and communicating a project, further research could address how to create a poster also for the meta-design project, whether through standardization, customization of a template or software for automatic generation.

Furthermore, the meta-design project is a shared way for explaining how a design process should develop and how the actors should interact, but the documentation is not necessarily a proof of what is actually taking places inside the design process. Therefore, the meta-design project should always be compared with the actual process and interactions, so future research may try to address this issue by finding methods and tools for this comparison. Making the meta-design open source enables the designers and the users to continuously check their course and modify it, but more specific methods and tools are needed. A possible future direction of this research is about promising methods, tools and practices for understanding the development of the meta-design process according to the complexity of the social networks inside the community of users and designers.

8. Conclusions

The Open P2P Design approach was developed in order to provide a methodology for setting up meta-design projects for enabling the mass-collaboration of Open Source and P2P distributed systems in specific projects.

Three workshops were organized for testing its adoption by designers, and for understanding the possible use of tools and software coming from different approaches and disciplines. The meta-design approach proved to be useful to the participants of the workshops, and the adoption of tools, principles and practices from Open Source and P2P distributed systems by designers proved to be possible and also promising for future research and adoption. Some tools (system map, participation matrix) proved to be easy to use by the participants, while others (business model canvas, Activity System) proved more difficult to be understood and adopted because their concepts may be different to some cultures (as it happened in the Seoul workshop) or because they need to be adapted to the distributed nature of Open Source and P2P initiatives. Overall, the workshop proved that the meta-design approach is useful and promising for the design and facilitation of Open Source and P2P distributed systems, while at the same time they pointed future directions of research for further refinement.

9. References

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3. ART. 3

Menichinelli, Massimo. 2017. 'A Data-Driven Approach for Understanding Open Design. Mapping Social Interactions in Collaborative Processes on GitHub'. *The Design Journal* 20 (sup1): S3643–58. https://doi.org/10.1080/14606925.2017.1352869.

A data-driven approach for understanding Open Design. Mapping social interactions in collaborative processes on GitHub

Massimo Menichinelli

IAAC | Fab City Research Lab

Aalto University – School of Art, Design and Architecture – Department of Media – Media Lab Helsinki

SUPSI – Department of Environment Constructions and Design

massimo@fablabbcn.org – massimo.menichinelli@aalto.fi

Abstract

The development and adoption of digital technologies in the past decades has modified existing working conditions and introduced new ones in many fields and disciplines. This process has also influenced the field of Design especially with the Open Design and the Maker movements. The article proposes a software library for analysing networks of social interactions over time on Git projects hosted on GitHub and its application to three cases of (a) discussing the nature and concepts of Open Design; (b) teaching Open Design to interaction design students; (c) the development of a Maker platform for laboratories and for Open Design project development. Such software may be useful for understanding social interactions over time on GitHub, enabling thus an overview of participation in collaborative processes. Such data-driven approach might then advance our understanding of how platforms connects

and influence makers and designers in their collaborative work on Open Design.

Keywords

Platforms, Open Design, Process, Community, Social Network Analysis

1. Introduction

The introduction of digital technologies of the past decades has enabled new forms of organization and new forms of distribution of resources or it has modified or rendered obsolete old forms. These technologies have shaped new ways of working and of participating in projects, which in turn have contributed to shaping these technologies, not only in software and web projects, but also in projects related to music, biotechnology, movies, science, art, design and so on (Goetz, 2003). These new conditions have often adopted practices, organizational formats and tools that revolve around the ideas of openness, collaboration, sharing of information, discussion and peer-to-peer interactions. This process has also influenced the field of Design in several ways and especially in two directions, that often overlap, where the boundaries between professional designers and amateur designers are blurry thanks to the sharing of projects and the access of digital fabrication technologies able to manufacture them locally: 1) with the Open Design movement (Abel, Evers, Klaassen, & Troxler, 2011) and 2) with the Maker movement and its Maker laboratories like Fab Labs, Makerspaces and Hackerspaces (Anderson, 2012; Gershenfeld, 2005). On the direction of the Open Design movement (1), the Design discipline started adopting the tools and principles from Open Source and P2P software development community, opening the design processes, documentations and outcomes to digitally-enabled communities. Some authors suggests that the possibilities emerging from this intersection are broader than just the sharing and opening of design projects (Menichinelli, 2016a), along the two main directions of applying such systems in the Design practice or by facilitating, designing and enabling of such systems through the Design practice with the analysis, visualization and design of their collaborative tools, platforms, processes and organizations. Other authors tend to de-emphasize the role of technology in Open Design and adopt instead it as a broad term representing a wide range of approaches where the pre-eminence of the professional designer is not recognised in the creative process: digital technologies are important for their accelerating effect, but cases of Open Design pre-dates them (Cruickshank, 2014). One of the main topics of Open Design is therefore an increasingly complex ecosystem of tools, approaches and projects where the boundaries between professional designers and amateur designers are increasingly blurry (Atkinson, 2010; Cruickshank & Atkinson, 2014). This topic is strongly connected with the Maker movement (2), a loose global movement of individuals who focus on making physical projects but with a digital layer and digital tools, often with collaborative processes and the sharing of the digital files or documentation. Makers often meet and work in globally-networked laboratories such as Fab Labs, Makerspaces and Hackerspaces that provide access to a local and global community of like-minded actors and to several digital fabrication technologies able to manufacture easily and locally digital projects. The democratization of technology, education, content and community-building of such laboratories increases the possibilities for professional and amateur designers and at the same time it opens up new possibilities of collaboration and interaction among them and with other stakeholders. Furthermore, the Open Design and Maker movements could have an impact also in design education, especially with the emergence of the new working condition of designers-producers, as an extensive research of the Maker movement in Italy suggested (Menichinelli, Bianchini, Carosi, & Maffei, 2015).

The integration of software, data, platforms and digital fabrication technologies offer promising opportunities for actors of the Design field by enabling collaborative, open and potentially large-scale processes and systems in the design practice, research and education. Such platforms could change established practices and also give more tools for understanding them: how could the analysis of social interactions over time on such platforms improve the understanding of design-related collaborative processes? This article aims at proposing a small contribution in this direction by providing insights on the role of a popular platform commonly used for open source software development, GitHub[12], but also used by makers and designers. This article proposes a custom software library that reconstructs interactions among users from GitHub data (Menichinelli, 2017), and a first test of such library is done with three Open Design-related case studies. This article considers Open Design as the adoption of tools, processes and principles from Open Source software development in the Design discipline, and therefore GitHub becomes an extremely interesting case for understanding how the Open Source approach could impact the Design discipline by understanding the social interactions it enables. Moreover, GitHub is not only useful for Open Design projects, but also for discussing it, understanding it, teaching it and supporting it with custom platforms: its adoption by the Design discipline could be therefore a complex phenomenon. In order to shed some lights on this, the article provides an overview of:

1. the intersections of platforms, makers and designers (section 1-2);
2. existing approaches in understanding social interactions in GitHub and related tools and platforms (section 2);
3. a proposal of a software library for analysing networks of social interactions over time on GitHub (section 2);
4. its application to three cases (section 3) of

[12] https://github.com/

   a. discussing the nature and concepts of Open Design (section 3.2);
   b. teaching Open Design to interaction design students (section 3.3);
   c. the development of a Maker platform for laboratories and for Open Design project development (section 3.4);
5. conclusions regarding the results obtained, the limits of the research and potential future directions for improving it (section 4).

2. Understanding collaborative processes on online platforms: Git and GitHub

Among the digital technologies that have had a relevant role in this process, online platforms are particularly interesting. The concept of online platforms has become increasingly popular with the success of companies like Amazon, Apple, Facebook, and Google, which have based their business models less on competition and more on building ecosystems, partnerships and communities where it is easy for providers and users to participate (Simon, 2011). Online platforms are interesting for their ability to leverage the long-tail of markets and communities (Anderson, 2008), for their dimension, influence and ability of offering a place for multiple individuals or groups to get together in order to exchange goods and services (multisided platforms) (Evans & Schmalensee, 2016) or for supporting democratic practices that are environmentally aware, participatory and based on sharing and collaboration (Collective Awareness Platforms: CAPS) (Sestini, 2012). The huge dimension, impact and related ecosystems are increasingly generating attention and also criticism towards them, whatever their business model is, especially regarding their real position and influence on the social, political and economic dimensions of society. The growth of such platforms has brought side effects to society and welfare (Morozov, 2016), to politics (Epstein, 2015) and even our relationship with knowledge is affected by making us overvalue some ways of processing information over others, with novel dynamics that are not always necessarily democratic or expressions of a collective intelligence, with more profound philosophical and epistemological implications (Lynch, 2016). These critical dimensions further suggest how platforms are not necessarily always positive, stressing the importance of researching such platforms and their impact on society. The importance of platforms cannot be found only on the features and processes that they offer and their ability to scale participation up, but also on the vast amount of data they gather. This leads to the development of data-driven products and services that platforms offer, but it also enables platforms and external researchers to understand social, political and economic trends.

These platforms also extend to the design and manufacturing of physical goods thanks to the emergence of digital fabrication technologies and their democratization by commercial platforms, the Maker movement, its laboratories and platforms. Furthermore, the members of the Maker movement and especially their laboratories are already using common social media platforms like Twitter, and from their publicly available data researchers may explore the social structure and dynamics of such movements (Menichinelli, 2016b), providing insights that could potentially lead at management and policy outcomes for improving the movement. The analysis of such platforms could then shed light on their influence on the work of makers, which are often also designers and engineers: for this reason, this article focuses on GitHub in order to make a contribution along this direction. GitHub offers free hosting for open source project development with the use of the Git[13] software for managing the history of a project developed by Linus Torvalds, the founder of the Linux project. Git was introduced for improving the development of the Linux project with an open source tool capable of managing the work of thousands of participants (Cloer, 2015). Git and GitHub have become very popular as a tool and a platform for managing software projects[14], being used not only for software projects, becoming thus a mainstream platform that also promotes an easier access to participation in open source projects (McMillan, 2013; Rogers, 2013). Understanding how developers and makers interact on projects using Git and GitHub may help understanding current and future design processes that use the same tools.

Furthermore, GitHub is an extremely popular platform with more than 49 millions projects hosted[15], and thanks to its API[16] and archived data[17] there is a strong literature about analysing and visualizing its data, from platform-scale visualizations to single-project visualizations[18]. Existing literature could be organized by approaches on analysing:

1. Git (and other version control systems) projects;
2. projects hosted on several platforms;
3. projects hosted on GitHub.

Some authors (1) have worked on analysing the structure of commits in a Git project (M. Biazzini, Monperrus, & Baudry, 2014; Marco Biazzini & Baudry, 2014); other authors have tried to analyse Git (and other version control systems) projects by developing open source softwares that create animations or static visualizations of the interactions of users through time (Caudwell, 2010; Ogawa & Ma, 2010, 2010). Some authors (2) have adopted social network analysis methods for understanding interactions on self-hosted open source platforms like Bugzilla[19] (Zanetti, Sarigol, Scholtes, Tessone, & Schweitzer, 2012) or platforms that were popular before GitHub like

[1313] https://git-scm.com/

[14] An infographic of the first ten years of life of the Git project can be accessed here: https://www.atlassian.com/git/articles/10-years-of-git/

[15] https://github.com/about

[16] https://developer.github.com/v3/

[17] https://www.githubarchive.org/

[18] http://githubstats.com/

[19] https://www.bugzilla.org/

SourceForge (Shen & Monge, 2011) or the Apache Software Foundation[20] (Chełkowski, Gloor, & Jemielniak, 2016), or even individual projects hosted without a platform (Bird, Pattison, D'Souza, Filkov, & Devanbu, 2008). These approaches have mostly worked with social network analysis methods in order to understand latent organizations, community structure, team dynamics, participation of developers and project evolution: this has become a very popular approach that has also been investigated in its validity (Nia, Bird, Devanbu, & Filkov, 2010). Other authors have focused instead only on GitHub (3) with a similar approach (Lima, Rossi, & Musolesi, 2014; Yoshikawa, Iwata, & Sawada, 2014) and also with in-depth interviews (Dabbish, Stuart, Tsay, & Herbsleb, 2012). The social network approach has also been integrated with the geographic dimension in order to understand the global scale of collaboration on GitHub (Heller, Marschner, Rosenfeld, & Heer, 2011). Large-scale mining of GitHub data has become a popular strategy for understanding large-scale dynamics in software development, but some authors have pointed out that most projects hosted on GitHub are small, inactive or only personal, or not for software development like free storage or web hosting, or the projects are only partially hosted on GitHub (Kalliamvakou et al., 2014). These findings are similar also on related platforms like SourceForge (Rainer & Gale, 2005) or the Apache Software Foundation (Chełkowski et al., 2016).

While understanding collaboration at platform-scale might be a complex and difficult task, analysing single projects on GitHub could be an important strategy for understanding interactions among users over time. Within this direction, this article proposes the first results obtained with a custom developed software library that analyses the interactions among users in a Git project hosted on the GitHub platform. The library is written in the Python programming language, and the interactions are mapped into networks with the use of the NetworkX library (Hagberg, Schult, & Swart, 2008). The choice of Python is based on the rich ecosystem of libraries, frameworks, documentation and users for data analysis, visualization and platform development it provides, combined with its high popularity, making it thus possible not only to analyse interactions on platform, but also to integrate such analysis in existing or new platforms with the same programming language. The library itself is open source, developed on GitHub, and it could be extended in the future to analyse other version control systems (Subversion[21], Mercurial[22]), coding development platform (BitBucket[23]) or social media platform (Twitter, YouTube, Facebook). In this way, it will be possible to understand the interactions in a project on the different online platforms it adopts for development, discussion, promotion, commercialization and so on. The library aims at providing only the reconstruction of the networks of interactions on Git (local) and GitHub (online) projects and the output and saving of such network with common data format; data analyses are left to the users which can

[20] http://apache.org/foundation/

[21] https://subversion.apache.org/

[22] https://www.mercurial-scm.org/

[23] https://bitbucket.org/

thus adopt their favourite tools and approaches. From such interactions the library reconstructs a time-based graph for social network analysis and plotting of interactions through time: the library does not analyse individual efforts but only social interactions. The library is inspired by (but not based on) the approach taken by the TracSNAP[24] plugin for the open source self-hosted platform Trac[25] (Easterbrook, Lawson, & Strong, 2009). TracSNAP aims at understanding the networks of interactions among developers of a project managed by the Trac platform by finding them in commonality of file edits and in discussion in bug and feature tickets[26]. The library here proposed adopts two strategies for modelling interactions on Git and GitHub:

1. in Git projects, interactions are based on the editing of the same file through all the versions of a file (called *commits* in Git) (Figure 1);
2. in GitHub projects, interactions are based on the Git project hosted (Figure 1) and on online discussions in two ways (Figure 2):
    a. each user that participates in a discussion, is understood as interacting with all the previous users in the discussion;
    b. users may directly mention other users with the *@username* text like on Facebook and Twitter, and this is considered as a direct interaction.

In the current version of the library, interactions and discussions are regarded as a linear thread, since GitHub does not use hierarchical discussion threads: therefore, each discussion is a single line of messages without any further branches to secondary lines of messages. Git and other platforms utilize hierarchical threads, therefore future versions of the library will have to consider such formats as well. The data gathered from Git and GitHub is formatted with a generalized simple structure, that can be used also for modelling interactions in other tools and platforms as well (Table 1).

[24] TracSNAP can be found here: https://trac-hacks.org/wiki/TracSnapPlugin

[25] https://trac.edgewall.org/

[26] A video explanation of TracSNAP is available on YouTube here: https://www.youtube.com/watch?v=FMQWur9A3DE

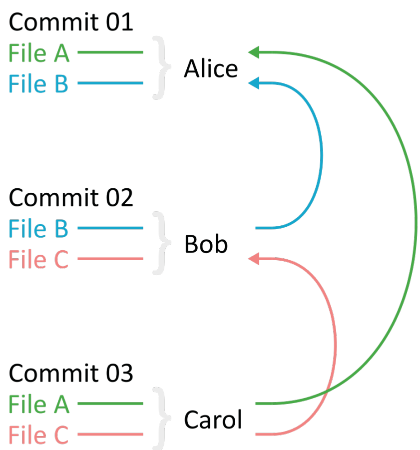

Figure 1. The model adopted for extracting data regarding interactions among users from a Git project.

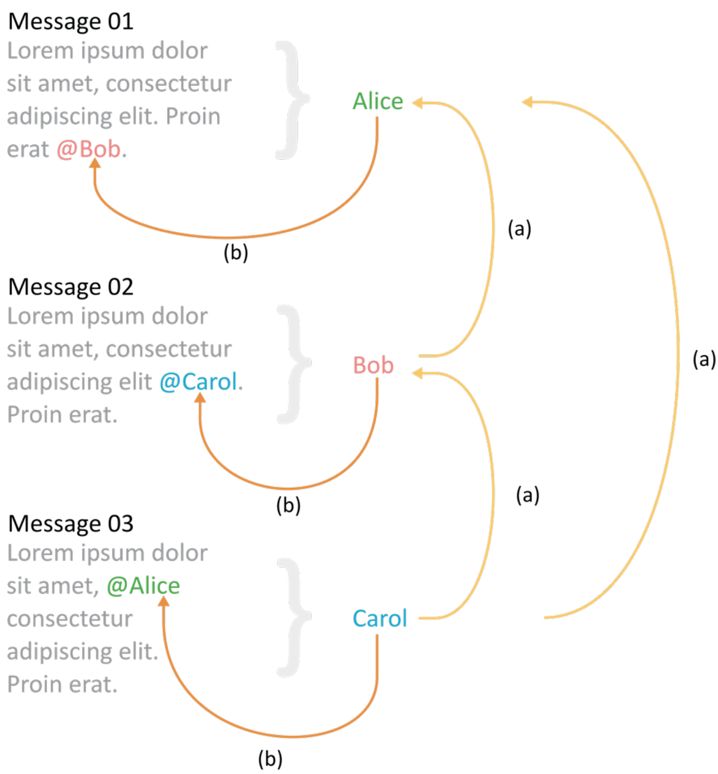

Figure 2. The model adopted for extracting data regarding interactions among users from a GitHub project.

```
[{
"@node": "Content id",
"date": "Content creation date",
"msg": "Content title or body",
"author": {
"#text": "User name",
"@email": "User e-mail",
"avatar_url": "User avatar URL on GitHub"
}
}]
```


Table 1. A simplified version in JSON format of the data that describes each action in a Git or GitHub project, from which interactions are reconstructed. Any activity from any tool or platform, if described with such format, could be used by the software library for extracting data regarding interactions among users.

3. Design, openness and platforms: three case studies

3.1 A data-driven approach for action research

The software library here proposed adopts quantitative methods for extracting data from social interactions over time in Git and GitHub projects. Since the library itself does not compute any analysis but instead focuses on extracting and formatting data, it could be used in different contexts and research approaches. For the sake of showing applications of the library and for further understanding how platforms influence makers and designers, especially within Open Design projects, this paper analyses three cases of design-related projects hosted on GitHub. Furthermore, these are cases in which the Author has participated: the library is then tested as a support for action research experiments where the Author acts as a reflective practitioner. The importance of releasing the library as open source lays in the fact that more researchers but also makers and designers could then use it with any repository in order to understand their practice. The analysis of these cases might then advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design. The proposed software library generates enough data from which several analyses are possible, for example:

1. a graph of interactions among users (a social network analysis):
    1. centrality of users (degree, betweenness, closeness, eigenvector, ...);
    2. users who produced commits, or just online comments;
    3. community structure;
2. a plot of interactions over time among users (a time series analysis):
    1. all interactions;

2. interactions split by type;
3. interactions split by user.

Only a subset of these options is adopted in each case in relation to the specific data.

3.2 Defining Open Design

Within the Free Software and Open Source movement, definitions are more important than manifestos, and this case tried to write collaboratively an Open Design definition in GitHub[27]. This project started in May 2012 and it is still active, with 71 participants and 72 interactions so far. The extracted data shows how the great majority of interactions has taken place as issue comments, and to a much lesser extent commits and forks: the project has hosted more discussion than writing (Figure 3.). Only 7.04% of participants created a commit, while 83.1% of them left an issue comment. The majority of users (64.78%) has no interaction, and two clusters form around the project itself (the interactions are technical operations) and especially in a group of users, where we can see that only some of them created a commit (Figure 4). Most of the interactions took place in 2012 and 2013, with some recent interactions in 2016: interactions took place mostly in the first months of the project, and are starting again to take place, especially as issues comments (Figure 5), by the most active user. At the moment the project seems to be declining and becoming the effort of mainly one user.

[27] The GitHub repository can be found at: https://github.com/OpenDesign-WorkingGroup/Open-Design-Definition

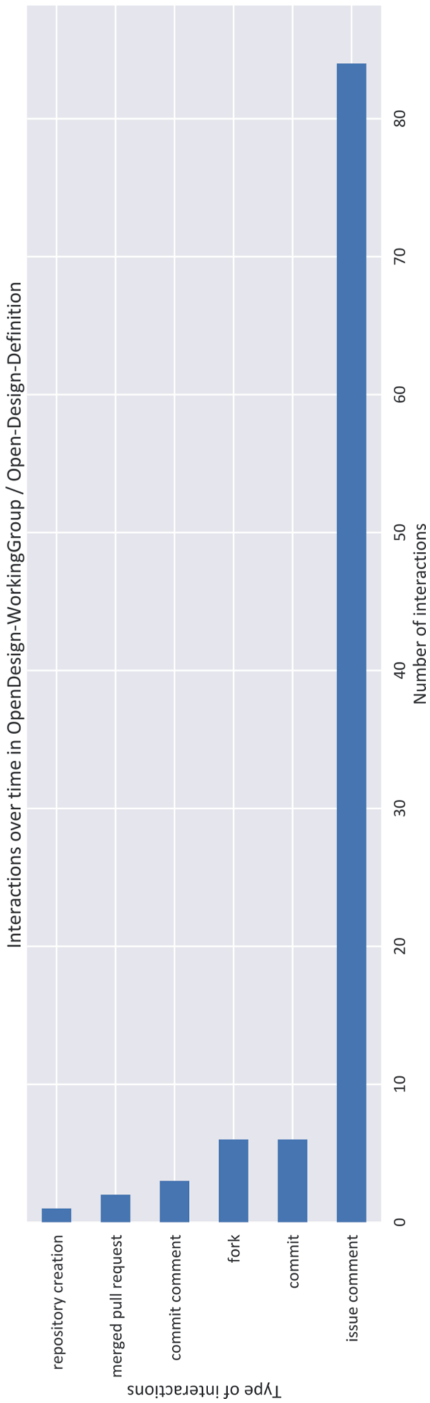

Figure 3. Amount of interactions by type in the Open Design definition project.

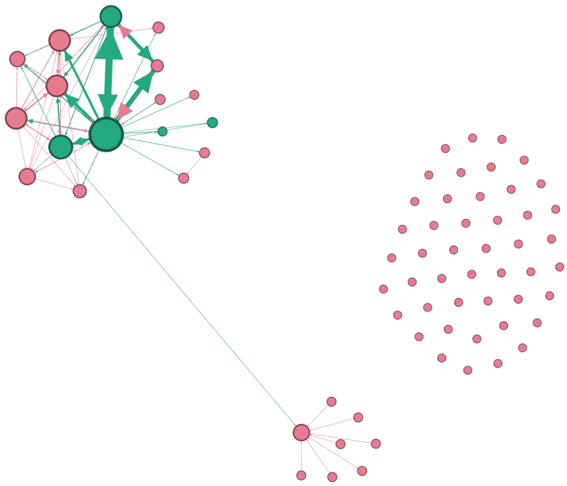

Figure 4. Graph of the social interactions in the Open Design definition project. Green nodes interact in commits. The size of each node is proportional to its degree and the thickness of each edge is proportional to its weight.

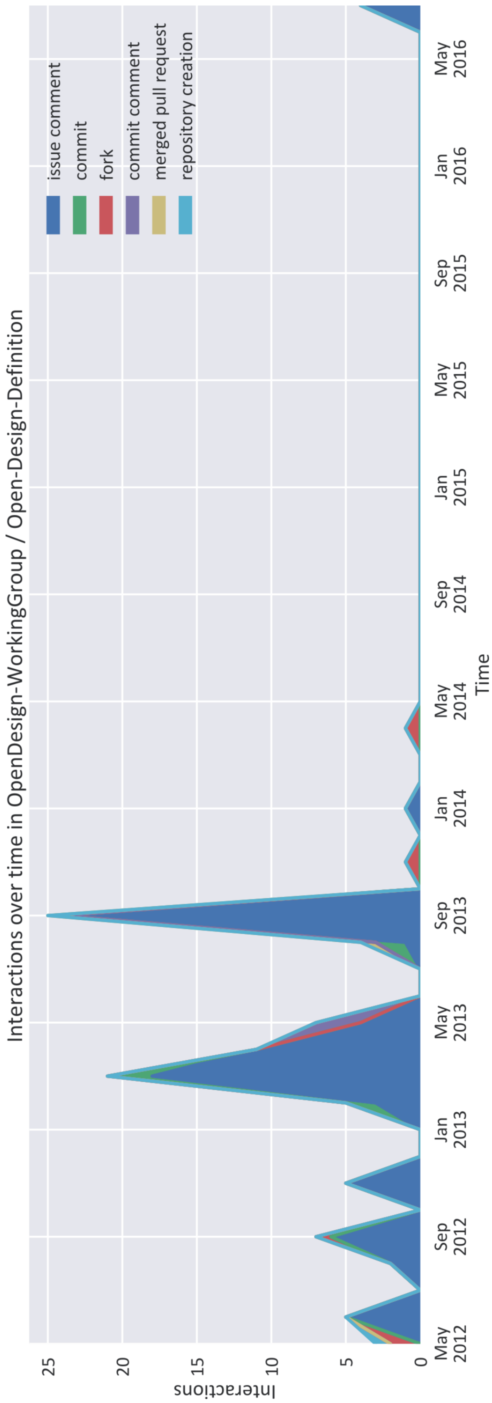

Figure 5. Interactions over time in the Open Design definition project (resampled by month).

3.3 Teaching Open Design

The second case consists of a course about learning GitHub for design projects, lectured within a Master in Interaction Design twice, in November-January 2013-14 (groups of 2 students) and 2014-15 (groups of 4 students)[28]. In this case, several projects were analysed together since the activity was split among multiple projects. As a whole, 34 users participated with 78 interactions. Here the graph of the interactions, coloured by the sub-communities identified (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008; Lambiotte, Delvenne, & Barahona, 2008), shows only 3 inactive users, some technical users and interactions, and especially all the students group connected to the lecturer as the main hub (Figure 9). Two groups of two students interacted more with technical users than with the lecturer, becoming part of the technical users subgroup; two groups of 2 and 4 students instead become part of a single subgroup with the lecturer. One group of two students has most of the interactions, and one group of 4 students has much more interactions than the other: these are important outcomes taking into account that the purpose of the course was to experiment online collaboration. The time plot of interactions show bursts of activity instead of a continuous activity within the two courses, separated by several months of inactivity (Figure 10).

[28] The GitHub repositories can be found at: https://github.com/orgs/OpenDesign-SUPSI/

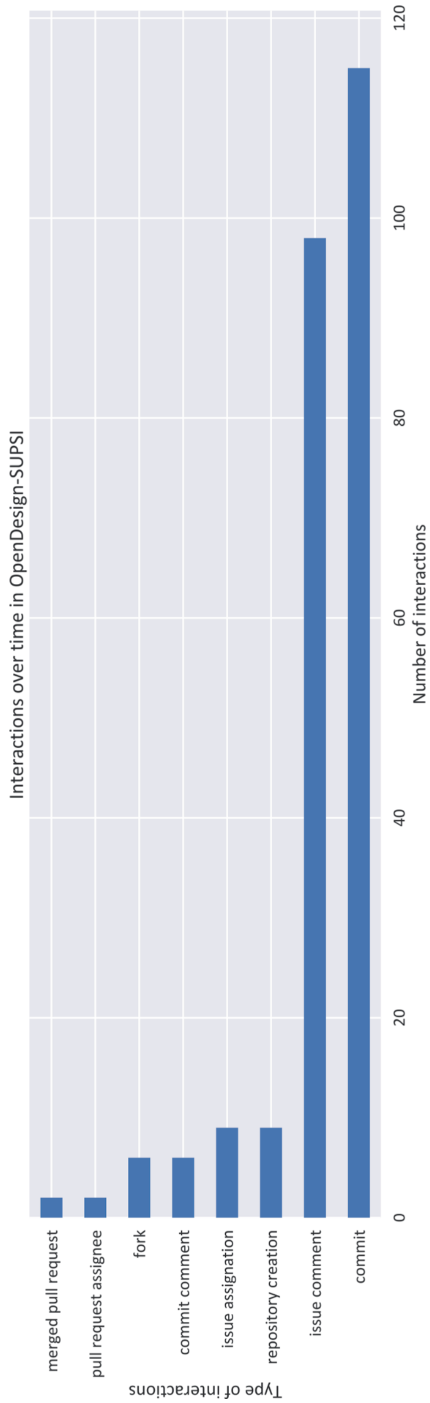

Figure 6. Amount of interactions by type in the Open Design courses projects.

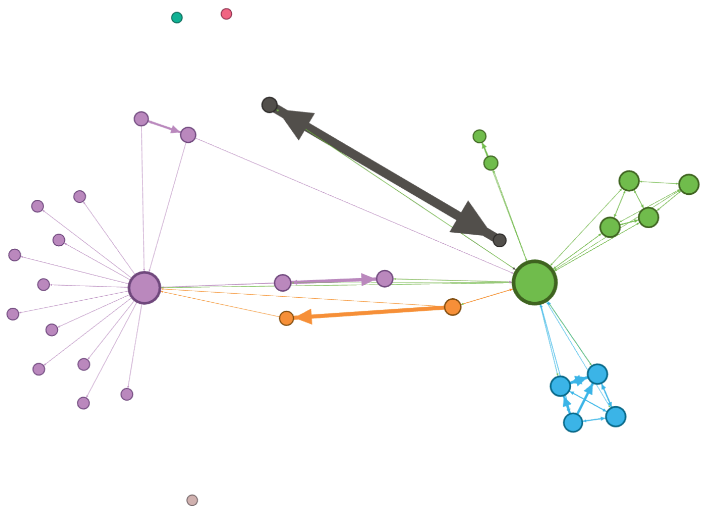

Figure 7. Graph of the social interactions in the Open Design courses projects. The size of each node is proportional to its degree, the colour is based on the subgroups identified (Blondel et al., 2008; Lambiotte et al., 2008).

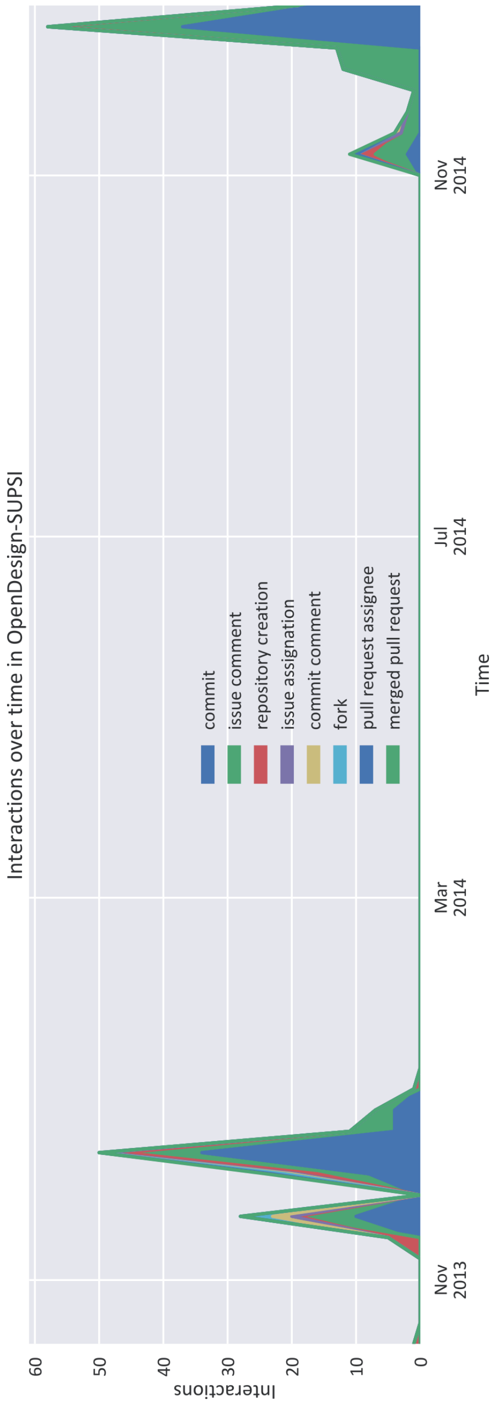

Figure 8. Interactions over time in the Open Design courses projects (resampled by week).

3.4 Developing a Maker platform for Open Design projects

The third case is represented by a Maker platform, Fablabs.io[29], that connects the global Fab Lab network and that hosts Open Design projects[30]; even if the project hosting features are currently limited if compared to GitHub, it represents potentially a platform that connect projects with people and laboratories, and therefore design with manufacturing. The project started at the end of 2013 and is still active nowadays, with 56 users and 74 interactions, but only 42.85% are active users, and the interactions are concentrated in one subgroup (Figure 13). Here most of the interactions can be found in commits, almost the double of issue comments (Figure 12). More specifically, the connections with most of the interaction can be found with the main developers of the project (Figure 13). Interactions however started only in 2015 and mainly with commits, and issue comments and assignation emerged slowly after that (Figure 14): this could point to the fact that the initially the work was not collaborative, collaboration emerged later and increased with more discussion in the last months of 2016. This is probably the consequence of the change in the users activity, where the main active user stopped working in the second half of 2016 and two more users stepped in the project since then.

[29] https://www.fablabs.io/

[30] The GitHub repository can be found at: https://github.com/fablabbcn/fablabs

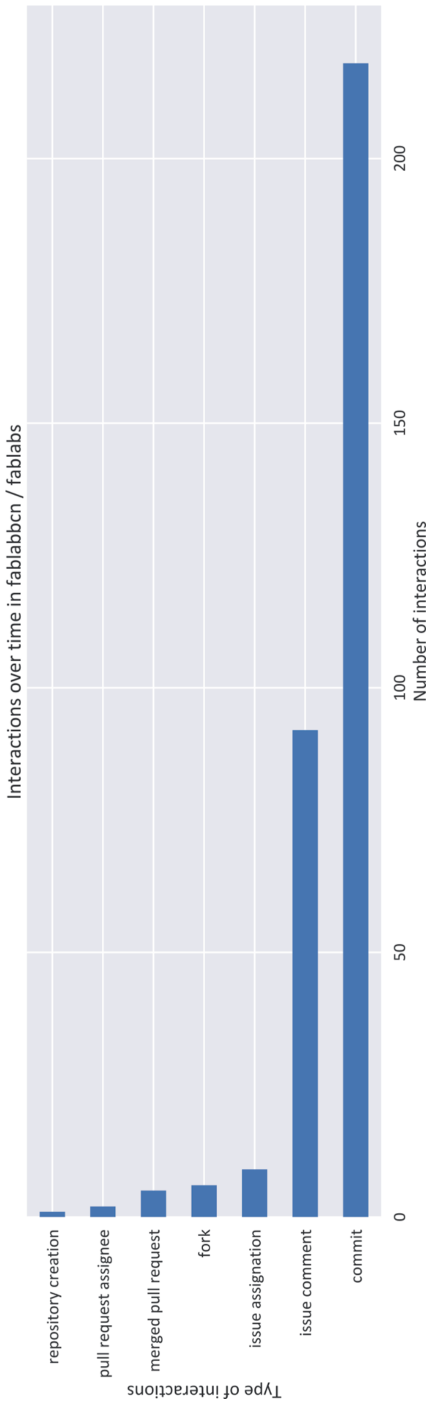

Figure 9. Amount of interactions by type in the Maker platform project.

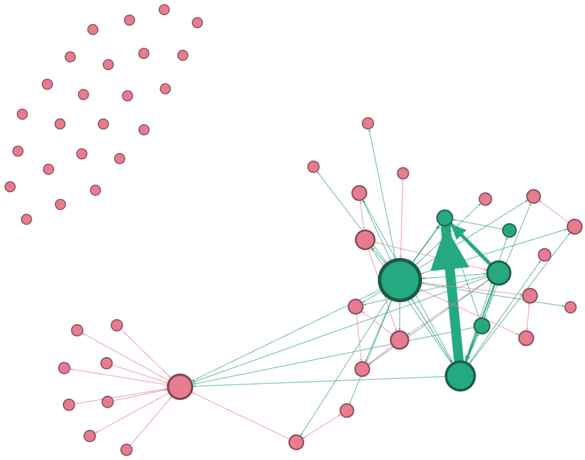

Figure 10. Graph of the social interactions in the Maker platform project. Green nodes interact in commits. The size of each node is proportional to its degree and the thickness of each edge is proportional to its weight.

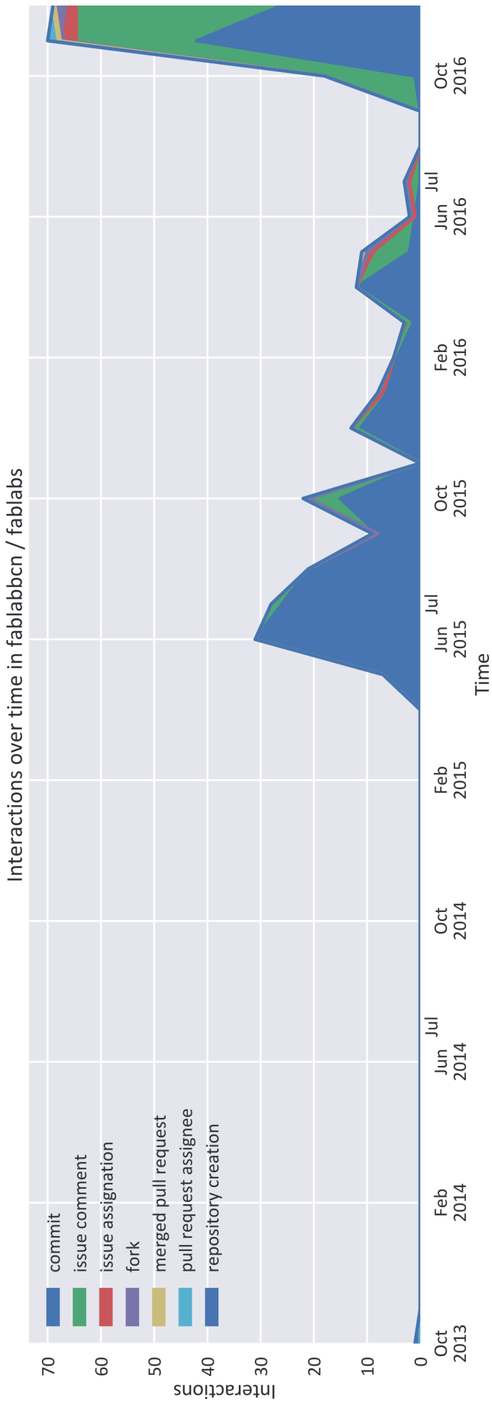

Figure 11. Interactions over time in the Maker platform project (resampled by month).

4. Conclusions

The increasing digitalization of content and activities might affect designers, especially thanks to their integration with the Maker movement, and it is therefore critical to start understanding the role of platforms in enabling projects and collaboration in them. This paper proposes a software library that extract data of interactions from Git and GitHub projects, a highly popular tool/platform ecosystem for software development that is also used for both Maker and Design projects. The software library was tested in three cases with similar size related to Open Design where the Author participated, in order to (1) advance our understanding of how platforms connects and influence makers and designers in their collaborative work on Open Design, (2) provide support to the activity of Maker and Design researcher and reflective practitioners. In the case of the Open Design definition (a)(3.2), the data shows how interactions took mainly place in the first two years but mostly on discussing the definition rather than on writing it, and with one main active user who is still active. In the case of teaching Open Design (b)(3.3), the data shows how differently the students worked together and when. In the case of the Maker platform that hosts Open Design projects (c)(3.4), the data shows how interactions started later in the project and how the development process has become increasingly more organized and structured, but still with a small core group. Overall, such analyses show that this approach is useful for understanding the process of a project, the interactions that constitute it, the influence of specific actors on it, and the amount of participation in it. Further research, especially at large scale, might uncover more insights about the impact of platforms on maker and designer activities, while research on single projects might uncover specific insights.

The software library proposed is able to extract enough data for several analyses, but this requires more analyses or custom interactive visualizations tools for exploring all the available data, which could be developed in further research. Git and GitHub are highly complex tools, and data extraction might be refined. This version of the library only shows interactions among users through time, these could be compared with the overall individual activity that is not collaborative, in order to understand the balance between autonomous work and collaboration. Furthermore, such library could be expanded to integrate more version control systems tools and social media platforms. Finally, the tool is mainly a quantitative one, and future research should combine it with qualitative methods like interviews or surveys, in order to understand not just the activity of a project as a whole, but also the experience of each participant.

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About the Authors

Massimo Menichinelli, project manager at IAAC | Fab City Research Lab and doctoral candidate at Media Lab Helsinki (Aalto University), has investigated, lectured and work on the connections between Design and Open Source, Fab Lab and Maker movements since 2005.

Acknowledgements

The research leading to these results started in 2012 while Massimo Menichinelli worked at Aalto Media Factory in the Aalto University, especially in the organization of the Open Knowledge Festival 2012, of which the discussion of the Open Design Definition was a part; the research continued while working as a lecturer at SUPSI during 2013-15. These activities provided an informal context for the first reflections and experimentations with simple software scripts. These first informal tests were later elaborated into a full library and full analysis while working at IAAC | Fab City Research Lab in 2016-17 within the Horizon 2020 project MAKE-IT.

The finalization of this research has received funding from the Horizon 2020 Programme of the European Union within the MAKE-IT project under grant agreement n° 688241. This publication reflects only the author's view and that the Union is not liable for any use that may be made of the information contained therein.

4. ART. 4

Menichinelli, Massimo, and Francesca Valsecchi. 2016. 'The Meta-Design of Systems: How Design, Data and Software Enable the Organizing of Open, Distributed, and Collaborative Processes'. In *6th IFDP - Systems & Design: Beyond Processes and Thinking*, 518–37. Valencia: Editorial Universitat Politècnica de València. https://doi.org/10.4995/IFDP.2016.3301.

The meta-design of systems: how design, data and software enable the organizing of open, distributed, and collaborative processes

Massimo Menichinelli

Aalto University, School of Art, Design and Architecture, Department of Media, Media Lab Helsinki

IAAC | Fab Lab Barcelona

massimo.menichinelli@aalto.fi

massimo@fablabbcn.org

Francesca Valsecchi

Tongji University, College of Design and Innovation

francesca@tongji.edu.cn

Abstract

The challenges posed by the complexity of our times requires the Design discipline to understand the many complex relationships behind the social, business, technology and territory dimensions of each project. Such nature of complex systems lays not only inside design projects, but also inside the design processes that generate them, and the ability of organizing them through meta-design approaches is becoming strategic. Since the turn of the century, the design discipline has increasingly moved its scope from single users to local and online communities, from isolated projects to system of solutions. This shift has brought researchers and practitioners to investigate tools and strategies to enable mass-scale interactions by adopting several models and tools coming from software development and web-based technologies: Open Source, P2P, DDD (Diffuse, Distributed, and Decentralized) systems. This influence has matured over the years, and if we observed in the past how such systemic models can be applied in the design practice (part 1), we are facing now a new phase where Design will have an increasing role in enabling such systems through the analysis, visualization and design of their collaborative tools, platforms, processes and organizations (part 2). This scope falls into the Meta-Design domain, where designers build environments for the collaborative design of open processes and their resulting organizations (part 3). In this paper, we address this phenomena by elaborating the Open Meta-Design framework (part 4), that provides a way for designing open, collaborative and distributed processes (including those in the professional design domain). The paper positions the framework among current meta-design and design approaches and develops its features of modeling, analysis, management and visualization of processes. This framework is based on four dimensions: conceptual (describing the philosophy, context and limitations of the approach), data (describing the ontology of design processes), design (visualizing designing processes) and software (managing the connections between the ontology and the visualization, the data and design dimensions). We believe that such a framework could potentially facilitate the participation and the creation of open, collaborative and distributed processes, enabling therefore more relevant interactions for communities. As a conclusion, the paper provides a roadmap for developing and testing the Open Meta-Design framework, and therefore evaluating its relevance in supporting complex projects (part 5).

Keywords

Open Design, Meta-Design, Design Process, Data Visualization, Organization

1. Introduction

During the last century, the industries of manufacturing, commerce, distribution and design have been expanding their borders globally. At first through the slow evolution of industrial infrastructures and then rapidly since the last decades through connectivity enhancement and the service industry that is transforming management and organizations. Globalization has quickly eroded the borders of national economies by redistributing activities, business, and actors all over the world, while connecting them at the same time with ICT technologies.

This phenomenon has changed the nature of several economic - and to a larger extent also social and cultural - structures, and their consequent dependency to national laws: supply-chains and value-chains are increasingly distributed, opaque, and less and less under public understanding and control. Tools and approaches for mapping and understanding such distributed systems in an open and participatory way are therefore increasingly relevant. The rise in global communication capacity, and the distributed workflows had scaled-up the complexity of economy, its impact on a global scale, its sustainability risks; it also generated many possibilities to organize distributed collaborative processes that would benefit and affect also cultural, non-profit industries, and those initiatives that addressed global sustainability challenges.

By its connection with economic and management domains, the Design discipline is also being affected by this global changes. Design is increasingly focused on speculating and experimenting on the complex and systemic nature of projects, practices and issues to be addressed, in many different disciplinary streams. Through many approaches, the scope of design projects moves from single users to local and online communities, from isolated projects to system of solutions, reaching groups at a larger scale and within global domains. This shift has brought researchers and practitioners to investigate tools and strategies that enable mass-scale and remote interactions, by adopting several models coming from software development and web-based technologies: Open Source, P2P, DDD (Diffuse, Distributed, and Decentralized) systems. The integration of Design projects with large groups of users and of their localities has increased the level of complexity (or rather, the focus on the level of complexity) of the Design discipline not only inside design projects, but also inside the design processes that generate them, and the ability of organizing them, especially through meta-design approaches, is increasingly becoming strategic. Such direction is important for the management and visualization of the intangible aspects of design processes, and for the enabling of changes within the design processes and thanks to them through society and the economy.

In this paper, addressing the relationship between design and the action within complexity, we focus on the visualization challenge of meta-design: how you do represent a system, its relationships, the complexity of social and local dimensions, and at the same time how visualization can inform the design of meaningful complexity in within organizational, productive, and information structures. We will conclude providing a framework of practice for Design when dealing with: the visualization of complex systems, the participation to complex social interactions, the contextualization of projects in complex local systems, and the implementation of Open Source, P2P, DDD Systems.

The article provides a first an overview of Open Source, P2P, DDD systems and their application in design practice (part 2), an overview of existing meta-design approaches (part 3) and then propose the Open Meta-Design framework as the synthesis of these two domains (part 4).

The framework, named Open Meta-Design, enables designers to model, analyse, manage and visualize open, collaborative and distributed processes. It is composed by 1) conceptual dimension; 2) data format; 3) data visualization layout; 4) software guidelines. The proposed framework however needs experimentation, testing and refinement: therefore, as a conclusion, we highlight possible limitations in the Open Meta-Design proposal and we propose a possible roadmap for its further development and testing (part 5).

2. Open source, P2P, Distributed, Decentralized, Systems, and Design

Designers and design researchers have been increasingly interested in tools and strategies that can enable their interactions with larger groups of people distributed in several localities. This interest has especially focused on approaches coming from software development and web-based initiatives and technologies, like Open Source, P2P, Distributed, Diffuse and Decentralized (DDD) Systems. In the recent decades ICT technologies have shaped new ways of working, participating, and assessing projects, which in turn have contributed to shaping these technologies and adapt them to larger community of users and variety of cases. In fact, although the roots of online collaborative organizations of any kind can be traced to Free Software and Open Source first, and and P2P afterwards, these new technologies and their related organizational forms have been experimented not only within software and web domain, but basically in all the field of human creativity, music, biotechnology, movies, science, art, design and so on (Goetz 2003).

The variety of these implementations has been discussed and interpret through many theories, cases studies, and analytical framework, such as Web 2.0 (O'Reilly, 2005), Wikinomics (Tapscott & Williams, 2010, 2006), Crowdsourcing (Howe, 2008, 2006), Collective Intelligence or Wisdom of the Crowds (Leadbeater, 2009; Levy, 1997; Shirky, 2011, 2008; Surowiecki, 2005), Peer Production (Benkler, 2002). Free / Open Source and P2P software were initially technological projects, but then innovateed critically the organizational level (Fogel, 2005; Weber, 2005), and time after time they became promising formats for the management of online, distributed, and community based activities .

For instances, since the new century Open Source principles and practices have been adopted outside the software industry (Goetz, 2003), and shaped large cultural phenomena such as the so called Open Source Everything (Steele, 2012). P2P dynamics have been generalized from software and adopted in many other contexts as well: the nodes in the network (devices, but also users, or any entities you may have as your network components) are not related to any central servers or middleman; this configuration has been considered a more efficient distribution model for a large variety of contents and flows (Benkler, 2002). Furthermore, many principles and guidelines based on P2P dynamics have been elaborated out of the scope of software applications as grounds for whole scenarios of sustainable future social structures (Bauwens, 2005; Kostakis & Bauwens, 2014). All these models mostly refer to decentralized communications where each participant is a peer, where the work is based on shared assets and outcomes, and agency and work are distributed over networks. It is this property of diffuse, distributed and decentralized networks the central structure to the nature of bottom-up phenomena such as Open and P2P systems; and they represent the broad framework we have to underst the formats of online mass-participation that have emerged in the past decades.

The relevance of Open, P2P and DDD systems with design discipline displays along two directions: 1) by embracing them in design practice, as collaborative and methodological tools at a local and global scale, or 2) by having them as objects of design, and applying design principles and creativity to their improvement and implementation. More recents examples of the first direction include Open Design cases (Abel et al., 2011; Ciuccarelli, 2008; Romano, 2015), which are especially linked to the emergence of the Distributed Manufacturing scenario (Bauwens, 2009) and of the Maker Movement (Anderson, 2012; Hatch, 2014): the collaboration around manufacturing technology is evolving around design projects developed collaboratively in a global community of Maker Laboratories - Fab Labs, Makerspaces, Hackerspaces and so on - that share traditional and digital manufacturing technologies (Abel et al., 2011; Anderson, 2012; Gershenfeld, 2005; Menichinelli, 2016).

On the second direction, design acts to enable and replicate such Open, P2P and DDD Systems through the analysis, visualization and implementation of their softwares, toolkits, platforms and collaborative processes and organization models. Examples as follow, cover the broad span of design outcomes: projects focusing on tools and components to support Open, P2P and DDD interactions such as OpenStructures (TEDx Talks, 2012), an open grid designed in order to facilitate the effective integration of several open projects into larger assemblies. As another case, P2P platforms have been designed to support interactions among participants - mostly in physical local contexts - and to offer comprehensive methodologies where the main design goal is to facilitate the emergence and growth of new network of participations (Cottam & Leadbeater, 2004). Custom online platform have been designed to build global community of designers that produce open projects, contributing this way to innovative but not-mainstream knowledge bases and organizational forms: a major example is OpenIDEO (Fuge & Agogino, 2014), the online platform (coupled with a toolkit) developed by IDEO for the development of solution to global scale social challenges. Further in this direction, other approaches have integrated open and p2p organizational forms feeding with the design practice in theOpen P2P Design framework (Menichinelli, 2006), and lastly introducing open and collaborative approaches to reflection and practice of meta-design in the Open Meta-Design framework (Menichinelli, 2015).

3. Open Meta-Design for the design of open processes and organizations

3.1 Meta-Design: an overview

The Design discipline adopts and learns from Open Source, P2P, DDD systems, it also builds and improves them, and designers can furthemore have a role in building environments for the collaborative design of open processes and their resulting organizations: we are particularly interested in reflecting and contributing to this cross-influence of Open Source, P2P, DDD systems and meta-design issues. In fact, in literature we found Meta-Design has been associated with many technologies which are now related with such systems - to mention: mass-customization, digital fabrication, generative design, open processes and the participation in online communities (Giaccardi, 2003). The technological variety has been crucial for the development of design processes and projects scaled and adequate to each community and their context.

Furthermore, Open Source, P2P, DDD systems and their integration with design bring new roles for both users and designers. The Design discipline has been discussing extensively about the integration of users in the design process, and elaborated many established approaches such as Participatory Design, User-Centered Design, User Experience Design and Co-Design (Rizzo, 2009). This literature offers many reflections about the meta-design practice. For example, Participatory Design implies a forecasting activity about how a design outcome will be used before it is designed, since this is also something that will be elaborate collectively through common design choices. Ehn (Ehn, 2008) identifies meta-design as a successful strategy to this design challenge, by considering it as a way to leave space for user participation in the design process even after the design concludes, suggesting the concept of 'design-after-design'. Also Fischer has valued the meta-design approach for its capacity to extend designed systems beyond their original nature, and because it includes the ongoing process in which stakeholders become co-designers. For Fischer, meta-design takes place not only at the time of design implementation, but throughout the whole existence of the system (Fischer & Scharff, 2000). According to Fischer, Meta-design characterizes objectives, techniques, and processes for creating new media and environments that allow the owners of problems to act as designers. Within this perspective on meta-design, the activity of designing is more about generating the seeds for the emergence of projects, rather than carefully and precisely planning all the features and specifications (Fischer, 2003). He speculates about Meta-Design being more elaborate than User-Centered Design and Participatory Design because it shifts the control of the design process from designers to the hands of the users, embedding the action of 'designing the design process'; he ultimately acknowledge that "*creating the technical and social conditions for broad* *participation in design activities is as important as creating the artifact itself*" (Fischer & Scharff, 2000), to the extent of elaborating a framework for understanding Meta-Design processes, known as "the Seeding, Evolutionary growth, Reseeding process model" (SER) (Fischer et al., 2009):

- Seeding: provide seeds that evolve over time through the small contributions of many people instead of complete systems.
- Evolutionary growth: a decentralized evolution of the seeds through use, exploration and extension by users.
- Reseeding: a deliberate, centralized effort to organize, formalize, and generalize solutions and artifacts created during evolutionary growth.

Being Meta-design a broad concept with different context of usage and understanding - extending from design to technology, society and biology - we here refers also especially to the broader overview offered by Giaccardi, who traces its roots, meanings and implications with a particular interest to creative industries (Giaccardi, 2003). Giaccardi considers Meta-Design an an emerging design culture more than an established design approach; it generates at the intersections of ICTs and Design, and to the extent, to Interaction Design and Net Art. The implications of "meta-" change the perspectives to designers from objects to process, from contents to structures; Giaccardi identifies three different declinations of Meta-Design, crossing etymological facts with extensive literature review: *meta-* as

- *behind* (or *designing design*): "Design of Design processes" / "Design of the generative principle of forms" / "Design of the Design tools";
- *with* (or *designing together*): "Design of media and environments that allow users to act as designers" / "Design of the organization of flows";
- *between/among* (or *designing the "in- between"*): "Designing the spaces of participation" / "Design of relational settings and affective bodies".

The focus on evolutionary environments brought by Fischer and the cultural value that Giaccardi refers to meta-design both imply that design projects are not acts of planning of features and procedures to be implemented; they are instead the (creative) configuration of possibilities that will emerge from opening the mechanism of participation and manipulation. Both of these approaches to meta-design practice value grandly the property of emergence, that we learn from complex system being the ability of the individual components of a large system to coordinate actions together, and rising diverse productive behaviors; emergence happens when this coordination arises spontaneously from simple interactions among the parts, and include to consider their effect on the environment. This inspiration from the emergence property of complex systems would require meta-design propositions to support the process of continual adaptation of the project organization within an ever-changing environment.

To say and favour that processes need to be emergent, however, is not to abandon all plans and structures, rather to make them open: an effective way to display complex processes is by focusing on creating effective opportunities for interaction. These rules ensure alignment among participants that increases the likelihood of emergent solutions leading to the intended goal, a phenomenon that is being studying as collective impact.

We contribute through this paper elaborating the Open Meta-Design framework, that provides a way for collaboratively design open, collaborative and distributed processes (including both the professional design domain and the amateur design domain), and that embraces this proposition of facilitating interactions and stimulate unplanned changes on the design environment. Implementing an open approach to meta-design strategies will more favourably generate design projects that can adapt and scale to each specific context, its constraints and requirements, and therefore will facilitate organizations to adapt the process of collaboration to their own configurations of actors, places and networks.

3.2 Tools for Process Design and Meta-Design

For the purpose of *the design of design processes*, Meta-Design has to adopt or create frameworks, tools, and methods, that allow to implement visualizations, analysis, modeling, managing, and controlling processes. Because of the aim of this paper to contribute a new framework outline for Open Meta-Design, and because of the interest in contextualizing the proposed framework among similar approaches, in this section we briefly cover the main existing frameworks in literature used to design processes, and compare them (see Table 1).

Family	Origin	Name	Focus	Understanding	Purpose
Engineering & Management	1910-1915	Gantt Chart	Time Dependencies	Intuitive	Planning Management
Engineering & Management	1921	Gilbreth's Process Chart / Flow Chart	Logic Tasks	Codified	Planning Management
Engineering & Management	1950s	Functional Flow Block Diagram (FFBD)	Logic Tasks Dependencies Time Network	Codified	Planning Management
Engineering & Management	1957	Program Evaluation and Review Technique (PERT)	Logic Time Time needed Tasks Dependencies Network	Codified	Planning Management
Engineering	1970s	Data Flow	Data	Intuitive	Planning

& Manage-ment		Diagram (DFD)	Flows		Management
Engineering & Manage-ment	2006 - ongoing	Business Process Model and Notation (BPMN)	Time Logic Data Tasks Flows Network	Codified	Planning Execution Control Standard Data format Prescription
Meta-Design	2005 - ongoing	Open P2P Design	Activities Flows Participation	Intuitive (Flows, partic-ipation) Codified (Ac-tivities)	Planning Visualization Communication Discussion
Meta-Design	2013 - ongoing	Open Meta-Design	Activities Flows Participation Data Time Network	Intuitive	Planning Visualization Analysis Democratization Communication Discussion Data format API

Table 1. Comparison of tools, frameworks and approaches for visualizing processes

The development of such frameworks emerged with scientific management, proceeded with large engineering and military efforts, then embraced also information and computing disciplines with the introduction of digital technologies, and recently focused on the standardization of data formats, visualization and execution tools (Henrink von Scheel et al., 2015: 2). Henry Laurence Gantt developed his meth-odology and the Gantt Chart while working for Frederick W. Taylor in the realization of major infrastructure projects. Frank B. Gilbreth was studying and documenting the movements associated with physical labor, and implemented Process Charts to reduce them and make the flow of the process more efficient. In 1947, the American Society of Mechanical Engineers (ASME) became the first organization to develop and establish an international standard of process symbols by extending Gilbreth's work. Functional Flow Block Diagrams (FFBD) were introduced in the 1950s to describe production environment as systems, by showing the sequential relations between all the functions. Later, the introduction of PERT methodology changed the use of timelines by adding the estimation of necessary times and possible delays. The Data Flow Diagram was instead introduced in order to enable the visualization of where information (data) is stored, and how inputs, outputs and flows of information are organized in the process among the tasks.

In the 2000s, the Business Process Model and Notation (BPMN) emerged as a standard for graphical notation by extending previous flowchart techniques, with the goal to ensure that BPMN models can be executable through a machine-readable XML data format. The standard and its specification are currently at the third draft (1.0 in 2004, 1.1 in 2008, and 2.0 in 2011). BPMN focuses on process and it is not therefore comprehensive; for example several authors note that it does not attempt to model organizations and strategic direction: for example, it does not cover the relation between organizational structures, including business competencies, capabilities, and resources to processes (Henrik von Scheel et al., 2015).

Through the decades, several framework have been developed with ontology more appropriated to processes, improved elements for its graphical notation, integrated softwares.

Despite the large case study value, most of these approaches from engineering and management domain mainly consider processes as business processes: "*a collection of tasks and activities (business operations and actions) consisting of employees, materials, machines, systems, and methods that are being structured in such way as to design, create, and deliver a product or a service to the consumer*" (Henrik von Scheel et al., 2015: 1); moreover, in such frameworks, graphical notation is much more than intuitive, and therefore they are mainly accessible only to stakeholders already trained or used to business settings. These might be relevant limitations for their adoption in Open and P2P systems, based on a potentially large participation of users with a different background and which which may not always be a driven by business relations and values.

A first attempt at building a bridge between meta-design and business process modeling has been done by Selim Erol, whose research focused on applying meta-design guidelines from Fischer (Fischer et al., 2009) to BPMN. Erol noticed that research on business processes has mainly focused on creating flexible process modeling techniques, and workflow management systems, rather than on the flexibility and openness of modeling environments, especially to enable end-user or diverse and unplanned stakeholders participation in modeling. Furthermore, typical process modeling follows a linear model limited to design-time, and where requirements are previously defined (Erol et al., 2010). He therefore developed and tested a flexible and open wiki-based BPMN meta-design modeling environment called xoProcessWiki (Erol, 2012): the environment proved to be very useful but at the same time it showed a strong need for instruction and facilitation during the modeling process, showing the limitation in large-scale adoption, and missing function of evaluation and assessments.

In the last decade, a more direct connection between meta-design and Open, P2P and DDD Systems has been investigated outside of the business domain by the two frameworks of Open P2P Design, and its derived Open Meta-Design: these frameworks are oriented to collaborative processes generated by communities and deployed within their social networks. The Open

P2P Design approach develops at the intersection between Service Design, Activity Theory, and Participatory Urbanism and focuses on communities and their open and p2p processes, meaning networks of activities with different levels of participation (Menichinelli, 2011, 2006). It is mainly based on open methodologies and toolkits for modeling processes, which are shared with the community the process is intended for. Open P2P Design have been experimented in a series of short workshops about Open Design and Distributed Manufacturing, where it proved to be promising but with limitations in the lack of the time dimension in the visualization, an overtly complex description of activities, and the difficulty in working with several unrelated visualizations. These workshops pointed to the need of a simpler approach, an unified visualization in a single image or poster, and on the need for a framework for evaluating the real-life processes generated from the documentation of the designed processes. These results led to its simplification into the Open Meta-Design framework (FAD Barcelona, 2013; Menichinelli, 2015).

The Open Meta-Design framework is linked to Activity-centered Design (Gay & Hembrooke, 2004; Kaptelinin & Nardi, 2009); it defines that platform where collaborative communities can act are more than online services, they are instead network-based architecture that support also online services by shared productive components within the social network of the participants, such as artifacts, rules and roles. Having activity as its core goal, Open Meta-Design aims to clear communication, to produce easy visualization, to offer integrated tool and data format and the versatility to more generic domain of application. Implementing Meta-Design principles and the properties of Open, P2P and DDD Systems for the facilitation of socio-technical communities can be useful to benefit their openness, adaptability to local conditions and emergent behaviors. Such approaches should be intuitive and not restricted to professionals only, should have a clear data strategy that enables tools, functionalities and data interchange, and should provide the function of development assessment.

We believe the Open Meta-Design will be promisingly explored with further research and practice; however it is still a very recent framework who is lacking complete formulation in current literature. For this reason, in the next section we contribute to elaborate its structure, which is based on:

1. A contextual description of Open Meta-Design within the life-cycle of projects and their organizations;
2. A data format that describes a process ontology, and it represents the basic layer for a tool for collaborative design;
3. A visualization format that renders the data format in an intuitive way;
4. A software layer which binds together data, visualization, graphical user interface and collaborative editing, being this one the interface of production.

4. Open Meta-Design: a proposal for a meta-design framework along four dimensions

4.1 The conceptual dimension of Open Meta-Design

The main concept of Open Meta-Design is that designers and stakeholders can work together as network of peers in defining the process and the methods of their collaborative activities. The meta-design component refer to the design of a tool that enables stakeholders to collaboratively design processes in online environment where they can discuss their participation. The open component focuses on the open source and p2p features of the relationships that are generated and of the projects that are developed. The roots of Open Meta-Design for both concepts and tools can be traced in the Open P2P Design framework along three directions:

- Cultural-historical Activity Theory (CHAT): a framework that focuses on studying work and organizations, analysed through the model of Activity System which enables a complex overview of the mediational structure of the activities, the contradictions within activities and among activities as critical issues but also potential paths for development, since activities incessantly reconstruct themselves (Engestrom, 1987). An activity-centered approach focuses also more on how tools mediate activities among multiple actors, and is therefore more apt to the meta-design of a process where multiple actors interact.
- Service Design: a design discipline dedicated to the planning of services between providers and customers with a focus on both immaterial interactions and flows among people, infrastructures, organizations, and on physical touch-points in space, artifacts, interfaces. The Service Design community has developed several tools useful to map the interactions and flows among people, spaces and artifacts (Alves & Nunes, 2013; Tassi, 2008) that can be adopted for Meta-Design. Furthermore, some approaches tried to adopt Activity Theory in Service Design as reference model for service evaluation thanks to its systemic, social and artefact-mediated conception of activity and are therefore promising for meta-design processes (Maffei & Sangiorgi, 2006; Sangiorgi, 2004).
- Studies on the structure and classification of participation: several researchers and practitioners pointed out that participation is not just a final goal, but also an intermediate tool for structuring design processes and that there are different levels of participation of stakeholders (Arnstein, 1969; Friedman & Miles, 2006; Hamdi & Goethert, 1997). Participation is not always uniform and tota: these approaches can be considered as a tool for shaping the amount and quality of participation in processes; the participation matrix is an example in this direction (Hamdi & Goethert, 1997).

These directions outline an implementation scenario of Open Meta-Design approach, compliant to the classification of meta-design from Giaccardi (Giaccardi):

- *behind* (or *designing design*): Open Meta-Design is a framework of design tools that generate the design of processes;
- *with* (or *designing together*): Open Meta-Design is a framework with an online environment and a data format that allow users to design the organization of flows;
- *between/among* (or *designing the "in-between"*): Open Meta-Design is a framework for collaboratively designing the organization of participation in processes through an open discussion.

Furthermore, the Open Meta-Design framework offers a new model for how phases of the project are organized over time (Figure 1). Any design process (intended as the development of human-made artifacts) undergo two basic stages: design time and use time. (Fischer 2009) (Figure 1, A). When a meta-design approach focuses only on design tools and processes, it tends to take place at the beginning of such generic processes, before design time (Figure 1, B). When a meta-design approach focuses on the development of an interactive environment, this approach last for all the life of a project since the environment sustains it (Figure 1, C). In the Open Meta-Design framework instead, the meta-design approach precedes all the other phases, and beside design time and use time it includes production (which is increasingly important in Open Design projects and in new initiatives with many non-professionals), distribution, and project life cycle, and possible future projects time that is the case when the project is open source.

The Open Meta-Design framework has been developed as a more general version of the Open P2P Design framework, making its application broader. As any framework, it cannot encompass all the complexity of socio-technical systems, therefore it is important to understand its limitations. The framework is thought for developing processes, but these are part of a larger system: when they are implemented, they generate social interactions and therefore social networks; these networks give place to organizations for the management of their social dimension; such organizations then bring governance structures and rules for the management of the system, and the governance influences the processes and their design (Figure 2).

The Open Meta-Design framework has then a specific and limited place in the life cycle of the social and organizational dimension of the projects it enables, and other approaches might be coupled to it in order to improve all the aspects of its life cycle: social network analysis for understanding the networks, visualization and other techniques for making the organization visible, conflict management for facilitating the governance. All these approaches can be implemented in Open Meta-Design platforms with time, extending the design of processes to a complete management of collaborative systems.

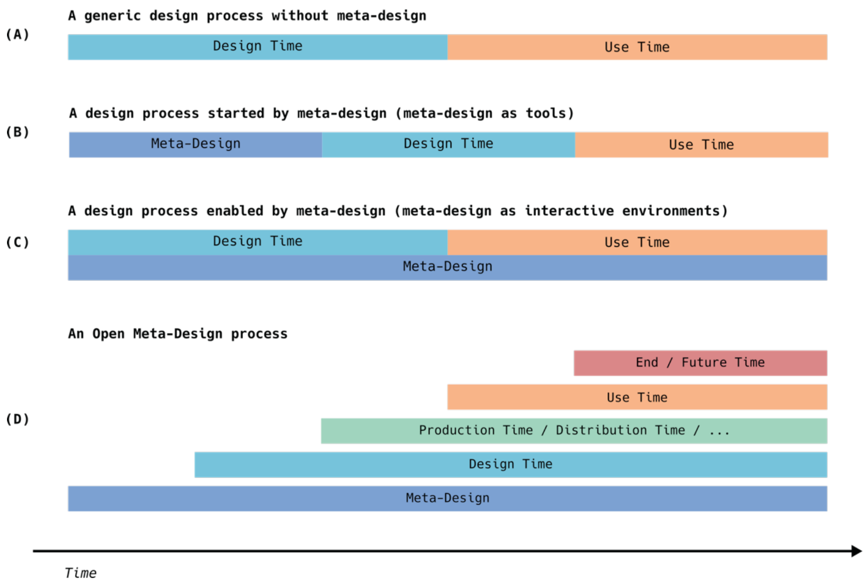

Figure 1. Time and activities in Open Meta-Design process compared to other conventional design processes

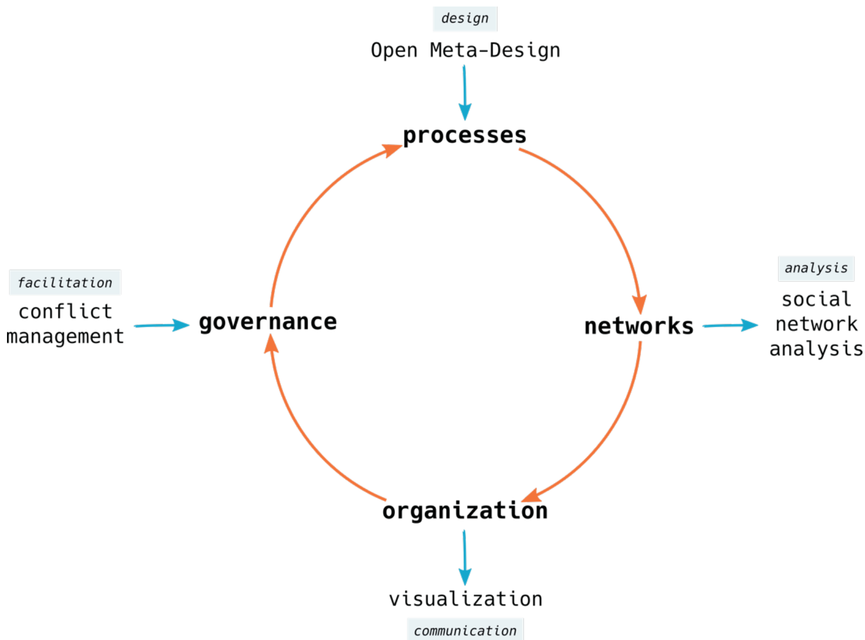

Figure 2. The role of Open Meta-Design in the life cycle of the social and organizational dimension of a project.

4.2 The data dimension of Open Meta-Design

A custom data format that store a specific process ontology is needed in order to enable the development of an interactive environment for design, discussion and sharing, The data dimension and the design dimension of the following section have been designed in parallel way with multiple feedback loops between them. In this case therefore, the ontology has been designed from the bottom-up, re-elaborating previous tools and experiences into a single tool, multiple sources of data into a single data format. The data is managed by a software dimension (section 4.4) that connects it to the design visualization and that manages its sharing, accessibility and export: for an online platform, the implementation of custom APIs can manage the access to the data through different file formats. For these reasons, the data ontology has been structured from the bottom-up starting with software code, from which a graphical representation in UML has been automatically generated (Figure 3). After this iterative design phase, the results point out how Location (online or offline) is the starting point of a process, from which Time Intervals, Persons and Activity Elements generate. Activity Elements constitute together Activities, which are linked by Flows into Processes and by Contradictions into a Discussions (based on single items called Issues to mirror the collective discussion in open source projects on platforms like GitHub) among the participants in the meta-design project. More Processes constitute an Open Meta-Design Project, which is shared through a License that governs its IP. Activities and the flows among them constitute processes, activities and contradictions among them and in them generate discussions, and discussions and processes constitute Open Meta-Design projects.

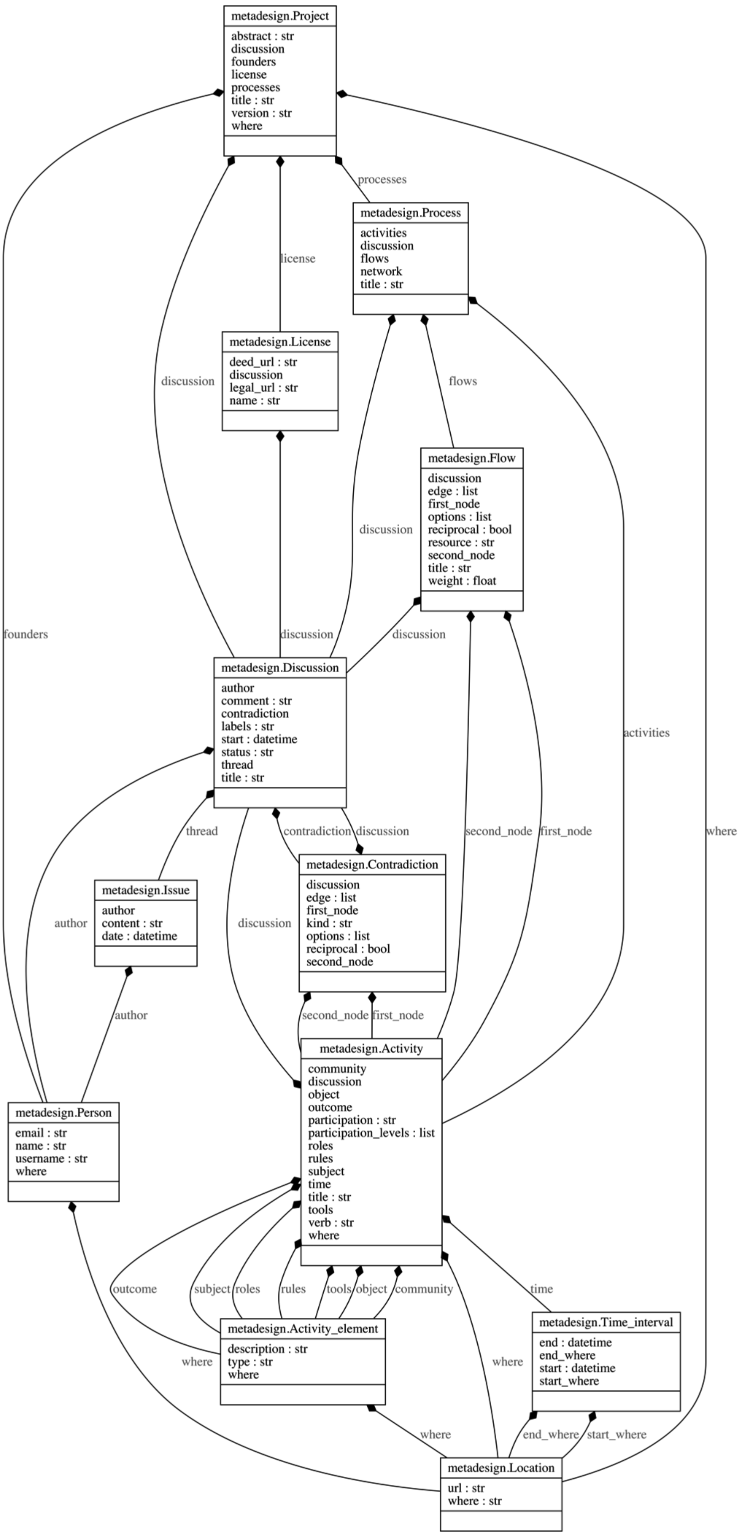

Figure 3. A preliminary UML visualization of the classes describing the datastructure of an Open Meta-Design project.

4.3 The design dimension of an Open Meta-Design tool

The first proposal of the design dimension of Open Meta-Design (Figure 4) has been developed during several iterations together with the data ontology, since they are interconnected: processes are visualized by the design dimension that renders the data and the data dimension describes the design of processes which are designed on the platform or environment. Furthermore, it integrates the various design tools tested within the Open P2P Design framework in one single visualization, and tries to simplify the more complex tools (Menichinelli, 2015). The workshops where the Open P2P Design framework was tested showed in fact that one single visualization would have been more understandable and easy to use, and that activities were too complex to be designed and analyzed with Activity Theory by untrained users. Furthermore, the time element was missing or poorly implemented. For these reasons, some of the tools adopted by Open P2P Design (System Map, Participation Matrix) are now integrated in one single visualization where time is represented and managed like in Gantt charts and where activities are represented in a textual way in order to make it easier for the users to understand them. The Activity System is a powerful framework for understanding and designing activities, but its visualization is not very useful to untrained users. Therefore, the Activity Systems are here represented as a short text scripts that explain their structure and help the users to edit them. Activities are then grouped by similarity in processes. The script analogy has been also adopted for the title and a short description of the main project at the top / beginning of the visualization. The use of the script metaphor could be useful then for obtaining a clear representation of complex and intangible activities, and it could also be useful for their data analysis. The text as an interface for complex systems, that could be analyzed and visualized later with a global overview of all the activities. Movies script have been adopted for data analysis and visualization several times; an interesting example can be found in the Star Wars movies, which have been at first depicted in a hand-drawn chart on the XCKD website (Munroe, 2009). The popularity of this visualization has lead data scientists and designers to develop software for automatizing the analysis and visualization of such scripts as processes (Franklin et al., 2015), but also for understanding their social networks (Gabasova, 2016, 2015) and activities and performance (Diamond et al., 2015). From a single script (or more shorter scripts) it is therefore possible to analyze and visualize complex processes and activities.

Contradictions and flows are instead represented as connections between different scripts or elements of the scripts, in order to show the systemic nature of processes generated by several activities. Furthermore, a preliminary study of a possible integration of the design dimension with a GUI for an online platform has led to the integration of elements for user interaction (the orange elements in Figure 4).

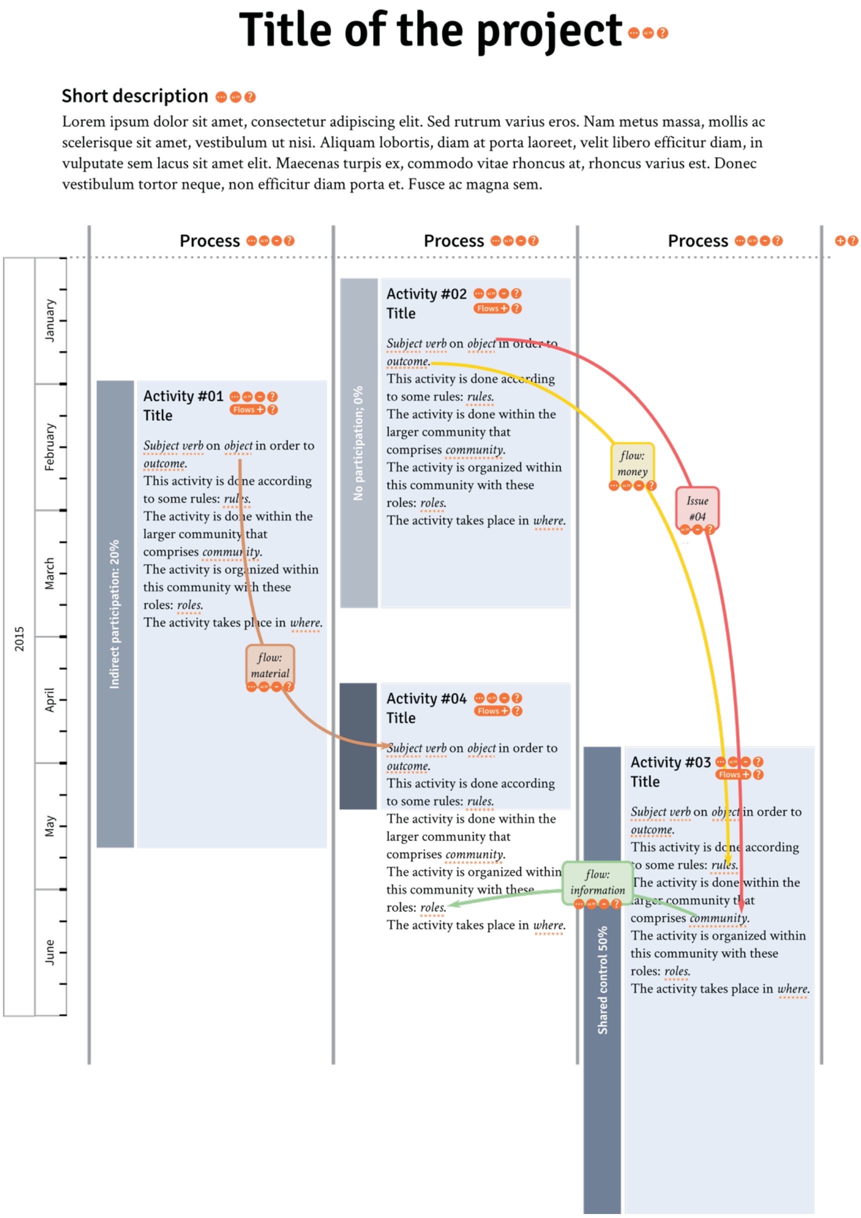

Figure 4. A proposal for an Open Meta-Design visualization tool and interface

4.4 The software dimension of an Open Meta-Design tool

The conceptual dimension clarifies the position of Open Meta-Design within design, analysis and meta-design approaches and within the life cycle of the organizations behind projects. The data dimension describes the ontology of projects as processes built from networks of activities. The design dimension renders the ontology and enables the users to understand it and design it. These dimensions could be implemented with analog tools like a paper toolkit as in the Business Model Canvas (Osterwalder & Pigneur, 2010), but we think that the complexity of socio-technical systems could be facilitated with more flexibility and scalability with digital platforms and data. In this direction, the software dimension of Open Meta-Design would represent the common layer that binds together the data, design and user interface dimensions. Such layer would enable the collaborative editing of processes by multiple users, the sharing and accessibility of projects, the interfacing and application of meta-design approaches to other platforms and therefore contexts as well. For example, the UML visualization of the data structure (Figure 4) was already automatically generated from software code. Such a dimension would require extensive development, but for the scope of this proposal we identify some design guidelines, following the example of Erol (Erol et al., 2010) that defined the guidelines for the xoProcessWiki platform according to Fischer's guidelines for meta-design environments and software systems (Fischer et al., 2009)(Table 2).

Meta-Design guidelines (Fischer et al., 2009)	Related key features to be implemented in software
1. Support Human-Problem Interaction	GUI for collaborative design Clear explanations or tours of the GUI and the visualization Open APIs and libraries for developers
2. Underdesign for Emergent Behavior	Empty or half-empty templates of projects
3. Enable Legitimate Peripheral Participation	Discussion with issues Analyse and visualize the contribution of participants Analyse and visualize the reputation obtained by participants
4. Share Control	Data export Open APIs Open source software and libraries
5. Promote Mutual Learning and Support	Discussion
6. Reward and Recognize Contributions	Document motivations in discussions Analyse and visualise contributions in the discussion
7. Foster Reflective Communities	Describe the background and expertise of each participant Foster the collaboration and sharing among participants with different background and expertise

Table 2. Key features of an Open Meta-Design software platform. Source: Fischer (2009)

5. Conclusions

The increasing complexity brought by globalization and by the quest for sustainability in society and the economy might find suitable approaches in the increasing involvement of all stakeholders in the design processes and in the management of such processes. Open, P2P and DDD Systems could represent a promising direction for enabling the participation of a potentially large pool of distributed users in design processes. These systems however brings also new organizational forms and new principles and practices, making their design not a straightforward task. Stakeholders could be therefore involved in the definition of such systems and of their processes, and meta-design approaches could be useful for enabling designers to have a role in the definition and management of such systems and processes. Existing frameworks and tools for designing, managing or meta-designing processes are complex to use for non-professionals or incomplete: for this reason we propose the Open Meta-Design framework in this article. The framework represents a bridge between design, meta-design, social sciences, computer science. Compared to previous frameworks like Open P2P Design, this framework provides a more structured approach, based on the modeling, analysis, management and visualization of open, collaborative and distributed processes. This framework is based four dimensions: concept (describing the philosophy, context and limitations of the approach), data (describing the ontology of design processes), design (visualizing designing processes) and software (managing the connections between the ontology and the visualization, the data and design dimensions). Such approach and framework could potentially lower the barriers to the participation in the design and discussion of open, collaborative and distributed processes, enabling therefore mass-scale interactions and a new role for designers, based on an augmented awareness of the possibilities of design processes and organizations.

The proposal is still preliminary, and a complete implementation and testing is needed in order to understand its viability. More dimensions, domains, features or tools could be added but this direction requires a careful consideration in order to balance the trade-off between ease of use and complexity. Since most of the process design frameworks focused only on business processes, the current proposal does not include a business dimension. This could be a critical limitation, given the fact that even collaborative processes needs to reach a sustainability in order to proceed with their activities. Furthermore, a final implementation in an online platform for example, could show more critical issues and missing elements. As a conclusion, we suggest a roadmap for developing and testing the Open Meta-Design framework, and therefore evaluating its relevance in supporting complex projects. The conceptual dimension of the framework represented in Figure 4 could represent not only a way for understanding its limitations, but also a way for testing it and developing it further. For this reason, we suggest that the impact of such framework could be analyzed along the dimensions of networks, organization and governance. However, the conceptual dimension could need further refinement in order to constitute a complete evaluation framework for the testing of Open Meta-Design. The next steps in this direction could be: 1) implement and refine the framework within an online platform; 2) test the platform: the adoption of the same or similar context of the testing of the Open P2P Design framework could provide a useful reference; 3) dissemination of results, tools and documentation for the replication and diffusion of the framework through its platforms or similarly related platforms.

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5. ART. 5

Menichinelli, Massimo. 2018. 'A Shared Data Format for Describing Collaborative Design Processes'. In *Cumulus Conference Proceedings Paris 2018 – To Get There: Designing Together*, Cumulus Conference Proceedings Series 03/2018 Paris:190–215. Cumulus. https://www.cumulusassociation.org/cumulus-conference-proceedings-paris-2018-to-get-there-designing-together/.

A shared data format for describing collaborative design processes

Massimo Menichinelli

Aalto University, School of Art, Design and Architecture, Department of Media, Media Lab Helsinki

massimo.menichinelli@aalto.fi

Abstract

The design research and practice have recently been investigating how to have an active role in enabling collaborative and distributed systems through the analysis, visualization and design of their collaborative tools, platforms, processes and organizations. By adopting a meta-design perspective, new possibilities have emerged for designers to be active agents in the organization and management of collaborative and distributed processes, especially design ones. This paper presents a data format for describing collaborative design processes, building on existing literature and cases and encoded in the development of an experimental digital platform for the co-design of collaborative processes. This data format is a key component of a framework for modelling, analysis, management and visualization of design processes and such a framework could potentially facilitate the design, understanding, management and participation in open, collaborative and distributed processes.

One research question is the basis of this paper: how can be collaborative design processes documented, analysed, managed, shared? This paper aims at bringing a contribution to these questions focusing specifically on a design process ontology encoded in a data format and software. The paper focuses on the context of Indie Designers and the Maker Movement, and provides a) an overview of the existing approaches to documenting design projects and processes, b) a proposal of an ontology and data format for describing collaborative design processes and d) directions for future research, especially in the validation of the proposal.

Theme

Language

Keywords

data, process, collaboration, organization, meta-design

1. Introduction

In the recent decades ICT technologies have shaped new ways of working, participating, and assessing projects, which in turn have contributed to shaping these technologies. The introduction of ICT technologies, from desktop software to digital online platforms, have had an impact on design not just for few activities like 2D or 3D modelling, but also on all the activities and actors of the design ecosystem (discussion, research, manufacturing, distribution, ...) and not just in terms of tools, but also in terms of approaches, business models, trends, processes. For example, the boundaries between amateur and professional designers have been blurring (Atkinson, 2010; Gerritzen & Lovink, 2010; Manzini, 2015), especially regarding design and production especially with the emergence of the Maker Movement (Anderson, 2012; Gershenfeld, 2005; Hatch, 2014) but also of Indie Designers, professional designers producing their projects independently (Bianchini & Maffei, 2012, 2013); these two phenomena represents the context explored in this paper. Online platforms and practices have generated initiatives with new modalities of interaction and management of intellectual properties in design processes that mix Design with Crowdsourcing dynamics (Howard, Achiche, Özkil, & McAloone, 2012; Howe, 2006; Nickerson, Sakamoto, & Yu, 2011) or with Open Source and P2P dynamics (Abel, Evers, Klaassen, & Troxler, 2011; Bauwens, 2009; Ciuccarelli, 2008; Cruickshank, 2014; Menichinelli, 2016). Thanks to the introduction of software and programming languages like Processing (Reas & Fry, 2014), designers and architects are increasingly shifting their focus from designing artifacts with the help of a software, to writing a software that directly generates artifacts, often with genetic and evolutionary algorithms (Shiffman, Fry, & Marsh, 2012), with a Generative Design approach (Bohnacker, Gross, & Laub, 2012; Reas & McWilliams, 2010).

Consequently, the Design discipline has changed in several ways, for example by increasingly moving its scope from single users to local and online communities, from isolated projects to complex system of solutions, while investigating tools and strategies that enable and understand both complex artifacts and mass-scale interactions. Not only practitioners, but also researchers have started investigating these directions, for example a) with a focus on localities and their traditions, production systems and communities (Maffei & Villari, 2006; Verwijnen & Karkku, 2004; Villari, 2013), or b) with a focus on social innovations, especially developed by citizens and informal designers (Manzini, 2015; Meroni, 2007), or c) with a focus on how ICT technologies enable new modelling techniques (Menges & Ahlquist, 2011; Poole & Shvartzberg, 2015; Singh & Gu, 2012) or d) enable the organization of collaborative initiatives (Menichinelli, 2016). Broadly speaking, one of the common elements among these trends and phenomena is the new understanding of designers as facilitators and organizers of socio-technical systems made of creative and productive agents. Designers are seen as having more focus on creating the contexts for complex and multi-agent and multi-stakeholder design processes, rather than directly designing artifacts themselves, and this perspective falls into the domain of the Meta-Design perspective.

More specifically, this paper focuses on how, being transformed in all its activities, the Design discipline has also been investigating how to have an active role in shaping these transformations by focusing on enabling collaborative and distributed systems through the analysis, visualization and design of their collaborative tools, platforms, processes and organizations. By adopting a Meta-Design perspective, new possibilities have emerged for designers to be active agents in the organization and management of collaborative and distributed processes, especially design ones. This perspective works in several directions regarding collaborative processes and organizations, and this paper focuses specifically on its data dimension and on its related software dimension. This paper explores how the description of a process could be encoded into data and thus documented, shared and executed. The focus is not or not only on applying data science to design processes, but rather to understand the datafication and digitalization of the design practice and how to improve them by empowering designers in managing them. By adopting a Meta-Design perspective, after 2D and 3D modelling, designers will increasingly focus also on modelling processes and organizations through data science and software development.

This paper presents a shared data format for describing collaborative design processes, building on existing literature and cases and the development of an experimental digital platform for the co-design of collaborative processes. This data format is a key component of a framework for modelling, analysis, management and visualization of design processes and based on four interconnected dimensions: conceptual, data, design, software. Such a framework could potentially facilitate the design, understanding, management and participation in open, collaborative and distributed processes. Furthermore, this investigation might advance our understanding our knowledge of the relations among data and design, as a possible new language and tool for working with processes and organizations. One main research question (RQ1) is the basis of this paper, to which two subsidiary research questions might be added in order to proceed with a more complete approach:

1. RQ1: How can be collaborative design processes documented, analyzed, managed, shared?
2. RQ2: How collaborative design processes have been documented and defined with a common language so far?
3. RQ3: How could we improve the documentation of collaborative design processes with a shared data format as a common language?

In order to support RQ1, RQ2 focuses on the theoretical background and the existing approaches, RQ3 focuses more on the development of a potential meta-design platform and on the strategies for its validation. This approach is developed in the paper with this structure:

1. *Introduction:* this section introduces the context, the overall scope of the paper, its research questions and structure.
2. *Describing (design) processes:* this section proposes an overview of the possibilities regarding the documentation of design processes for the Indie Designers and Maker Movement context with the use of data formats as shared languages. This section addresses RQ2.
3. *A shared data format for describing collaborative design processes:* this section elaborates a proposal of a data format and a related meta-design digital platform that documents collaborative design processes. This proposal is the result of a the previous section and of a process of software prototyping. This section addresses RQ3.
4. *Validation and future research:* this section proposes validation strategies for the data format and related digital platform presented in the previous section and proposes further research questions to be addressed in future research. This section addresses RQ3.
5. *Conclusions:* this section resumes how each of the previous sections has replied to the three research questions (RQ1-RQ2-RQ3) proposed in the first section.

2. Describing (design) processes

How collaborative design processes have been documented and defined with a common language so far (RQ2)? This section provides an overview of the possibilities, especially with a focus on the context of makers and independent designers. Within design research, design processes have been examined considering *design as the work done by designers,* studying thus the actual practice. For example, Cross (2006) elaborated that there is a distinct '*designerly*' form of activity and ways of knowing different from the scientific tradition, and he identified three sources of design knowledge for studying this: people, processes and product. According to him designers learn and adopt a language that connects and translate between different domains (needs and design, meaning and design, and so on) by means of a system of codes, and these embodies the '*designerly ways of knowing*'. However, he points out that typically the knowledge and awareness that designers have of their practice is basically tacit, making it thus difficult to elaborate, document and share with the consequence that design education is generally based on an apprenticeship system of learning. In their analysis of existing literature about design processes and a proposal of a design process ontology, Green, Southee and Boult (2014) point out that research on design processes has a relatively short history, where models are highly edited and rationalized abstractions of reality but disconnected from the actual practice and with limited consensus on their structure. Even within the design practice, the recently popular phenomenon of design thinking consultancies is highly criticized also for the simplistic perspective, the extreme generalization and poor consideration of design processes (Vinsel, 2017).

The previous section highlighted the importance of the Meta-Design perspective, that considers designers as having more focus on creating the contexts for complex and multi-agent and multi-stakeholder design processes, rather than directly designing artifacts themselves. For example, Ehn (Ehn, 2008) considers it as a way to leave space for user participation in the design process even after the design concludes, suggesting the concept of '*design-after-design*'. Also Fischer has valued such approach for its capacity to extend designed systems beyond their original nature, and because it includes the ongoing process in which stakeholders become co-designers, but taking place not only at the time of design implementation, but throughout the whole existence of the system (Fischer, 2003; Fischer & Scharff, 2000). According to Fischer, Meta-design characterises objectives, techniques, and processes for creating new media and environments that allow the owners of problems to act as designers. Furthermore, he considers Meta-Design being as more elaborate than User-Centered Design and Participatory Design because it shifts the control of the design process from designers to the hands of the users, embedding the action of '*designing the design process*'. Giaccardi considers Meta-Design more as an emerging design culture than an established design approach, and after crossing etymological facts with extensive literature review (Giaccardi, 2003), she identified three different declinations of Meta-Design, with meta- considered as:

- *'behind'* (or *'designing design'*): "Design of Design processes" / "Design of the generative principle of forms" / "Design of the Design tools";
- *'with'* (or '*designing together*'): "Design of media and environments that allow users to act as designers" / "Design of the organization of flows";

- *'between/among'* (or '*designing the "in- between"*'): "Designing the spaces of participation" / "Design of relational settings and affective bodies".

Rather than studying existing processes, the Meta-Design approach focuses often on designing environments and tools for facilitating the emergence of design processes, and therefore it is a promising approach for improving professional, independent and amateur designers in their practice. For this reason, this section proposes a brief overview of the practice of analyzing, documenting, sharing and designing processes in the Indie Design and Maker Movement. The practice of Makers has been analysed and shared by both researchers (Toombs, Bardzell, & Bardzell, 2014), practitioners (Lang, 2013) and researchers-practitioners (Gershenfeld, 2005); in the case of this article, the author has worked both as a researcher and as practitioner, reflecting thus here on the practice of documenting design processes in all their possibilities as experienced during the previous years. Documenting and sharing projects with an Open Source approach is a common practice in the Maker Movement (Menichinelli, Bianchini, Carosi, & Maffei, 2017; Troxler, 2011), and for this reason the issue of documenting how to design and produce a project among different individuals, groups and locations is a relevant one for this context, and several options are possible. For example, design processes can be documented as step by step instructions (Instructables[1], Fablabs.io[2]), or files ready for manufacturing are documented (Thingiverse[3]), or can even be automatized through custom software that control the API of cloud manufacturing services (Shapeways API[4]) or can be analyzed and rebuilt from files and users' activity on online platforms like GitHub and Google Drive (Menichinelli, 2017; Velis & Robles, 2017). These are less common approaches, with a focus on processes and the immaterial aspects of projects, more common approaches are still the ones that document artifacts, be them existing or to be produced (Table 1). In the Indie Design and Maker Movement, the task of documenting design processes can take place in different ways of design documentation (DD), depending on how design is considered:

1. DD1: design as *a process* ("i.e. step by step instructions");
2. DD2: design as *an organization* ("i.e. networks of interactions, work organization");
3. DD3: design as *a documentation* ("i.e. blueprints");
4. DD4: design as *production* ("i.e. files ready for direct fabrication");
5. DD5: design as *an artifact* ("the artifact and its description").

[1] http://www.instructables.com/
[2] https://www.fablabs.io/projects
[3] https://www.thingiverse.com/
[4] http://developers.shapeways.com/

Perspectives	DD1: Design as *a process*	DD2: Design as *an organization*	DD3: Design as *a documentation*	DD4: Design as *a production*	DD5: Design as *an artifact*
Dimension	Meta-Design	Meta-Design	Design	Design	Design
Focus	Process	Process	Artefact	Process	Artefact
Examples	Instructables Fablabs.io …	Rebuilt from files and users' activity on online platforms …	Blueprints Sketches …	Thingiverse Shapeways API GitHub …	Pictures Videos 3D scan …
Data	API, databases	API, databases	2D / 3D data representing an artifact not yet produced	API, databases	2D / 3D data representing an existing artifact
Process as	Execution of activities	Dialogue	Execution of the documentation	Execution of activities	Outcome of an execution of activities and dialogues

Table 3. Design Documentation typologies

A common element of these main approaches for documenting design projects and processes is the pervasive presence of the digital and data dimension, and how these two dimensions have been applied to several aspects of the practice. DD1 and DD2 can be categorized as Meta-Design since they both represent and enables the development of individual and collective work in design processes, while DD3, DD4 and DD5 as Design since they represent a design project and its output or transformation into the final output (Figure 1). While only DD2 focuses on processes as generally considered (i.e. a sequence of steps depicting how to replicate a process), all of these perspectives are important for the Maker practice and therefore for applying a Meta-Design approach to it because:

- they represent all aspects of design processes in the practice, and therefore can be integrated in order to further understand them with a more complex perspective;
- they represent building blocks for Meta-Design tools and environments, and could be recombined and integrated in order to further support collaborative design processes with a more complex offer.

As a consequence of this, a *Design Documentation Score* (DDS) could be calculated for Meta-Design environments based on this framework, ranging from 0 to 5 depending on the number of Design Documentation perspectives a meta-design platform includes. Rather than providing a judgement about a platform, this score could provide an indication of the complexity of approach and possibilities that a platform adopts and provides to its users. Furthermore, it should be note how these five perspectives could be broadly clustered into three main approaches for documenting design processes, whether they are explicitly designed and documented or analysed and rebuilt from the practice:

1. ADD1: processes are considered *as the execution of activities*;
2. ADD2: processes are considered *as a dialogue between actors*;
3. ADD3: processes are reconstructed *from the reverse engineering of artifacts and documents*.

Encoding and visualization are common actions for these three approaches, representing the translation between machine-readable data to human-readable representations, for both existing processes and projects and for future ones (Figure 2). These three approaches can also be found in the research and practice of designing and analysing processes outside the Design discipline. For example, the ADD1 approach is similar to most of the approaches from engineering and management domain that mainly consider processes as business processes: "*a collection of tasks and activities (business operations and actions) consisting of employees, materials, machines, systems, and methods that are being structured in such way as to design, create, and deliver a product or a service to the consumer*" (Scheel, Rosing, Fonseca, & Foldager, 2015, p. 1). Examples of this are the Business Process Model and Notation (BPMN), a standard for graphical notation that extends flowchart techniques through models that can be executed through a machine-readable XML data format (Scheel et al., 2015), and Process Mining, the analysis of existing processes from the log of their activities (van der Aalst, 2011). In design research, this direction has already been adopted by few researchers that reconstruct processes from files, logs and databases of design projects (Menichinelli, 2017; Velis & Robles, 2017).

The ADD2 approach is similar to several initiatives that work on the analysis, visualization and design of narrative texts. For example, researchers have been able to identify the most common processes of storytelling by analysing the emotional trajectory of novels (Reagan, Mitchell, Kiley, Danforth, & Dodds, 2016), or in some cases software facilitates the writing of scripts while also visualizing its dynamics, characters, emotional arcs (Story Touch, n.d.) or translates scripts into comic strips (KesieV, 2011) (see Figures 3, and 5 for an example application). Scripts (i.e. just the dialogues of a plot) have been particularly popular in analyses that are able to uncover their hidden social dynamics: an interesting example can be found in the Star Wars movies, which have been analysed and visualized in several different ways and methods, proving how the same data source (the script) could be a rich document for understanding processes with different perspectives. One of the first examples of visualizing the storyline of Star Wars can be found in a hand-drawn chart on the XCKD website (Munroe, 2009); the popularity of this visualization has lead data scientists and designers to develop software for automatizing the analysis and visualization of such scripts as processes (Franklin, Elvery, & Spraggon, 2015), but also for understanding their social networks

(Gabasova, 2015, 2016) and activities and performance (Diamond, Glassman, Illick, & Whiteaker, 2015). The Star Wars storyline was also elaborated in hand-drawn illustration in the Cinemaps book by DeGraff (DeGraff & Jameson, 2017), where the process is depicted together with the locations where it takes place. In design research, this direction has already been adopted by several researchers that reconstruct processes from verbal data through protocol analysis in order to study cognitive processes, with both quantitative and qualitative approaches (Goldschmidt, 2014; Kan, 2017).

The ADD3 approach may be the more informal, less structured and researched but more adopted by makers, consisting in reconstructing how to design and make an artifact from the artifact itself. This task could be simplified by digitalization technologies like 3D scanning, but while these techniques can convey a documentation that can be manufactured, the identification of more complex processes is a harder task.

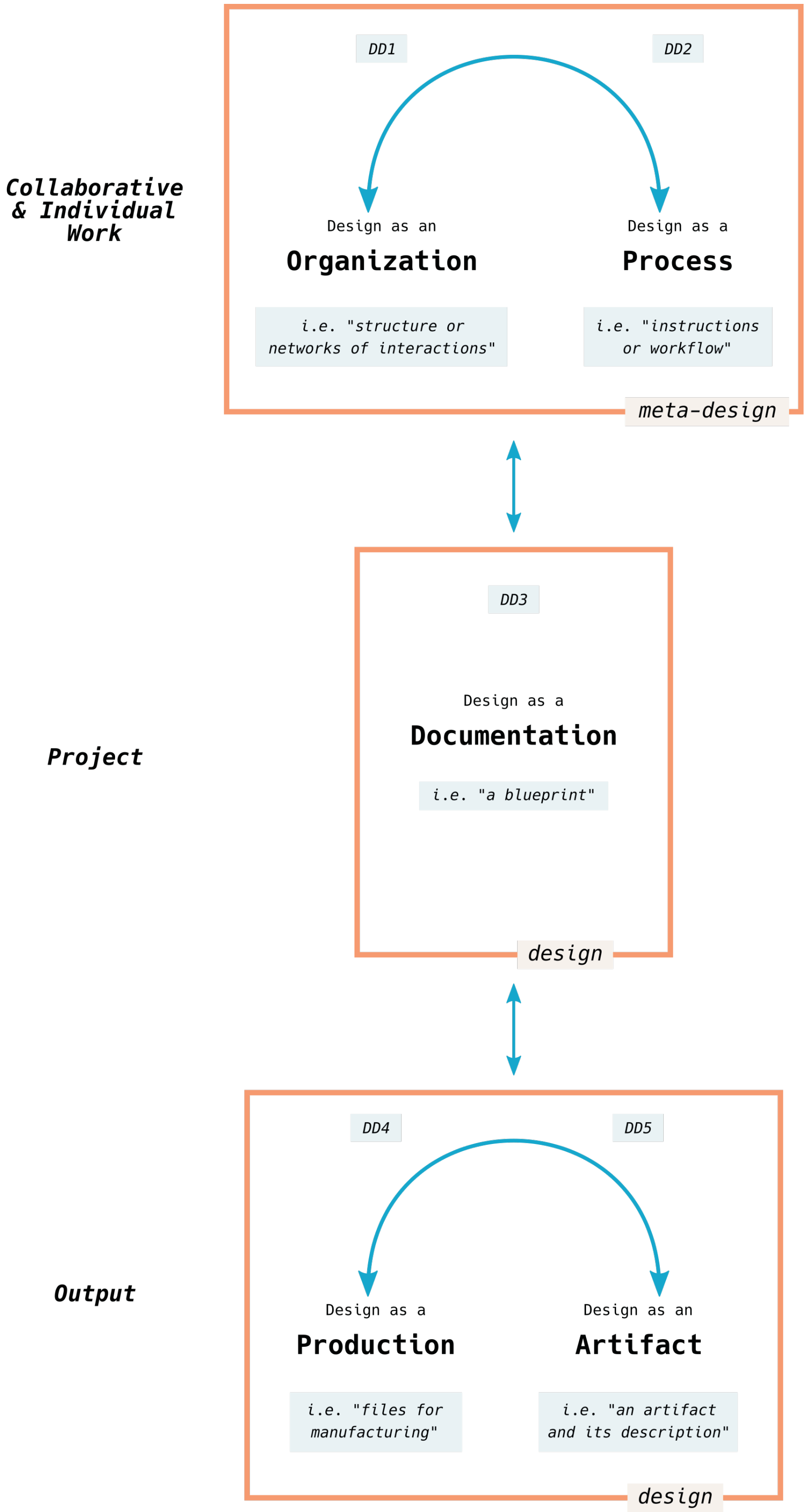

Figure 1. Design Documentation typologies

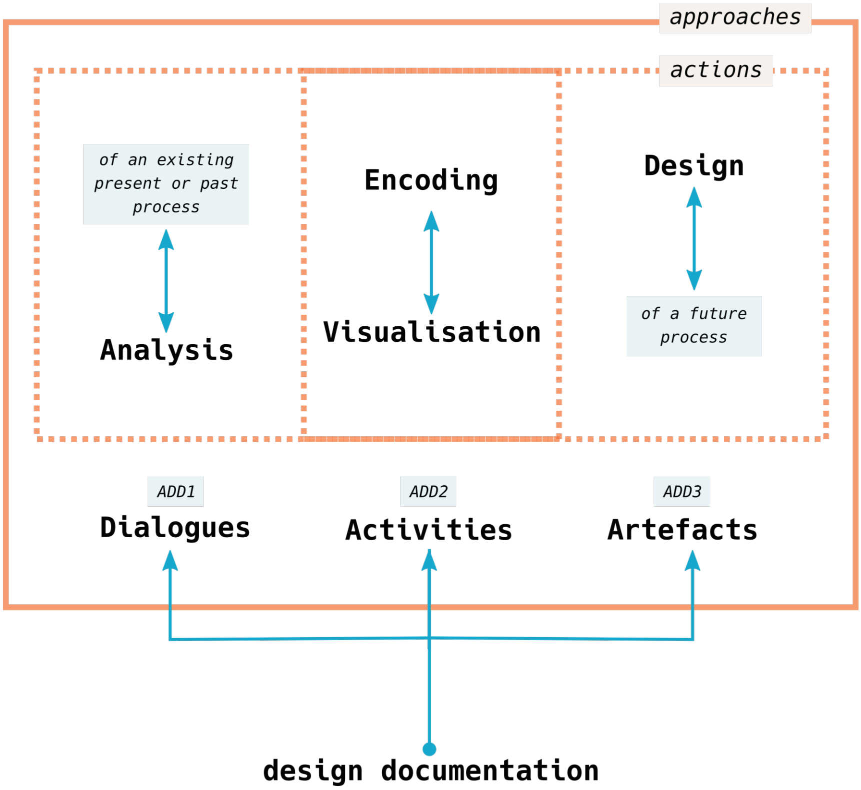

Figure 2. Design Documentation approaches and their actions

3. A shared data format for describing collaborative design processes

The previous section provided an overview of existing practices in the Maker Movement regarding the documentation of design projects and processes, and this section proposes a data format as a common language for improving these practices while learning from them (RQ3). The main starting point for the development of the data format is to consider its ontology, "*a set of concepts and categories in a subject area or domain that shows their properties and the relations between them*" (Oxford Dictionaries, 2018), a terminological framework that describes thus design processes. The research done by Green, Southee and Boult has shown how an ontology of design processes is still an open issue, an iterative process with many possible solutions (Green et al., 2014) but a very important one, especially for design protocol analysis (Kan, 2017). They consider design processes as the foundational framework for exploring where value is added through design, adopting an *input-process-output* (IPO) model: in this way, analyzing the output could provide a measurement of the impact of the process, and comparing output and input could provide a measurement of the efficiency of the process and of the value obtained from it. This section proposes to focus on the approach of processes *as a set of activities* (ADD1) as the main perspective for the ontology encoded in the data format, while also adding (but elaborating to a less extent) also the possibility of considering processes *as a dialogue* (ADD2). As a consequence, this article propose to adopt Activity Theory as the conceptual basis for the ontology of the data format, since it is a framework for orienting researchers in understanding complex socio-technical phenomena and, especially in the version elaborated by Engeström (1987), it provides a way for understanding the dialectic contradictions and continuous development of individual contributions to collaborative initiatives taking into consideration all the elements that mediate all the activities and their contexts. Activity Theory has an established tradition of being adopted in the Design discipline, for example by Human Computer Interaction research and practice since the 1980s' in several directions (Kaptelinin & Nardi, 2012, 2009), for example in order to improve the theoretical background of Human Computer Interaction or as a potential strategy that evolves from Human-Centered Design (Norman, 2005). Furthermore, Activity Theory has already been directly applied to collaborative design processes by researchers that analysed the design practice in collaborative settings in order to understand teams' interactions and relative collaborative evolution and its dynamics (Zahedi, Tessier, & Hawey, 2017) and also in the design of communities (Barab, Schatz, & Scheckler, 2004). Activity Theory thus provides the concepts for framing, understanding and designing processes, and together with the Meta-Design approach (Fischer & Scharff, 2000) its adoption would be a promising strategy along three main scenarios:

1. S1: for providing a well established ontology of activities, which can be integrated with other elements (Figure 3);
2. S2: for the generation of guidelines for the development of the digital platforms that enable the former point; the importance of a platform here lays in its abilities to enable the participation of more users (Figure 4);
3. S3: for enabling both professional designers and untrained users to work together in collaborative design processes thanks to the conscious and reflexive design of the activities constituting such collaborative design processes (Figure 5).

These three scenarios can be visualized with three simple storyboards of figures 3, 4 and 5, generated with generated with the ScriptThis! Software (KesieV 2011) that visualizes scripts as comics[5].

[5] The scripts can be found at: https://gist.github.com/openp2pdesign/2507e63079da27100f22e673903ab731

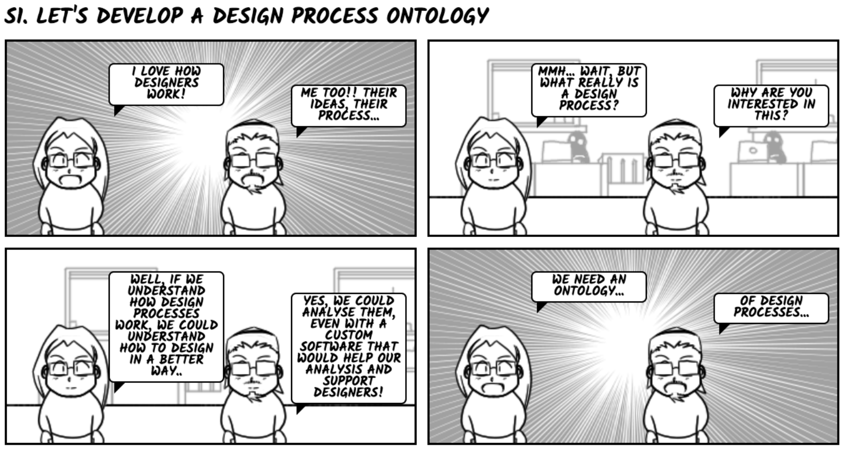

Figure 3. Storyboard example for S1, generated with the ScriptThis! software

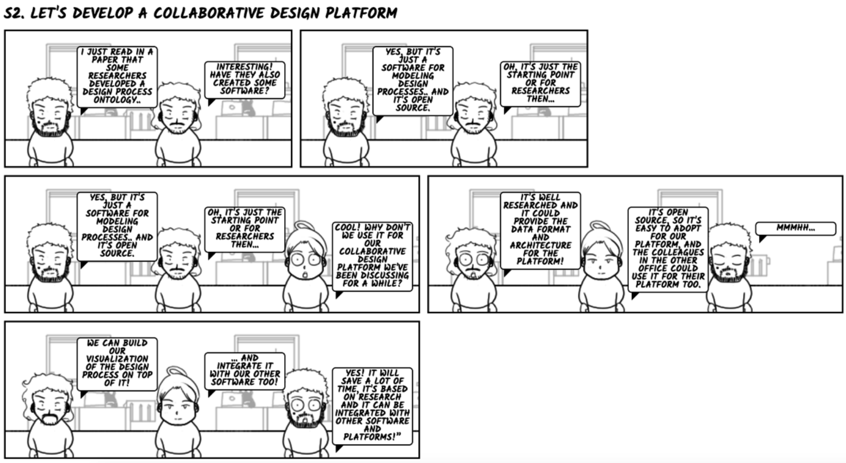

Figure 4. Storyboard example for S2, generated with the ScriptThis! software

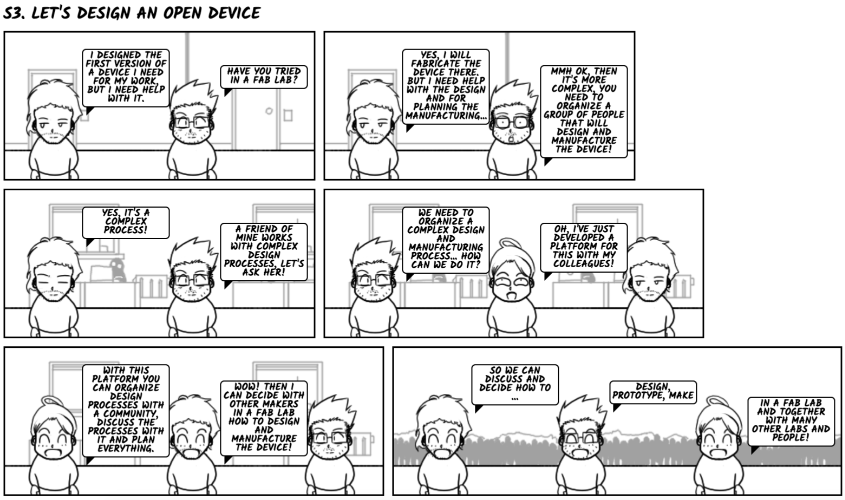

Figure 5. Storyboard example for S1, generated with the ScriptThis! software

The data format would then encode the ontology describing the activities of design processes, and if dialogues between the participants of such processes are included in the data format, also further approaches like protocol analysis (Goldschmidt, 2014; Kan, 2017) or natural language processing (Crowston, Allen, & Heckman, 2012) could be then applied to the same data. It is important to consider here that while the data format could be already considered alone as a shared language (provided that its description and guidelines of usage are shared openly), it is of little use if not for developers or researchers, and should be then embedded into a software that would enable anybody to edit and visualize the data in an intuitive way, and in a collaborative way since the purpose of documenting and sharing collaborative design processes is to improve their dimension of collaboration. Such software could take several shapes and this article suggests to focus on developing a platform for it, thanks to its ability to connect multiple users. Such a platform would then be based on three dimensions:

- **a.** Data (the data format);
- **b.** Design (the intuitive visualization of the data format);
- **c.** Software (the agent that binds the data format, the visualization and the interactions users have with it and among them).

The platform is then built on a conceptual framework that includes Activity Theory (Figure 6).

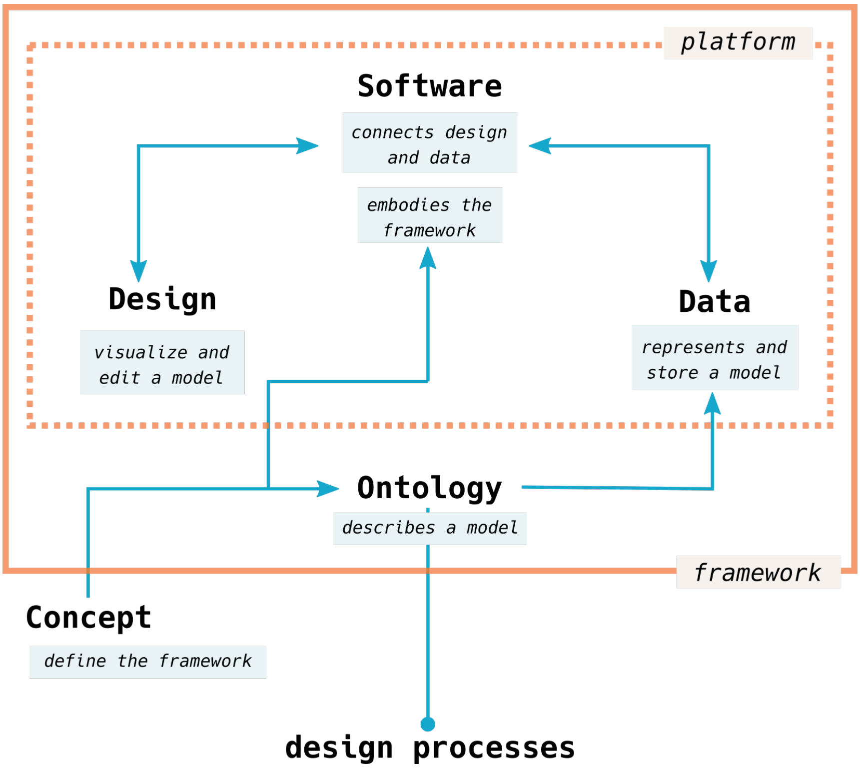

Figure 6. The framework of the Meta-Design approach presented.

The data format here proposed has been developed through a software-based prototyping of the platform, i.e. the data format has been developed in parallel with the software and the visualization, and it is already at the second iteration after a first version was briefly discussed in a conference paper (Menichinelli & Valsecchi, 2016). The importance of this approach lays in providing a context for reflection for the researcher (as reflective practitioner), for thinking about the ontology with a research-through-design approach instead of drafting the ontology from theoretical contributions without a connection to the practice. The data format and its ontology are in fact encoded in the software that handles the visualization and the users interactions, and the practice of development and research has contributed to inform it[6]. The main entities of the ontology in the current version of the software code that encode the data format are:

- *Location*: a geographical location that describes *where* activities and processes take place.
- *Time Interval:* a time dimension describing *when* activities and processes take place, with a beginning and an end.

[6] https://github.com/openp2pdesign/openmetadesign

- *Activity Element:* the individual element part of an Activity System that describes an *activity*, according to Activity Theory (subject, object, outcome, tools, community, rules, division of labour).
- *Activity*: an Activity System describing an *activity*.
- *Contradiction:* a conflict between *elements of activities* and *activities*, according to Activity Theory; a contradiction enables the *discussion* and understanding of critical elements of *activities* that will evolve in the future.
- *Flow*: a flow of information, physical resources or financial resources between *activities*.
- *Process*: a collection of *activities* of one *project*.
- *Discussion*: a *dialogue* between the users of the platform that can discuss the specific element (a discussion is connected to several element of the data format, see figures 7 and 8).
- *Separator*: an element separating *processes*, with the ability to then add meaning to their separations and order.
- *Version:* an element tracking the history of the *project* by storing all its changes done by users of the platform.
- *User:* a list of the users that discussed the *project*.
- *License:* a Creative Commons license that legally describes how the *project* can be shared.
- *Project:* the main project all the *users* collaboratively discuss in the platform, and that embeds all the previous elements.

As in the cases of text analyses and visualization of the previous section, the architecture and ontology software code can be automatically visualized and reconstructed, especially with UML diagrams (at the same time, software code can be automatically generated from UML diagram). The ontology of the data format here presented is visualized in figure 7 with an UML diagram and in figure 8 with a graph diagram: the UML diagram shows the classes of the data (structured following an object-oriented approach at programming) and their connections, the graph diagram represents a network perspective of them. The UML diagram presented in figure 7 was automatically generated from the software code describing the data format[7] with the help of the pyreverse[8] software, and it later provided the data for the network visualization. This step then provides the ability to see how the individual elements are organized through their connections: the UML diagram shows the hierarchy of the data format (with *Project* as the higher level, and *Location* as the lower level) and extensive details about their connections. The graph shows the importance of each element (a bigger size and darker colour of a node corresponds to more connections it has in the network, i.e. degree). We can then

[7] https://gist.github.com/openp2pdesign/bd64fe6771569e36ab97e5631f00beff

[8] http://manpages.ubuntu.com/manpages/trusty/man1/pyreverse.1.html

see that *Activity* and then *Project* are the main nodes in the network, with *Discussion, Contradiction* and *Process* as the nodes connecting them. *Location* (space) and *Time Interval* (time) and *Activity Element* (the various building blocks of an Activity) are the main starting point for any *Activity*, the necessary conditions for an *Activity* to take place. The importance of *Discussion* can be found in the fact that several items (including the *License* regulating the sharing of the *Project*) can be discussed by participants. Such a structure is the result of interactions between theoretical frameworks, technical requirements and design choices, and the reflection upon the code and the data format enables the understanding of implicit assumptions.

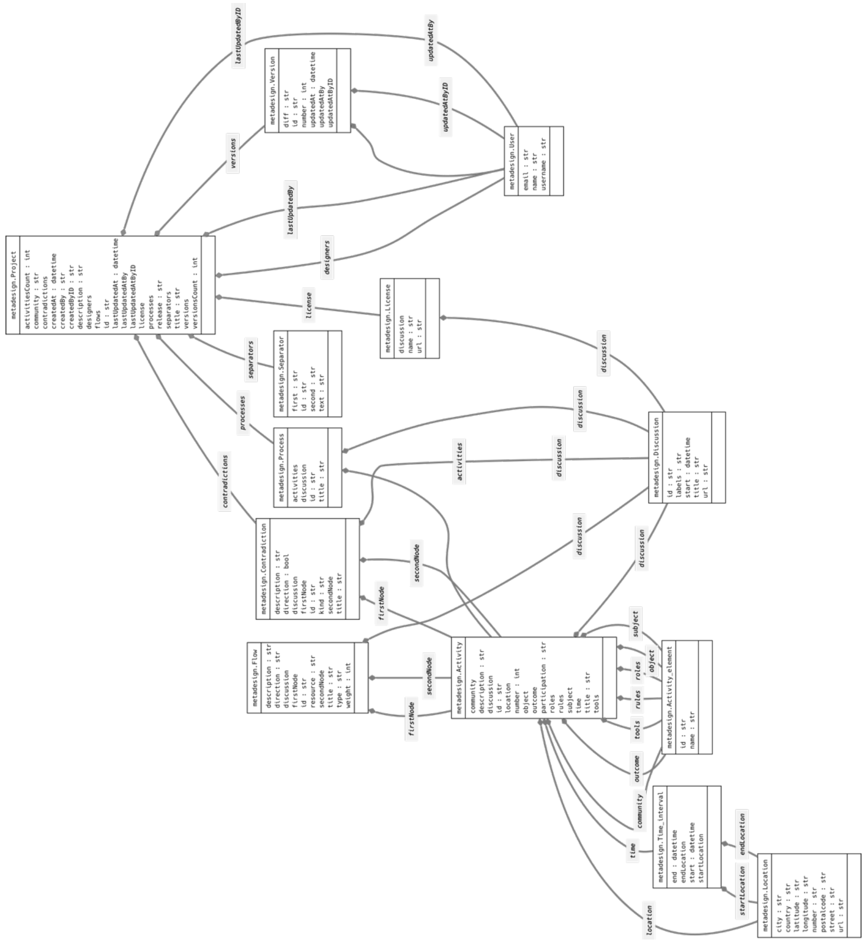

Figure 7. The UML diagram representing the classes of the Design Process data format

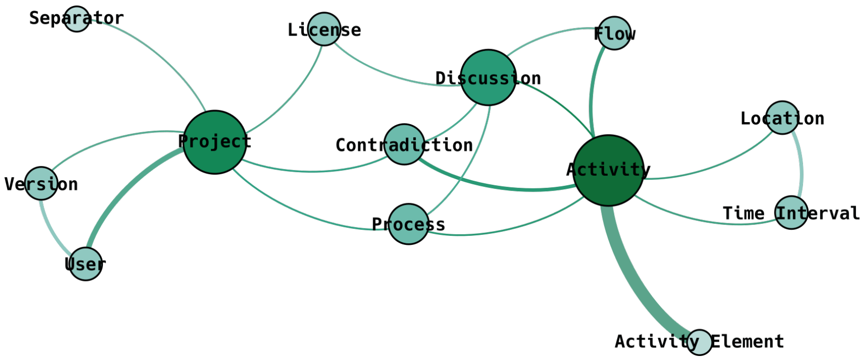

Figure 8. The network of references between the classes of the data format presented

4. Validation and future research

The meta-design data format presented in the previous section is based on a series of workshops (Menichinelli, 2015) and following reflections (Menichinelli & Valsecchi, 2016), but more steps for validation and future research are essential in order to make sure that such a complex topic, framework and visualization are valuable for users. This section elaborates further strategies and directions for evaluating the integration of Activity Theory concepts into the data format and meta-design platform. As a first step, we can elaborate the research objectives of the validation process:

1. VRO1: validate whether the meta-design framework, platform and visualization are easy to understand and to use, and it has a positive impact on collaborative design processes. This objective is related to the Software and Design dimension, and could be addressed with an Action Research approach and User Experience methods.
2. VRO2: validate whether the ontology and data format is easy to understand and to use, and it has a positive impact on collaborative design processes. This objective is related to the Software and Data dimension, and could be addressed with an Action Research approach and User Experience methods.

The meta-design platform, as explained in figure 6, is based on three main dimensions in it: Software, Design and Data. Therefore, the validation of the platform, of its concepts, functions and data format should address all three directions with the specific stakeholders and users of each dimension. This article focus only on the Data dimension, and its validation objectives could be then formulated with the following topics and research questions:

1. VRQ1. The shared understanding of collaborative design processes: how does the data format influence the understanding of collaborative design processes?
2. VRQ2. The experience and practice of the users: how has the data format modified the user experience of collaborative processes?

Based on these perspectives, this paper suggests to adopt a triangulation of three different methods for analyzing the platform and its impact on the courses/workshops in order to understand more the dimensions of the results (Gray & Malins, 2004):

1. VM1. A qualitative analysis: the data format could be discussed with design researchers and practitioners, in order to understand how its representation of design processes is perceived. This method would answer to VRQ1.
2. VM2: a qualitative analysis: the data format could be discussed with software developers and data scientists, in order to understand how it could support the integration with other platforms and tools, and how the data it provides could be analyzed by researchers. This method would answer to VRQ2.
3. VM3: a qualitative analysis: the data format could be discussed with design researchers, practitioners and developers in order to understand how the development of such an open system, and the integration with other software and platforms, could provide a shared understanding of design processes. This method would answer to VRQ2 and provide support to the research for VRQ1.

5. Conclusions

The paper explores how design projects and processes are documented in the context of Indie Designers and the Maker Movement, and it provides a proposal of a data format for describing collaborative design approaches with an ontology partially based on Activity Theory, and directions for future research, especially in the validation of the proposal. The data format is considered within the ecosystem of software and design elements that enables it to be encoded, visualized and used by users in the conscious and reflexive design of the activities constituting such collaborative design processes. How can be collaborative design processes documented and how could we improve the documentation of collaborative design processes with a shared data format as a common language? The paper tries to answer to this question by providing a) an overview of the approaches to documenting design projects and processes, b) elaborating a proposal of an ontology and data format for describing collaborative design processes and d) suggesting directions for future research, especially in the validation of the proposal. Further research might be important for understanding how processes, and especially design ones, are perceived by both trained and untrained designers and which are the most promising metaphors, formats and strategies for visualizing them.

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Menichinelli, Massimo. 2018. 'Service Design and Activity Theory for the Meta-Design of Collaborative Design Processes'. In *ServDes2018. Service Design Proof of Concept, Proceedings of the ServDes.2018 Conference, 18-20 June, Milano, Italy*, 994–1008. Linköping, Sweden: Linköping University Electronic Press, Linköpings universitet. https://ep.liu.se/ecp/article.asp?issue=150&article=083&volume=#.

Service design and activity theory for the meta-design of collaborative design processes

Massimo Menichinelli

Media Lab Helsinki, Aalto University School of Arts, Design and Architecture, Miestentie 3 02150 Espoo (Finland)

massimo.menichinelli@aalto.fi

Abstract

This paper explores how the approach, logic and tools of Service Design could support the development of a digital platform that enable the collaborative design of open and collaborative design processes. By integrating Service Design, Activity Theory and Meta-Design, such platform could foster community building and management providing concepts and visualizations that help users in the conscious and reflexive design of the activities constituting their community-based collaborative design processes. How could Service Design enable the meta-design of collaborative design processes on digital platforms? This paper elaborates a proposal for integrating Service Design concepts and tools into a meta-design digital platform for the design and management of collaborative design processes, by providing 1) a reflection on the theoretical connections between Service Design, Activity Theory and

Meta-Design, 2) a proposal of a meta-design platform that represents a proof of concept of such connections and 3) a proposal of evaluation strategies for validating such platform.

Keywords

meta-design, visualization, process, collaboration, activity theory

1. Introduction

In the recent decades ICT technologies have shaped new ways of working, participating in and assessing projects, which in turn have contributed to shaping these technologies even further. Such technologies have had an impact on design on all the activities and actors of the Design ecosystem (discussion, research, manufacturing, distribution, …) at any scale, from desktop software to digital online platforms, from single actors to whole ecosystems. Consequently, the Design discipline has changed in several ways, for example by increasingly moving its scope from single users to local and online communities, from isolated projects to system of solutions. This direction has sometimes been based on learning from trends in software development and web-based technologies that have created tools and strategies that enable mass-scale and remote and distributed interactions, especially with community-based organizations (examples are open source and peer-to-peer initiatives). In turn, this has increased the interest in the role of design researchers and practitioners in being able to organize collaborative design processes, especially through meta-design approaches that focus on the management and visualization of their intangible aspects and social dynamics. By adopting a meta-design perspective, new possibilities have emerged in making designers active in the organization and management of collaborative and distributed processes, especially design ones and with multiple stakeholders, especially in their social dimension.

This paper explores how the approach, logic and tools of Service Design could be part of this trend by supporting the development of a digital platform that enable the collaborative design of open and collaborative design processes and therefore the management of the communities behind them. By integrating Service Design, Activity Theory and Meta-Design, such digital platform could foster community building and management through a meta-design activity that enable the emergence of communities as organizations that arise from the networks of interactions generated in designing and deciding the collaborative efforts with all the actors involved. The collaborative process of designing collaborative design processes enables digital platform to be places for a community to form and self-organize. Such approach would extend the adoption of the Service Design logic and tools from designers to any kind of stakeholder participating in such open collaborative ecosystems. This can also be considered the result of the digitalization of the design of services through the increasing role of software development and data modeling on facilitating but also influencing available visualization tools. Therefore, this research might also advance our understanding of the connections between design tools and the software and data supporting them.

This paper therefore focuses on how the Service Design logic and tools can be adopted for visualizing, understanding, discussing and designing collaborative design processes and the communities that manage and implement them over time. Furthermore, the role of software and digital platforms in influencing both communities, collaborative processes and service design tools and practice is another key part of this paper. The specific context of this paper is one where communities of formally trained and informal amateurs collaboratively design and produce artifacts, the Maker movement (Anderson, 2012; Gershenfeld, 2005). Here in this context communities can be found on three levels:

1. a global community of local events and laboratories with a complex social structure (Menichinelli, 2016b);
2. local communities that form in and around local laboratories such as Fab Labs (Ghalim, 2013; Maldini, 2014);
3. the communities that form around the development of projects, especially the ones that are shared openly as Open Design, which then become community-based initiatives (Menichinelli, 2017).

These communities are often integrated as participation in the Maker movement takes place in activities that can span between them; this paper focuses on the community around specific projects (3) but that can extend also to local (2) and global dimensions (1). Following these specific kind of communities, here collaborative design is intended especially in the development of shared projects within the Maker movement: in this direction, the initiatives inspired by open source and peer-to-peer software seems promising (Abel, Evers, Klaassen, & Troxler, 2011; Cruickshank, 2014) especially for their ability to generate community-based initiatives around the sharing of projects but also for fostering several different potential social dynamics for both design and meta-design practice and research (Menichinelli, 2016a).

This paper elaborates a proposal for integrating Service Design concepts and tools into a meta-design digital platform for the design and management of collaborative design processes, by providing a) a reflection on the theoretical background behind the connections between Service Design, Activity Theory and Meta-Design, b) a proposal of a meta-design platform that represents a proof of concept of an implementation of the possibilities emerging from such connections and c) a proposal of evaluation strategies for validating such platform with users. This meta-design platform is based on four interconnected dimensions: conceptual, data, design, software; its research might advance or understanding of 1) how Service Design might be connected with Activity Theory and Meta-Design in the development of community-based processes and organizations and 2) the relations among design and software, data, processes and organizations. The main research question (RQ0) could be structured in more research sub-questions in order to be addressed more easily:

1. RQ0: How could Service Design enable the meta-design of collaborative design processes on digital platforms?
2. RQ1: How could the Service Design logic and tools be adopted in the design of community-based and collaborative design processes?
3. RQ2: How could the Service Design logic and tools be integrated in digital platforms in order to help communities design, document, visualize, manage, share and understand their collaborative design processes?
4. RQ3: How could we evaluate this integration of Service Design logic and tools into meta-design platforms?

RQ1 focuses on the theoretical background, RQ2 focuses more on the development of a meta-design platform emerging from it and RQ3 focuses on the validation of such platform. This organization of research questions is mirrored in the structure of the paper: RQ1 is addressed in the *Service Design, Meta-design and Activity Theory for Open and Collaborative Design* section, RQ2 is addressed in the *A meta-design platform based on service design tools* section and RQ3 is addressed in the *Validation and future research* section. The Conclusions section resumes how each of the three previous sections has replied to the research questions proposed in the first section.

This paper represents a further improvement of previous researches in this direction (Menichinelli, 2015; Menichinelli & Valsecchi, 2016) but that were missing the Service Design logic and tools, here developed with more focus especially in the conceptual and design dimensions. The data and software dimensions have been also explored recently in other publications (Menichinelli, Forthcoming).

2. Service Design, Meta-design and Activity Theory for Open and Collaborative Design

Collaborative dynamics in design processes are not a new phenomenon, since teamwork has always been a common practice among designers, and it has been approached in several different ways, from practitioners recollecting techniques and experiences (Brown, 2013) to researchers analysing practitioners through cognitive psychology (Goldschmidt, 2014). The focus of this paper is especially on design processes enabled or influenced by the adoption of ICT technologies and with wider communities of participants. The aim of this section is to establish through literature review how Service Design can approach the design of collaborative design processes through Activity Theory and Meta-Design by framing, analysing and designing collaborative processes as ecosystems of activities with the help of digital platforms:

- Activity Theory provides the conceptual basis for framing, understanding and designing activities;
- Service Design provides the operational basis for designing activities as services with the help of service design tools and logic;
- the Meta-Design approach provides the conceptual basis for designing collaborative design processes (*designing design processes and organizations*) and the operational basis for designing the platforms that enable such task (*designing design tools, environments, spaces for participation*).

Activity Theory is a framework for orienting researchers in understanding complex socio-technical phenomena and, especially in the version elaborated by Engeström (1987), it provides a way for understanding the dialectic contradictions and continuous development of individual contributions to collaborative initiatives taking into consideration all the elements that mediate all the activities and their contexts. Activity Theory has been adopted and elaborated inside Human Computer Interaction research and practice since the 1980s' in several directions (Kaptelinin & Nardi, 2012, 2009), for example in order to improve the theoretical background of Human Computer Interaction or as a potential strategy that evolves from Human-Centered Design (Norman, 2005). Kaptelinin and Nardi (2012) identify three ways Activity Theory has been integrated into Human Computer Interaction:

1. as a theoretical re-framing of concepts;
2. as a provider of conceptual tools for design and evaluation;
3. as a theoretical lens in empirical studies.

Activity Theory has also been adopted in Service Design in order to extend Human Computer Interaction beyond individual digital artefacts to the analysis and design of services (Kaptelinin & Uden, 2012), for example by elaborating "an activity based approach that could be used as an analytical tool for communication design practitioners to improve the design of service communication interfaces" that "generates a shift from a service (and communication) design to what we call the design of activity systems" (Maffei & Sangiorgi, 2006, p. 2). Services can be then understood and designed as activities (and thus activities designed as services), and Service Design provides several tools for completing this task in a more intuitive way. Especially when services are considered as the outcome of complex systems of people, artifacts and organizations, they usually have a very limited visual evidence that benefits from visualizations. Services (and therefore activities) can be represented with several tools following four main visual archetypes (maps, flows, images and narratives) with different level of iconicity and representation of time and that, however, cannot render what a service is with just one representation (Diana, Pacenti, & Tassi, 2009). Beside Human Computer Interaction, Activity Theory has also been directly applied to collaborative design by researchers that analyzed the design practice in collaborative settings in order to understand teams' interactions and relative collaborative evolution and its dynamics (Zahedi, Tessier, & Hawey, 2017) and also in the design of communities (Barab, Schatz, & Scheckler, 2004). Activity Theory has also been implemented not just in analyzing but also in redesigning activities through the creation of a shared vision thanks to the identification of contradictions (Engeström, 2000). Activity Theory can be applied not only in the understanding of activities but also in their designing, and this paper suggests that the introduction of the Meta-Design approach (Fischer & Scharff, 2000; Giaccardi, 2003) would be a promising strategy along two main directions:

1. for enabling both professional designers and untrained or amateur designers and users to work together in collaborative design processes thanks to the conscious and reflexive design of the activities constituting such collaborative design processes;
2. for the generation of guidelines for the development of the digital platforms that enable the former point; the importance of a platform here lays in its abilities to enable the participation and networking of a potentially large scale pool of users.

This paper therefore proposes to use digital platforms for exploring how Activity Theory and Service Design could be integrated in order to enable participants in the design of the collaborative design processes they are part of. Meta-Design can provide a complex perspective in this direction since it has several meanings: for example, Giaccardi (2003), crossing etymological facts with extensive literature review identifies three different declinations of Meta-Design where *meta-* is regarded as:

- *behind* (or *designing design*): "Design of Design processes" / "Design of the generative principle of forms" / "Design of the Design tools";
- *with* (or *designing together*): "Design of media and environments that allow users to act as designers" / "Design of the organization of flows";
- *between/among* (or *designing the "in- between"*): "Designing the spaces of participation" / "Design of relational settings and affective bodies".

Therefore, Activity Theory can be then integrated in design along three directions:

1. as a design research tool, in order to identify the problems and contradictions related to a specific project or context;
2. as a qualitative analytical framework for understanding and describing design processes;
3. as a framework for meta-design approaches that adopt the understanding of design processes in order to consciously design them collaboratively in a custom designed digital platform: meta-design of design processes and meta-design of digital platforms that support the former.

Furthermore, an activity-centred approach could represent a systematic view also for understanding business models extending the focus from one single organization (a firm, for example, but in collaborative design initiatives there could be different forms of organization involved) to a system of interdependent activities. Here the focus would be not just on one organization but on one organization and on its network of partners, and all their activities that enable them to create and appropriate value (Zott and Amit 2010). As an example of this direction, Activity Theory has been adopted also in the exploration of business models of Open Design initiatives by analysing the work of digital maker-entrepreneurs on the Thingiverse platform that enable the sharing of 3D printing projects (Troxler and Wolf 2017). This research then also points out to possible applications of Service Design, Activity Theory and Meta-Design also to the business dimensions of collaborative design processes.

As a conclusion of this section, Figure 1 highlights the main traits of the framework here elaborated, a Meta-Design approach based on digital platforms that would emerge from Activity Theory and Service Design:

1. Service Design and Activity Theory provide the concepts and tools for understanding and designing activities;
2. Meta-Design provides the concepts for applying the former point to the reflexive and conscious design of design processes;
3. Meta-Design provides the concepts and providing guidelines for developing digital platforms that enable the former two points; such platforms are based on concepts, data formats, a visualization format that renders the data and a software layer that binds together data, visualization, graphical user interface and collaborative editing; the following section focuses on the visualization dimension;
4. such platforms can be applied to the design of, at least, any processes (whether design processes or any processes, whether individual processes or collaborative processes) and especially collaborative design processes but also business models and business ecosystems.

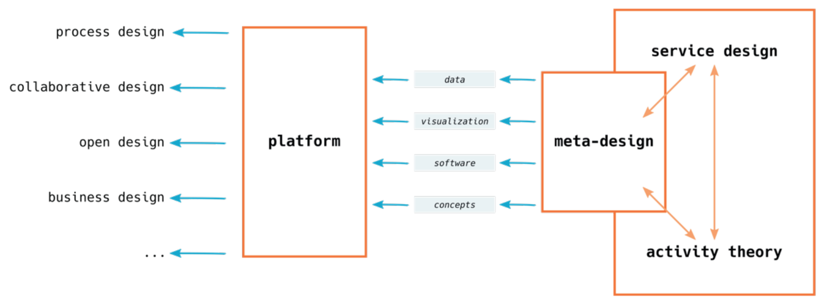

Figure 1. The framework of the meta-design platform based on the connections among Service Design, Activity Theory and Meta-Design

3. A meta-design platform based on service design tools

The previous section highlighted how collaborative activities could be designed both conceptually and operationally, especially into a digital platform that facilitates the participation of users. This section focuses on the visualization dimension of such meta-design framework elaborated in the previous section, proposing a visualization format that could embed the Service Design logic in a digital platform in order to help communities design, document, visualize, manage, share and understand collaborative design processes. This is, ultimately, a task of democratizing Activity Theory to users who are not familiar with it, transforming (at least partially) from a complex research framework to a more intuitive digital platform with a design focus. The need for a democratization and simplification of Activity Theory emerged in previous workshops with students, that found it too complex to use without a previous knowledge or proper visualization (Menichinelli, 2015). Therefore this visualization proposal has three main characteristics:

1. it simplifies the application of Activity Theory in order to make it more understandable; a first step in this direction was taken by simplifying the visualization of an Activity System, with a process that lead to a simpler representation with the use of icons, and that itself could be represented as an icon in the main visualization (Figure 2, 5);
2. it integrates Activity Theory with several other design tools in order to provide a more comprehensive and intuitive understanding of the several dimensions of collaborative design processes;
3. it represents a proposal to be tested, validated and further improved (this will be developed in the following section).

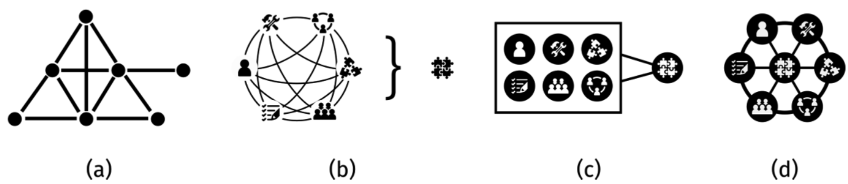

Figure 2. Simplification of the Activity System representation, from the traditional representation (a) to the one eventually adopted in the meta-design platform (d) (Icons under CC-BY license by Gregor Cresnar, https://thenounproject.com/grega.cresnar/

The tools considered and integrated in the meta-design platform, based on previous experimentations (Menichinelli, 2015; Menichinelli & Valsecchi, 2016), are listed in Table 1, where they are classified by discipline of origin (three of them are from Service Design); these tools work focusing on these elements that they provide a visualization of (Figure 3):

1. activity,
2. time,
3. participation,
4. boundaries,

5. resources
6. flows.

These elements and tools constitute the architecture of the visualization here presented, which can be described as Gantt chart of Activity Systems with flows of resources among them as in a System Map organized according to a Service Blueprint (Table 1, Figure 3). More tools are included or can be potentially included in the visualization beside these main ones (Table 1). The visualization (Figure 4) consists of these visual and interface elements:

1. *Title:* title of the collaborative design process described in the current document.
2. *Version:* version number that shows the evolution of the current document.
3. *Project Description:* description of the collaborative design process of the current document.
4. *Community Description:* description of the main community that the collaborative design processes is meta-designed with / for.
5. *Created / Updated at …:* quick overview of time and user of the creation and last update of the document.
6. *Edits over time:* a chart plotting the edits of the document over time.
7. *Processes:* activities can be added under four categories as in a service blueprint: Customer processes, Front-Office processes, Back-Office Processes, Support Processes.
8. *Tooltips on buttons:* all the buttons in the interface have tooltips for showing indications to the users, and open modal windows with more in-depth details about the visualization.
9. *Activity description:* visualization of an activity with its flows, contradictions, levels of participations and so on.
10. *Buttons for editing an activity:* these are the main buttons for editing and discussing an activity and all its components.
11. *Participation:* this element visualizes how much an an activity is done by the community i.e. the users who are less active or not active in the meta-designing. Results are then plotted in a customer journey chart (15), along with the feedback of the users.
12. *Contradictions:* contradictions of activities according to Activity Theory. Quaternary contradictions are visualized like flows (13), other kind of contradictions can be edited and visualized in a modal window.
13. *Flows:* flows of resources between activities, like in a system map.
14. *Time span of an activity:* This line depicts the time span of an activity
15. *Journey:* users can give a feedback to each activity (this can be easily extended with more options). Results are then plotted in a customer journey chart, along with the participation levels.

16. *Other visualizations of the project:* the platform enables the rendering of other perspectives of the same visualization, for example a list of activities, flows, contradictions and so on, in order to help users in the navigation of the visualization and of its data.

Tools	Source	Activity	Time	Participation	Boundaries	Resources	Flows
Activity Theory	Psychology	X					X
Gantt	Management	X	X				
Service Blueprint	Service Design	X	X	X	X		
System Map	Service Design	X			X	X	X
Customer Journey	Service Design		X	X			
Participation level	Urbanism			X			
User activity	Data visualization	X		X			

Table 1. Tools integrated in the meta-design visualization

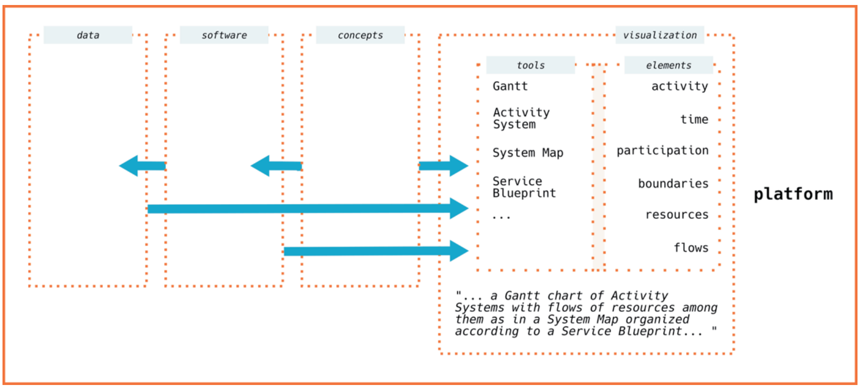

Figure 3. The dimensions of the meta-design platform, with a focus on the visualization dimension and of its tools and elements

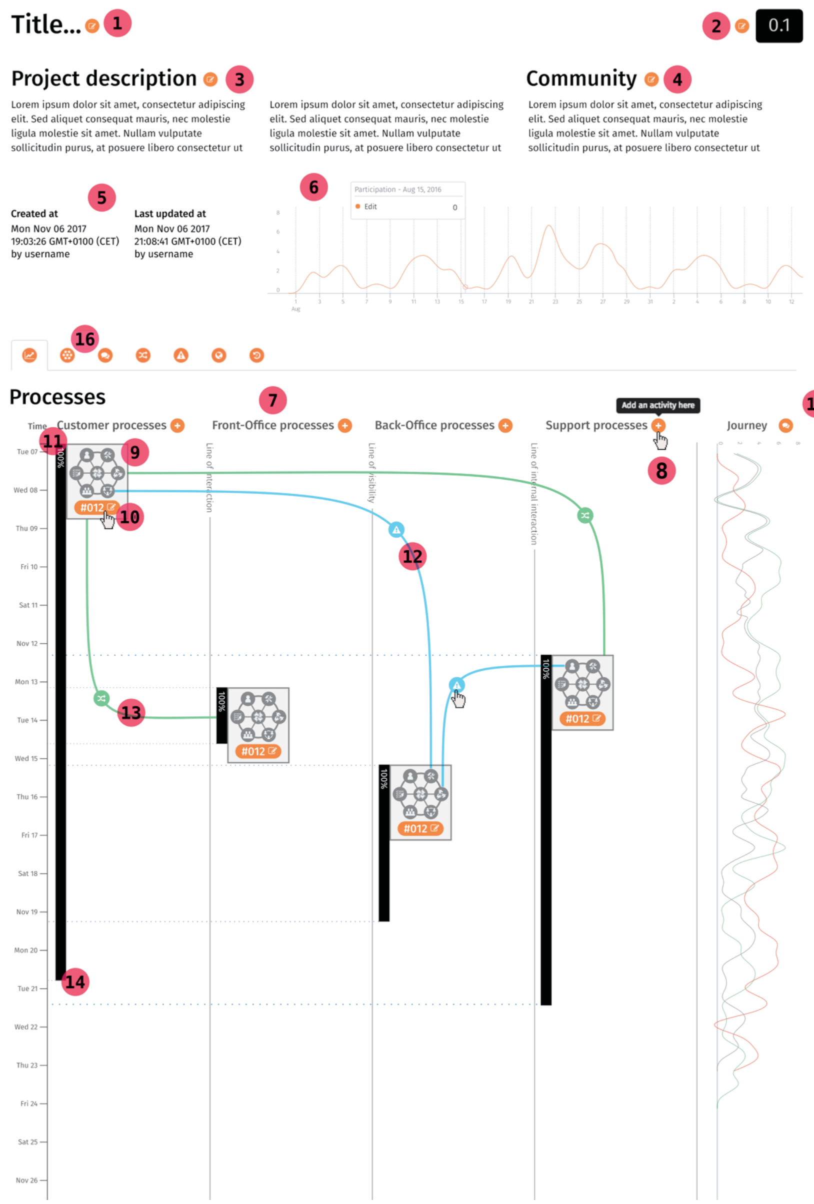

Figure 4. An overview of the meta-design visualization and digital platform interface

Figure 4 shows the current status of the meta-design platform pointing out the most relevant elements: the visualization can be edited and discussed in realtime by clicking on the orange buttons, which open a modal window showing more details of each element, enabling its editing and discussion (Figure 6); such discussions can be also analysed in order to understand better the meta-design activity. The visualization went through a simplification process regarding the representation of activities and their interface (Figure 5), moving more details and functionalities to modal windows (Figure 6).

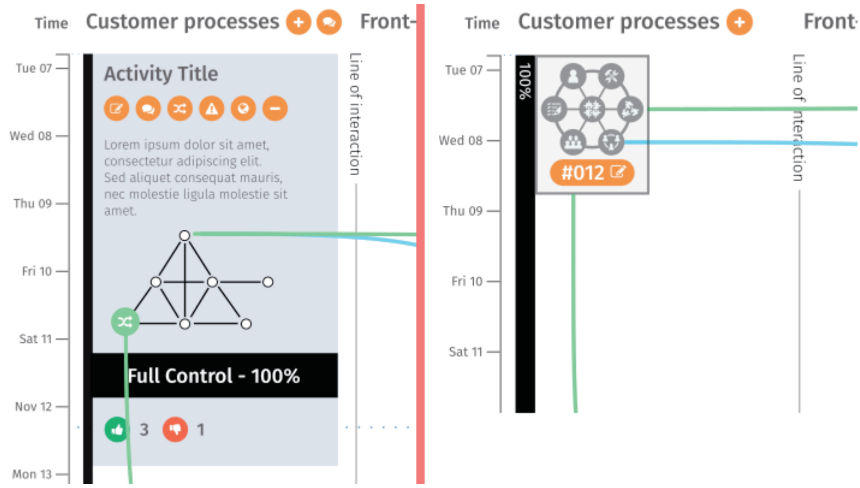

Figure 5. Comparison between a former visualization of activities and the current one, after a process of simplification of both the activity system representation and of its interface

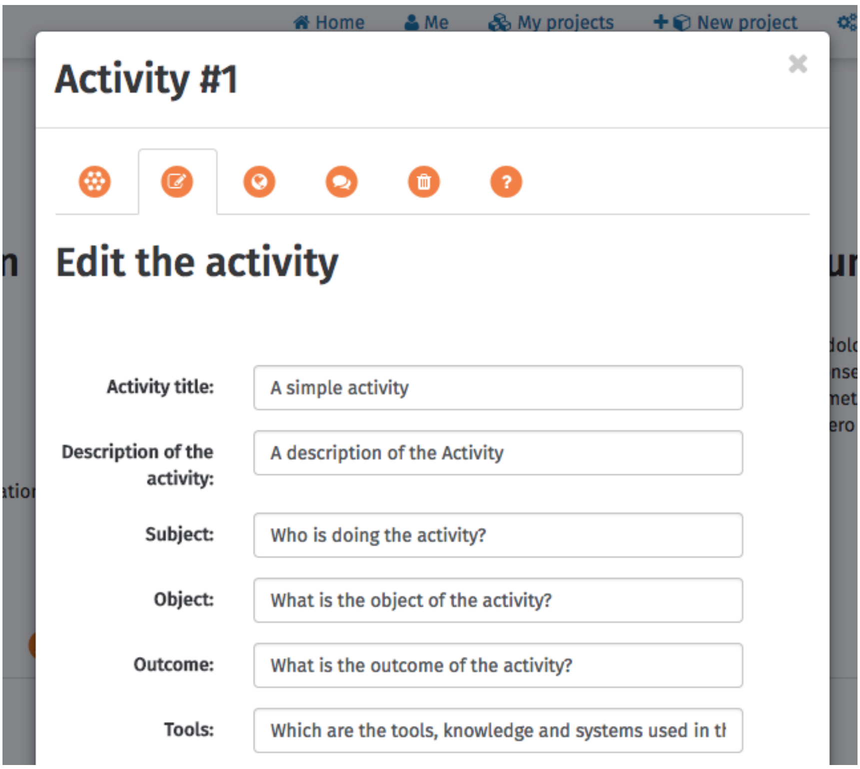

Figure 6. A modal window for the edit and discussion of an activity

4. Validation and future research

The meta-design visualization and platform presented in the previous section is based on a series of workshops (Menichinelli, 2015) and following reflections (Menichinelli & Valsecchi, 2016), but more steps for validation and future research are essential in order to make sure that such a complex topic, framework and visualization are valuable for users. This section elaborates further strategies and directions for evaluating the integration of Service Design logic and tools in meta-design platforms. As a first step, we can elaborate the research objectives of the validation process:

1. VRO1: validate whether the meta-design framework and visualization are easy to understand and use. This objective could be addressed with User Experience methods.
2. VRO2: validate whether the meta-design framework and visualization have a positive impact on collaborative design processes already established or to be developed. This objective could be addressed with an Action Research approach.

These validation objectives could be then formulated with the following topics and research questions:

1. VRQ1. The experience of the users: how has the platform modified their experience of collaborative processes?
2. VRQ2. The shared understanding of collaborative design processes: how does the platform influence the understanding of collaborative design processes?
3. VRQ3. The social interactions among users: how has the platform modified the social dynamics among them? Has the platform improved collaboration among users?
4. VRQ4. The practice of users: how has the platform modified the collaborative design practice users?

Based on these perspectives, this paper suggests to adopt a triangulation of three different methods for analyzing the visualization / platform and its impact on the courses/workshops in order to understand more the dimensions of the results (Gray & Malins, 2004):

1. VM1. A qualitative analysis: a think-aloud session where participants test the platform and openly discuss its functioning. The think aloud technique is a qualitative data collection technique in which user participants verbally externalize their thoughts about their interaction experience, including their motives, rationale, and perceptions of UX problems. By this method, participants give the evaluator access to an understanding of their thinking about the task and the interaction design (Hartson & Pyla, 2012). This method would answer to VRQ1 and VRQ2.
2. VM2. A quantitative and qualitative analysis: a survey with questions for the participants (in order to understand the impact of the platform in their experience). It will consists of both open and closed questions. The survey will cover the needs of the participants, their expectations, their experience in using the platform; for this reason,

the survey will include established questions like SUS1, USE2, AttrakDiff3 (Hartson & Pyla, 2012). This method would answer to VRQ1, VRQ2 and VRQ4.

3. VM3. A quantitative analysis: a social network analysis based on the work on the platform and on specific questions in the survey (in order to understand the collaboration, social structure and organization among the participants). Data from social media platforms could be also considered in order to improve the understanding of these interactions. This method would answer to VRQ3.

The focus of this paper is especially on collaborative design around the development of shared projects within digital environments; in this direction, the initiatives inspired by open source and peer-to-peer software seems promising (Abel, Evers, Klaassen, & Troxler, 2011; Cruickshank, 2014). Therefore context for validating this meta-design visualization and platform could consist in the collaborative efforts around Open Design projects developed by designers and makers in Fab Labs and other Maker Facilities. Testing the platform in a real-life setting (a maker collaborative project) would be the optimal context, following the Action Research approach, and User Experience methods could be applied there.

This paper has focused only on the concepts (section 2) and visualization dimension (section 3) of a meta-design platform, and further research and validation might be necessary for the other dimensions of software and data. Furthermore, this paper has not focused on the governance dynamics of the platforms and of the potential conflicts emerging from the interactions among users, which could be a very important topic for future research; Activity Theory could be here adopted for its ability to deal with contradictions and modify activities by learning from them (Engeström, 2008). Furthermore, future research could investigate the organizations emerging from this platform, and here Activity Theory could be implemented as well (Blackler, 1993).

5. Conclusions

This paper explores how the approach, logic and tools of Service Design could support the development of a digital meta-design platform that enable the collaborative design of open and collaborative design processes. By integrating Service Design, Activity Theory and Meta-Design, such meta-design platform could foster community building and management providing concepts and visualizations that help users forming a community during the conscious and reflexive design of the activities constituting the community's own collaborative design processes. How could Service Design enable the meta-

[1] https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

[2] http://garyperlman.com/quest/quest.cgi?form=USE

[3] http://www.tandfonline.com/doi/pdf/10.1080/10447318.2015.1064664

design of collaborative design processes on digital platforms? This paper tries to answer to the main research question (RQ0) with three sub-questions:

1. How could the Service Design logic and tools be adopted in the design of community-based and collaborative design processes (RQ1)? This question was answered by establishing conceptual and operational basis of such platform by highlighting the already existing connections among Service Design, Activity Theory and Meta-Design. Service Design and Activity Theory provide the concepts and tools for understanding and designing activities while Meta-Design provides the concepts for applying them in the reflexive and conscious design of design processes and the guidelines for developing digital platforms supporting this. This answer provides insights about how collaborative activities could be designed both conceptually and operationally, especially into a digital platform that facilitates the participation of users.
2. How could the Service Design logic and tools be integrated in digital platforms in order to help communities design, document, visualize, manage, share and understand their collaborative design processes (RQ2)? This question was answered by developing the visualization dimension of a meta-design platform that integrates Service Design tools and logic with Activity Theory and other tools in order to enable users to meta-design collaborative design activities as ecosystems of activities. Such visualization is based on a set of tools that provide a visualization of collaborative design processes through the elements of: activity, time, participation, boundaries, resources, flows. Such visualization can be described as Gantt chart of Activity Systems with flows of resources among them as in a System Map organized according to a Service Blueprint.
3. How could we evaluate this integration of Service Design logic and tools into meta-design platforms (RQ3) This question was answered by suggesting validation strategies for testing the platform and improving it. The first step was the identification of two broad research objectives: validate whether 1) the meta-design framework and visualization are easy to understand and use; 2) validate whether the meta-design framework and visualization have a positive impact on collaborative design processes already established or to be developed. These research objectives where then translated into four research questions that aim at understanding how the proposed visualization and platform affects the users' experience and understanding of collaborative design processes, and their social interactions and practice. In order to answer these four research questions this paper proposes three different methods (qualitative and quantitative) for analyzing the platform and its impact on the users' practices.

This visualization and related meta-design platform could represent a tool for improving community-based initiatives thanks to its focus on designing, supporting and visualizing the communities emerging from collaborative practices, with the focus on making them aware of these collaborative practices and the social interactions, dynamics and organizations emerging from them. This paper documents a step in the development process of the platform, and therefore further research is necessary in order to understand how the visualization and the platform are used and perceived by communities, and how communities are impacted by them. The validation proposal is a further step in this direction. Furthermore, other limitations and related research questions could be elaborated here: for example, the context of this research is the Maker movement, but since it is a global phenomenon, the visualization might not be necessarily understood and used in the same way everywhere: previous experimentations highlighted how cultural differences could present a challenge for the adoption of the platform, especially regarding Activity Theory (Menichinelli, 2015). And beside the Maker movement, such platform should also be tested in community-based initiatives in other contexts, and adapted accordingly, in order to understand if the specific context has influenced the functionalities of the platform. Activity Theory and its representation with Activity Systems has been simplified in order to facilitate its understanding and application, and further specific research should improve this democratization; activities and processes, being intangible phenomena, should also be investigated more, especially regarding how they are perceived by designers and users and how their analysis and visualization could be then improved. Further research might be important also for understanding the social dynamics emerging from such platform especially in terms of conflicts and organizations emerging, and Activity Theory could be further implemented as a research approach along this direction. This paper focuses especially on the design and visualization dimension of the meta-design platform, but the software and data dimensions are equally important, and more research should analyze the connections between all these dimensions and how these could be improved (Menichinelli, Forthcoming).

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Menichinelli, Massimo. 2019. 'A Research through Design Framework from the Evaluation of a Meta-Design Platform for Open and Collaborative Design and Making Processes'. *Proceedings of the Design Society: International Conference on Engineering Design* 1 (1): 21–30. https://doi.org/10.1017/dsi.2019.5.

A Research through Design Framework from the Evaluation of a Meta-Design Platform for Open and Collaborative Design and Making Processes

Massimo Menichinelli

Aalto University, School of Art, Design and Architecture, Department of Media, Media Lab

RMIT University

massimo.menichinelli@aalto.fi

Abstract

The democratisation of technologies, knowledge and activities have been changing the world of designers, blurring the boundaries between amateur and professional designers, especially within the connected phenomena of the Maker Movement and Indie Designers. Within this context, how can be collaborative design processes documented, analysed, managed, shared? This article investigates the role of meta-design digital tools for the facilitation of distributed systems of creative agents, formally trained and informal amateurs that collaboratively design and produce artefacts. It documents a research study organised for testing a digital meta-design platform with users and the researcher as meta-designer: the results provide insights for improving the platform but also for building a comprehensive research through de-

sign framework that connects meta-design research and practice for exploring the role and nature of meta-design and meta-designers in facilitating collaborative design processes starting from their description with digital ontologies.

Keywords

Platform strategies, Research methodologies and methods, Collaborative design

1. Introduction

Design is inextricably connected and influenced by technology, economy and society, and by all the interactions emerging among them. The democratisation of technologies, knowledge and activities have been changing the world of designers, both at individual level and at organisational level. For example, the boundaries between amateur and professional designers have been blurring at individual level (Gerritzen and Lovink, 2010; Manzini, 2015). The same happened to the boundaries of organisations as well, either with the addition of organisational complexity and change of scale with meta-organisations (Ahrne and Brunsson, 2005) or with the boundaries becoming increasingly porous thanks to open innovation initiatives that increase the exchange of intellectual properties and expertise (Bogers et al., 2018). When the structure of the organisations and boundaries between amateur (or better: non-formally trained and non-professionally experienced designers) and professional designers are changing and becoming uncertain, the task of addressing the responsibility for future organisations and for future designers are intertwined. By adopting a meta-design perspective, new possibilities have emerged for designers to be active agents in the organisation and management of collaborative and distributed processes, especially design and making ones. How can be collaborative design processes documented, analysed, managed, shared? This article focuses on the tools, capabilities and approaches that future flexible, fluid, open and distributed designers and organisations can adopt in order to evolve along these changes. The context of this research is defined by the emerging phenomenon of the Maker Movement (Anderson, 2012; Gershenfeld, 2005): untrained amateur designers and professional designers producing their projects independently, with a more advanced awareness and knowledge of technology, which further merge design and engineering through the ability of designers to write software, develop electronics and define and set up manufacturing processes. Within this context, this article proposes an approach for testing the modelling and management of design processes and their organisations, in order to support distributed collaborative design processes that are open to participation of different kind of stakeholders. The focus of the article is on how developing a meta-design ontology into a digital platform can be helpful for designers in facilitating their collaborative practice and in redefining their work. Design here becomes increasingly a software development activity, representing thus another potential direction for engineering design.

Design research and practice are not always connected, and within this relatively recent and emergent context their integration is an even more complex issue. In order to contribute to the reduction of this gap, this article elaborates a research through design (RtD) framework that bridges the practice of Makers and their facilitators (or meta-designers), with the meta-design practice and research. The RtD framework here presented connects both practice and research, data formats and digital platforms, researches and experiments for exploring the role and nature of meta-design and meta-designers in facilitating collaborative design processes starting from their description with digital ontologies. The foundation of this framework can be then found in the digital dimension of the infrastructure that enable collaborative processes: from a digital ontology that describe design processes to digital platforms that enable the editing and visualisation of such ontology to the practice and its research. The approach adopted in this article is thus to elaborate an RtD framework on top of the practice and research of developing such a digital meta-design platform and testing it with users: the importance of the RtD approach can be found here in the focus on the insights gathered from the platform, rather than on the development of a complete product or the elaboration of generalised insights from research, in order to elaborate future strategies. The RtD framework is therefore based on both theoretical research, meta-design practice and on the profiles and expectations of (potential) future designers and the role of the researcher/meta-designer in this context order to build a framework for future research and practice. This article represents the summary of a research study but also of years of research, on both theoretical and experimental work, and the RtD framework is both a conclusion of this path and the strategic plan for future work. These are the research questions addressed by this article:

1. RQ1: how can we connect the research and practice of meta-designers in open and collaborative design and making processes?
2. RQ2: how can we facilitate meta-designers with digital tools for the facilitation of open and collaborative design and making processes?
3. RQ3: how can we adopt and test these digital tools in order to improve them and their contribution to the profile of meta-designers?

In order to support RQ1, RQ2 focuses on the development of a digital meta-design platform and RQ3 on presenting and documenting an approach for testing the digital meta-design platform. Finally, RQ1 connects meta-design research and practice by elaborating an RtD framework following Redström's approach (2017) on top of the structure and the results from the research study (following the approach addressed by RQ3) of the digital meta-design platform (addressed by RQ2).

2. Digital Meta-design ontology, platform and practice

How can we facilitate meta-designers with digital tools for the facilitation of open and collaborative design and making processes? (RQ2). This context of distributed systems of creative agents, formally trained and informal amateurs that collaboratively design and produce artefacts, can be described for many aspects: adoption of digital fabrication technologies, the importance of community-based initiatives and of the collaborative practice behind both design and making. One of the common elements emerging is the new understanding of designers as facilitators and organisers of open, distributed and collaborative socio-technical systems made of creative and productive agents. The role of designers can take many forms, from the traditional role of form-givers, to the role of sense-makers, and ultimately to the role of of organisers of the contexts for complex and multi-agent and multi-stakeholder design processes. This role moves designers from the Design perspective to the Meta-Design one: rather than directly designing artefacts themselves, designers focus instead on designing the tools, contexts, rules and systems that enable more actors to design. From taking part in design processes, to modelling and managing design processes. Within design research, design processes have been studied along three directions: a) design as the work done by designers, with a study of the actual practice (Cross, 2006), b) design processes described with ontologies (Green et al., 2014) and c) design processes facilitated by meta-design approaches and initiatives (Fischer and Scharff, 2000; Giaccardi, 2003). Design processes can be characterised by a distinct *'designerly'* form of activity and ways of knowing different from the scientific tradition based on people, processes and product (Cross, 2006). Their research, however, has a relatively short history, where models are highly edited and rationalised abstractions of reality but disconnected from the actual practice and with limited consensus on their structure (Green et al., 2014). Joining these two polarities, rather than studying existing processes, the Meta-Design approach focuses instead on designing environments and tools for facilitating the emergence of design processes: it can be a way to leave space for user participation in the design process even after the design concludes (*'design-after-design'*) (Ehn, 2008); it can be a way to extend designed systems beyond their original nature, and because it includes the ongoing process in which stakeholders become co-designers, but taking place not only at the time of design implementation, but throughout the whole existence of the system shifting the control of the design process from designers to the hands of the users (*'designing the design process'*) (Fischer and Scharff, 2000). Meta-Design is a rich emerging design culture that enable possibilities along more than one direction: Giaccardi (2003), crossing etymological facts with extensive literature review identifies three different declinations of Meta-Design where *'meta-'* is regarded as: 1) *behind* (or *designing design*), 2) *with* (or *designing together*), 3) *between/among* (or *designing the "in-between"*). The idea of *designing design* was explored also by Duffy (2002), who also worked on ontologies of engineering design activities (Sim and Duffy, 2003) with a strong focus on input and output of knowledge. Engineering design of design processes could then be applied directly to design processes or to the engineering of the digital meta-design platforms for the discussion of design processes (Figure 1).

Design processes can be then modelled, managed and researched by connecting both design research and practice through meta-design, and the framework behind this article, called OpenMetaDesign, has been developed by integrating Service Design, Activity Theory and Meta-Design. Service Design and Activity Theory provide the concepts and tools for understanding and designing activities, and Meta-Design Meta-Design provides the concepts for applying this to the reflexive and conscious design of design processes (Menichinelli, 2018a, 2018b; Menichinelli and Valsecchi, 2016). OpenMetaDesign has been encoded in a digital platform that aims at enabling users to meta-design collaborative design activities as ecosystems of activities. The platform integrates realtime edit and chat functionalities that provide a visualisation of collaborative design processes (and their discussion) through the elements of: activity, time, participation, boundaries, resources, flows. Such visualisation can be described as Gantt chart of Activity Systems with flows of resources among them as in a System Map organised according to a Service Blueprint. The platform is based on a data format describing the ontology of design processes in the context of the Maker Movement, with the focus of processes as a set of activities and dialogues about them. Activity Theory is the conceptual basis for the ontology of the data format, since it is a framework for orienting researchers in understanding complex socio-technical phenomena. The data format and its ontology are encoded in the software that handles the visualisation and the users interactions. On the platform, projects can be edited in their general title, description, version and community (Figure 2), then the processes can be edited in terms of activities and flows and contradictions between them along a time axis (Figure 3). A video of the demo of the platform, as tested in the experiment, can be viewed on YouTube (openp2pdesign, 2018), and the fully working code is free/open source software available under the AGPL license and can be quickly deployed with Docker (Menichinelli, 2019a).

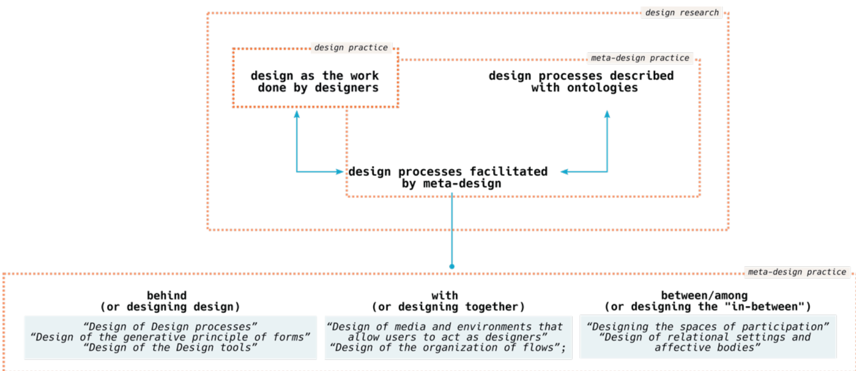

Figure 1. The research and practice connections among design processes and meta-design

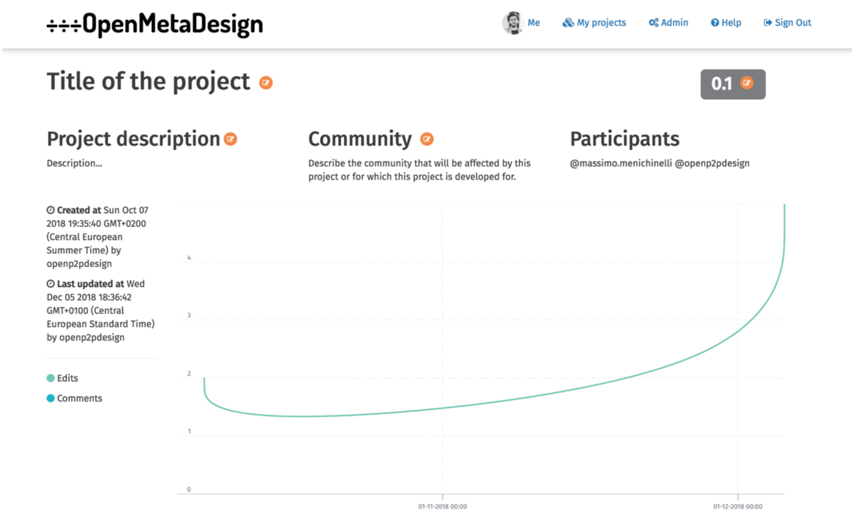

Figure 2. The OpenMetaDesign platform: first section of the Project page

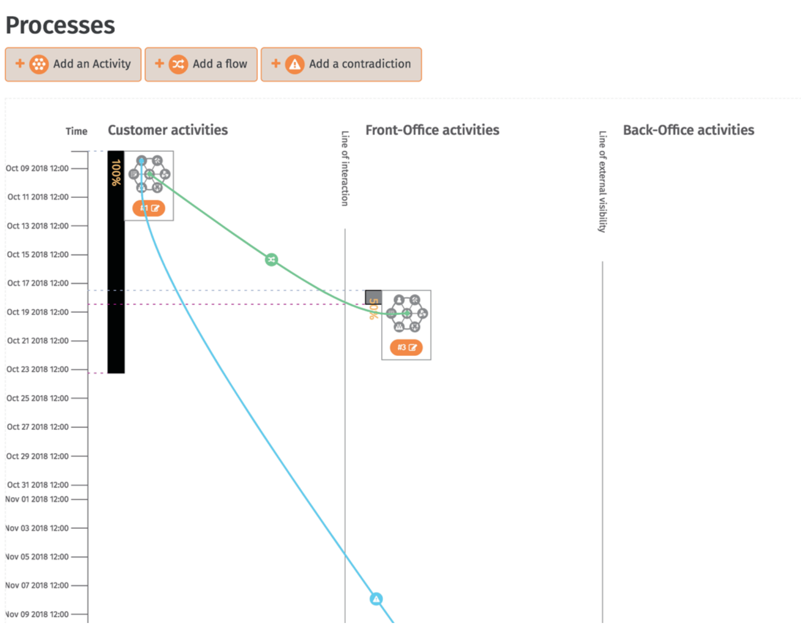

Figure 3. The OpenMetaDesign platform: second section of the Project page

3. Testing a meta-design platform

How can we adopt and test these digital tools in order to improve them and their contribution to the profile of meta-designers? (RQ3). This section documents a research study organised for testing the digital meta-design platform with users and the researcher as meta-designer, elaborating the main key results that contribute to the definition of the role of meta-designer and of digital tools in this practice.

The research study took place on 16th October 2018 in Polifactory, the makerspace of the Politecnico di Milano (Italy) and consisted in a presentation of the OpenMetaDesign framework and digital platform, followed by a test session of the first stable version of the digital platform (Menichinelli, 2019b) and finally with a questionnaire for the participants, which was structured with these sections: S1) *You*, S2) *You and Making*, S3) *You and Open Design*, S4) *Organisation in your open and making practice before this research study*, S5) *Organisation in your group during this research study*, S6) *Interactions in your group before the research study*, S7) *Interactions in your group during the research study*, S8) *You and OpenMetaDesign*. The full questionnaire is available online in a reusable format for the LimeSurvey software (LimeSurvey Project Team and Schmitz, 2015), as a readable PDF file exported from it, together with the software developed for analysing the data and all the generated charts and therefore the results of each question (Menichinelli, 2019c). An improved and stable version of the platform was released after reflecting upon the test (Menichinelli, 2019a). During the research study, 9 participants (all of them Italians) tested the platform and 8 completed the questionnaire, working in 4 groups of 2 participants each one (S1).

They mostly identified their gender as female (5 out of 8 participants) rather than male (3/8); their age was mostly 22 years old (3/8), which is also the lower age among participants (higher age is 32) and the mean age is 25. They all had a background in design (7/8) except for one participant that had it in computer science, in terms of education they mainly have a BA (5/8), then an MA (2/8) and only one participant had completed a doctorate. Their work experience covered different typologies, from just students and interns to social media managers, consultants, product designers, researchers and teachers (of design and even of meta-design). Their interest in future work mainly comprised game design, interaction design, product design, freelance work and research. These profiles determined the context of the open and making and related meta-design practices: the results of the research study apply to this context, and different contexts might results in different feedbacks about the ontology, the platform and the role of the meta-designer. In their experience with making (S2), participants had been mainly interested in making between 1 and 5 years (4/8) or for more than 10 years (2/8). Some of them considered themselves as makers (3/8) or even experienced makers (1/8), but the majority of them did not think they are makers (5/8). Two of them considered themselves as researchers, and at the same time not as makers. Professionally speaking, making for them was mainly either a hobby (3/8) or a secondary professional activity (3/8), except for one participant, and another participant did not answer. Their ambition towards the Maker Movement was strongly research-oriented (5/8), socially-oriented (4/8) and local community-oriented (3/8), while technically-oriented ambition was less strong and policy-oriented ambition showed mixed results. Regarding their connection with Open Design (S3), they were almost all (7/8) interested in adopting Open Source software, hardware and design to some of their future projects. Participants stated that they would mostly release design projects (5/8) and documentation of the process/manufacturing/use of the projects (5/8) as open source; 2/8 of them would use existing open source software or design in their work. The release and use of open source hardware projects was limited to one participant. Participants found interesting Open Design especially for collaboration (5/8), sharing and access to information (4/8), modification and use for personal fabrication to a lesser extent (2/8). None of the participants considered to understand the concept of Open Design and its implications completely, but most of them stated that they understand most of it (3/8) or something of it (3/8), and only one participant did not understand it at all. Interestingly, none of them reported to have difficulty in understanding its concepts and philosophy or its tools for managing the resources and files. Most of the difficulty was found in understanding Intellectual Property concepts, applications and strategies (4/8), business models (4/8) and tools for the coordination of collaborative processes (3/8), such as the OpenMetaDesign platform. Along this direction, it is important to note that participants could adopt Open Design better with proper tools for the coordination of collaborative processes (sequences of activities) (4/8) and tools for the coordination of collaborative systems (actors, roles, interactions, organisations (2/8). The questionnaire then explored organisation in participants' open and making practice before the research study (S4). Participants reported that they had never noticed any organised process, everything was decided at each moment (3/8) or that there was at least sometimes processes with a certain structure, and they had understood it and designed it with other people (3/8). In terms of whole systems (actors, roles, interactions, organisations, places), they at least sometimes had understood a system with a certain structure (3/8) and to a lesser extent they had also designed it (2/8). Furthermore, collaboration was reported as mainly a collaborative discussion about the project but work on individual projects/components (4/8) and to a lesser extent the collaborative design of the same files/components (3/8). During the research study instead (S5), the digital meta-design platform affected these dimensions more positively regarding the understanding the whole systems of collaborative processes (actors, roles, interactions, organisations, places) (5/8) than the understanding of processes, split between the understanding of processes (3/8) and a lack of understanding of processes with decisions taken at each moment (3/8). Half of the participant found collaborative discussion about the project but work on individual projects/components (4/8) and some of them found no collaboration at all (2/8). In terms of tools (more specifically: the percentage of their usage in the coordination of collaborative activities), previously participants have mostly collaborated with face-to-face interactions (45%), then with file storage services (Google Drive, DropBox) (20.375%) and mobile messaging (WhatsApp, ...) (11.875%). Interestingly, typical open source communities tools had been used very little: only 2 participants reported a small usage of mailing lists, and direct e-mail usage (4.125%) and version control repositories (such as GitHub) (5.375%) are low. Even project management platforms such as Basecamp had been used very little (3.375%), much less than realtime chats like Slack (8.125%) but much more than main social media platforms, with both Facebook and Twitter at less than 1%. For the participants, coordination of collaboration had been mainly an issue of face-to-face, file sharing and chatting discussion. The questionnaire then compared interactions in the group before the research study (S6) with the ones that took place during it (S7). Before the study, collaboration within the groups was reported by participants in the questionnaire as generally high, even if with some asymmetry between participants; interactions generally increased in frequency for all groups but one; quality of interactions remained the same, except for the group with highest collaboration before and a single participant. The last section of the questionnaire investigated how participants perceived the digital platform (S8). Usability of the platform was assessed with the System Usability Scale (SUS): participants were evenly distributed between agreeing, disagreeing or neutral (neither agreeing or disagreeing) in terms of using it frequently. With SUS, participants found the system unnecessarily complex (half of them agreeing, two strongly agreeing), and while 3/8 strongly disagreed and 2/8 disagreed it is easy to use, 3/8 is neutral; furthermore, as rather positive result, 5/8 of participants was neutral about the platform being difficult to learn. Results were polarised regarding the amount of things needed to learn before using it (3/8 considered less things, 2/8 instead considered more things). Functions of the platform were well integrated (4/8 agrees) and rather consistent (4/8 neutral and 2/8 disagreed about its inconsistency). Interestingly, participants stated the need of the support of a technical person to be able to use the platform (4/8 agrees and 2/8 strongly agrees). The platform was therefore complex but not too difficult to use and did not require too much knowledge for its usage; however, participants were not confident about using it (4/8 strongly agrees) because it was considered too cumbersome (3/8 agreed and 2/8 strongly agreed), and the help of a person was of critical importance. The platform was found useful for discussing activities (4/8 agrees), the organisation of projects (3/8 agreed and 2/8 strongly agreed), then flows (3/8 strongly agreed), processes (3/8 agreed) a with a 3-3 polarisation between agreement and neutral position projects and problems in projects. Participants mainly suggested to improve the Projects section (half of them strongly agreed, two agreed) and the discussion, chat, messages among users (half of them strongly agreed, three agreed). Participants suggested to make the platform more visual and with less text, generally with a more refined User Experience (UX) / User Interface (UI) and pointed out bugs and technical issues. Terms, concepts and the location of functionalities should be clearer; help sections should be part of the functionalities and not on a separated page. The activity of other users should be visible in realtime, and the chat should be improved by merging all the chats into a single one in a sidebar. Finally, participants rated how the platform could contribute to the development of the Open Design and Maker movement, especially with the improvement of the design of open and collaborative projects (5/8), of the supply chains (3/8) but not of the manufacturing of open and collaborative projects (0%). The platform was considered also useful for improving the organisation, coordination and collaboration within the networks of Maker laboratories (Fab Lab, Makerspace, Hackerspace, …) (3/8) and inside a single Maker laboratory (3/8). Less importance was given to the possibility of connecting Maker laboratories with non-maker organisations (companies, craftsmen, universities, workshops, associations, …) (1/8) or with a larger audience (1/8). The open questions of the questionnaire were manually coded into segments, and this analysis showed the importance of improving the interface and the chat systems: *UI* (21.82% of coded segments), *Chat* (14.55%), *No clear idea* (9.09%), *Bug* (5.45%). Then key elements of the organisation of design processes were identified in *Tasks* (12.73%), *Small Groups* (10.91%), *Roles* (5.45%). Finally, in terms of perspectives and metaphors for understanding processes, the key identified elements were *Text* (3.64%), *Branches* (5.45%), *Gear* (3.64%), *Complexity* (7.27%). Three metaphors for understanding process emerging here: as texts, as mechanisms or complex systems.

4. Discussion

How can we connect the research and practice of meta-designers in open and collaborative design and making processes? (RQ1). This section elaborates a research through design framework that connects meta-design research and practice, based on the digital meta-design platform and its research study. The research study provided useful information regarding the profiles of the participants as Makers, and for improving the platform. Since just the first version was tested, the results shows that it need improvements, while already pointing to potential changes in terms of UI, functionalities, approach and metaphors for the visualisation. For example, the importance of the chat system clearly emerges here, along with the idea of moving towards a more visual and less text-based visualisation. The mixed results in understanding processes may be explained by a combination of the realtime functionalities and by the little time available for testing the platform, leading to a less understanding of processes as a whole and more focus on decisions taken at each moment. Furthermore, the research study was the first test of the digital platform and also the first time the participants were exposed to the tool, so at least part of what was assessed in the study was rather their response to ease of use of the tool, and not the utility and adoption of the tool itself. The platform was judged as useful but complex, and thus it can be considered as a promising tool that needs some improvement; the lack of existing tools and approaches for facilitation the organisation of open and collaborative design and making processes is a further sign of the importance of the platform. The research study provided thus to be a promising tool not just for testing the platform, but for linking it to the participants' profile and practice and to the meta-designer's (the author) practice and research. Participants pointed out the importance of the role of a technical person in facilitating the users of the platforms leads directly to the role of the meta-designer, opening here a promising direction for further research not just on the meta-design platform, but more strategically on the practice of meta-designer. The platform was considered useful but more UX/UI work is needed, and considering that the author's practice is more towards meta-design and facilitation than UX, some considerations can be elaborated. From this study a further explanation of the role of the meta-designer is emerging: a) as facilitator, b) as software developer, c) as researcher but also d) as designer of building blocks for UX designers and developers for further improving the platform. We can thus elaborate a strategy from this research not just for improving the platform itself alone, but also for improving the practice (and therefore the role and profile) of the meta-designer that develops, deploys and uses the platform. The ontology, platform and research study can be considered positively as the building blocks of a future direction of research, as building blocks for future research. Since this is a first and exploratory research, such blocks should be organised in a more coherent structure for orienting research and practice. This article argue that the framework presented by Redström (2017) for developing design theories based on both research and practice is promising in order to further structure both research and practice around the meta-design platform: from the OpenMetaDesign platform as a product, to the author's doctoral work as project, to the OpenMetaDesign conceptual framework as program, to the author's practice as meta-designer and finally to the paradigm of Open Source, Peer-to-Peer, Open and Collaborative and Meta-Design (Figure 4).

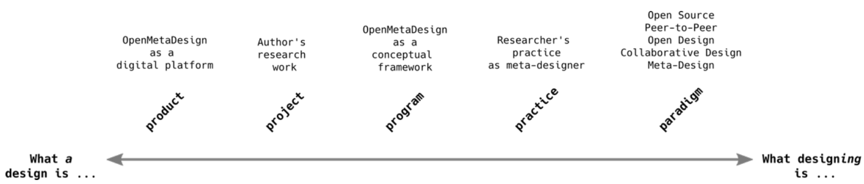

Figure 4. The RtD framework that connects meta-design research and practice

Following Redström's approach, such framework can be adopted in future research for elaborating a design theory of the meta-design practice and the role of meta-designers. This framework is thus a result from the research study: instead of just testing an improved version of the platform, this framework proposes a whole strategy for using it as the starting point for more complex work. Such RtD framework, that points to a future strategy for connecting research and practice for meta-designers (and therefore also Makers), could be also considered as one of the ways in which meta-designers plan for their future evolution, it is the strategic and tangible version of their responsibility towards future meta-designers and designers.

5. Conclusions

This article documents a research study organised for testing a digital meta-design platform with users and the researcher as meta-designer: its results were elaborated in order to improve the platform but also for building a more organised RtD framework that connects meta-design research and practice, in order to build the foundations for further research and practice towards the definition of the role of meta-designer and of digital tools in this practice. Developing and testing a platform is useful to designers and meta-designers in developing a strategy for redefining their roles, and in the future to any designer in creating their own platform for their practice. This approach could be promising for developing future profiles for design engineering and their facilitators. More specifically, the testing of such platforms is not considered here as a way for elaborating generalised insights, but it is proposed as a future common activity for designers for redefining their own work through a mix of research and practice.

Limitations of this research can mainly be found in the fact that the version of the platform that was tested was the first one, and therefore the interface clearly needed more refinement, as the results suggests. Furthermore, only short tests with groups of two participants were possible, and future research should focus on the usage of the platform in longer activities with an action research approach with larger groups and within real practice and not tests. Future research should also focus more on both the group and individual responses and their coherence or differences. The role of the meta-designer was investigated indirectly, and future research should directly address it. The questionnaire is a research tool that can be applied again in the process of refining the meta-design platform and practice, and it should be then improved further. The UI should be simplified and improved towards a more visual organisation; along this direction, the concepts of branches/complexity or gears could be powerful metaphor for developing a simpler visualisation format based on the same (or improved) ontology. Finally, the full RtD framework elaborated here is a starting point for more structured future research which therefore should adopt and evaluate it.

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8. Design Tools (Canvases)

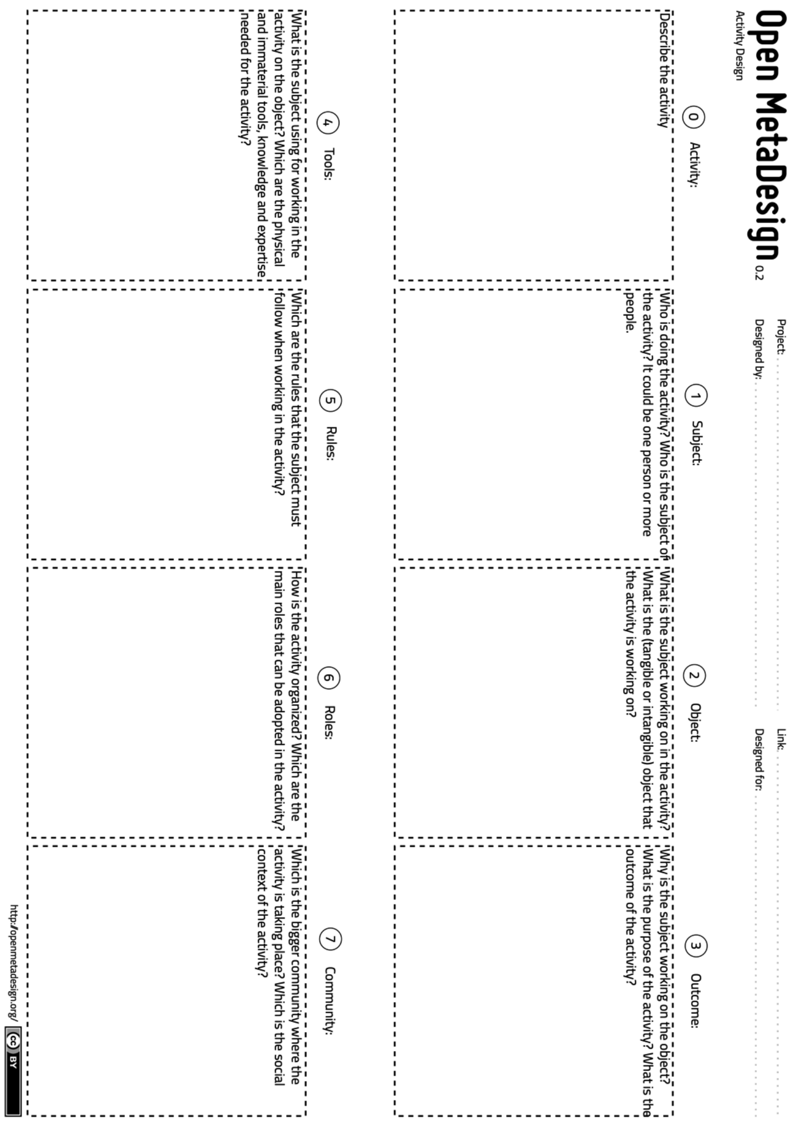

Figure 1. A design canvas for the design of OpenMetaDesign activities, developed during PHASE 2

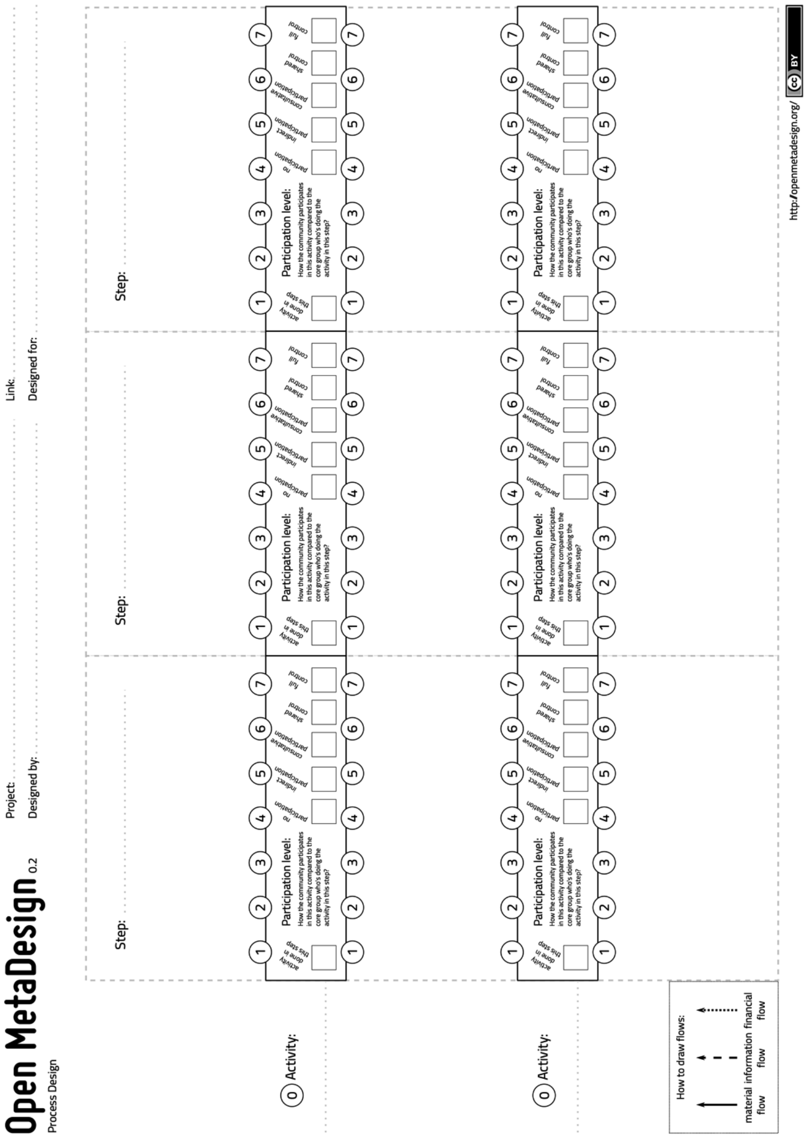

Figure 2. A design canvas for the design of OpenMetaDesign activities, developed during PHASE 2

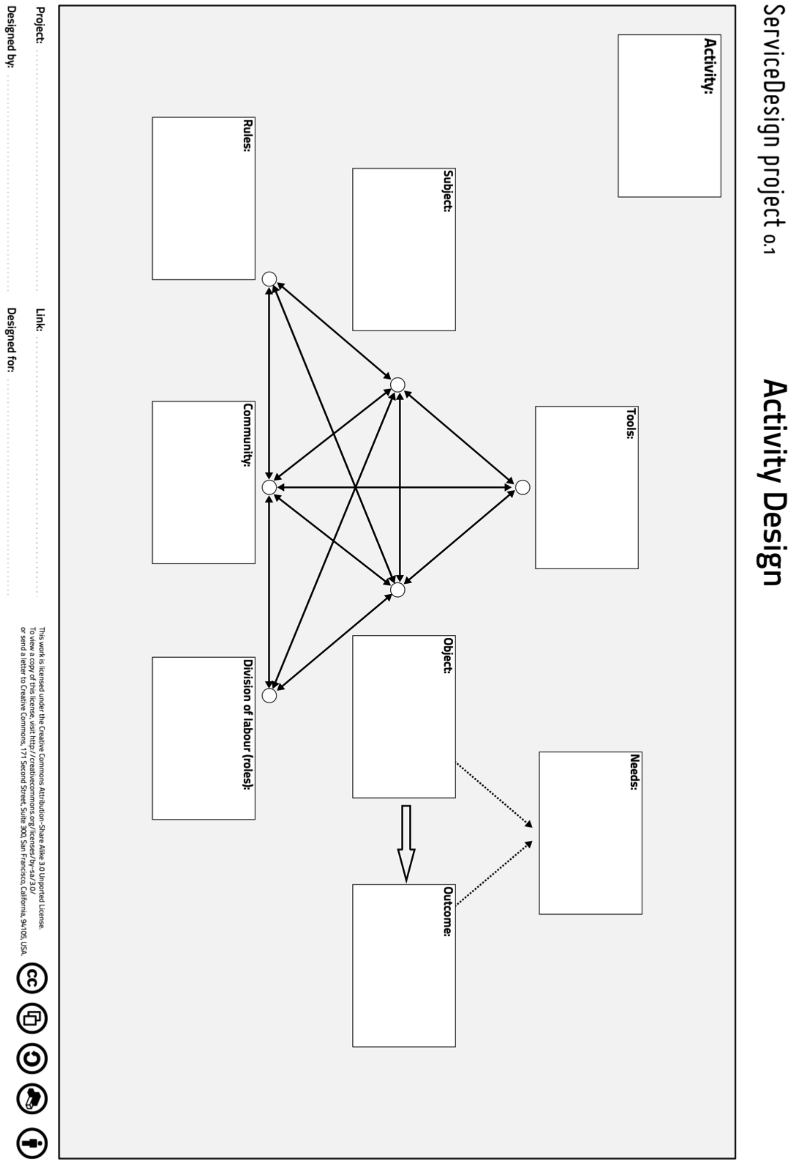

Figure 3. A design canvas for the design of OpenMetaDesign activities, developed during PHASE 2

9. A digital ontology of design processes described as object-oriented code

The digital ontology developed during, for and with the OpenMetaDesign platform is a first template for developing custom ontologies of design processes for any community. Within the OpenMetaDesign platform, the ontology cannot be completely separated from the interface, data handling and infrastructure, all written in Javascript using the Meteor framework and released as Free/Open Source software (Menichinelli 2019a). This section includes a simplified version of the digital ontology translated to the Python programming language, which was created for simplifying its presentation and that is also available online[1].

```python
# -*- coding: utf-8 -*-
#
# Open MetaDesign Classes v0.3
#
# Author:
# Massimo Menichinelli
# Website:
# http://openmetadesign.org
# http://openp2pdesign.org
# E-mail:
# info@openp2pdesign.org
# massimo.menichinelli@aalto.fi
#
# License: MIT License
#

import datetime
import networkx as nx


class Location(object):
    """A class for a location"""

    def __init__(self, street="", number="", city="", postalcode="", country="", latitude="", longitude="", url=""):
        self.street = street
        self.number = number
        self.city = city
        self.postalcode = postalcode
        self.country = country
        self.latitude = latitude
        self.longitude = longitude
        self.url = url

```

[1] https://gist.github.com/openp2pdesign/bd64fe6771569e36ab97e5631f00beff

```

class User(object):
    """A class for a User participating in the process"""

    def __init__(self,
                 name="",
                 username="",
                 email=""):
        self.name = name
        self.username = username
        self.email = email


class Time_interval(object):
    """A class for a time interval with a location"""

    def __init__(self,
                 start=datetime.datetime(),
                 end=datetime.datetime(),
                 start_location=Location(),
                 end_location=Location()):
        self.start = start
        self.end = end
        self.start_location = start_location
        self.end_location = end_location


class Discussion(object):
    """A class for each discussion thread"""

    def __init__(self,
                 id="",
                 title="",
                 start=datetime.datetime(),
                 labels="",
                 url=""):
        self.id = id
        self.title = title
        self.labels = labels
        self.start = start
        self.url = url


class Activity_element(object):
    """A class for an activity element"""

    def __init__(self,
                 id="",
                 name=""):
        self.id = id
        self.name = name


class Activity(object):
    """A class for an activity"""

    def __init__(self,
                 id="",
                 number=0,
                 title="",
                 description="",
                 subject=Activity_element(),
                 object=Activity_element(),
                 tools=Activity_element(),
                 community=Activity_element(),
                 rules=Activity_element(),
                        roles=Activity_element(),
                        outcome=Activity_element(),
                        participation="",
                        time=Time_interval(),
                        location=Location(),
```

```
                 discussion=Discussion()):
        self.id = id
        self.number = number
        self.title = title
        self.description = description
        self.time = time
        self.participation = participation
        self.subject = subject
        self.object = object
        self.outcome = outcome
        self.tools = tools
        self.community = community
        self.rules = rules
        self.roles = roles
        self.where = where
        self.discussion = discussion


class Flow(object):
    """A class for each flow in a process"""

    def __init__(self,
                 id="",
                 type="",
                 resource="",
                 title="",
                 description="",
                 weight= 0,
                 first_node=Activity(),
                 second_node=Activity(),
                 direction="",
                 discussion=Discussion()):
        self.id = id
        self.type = type
        self.description = description
        self.resource = resource
        self.title = title
        self.weight = weight
        self.first_node = first_node
        self.second_node = second_node
        self.discussion = discussion
        self.direction = direction


class Contradiction(Object):
    """A class for each contradiction"""

    def __init__(self,
                 id="",
                 title="",
                 description="",
                 kind="",
                 first_node=Activity(),
                 second_node=Activity(),
                 direction=True,
                 discussion=Discussion()):
        self.id = id
        self.title = title
        self.description = description
        self.kind = kind
        self.first_node = first_node
        self.second_node = second_node
        self.discussion = discussion
        self.direction = direction


class License(object):
    """A class for licenses for the project"""

    def __init__(self,
                 name="",
```

```
                 url="",
                 discussion=Discussion()):
        self.name = name
        self.url = url
        self.discussion = discussion


class Process(object):
    """A class for a process"""

    def __init__(self,
                 id="",
                 title="",
                 activities=Activity(),
                 discussion=Discussion()):
        self.id = id
        self.title = title
        self.activities = activities
        self.discussion = discussion


class Separator(object):
    """A class for a seprator between processes"""

    def __init__(self,
                 id="",
                 first="",
                 second="",
                 text=""):
        self.id = id
        self.first = first
        self.second = second
        self.text = text


class Version(object):
    """A class for versions of the project"""

    def __init__(self,
                 number=0,
                 id="",
                 diff="",
                 updatedAt=datetime.datetime(),
                 updatedAtBy="",
                 updatedAtByID=""):
        self.number = number
        self.id = id
        self.diff = diff
        self.updatedAt = updatedAt
        self.updatedAtBy = updatedAtBy
        self.updatedAtByID = updatedAtByID


class Project(object):
    """A class for a meta-design project"""

    def __init__(self,
                 id="",
                 title="",
                 description="",
                 license=License(),
                 release="",
                 createdBy="",
                 createdByID="",
                 createdAt=datetime.datetime(),
                 lastUpdatedAt=datetime.datetime(),
                 lastUpdatedAtBy="",
                 lastUpdatedAtByID="",
                 versions=Version(),
                 versionsCount=0,
                 designers=User(),
```

```
                 community="",
                 processes=Process(),
                 separators=Separator(),
                 flows=Flows(),
                 contradictions=Contradiction(),
                 activitiesCount=0):
        self.id = id
        self.title = title
        self.description = description
        self.license = license
        self.release = release
        self.createdBy = createdBy
        self.createdByID = createdByID
        self.createdAt = createdAt
        self.lastUpdatedAt = lastUpdatedAt
        self.lastUpdatedAtBy = lastUpdatedAtBy
        self.lastUpdatedAtByID = lastUpdatedAtByID
        self.versions = versions
        self.versionsCount = versionsCount
        self.designers = designers
        self.community = community
        self.processes = processes
        self.separators = separators
        self.flows = flows
        self.contradictions = contradictions
        self.activitiesCount = activitiesCount


if __name__ == "__main__":
```

pass

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The emergence of the Maker Movement has taken place in the context of a design practice and research that is now open, peer-to-peer, diffuse, distributed, decentralized; activity-based; meta-designed; ontologically-defined and defining; locally-bounded but globally-networked and community- centered. For many years the author participated and worked in the Maker Movement, with a special focus on its usage of digital platforms and digital fabrication tools for collaboratively designing and manufacturing digital and physical artifacts as Open Design projects.

How can we support and integrate the research and practice of meta-designers in analyzing, designing and sharing open and collaborative design and making processes within open, peer-to-peer and distributed systems? This dissertation explores with a Research through Design approach the possible role, practice and profile of meta-designers that work in facilitating distributed, open and collaborative design and making processes in the Maker Movement.

9 789526 400907

ISBN 978-952-64-0090-7 (printed)
ISBN 978-952-64-0091-4 (pdf)
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

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