How distributed design is changing the way makers and designers approach collaboration, tools and the market.

Edited by Kate Armstrong, Tomas Diez,
Lisa Goldapple, Alessandra Schmidt & Christian Villum

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EDIT
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PUSH

“The future is already here – it's just not very evenly distributed.”

William Gibson, science fiction novelist

The good news? It can be.

DESIGN REMIX SHAPE REPEAT

How distributed design is changing the way makers and designers approach collaboration, tools and the market.

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INTRODUCTION – CONSIDER IT DD-DAY FOR MASS PRODUCTION AND GAME OVER FOR THE ‘TAKE, MAKE, DISPOSE’ MODEL.

Welcome by co-editors Tomas Diez, Christian Villum, Kate Armstrong and Alessandra Schmidt

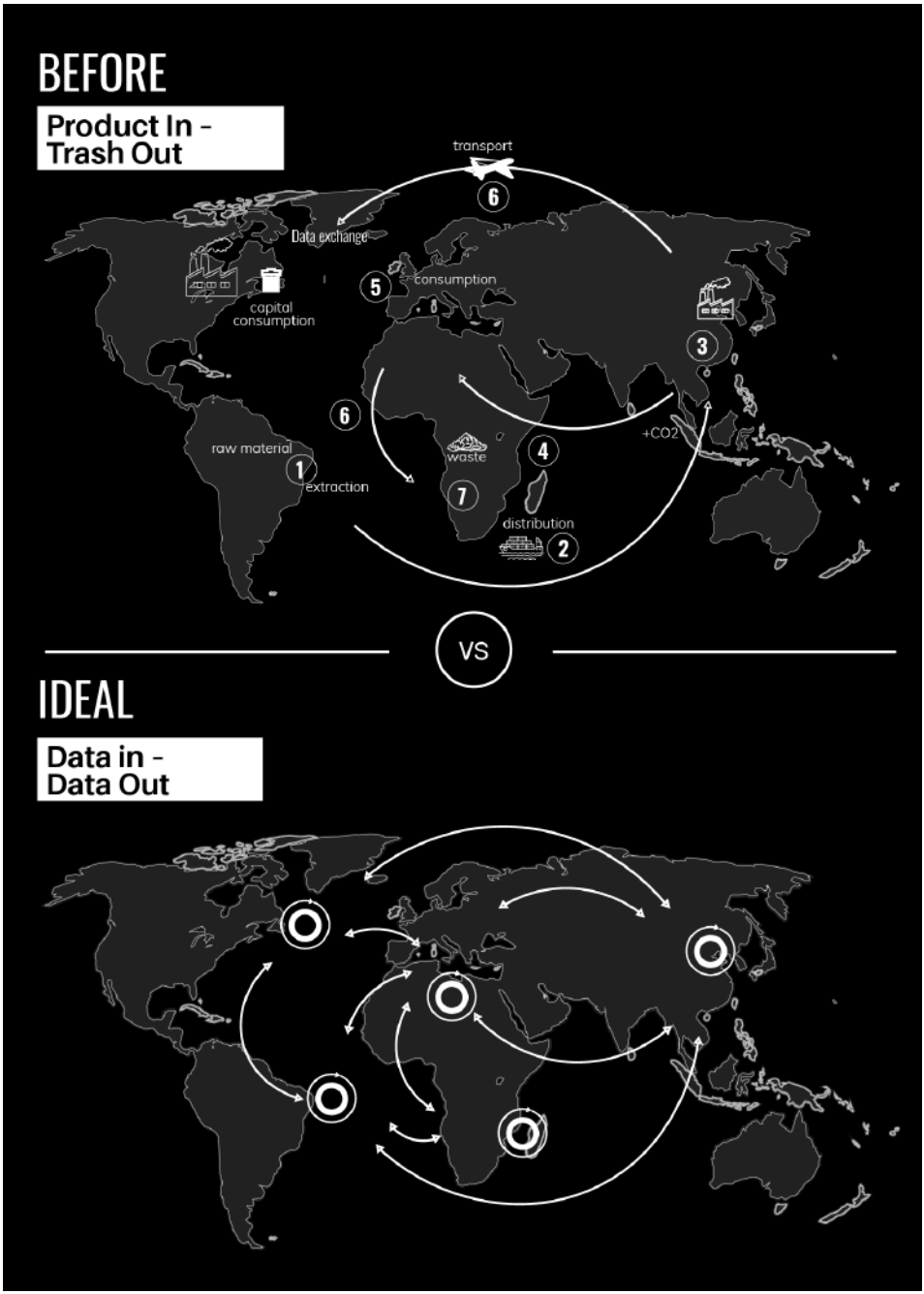


Figure 1 The shift from PITO to DIDO, Fab City Whitepaper

This is the second in a series of four books developed within the Distributed Design[1] platform. Distributed Design (DD) allows creatives, designers, makers and innovators to participate in the creation of a new model of production and consumption, in which "bits travel globally, while atoms stay locally".

The Distributed Design project is funded and supported by the Creative Europe program of the European Commission[2]. Each of these four books (published annually) will explore the advances of the platform. In our first book, 'Fab City: The Mass Distribution of (Almost) Everything' (2018), we introduced the overarching themes supporting the idea of Distributed Design as a new practice emerging from the digital revolution in fabrication, communications and computation. This book serves as an entry point into the state of the art.

The DD model challenges the existing linear paradigm of the First Industrial Revolution and its associated phenomena; patenting, access to fabrication tools, supply chain distribution, value chains and technological development. We live in a moment of technological and crisis convergence. The emergence of Industry 4.0 and the global shift away from fossil fuels; stress in natural ecosystems; climate change and over-consumption has raised questions about the nature of and culture around the products we buy, use and dispose of – as well as the support systems in which they circulate globally. Through the Distributed Design approach, we are promoting, implementing, researching and developing alternatives to mass production and linear consumption models after 200 years of Industrialisation.

Distributed design is one outcome of the intersection of two global trends: the maker movement and the digitisation of the design discipline.

Figure 2 Makers at Danish Design Centre, photo by Agnete Schlichtkrull under a Creative Commons BY-NC license

We contextualise this action-based research in a wider framework of the new urban model of the Fab City Global Initiative[3]. Created in 2014, it proposes a shift in the urban paradigm from 'PITO' (product-in, trash-out) to 'DIDO' (data-in, data-out). Fab City focuses on the movement of data, use of local material supply chains and digital fabrication as an alternative to the movement of materials and goods from production to consumer. In the case of design, this not only provides consumers with more control over their final products by allowing them a voice in the production process, but can also provide designers access to collaborators and tools across global infrastructure networks. This urban model can provide solutions to issues of social and environmental inequality by lessening our reliance on centralised systems and scarce resources to ultimately improve life.

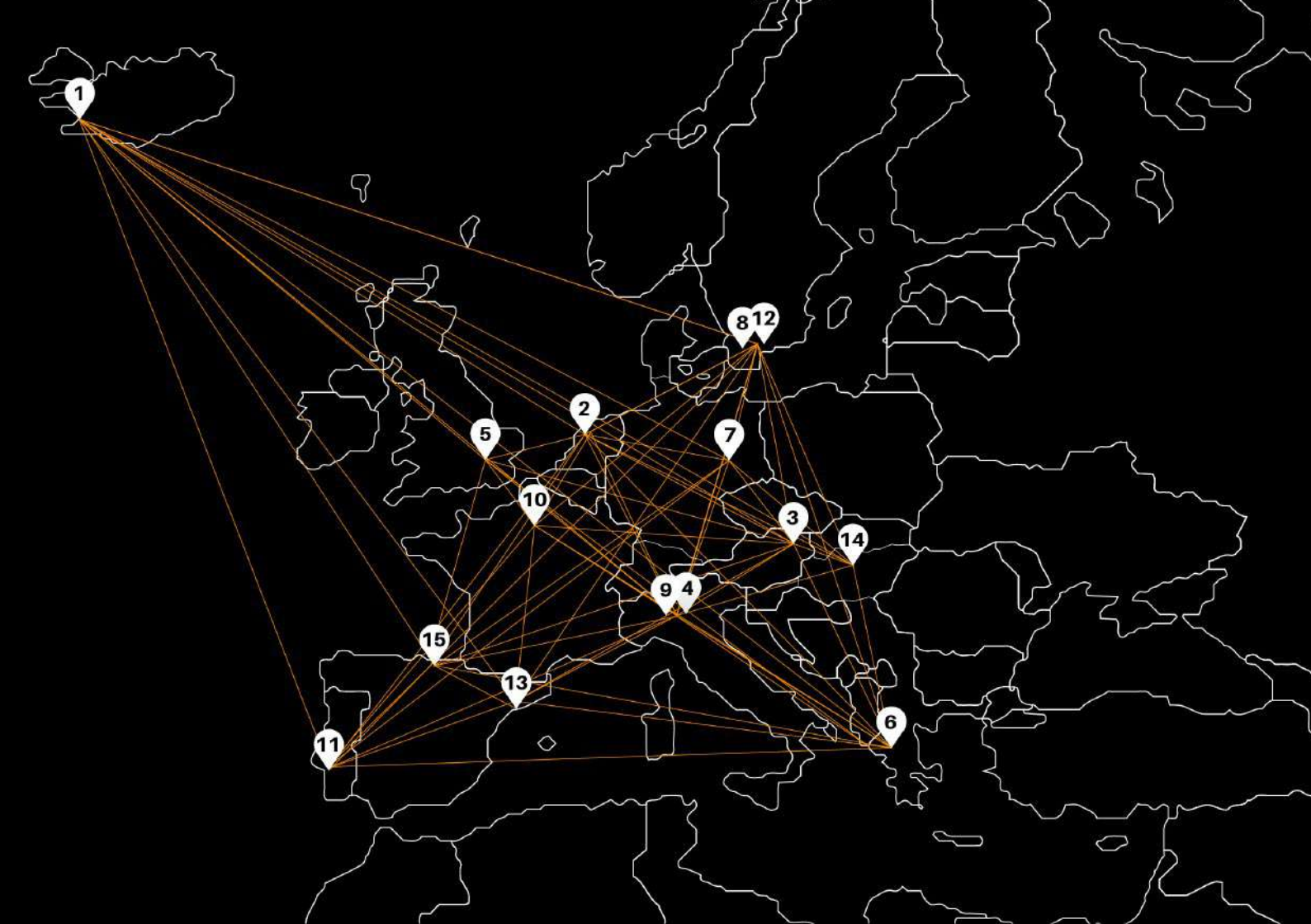
Distributed Design is a phenomenon that integrates design skills and the 'making' approach to enable the development of new entrepreneurial types of professional producers. On one hand, designers acquire more technological and practical skills. On the other, makers evolve their design attitude and capabilities. This convergence is generating new markets, which require new business models and distribution models. In turn, this breeds new ways of working, thinking and valuing, which are explored in the observations, research and case studies presented in this book. These accounts come from members and associated members of the Distributed Design platform, who gather from cultural organisations, industry and educational institutions to advocate for Distributed Design, and foster the role of European creatives in actively shaping this emerging field.

BOOK PROCESS –
COLLABORATING ON CONTENT

This book collates opinions, thoughts, case studies and research from the emerging field of distributed design. The Distributed Design Platform is an initiative lead by Fab Lab Barcelona at the Institute of Advanced Architecture of Catalonia and co-financed by the Creative Europe Programme of the European Union. It collects 14 members from across Europe who collectively articulate the field of distributed design. The content of this book was created collaboratively by these members and other associated members of the Platform, using the distributed technology of GitBook[4]. Put together in this way, its development become another case study that explores how distributed technologies can aid traditional publishing and content creation.

You can read this any way you like, but we suggest you explore the pages using the following Glossary to feed your knowledge, and refer to the values to guide your understanding of our subject's far-reaching impact. This is how we, the collective of authors, editors and advisors, have produced a Distributed Design book in a distributed manner.

Yes, that’s truly meta.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MAP OF MEMBERS –
DISTRIBUTED DESIGN

We live in a moment of technological and crisis convergence. The emergence of Industry 4.0, the global shift away from Fossil Fuels, climate change, stress in natural ecosystems and overconsumption have raised questions about the nature and culture around the products we buy, use and dispose of and the support systems in which they circulate globally. Through the Distributed Design approach, we are promoting, implementing, researching, and developing alternatives to mass-production and the linear consumption models after 200 years of industrialisation.

01 – Innovation Center Iceland
Reykjavík, Iceland

02 – Pakhuis De Zwijger
Amsterdam, Netherlands

03 – Happylab
Vienna, Austria

04 – Polifactory
Milan, Italy

05 – Other Today
London, United Kingdom

06 – P2P Lab
Ioánnina, Greece

07 – re:publica
Berlin, Germany

08 – Danish Design Centre
Copenhagen, Denmark

09 – OpenDot
Milan, Italy

10 – Ars Longa
Paris, France

11– Politecnico de Lisboa
Lisboa, Portugal

12 – Copehagen Maker
Copenhagen, Denmark

13 – IAAC | Fab Lab Barcelona
Barcelona, Spain

14 – FabLab Budapest
Budapest, Hungary

15 –Espacio Open
Bilbao, Spain

GLOSSARY
ENTER THE WORLD OF DISTRIBUTED DESIGN

By Lisa Goldapple

Can't tell the difference between the Fourth Industrial Revolution and Industry 4.0? Going in circles when it comes to the circular economy? Get to know the Distributed Design terminology with this glossary of the most important terms in this book.

DISTRIBUTED DESIGN (DD)

That's why we're here. As a platform, we're exploring how, and in which ways, the distributed design concept has evolved, and how we might find a secure place for it in the world of design.

Check case on page 39, 53, 56,

3D PRINTING

A milestone in modern making history that comes under the umbrella of ‘additive manufacturing’: the process of building a solid object from a computer aided design model by adding materials, one thin layer at a time.

Check case on page 84, 88, 118

Check platform on page 173

ARDUINO

This tiny blue development board has revolutionised making – spawning a community where code, resources and advice are shared freely. The popular open source platform consists of a programmable circuit board and software to write and upload easy computer code.

Check case on page 41, 77,

BITCOIN

Don’t be confused by the gold coin pictures. Bitcoin is a decentralised virtual ‘cryptocurrency’. Without a central bank, it can be sent between users on the peer-to-peer network without the need for intermediaries.

BLOCKCHAIN

An incorruptible digital ledger of economic transactions stored in a distributed network, programmed to record not just financial transactions, but virtually everything of value.

Check platform on page 171

CIRCULAR ECONOMY

An alternative regenerative system prioritising the longevity of goods by sharing or recycling – in contrast to the linear economy’s ‘take, make, dispose’ model of production.

Check platform on page 146

COMMONS-BASED PEER PRODUCTION (CBPP)

New model of socioeconomic production in which large numbers of people work cooperatively, usually over the internet.

Check case on page 67

COMPUTER AIDED DESIGN (CAD)

What it sounds like: a method of design where a computer program is used to create 3D objects in the form of electronic files.

DIGITAL FABRICATION

Check case on pages 53, 58, 92, 124

A manufacturing process in which the machine is controlled by a computer. Common machines include 3D printers, laser cutters and plastic-squirting CNC (Computer Numerical Control) milling machines.

DIGITAL TRANSFORMATION

A radical rethinking of how to use digital technology, people and processes as we move from the physical to digital. Effects extend beyond businesses – to society as a whole.

Check case on page 83

DISTRIBUTED AGENCY

The actions or operations of a range of different individuals often with different motivations, interests and in different places combine to create an outcome they all want. Can be coordinated or by chance.

Check case on page 84

ETHEREUM

Global, blockchain-based platform that creates decentralised processes to protect against censorship, fraud and hacking. With it, you can write code that controls money, and build applications accessible anywhere in the world.

FAB CITY

A creative collective of pioneers and makers who use digital technology to make the world more self-sufficient – collectively – through opening Fab Labs in the hearts of cities, towns and villages. The aim is to provide citizens with resources so they can eventually produce everything they consume.

Check case on Page 114

Check platform on Page 146

FAB LAB

Local fabrication laboratory or urban micro-factory that aims to democratise access to personal and collaborative invention, using digital technologies to make ‘almost anything’. The first ever lab was set up in 2003 in Boston within MIT’s Center for Bits and Atoms.

Check case on page 92, 98, 132

Check platform on page 145

FORK

To make a copy of a repository and freely experiment on it, using a previous design to make something new. At the heart of open source is the idea that by sharing code we can make better, more reliable software.

Check case on page 41

Check platform on page 151

FOURTH INDUSTRIAL REVOLUTION

New technologies are fusing the physical, digital and biological worlds; impacting all disciplines, economies and industries. Previous industrial revolutions liberated humankind from animal power, made mass production possible and brought digital capabilities to billions.

Check case on page 51

GITBOOK

You're reading a book that was created with a tool for creating and publishing documentation of open source projects, physical and digital books.

GITHUB

Development platform to host and review code, manage projects and build software alongside 40 million developers – as they collaborate together openly.

Check case on page 10

Check platform on page 148

HACKER

Someone who uses computers, networking or other skills to overcome a technical problem, usually through unauthorised access. It's not just about bringing down systems, but participating in forums to exchange understandings.

Check case on page 39,

Check platform on page 149

HACKERSPACE

Community-operated physical spaces where hackers convene to share their interest in tinkering with technology, meet and work on their projects, and learn from each other.

INDUSTRY 4.0

The 'intelligent industry' fosters smart factories; machines are augmented with wireless connectivity and sensors, connected to a system that can visualise the entire production line and make decisions on its own.

INTERNET OF THINGS (IOT)

System of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with the ability to transfer data over a network without requiring human interaction. There are concerns about privacy and security; not everything is as ‘smart’ as it seems.

Check case on pages 85, 88, 130

Check platform on page 171

MAKER

Put simply, a person who makes or produces something. Today's makers are skilled in coding, embedded electronics, design and all things computer-related.

Check article on pages 42, 75, 92, 98, 105

MAKER MOVEMENT

The resurgence in making can thank the rise of the internet, as the sharing of ideas, projects and knowledge leads us to mass collaboration in the creation of a movement.

Check article on pages 48, 54, 56,

Check platform on page 155

MAKERSPACE

Collaborative work space inside a school, library or separate facility where makers, designers and innovators make, learn, explore and share.

Check case on pages 88, 92, 98, 123

Check platform on page 177

MISSION-ORIENTED INNOVATION

Fresh approach to questions that focus on the potential of strategic public sector investment to catalyse economic activity, spark innovation, solve public problems, and lay the foundations for future economic growth.

MOONSHOT

Ambitious, exploratory and ground-breaking project – sometimes deemed ‘crazy’ – designed to solve some of the world's hardest problems using breakthrough technologies.

MOORE'S LAW

In 1965, Gordon Moore, co-founder of Intel, proposed that the number of transistors on a silicon chip would double every year. Put simply: overall processing power for computers will double every two years.

Check platform on page 169

NON-RIVAL GOODS

Public goods that are consumed or used without reducing the amount left for others. Non-rivalrous good can be used again and again at almost no additional cost. Examples are designs, movies, television, fireworks, algorithms and patents.

Check case on page 67

OPEN SOURCE

Decentralised software development model that encourages open collaboration, with products such as source code, blueprints and documentation freely available to the public and made available for use or modification.

Check case on pages 42, 58, 68, 72, 89, 106

Check platform on page 154

PARAMETRIC MODELLING

Components are interlinked and automatically change their features with others. The designer only needs to edit one parameter in an equation for the other dimensions to adjust the geometry automatically.

Check case on page 92

PLATFORM

A group of technologies that are used as a base upon which other applications, processes or technologies are developed, or a network of organisations working together to progress a topic from multiple perspectives across multiple localities – like Distributed Design.

Check case on page 48, 111

PROTOTYPING

Creating an early sample, model or release of a product built to test a concept or process – from design to electronics to programming.

Check case on page 76, 83, 124

REPRAP

Shorthand for ‘replicating rapid prototypers’, the open source 3D printers use a fused filament fabrication process and are capable of printing out their own parts.

STL FILE

The most common 3D printer file format. Generated by a CAD program, the ‘stereolithography’ file format describes the surface tiling or layering of geometric shapes and patterns of a three-dimensional object. Also referred to as ‘Standard Tessellation Language’.

Check platform on page 156

TRANSPARENCY

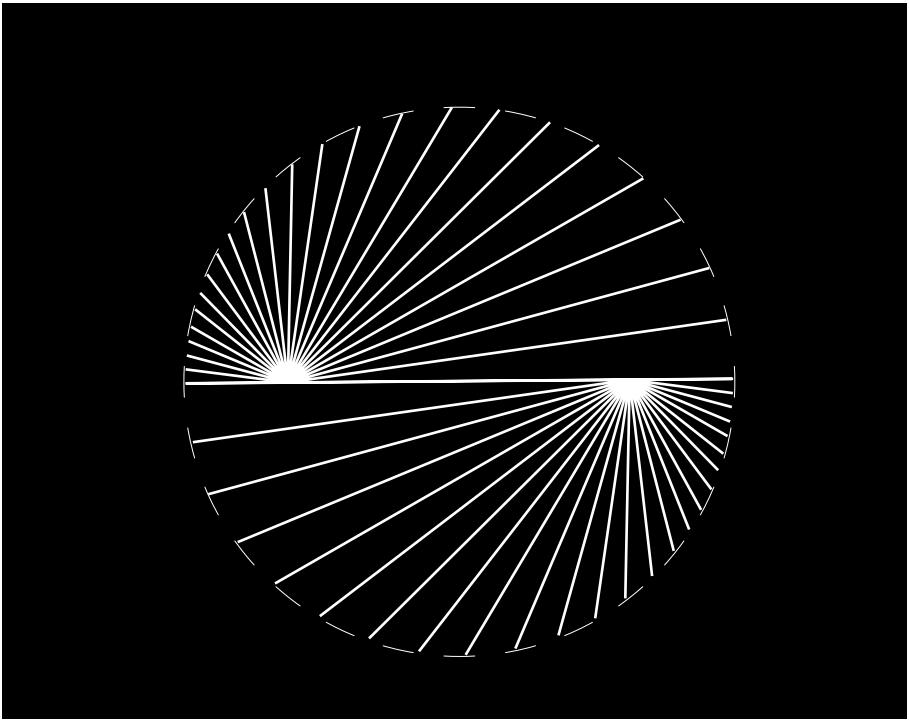
The resurgence in making can thank the rise of the internet, as the sharing of ideas, projects and knowledge leads us to mass collaboration in the creation of a movement.

Check article on page 48, 59,

VERSION CONTROL

A system of recording changes to a file or set of files over time so you can recall specific versions later.

Check platform on page 154

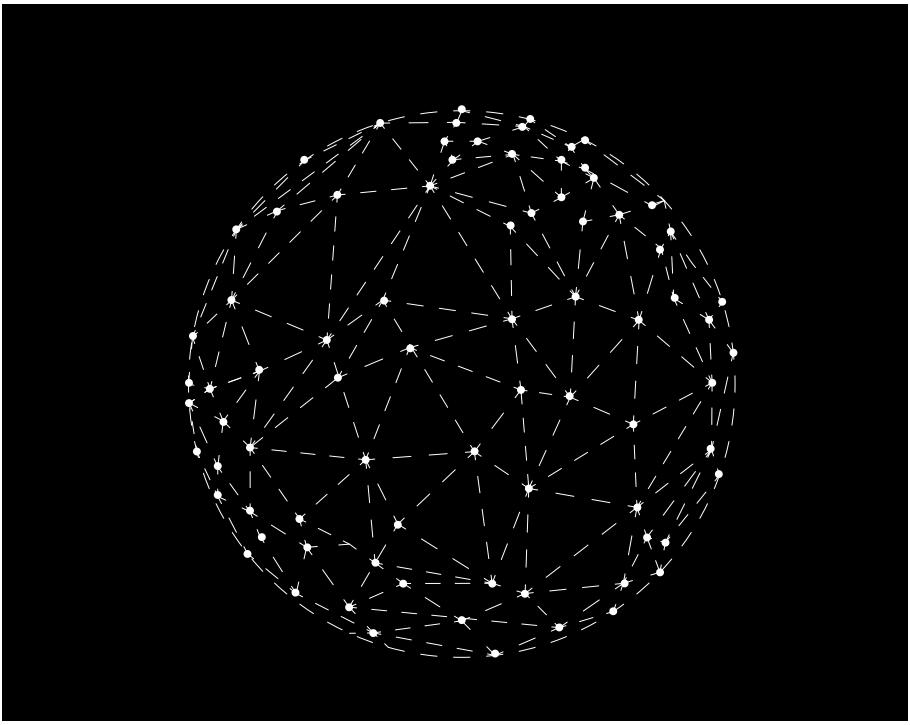


Value 01

SUPPORTIVE

We create opportunities for designers and makers who are working on new approaches to product development and commercialisation.

We’re making tools, resources, events and advocacy to help establish the distributed design field as a viable market for designers and makers.



Value 02

ECOSYSTEMIC

We facilitate an online and offline ecosystem of tools and methods to connect designers, makers and manufacturers with new emerging markets.

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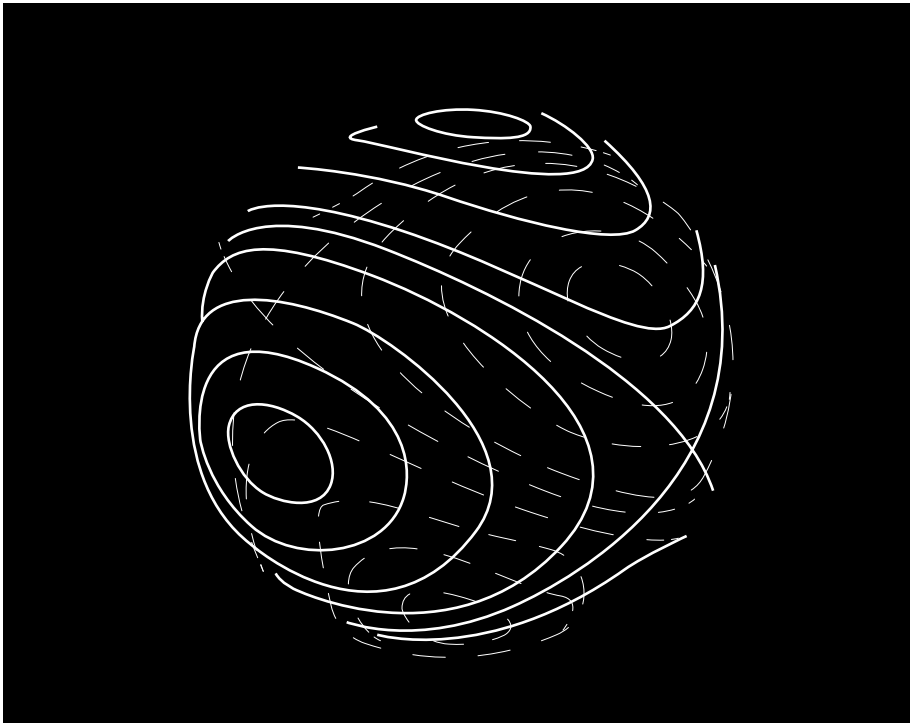
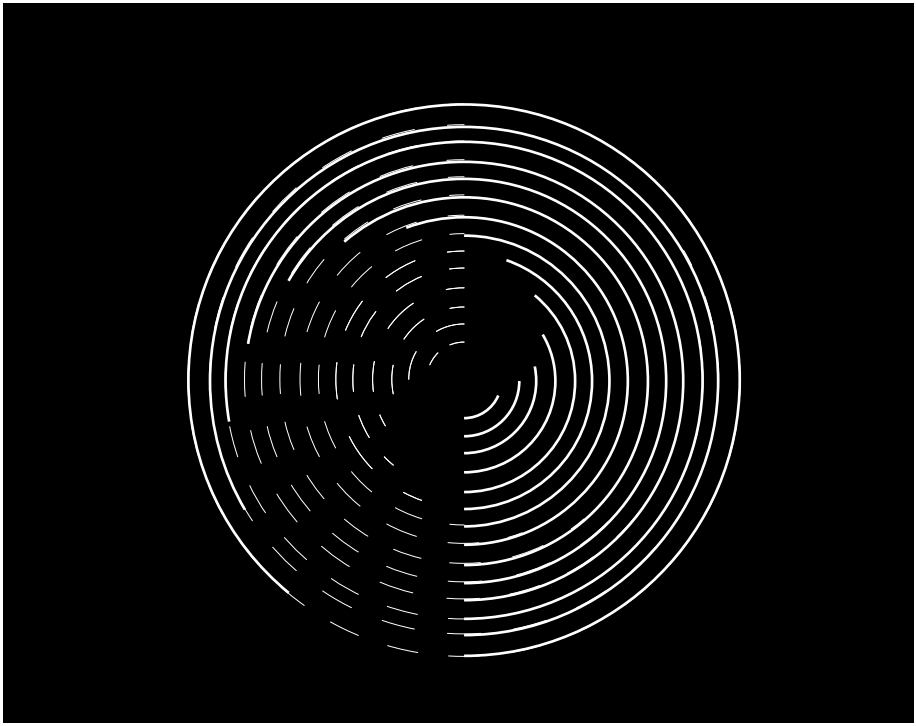


Value 03

OPEN

We’re into making design accessible by championing culture that benefits makers, designers and consumers to advance the design discipline as a force for change.

We believe in documentation and open source not only as a design practice, but as a community building tool; we collaborate, co-create and understand that transparency is important.



Value 04

REGENERATIVE

We're rethinking traditional production and consumption practices by considering design as a system. From fabrication to distribution, we're exploring low kilometre supply chains, open source distribution and thinking carefully about the materials we choose.

We want to make good quality products that last for people who will love them for generations, finding a use for their materials once their product life is over, not letting them go to waste.

STATE OF THE ART – OF DISTRIBUTED DESIGN

By Tomas Diez and Christian Villum

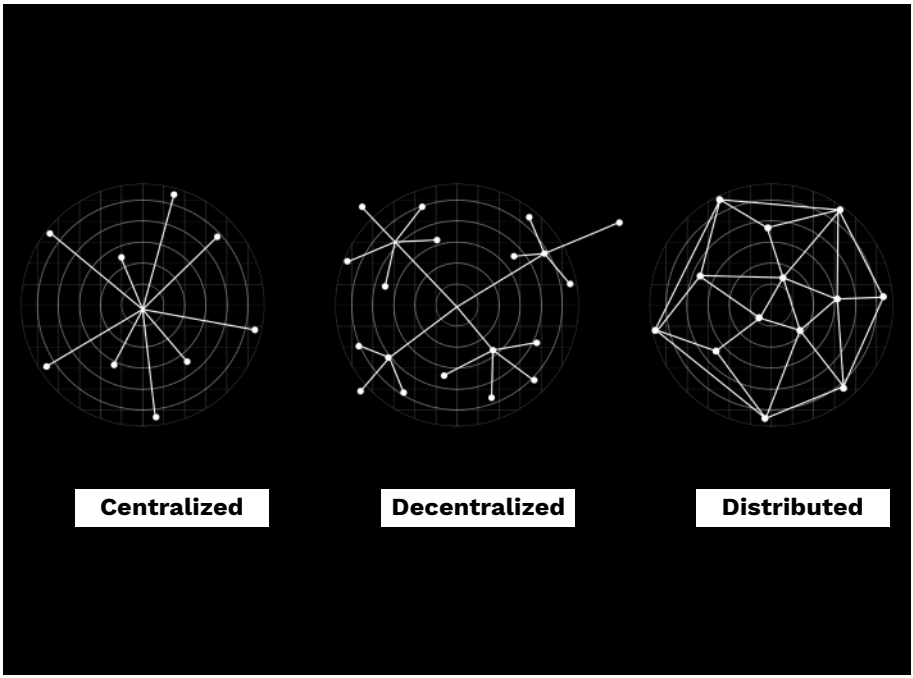


Figure 1 Centralised, decentralised & distributed network models by Paul Baran (1964), part of a RAND Institute study to create a robust and nonlinear military communication network.

You might recognise the spider web-like images above as some of the most widely used illustrations when it comes to explaining the topology of the world's computation and communications networks. The same images can be used to explain how the physical worlds of cities, products and supply chains are designed and manufactured by humans – and to show how the current paradigm of production operates somewhere between a centralised and decentralised model.

Centralised, decentralised or distributed?

- Radio and television models follow the model of a centralised or decentralised model.
- The Internet was designed as a distributed network.
- The World Wide Web (a way of accessing information over the medium of the internet) is in parts both decentralised and distributed.
- In industry, the current paradigm follows the decentralised model, moving towards a more centralised way of production while maximising benefits and capital.

Moving from centralised to distributed models

Medieval cities used to be independent centralised centres that were not considered communications 'nodes', as they were not connected with larger networks, at least at scale. After the invention of the printing press, cities could start to develop a sense of connection and exchange of knowledge. This renaissance could be considered a byproduct of the spread of knowledge that happened centuries before, but also the beginning of the industrial era.

Industrial cities operated as decentralised nodes of production, with their own capacity to satisfy most of the needs of local populations – but connected with larger networks of supply chains at a global scale. This explains the development of nation states as strong organisational powers. It was during the 20th century, and thanks to the globalisation process and efficiencies in time and profits, that cities were able to take the production of food and goods out of the cities, leaving the responsibility of supplying the needs of locals to the global market. As a result, corporations became stronger. Organisations could even establish and remove national governments.

The way we organise our production of knowledge, energy, goods, food and the resources needed to sustain life on this planet is directly related to the organisation of power – whether economic, political or social. It seems that we are on the verge of reorganising the way we produce almost everything,

Figure 2 Distributed manufacturing tools at Danish Design Centre by Agnete Schlichtkrull under a Creative Commons BY-NC license

thanks to the convergence of technological advancements and the need to solve the fundamental challenges of our times. We are moving to a more distributed model, with unexpected consequences in the definition of new roles of individuals, communities, organisations, political movements and even corporations.

The rapid drive of technological transformation sweeping the planet is underpinned by a range of what could be referred to as social undercurrents, or new norms for interaction and collaboration. One of these is arguably the global wave of digital collaborations that can be seen in the open source movement. Hundreds of thousands of people act as nodes in gigantic digital value creation networks that produce assets such as knowledge, science, software, services, virtual content and physical products. Above all, a rapidly expanding new commons of open design is available for anyone to build on. The classic models of design taking shape inside organisations are increasingly being supplemented – and will potentially eventually be replaced – by decentralised and distributed practices that dramatically accelerate development pace and innovation speed.

To understand the concept of **Distributed Design** go to page 20

Two parallel narratives define '**distributed design**' at this early stage:

To understand the concept of **Hacker** go to page 26

01. The maker/Fab Lab vision and global community: Builds on the bottom-up DIY movement and white hat **hacker** ethos of self-empowerment – and the co-creation spirit of tackling technology head on – in an effort to improve the world, one Arduino project at a time.

02. The web3/decentralisation/crypto crowd: Combines two very different arenas – on the one hand, the cyberpunks and tech-libertarians who originally dreamed of digital freedom utopias; and on the other, big money that has seen the light in new friction-less, unregulated and untaxed economies of scale.

Both narratives hold interesting visions for the future, and, arguably, find a shared denominator in the concept of distributed design – which is, in many ways, rooted in a more philosophical understanding of what super-connectedness and abundant computing power may do to improve the world.

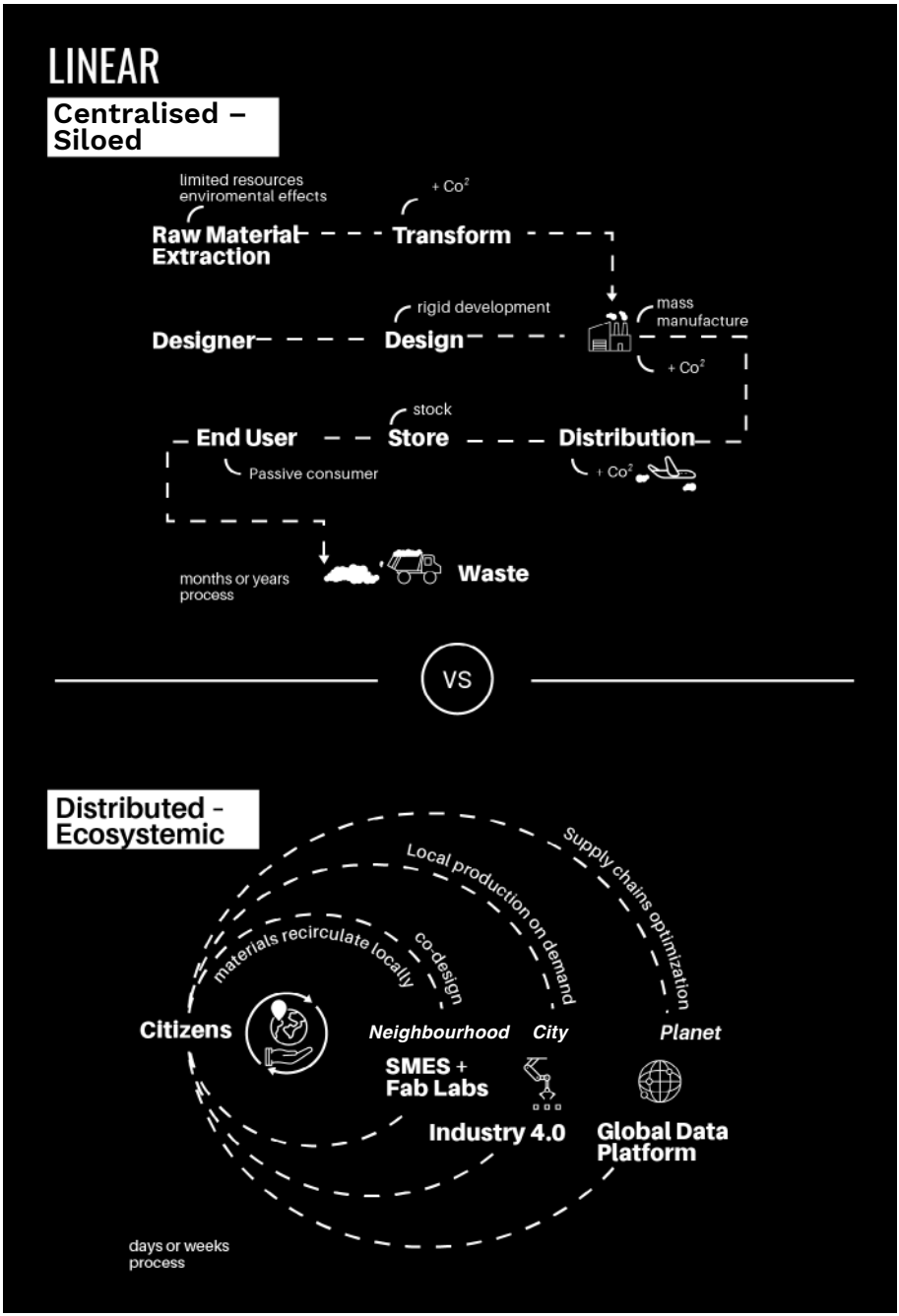


Figure 3 From PITO to DIDO, Inspired by Fab City Whitepaper

However, it seems that this techno-optimism has been plagued with unintended consequences of the digital revolution. Computers need rare minerals to be built, which are scarce and expensive to extract. When produced at scale, computers are causing both an ecological and a social disaster; these need to be reduced to its minimum, or to be hidden from consumers. Access to information lives inside another paradox. It can unleash the spread of knowledge and start a new renaissance, or it can create new mechanisms to manipulate entire populations to buy certain type of products or bring votes to political leaders. We live in a paradox of convergence, in which old philosophical understandings of the world and the ways to operate it live together alongside these new forms of production and distribution. While they are promising, they often seem to be held on hold as the old figures out how to deal with the new.

One thing that is becoming very clear is that this philosophical understanding embeds a strong fervour towards finding a more sustainable path – one that builds on the distribution of knowledge; and the capacity that 'bits' have to transform visions of the world and enable the articulation of collaboration at global scale. The relationship that humans have with 'atoms' that are extracted or dumped into ecosystems is also being redefined, and changing the many futures of humans and other species that share spaceship Earth. A distributed approach to design and manufacturing has implications both at local and global scale, and we have seen some of those effects already happened during the last couple of decades.

Here are a few examples that are referenced in later chapters:

— The Rep-Rap project[5] and 3D printers have made rapid prototyping of rapid prototyping machines accessible to millions of people, unleashing a huge global market of entrepreneurs around additive manufacturing. However, large corporations are trying to control this under the old patenting system and pushing to a centralisation of supply chains.

To understand the concept of **Arduino** go to page 20

— The **Arduino**[6] electronics prototyping board has made it possible for anyone to learn to program computers and understand the basics of electronics. The open source platform allows anyone to share their projects, but also enables anyone to '**fork**' the design of Arduino to create other new projects. The Arduino team has struggled to collaborate with

To understand the concept of **Fork** go to page 24

large electronics corporations, as they try to absorb an **open source** philosophy inside their very industrial mindset.

— Fab Labs[7] have been making digital fabrication accessible to everyone. We will dedicate a deep look to this network later on.

— Products such as OpenDesk[8], Kniterate[9], Smart Citizen[10], Nervous Systems[11], Ultimaker[12], OtherMachines[13] and Precious Plastic[14] are also becoming part of a new form of production and distribution.

To understand the concept of **Open Source** go to page 29

In this book we would like to extend the **makers**' approach to distributed design that was laid out in the first book, Fab City (2018), but also discuss current movements.

To understand the concept of **Makers** go to page 27

Figure 4 A maker takes to the tools in Denmark. Image by Agnete Schlichtkrull under a Creative Commons BY-NC license

We will focus on new business models that drive the most advanced distributed design

We will focus on new business models that drive the most advanced distributed design practitioners – makers, designers and crafters – showing how they represent a more equitable and sustainable way of producing goods; and how they are proof testing a new paradigm that may ultimately replace the current centralised and siloed norms.

To write about the state of the art of distributed design is quite challenging. As this book is written, edited and printed on demand, many practitioners are collaborating at scale within the distributed infrastructure of workshops – sharing files through open source repositories, and willing to be copied and remixed. This is in stark contrast to the industrial era's designer and creative, who would look for exclusive ownership of ideas and manufacturing capacity.

The challenges ahead rely on the capacity for distributed design and manufacturing to become the new industrial paradigm of the 21st century – based on values that follow a different type of growth; and relationships between each other, and with our ecosystems. In the face of huge social challenges and climate emergency, we believe that alternative models of production and consumption deserve to be tested and experimented with in cities around the world.

Over the last two years, Distributed Design has been enabling this process, starting with partners in Europe and scaling up collaborations in Latin America, Asia and Africa – as well as regions that have their own approaches to local manufacturing, but are struggling to not to be dragged back into the 20th century industrial paradigm. The story of Distributed Design needs to be written, developed and turned into a living repository of recipes on how to make our communities, cities and regions better places for humans and ecosystems to sustain life.

WORDS FROM OUR ADVISORY BOARD

The Advisory Board provides experience and knowledge to the development of Distributed Design.

01 CHAPTER

01 – Moving from an Individual to a Collective Worldview

02 – Fixing Education and Learning

03 – Making Machines that Make

MOVING FROM AN INDIVIDUAL TO A COLLECTIVE WORLDVIEW– UNDERSTANDING OUR INTERDEPENDENCE IN THE GLOBAL ECOSYSTEM

Edited by Emily Whyman from a podcast[15] interview with Indy Johar, architect and founder, Dark Matter Laboratories[16]

"Climate change is a symptom of a much more structural failure... and we're addressing the symptoms, not the underlying drivers."
Indy Johar

Climate change, poverty, hunger, division – these global challenges are all symptoms of a larger root problem. To solve them, we need to move in a meaningful way from an individual worldview to a collective one.
We are now responding to a series of transitions; 'we' being each planetary citizen. These transitions are a response to inherent structural failures in a system constructed upon the designed vulnerability of the ordinary consumer. The methods in which markets work objectify the surrounding environment, creating a disconnect between producer and consumer. Commercial language reduces plastics to 'single-use', trees to timber and food is considered a throwaway commodity with a 'sell-by' date.

Figure 1 Indy Johar shares his wisdom with the IAAC Master in Design for Emergent Futures students, ELISAVA Barcelona, 2019.

The methods in which markets work objectify the surrounding environment, creating a disconnect between producer and consumer.

"This reductive capacity has been fantastic for propelling civilisation to one type of complexity," explains architect Indy Johar. "I think what we are seeing is the end of that worldview."

Planetary transitions such as climate change, inequality and polar malnutrition can be perceived as feedback from an ecosystem imbalance. It stems from the consistent depletion of natural resources, where not enough time is given to recuperate and regenerate. We have now begun to feel the negative effects of this fatigued system. This feedback highlights our interdependence with other species in the wider ecosystem, which has too often gone ignored. Perhaps this moment in time can be seen as a saturation point; behaviours are beginning to shift in recognition of interdependence.

This brings human-machine ecology into perspective as it plays a great role in our present, and our future. Rapid advances in social media, 5G and technological accessibility, for example, have enabled communication on a global scale, but the full potential has not yet been reached. Recognition of ecological interdependency will lead to a redefinition of value in a human-machine ecology.

Language, branding and marketing play a large role in environmental degradation. Commercial language reflects the value we ascribe to objects we buy, which then further supports a wider global economy and production ecosystem.

The current objectification of language in commercial environments means we fail to ascribe meaning to purchasing and the creative process of making. This transaction is currently valued on price, branding or availability; actions which fail to acknowledge the wider ecosystem and intensive energy process of production. The rise of distributed design, **maker movements** and manufacturing justifies hope for a system based on meaningful exchange. In transparent production practices, open source knowledge sharing or revival of craft, we associate physical tactility to value. **Transparency** and the acknowledgement of production can surpass the commercial setting and price tag. Interdependency becomes embedded into design itself; educational models, market platforms or de-objectified environmental language.

To understand the concept of **Maker Movement** go to page 27

To understand the concept of **Transparency** go to page 31

"I would argue there's a new class of 21st century business. It will not be about private value – it will be about financing common value through massive interaction points and contracting," Johar adds. And that applies to hundreds of other things that we can talk about off the back of it. "We're fundamentally transitioning to a new model of capital facilitated by pretty much zero cost bureaucracy and a new transaction architecture."

We're fundamentally transitioning to a new model of capital facilitated by pretty much zero cost bureaucracy and a new transaction architecture.

What does recognising interdependence mean when it comes to human-machine ecology? As mentioned before, it may be through mechanisms based on the transparency of production processes, founded on common values – ranging from developing alternative markets to looking at implementing robotics for micro-farms. Open-source, sharing **platforms** and circular economies are also examples of common values. Once these mechanisms are scalable globally, we can begin to construct new identities that recognise true value, thus fostering positive ecological feedback.

To understand the concept of **Platform** go to page 30

Johar agrees: "Whether it's climate change or plastics or inequality, it is all about us recognising our interdependence. The great transition we are on is actually this transition in how we see ourselves, but also how we see ourselves in the world. The machine-human-ecological relationship is being transformed. And when you look at it from that perspective, I think that's the first thing we have to recognise." Recognising interdependence also acknowledges a change in the language we use towards material culture.

Figure 2 Design students immersed in Indy Johar's words. ELISAVA Barcelona, 2019.

Take Precious Plastic for example (more about this later in the book), this project has done wonders in changing how we view plastic as a material. Through addressing the underlying drivers of excessive consumption, Dutch designer Dave Hakkens and his team of collaborators are reworking the language around single-use to 're-use', rather than attempting to change the immense demand that the human ecosystem has around plastic. 'Precious Plastic' is one example of playing with alliteration and expectations. 'Distributed Design' is another. Projects such as these could change how cities and environments are sculpted on a global scale.

The need for rethinking the motivations placed into economies, markets and commercial environments is critical right now. Environmental feedback is already causing irreversible damage to ecosystems and human life. Recognition and appropriate allocation of value will lead to more steady economies, offering space for experimentation, creativity, respect and the freedom to care.

FIXING EDUCATION AND LEARNING – WHAT TYPE OF LEARNING IS NEEDED FOR SCHOOLS TO SUPPORT A CULTURE OF DISTRIBUTED DESIGN

By Daniel Charny & Dee Halligan

“Children can’t use scissors!”[17] “School leavers are more skilled at memorising than imagining!”[18] “Student surgeons lack the manual dexterity to sew!”[19]

Our relationship with making in education, as in life, is broken. And until recently the western world seemed generally comfortable with this trend, lost in a consumerist dream, where a never ending supply of goods could appear like magic without us lifting a finger or understanding the skills, processes or resources which go into making them.

We’re now finding, like the proverbial free lunch, this magic has come at a high cost. Arguably greater than the impact on our finite resources and our creation of emissions and waste, is the loss of knowledge, skills and cultures of making, for we lose some of the know-how to fix our problems, small and big. As societies, alongside the ability to cut and sew, saw and drill, we have lost something fundamental about the way we interact with our world and harness our creativity and ingenuity to improve it.

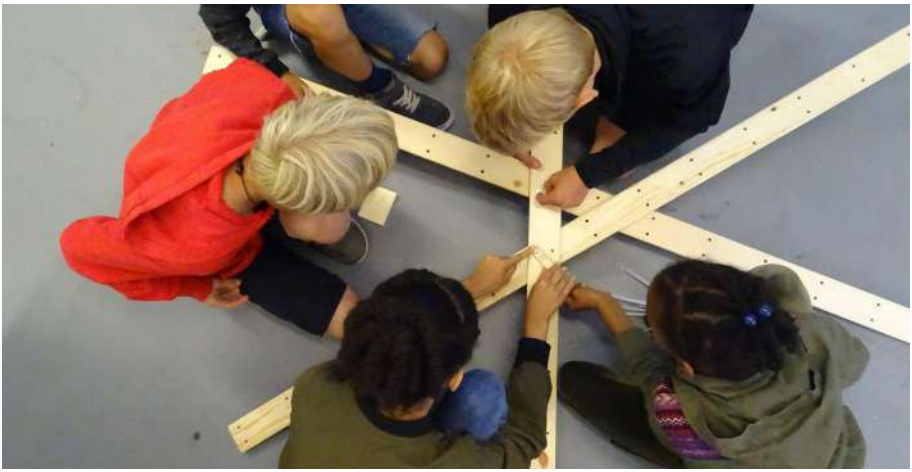


Figure 1 Students engaged in fixing their education and learning, London, 2019

The next generation's relationship with their planet will be radically different from ours, and local production and consumption will be a critical piece of that puzzle.

It's increasingly accepted that radical change is necessary, and in the brave new world we forge, education as always will shape values, culture and mindsets as well as engaging students with knowledge and skills. In our work at FixEd[20] in order to propose new approaches which might reinvigorate creative education we have to imagine the future society it serves. The future is always mysterious, but some things are blindingly obvious: the next generations relationship with their planet will be radically different from ours, and local production and consumption will be a critical piece of that puzzle.

Local manufacturing was once the only way. Sharing knowledge through families, guilds or traditions so obvious as to be unremarkable. Technology prompted us to break these systems and now technology reminds us and equips us to reconnect to them once more. What we could see as an irony is better seen as a correction, and as looking to the future rather than the past. Technology and tools have always been extensions of the body; the **fourth industrial revolution** offers new opportunities to bring them home and renegotiate the control and benefit.

To understand the concept of **Fourth Industrial Revolution** go to page 25

At first glance our flagship learning programme, Fixperts21, looks unconnected to these ideas. Teams of Fixperts develop their creative problem solving skills through a human-centred process; they've worked on problems from putting in earrings to opening doors, and made anything from cycling to sleeping

Figure 2 Students learning digital fabrication for learning, London, 2019

Fixperts is a conversation with a changing world, questioning the conventions of design, authorship and ownership, production and distribution.

easier. Encouraging a DIY, hands-on ethos and responding to need with creativity and resourcefulness is heartwarming, but Fixperts' agenda is way bigger: these students are engaging at micro-scale with global issues like ageing, waste and accessibility, working collaboratively and sharing their ideas openly and harnessing the newly available tools of the fourth industrial revolution to do so. Without these contexts it would be a nice project, instead it is quietly revolutionary. Fixperts is a conversation with a changing world, questioning the conventions of design, authorship and ownership, production and distribution.

Fixperts is one of many learning initiatives seeking to challenge current education agendas and test ideas about what cultures and attitudes, knowledge and skills will be needed to serve our improved future (see for example Mouse[22] or Girls Garage[23] in the US, the Waag[24] and Institute of Imagination[25] in Europe, and systemic change experiments in Finland[26] and Singapore[27]). Change happens slowly in education and these kinds of inspiring and pioneering initiatives are desperately needed to test new ideas and approaches, inform the future mainstream and help shift the paradigm. What's also needed are the big ideas which education will support.

To understand the concept of **Distributed Design** go to page 20

Distributed Design is one such big idea, Fab City another; both require us to question our ideas about how the world can or should work and rethink the systems we take for granted. It's a mammoth task to redesign systems at scale. The creative, resourceful and brave citizens – and the enlightened culture critical to securing these big ideas – can only be anchored in learning.

Fixperts is a learning programme run by not-for-profit 'think and do' tank, FixEd. It has been taught in 20 countries and in over 40 higher education institutes. In the academic year 2018-2019 over 200 school level teachers in the UK were trained in the Fixperts approach.

MAKING MACHINES THAT MAKE – A RADICALLY DIFFERENT ECOSYSTEM OF PRODUCTION

By Nadya Peek

Digital fabrication embodies the promise of a radically different ecosystem of production. With only changes in code, people can produce locally, on demand, just in time. However, undoing two hundred years of human consumption models cannot happen overnight. Shifting from shopping to making, from discard to reuse, and from products-in-trash-out (PITO) to data-in-data-out (DIDO) will take not only a reshaping of human behavior, but also of the infrastructure that underlies it.

Industrial manufacturing relies on machines that are complex to set up and run. Using those machines is predicated on mass consumption to offset start-up costs of production. Humans come to the factories to tend to the machines. Inventory is produced, shipped and stored, to be immediately available to the consumer – but it is not on-demand production. It's just-in-case production. The excess inventory is trashed.

How do we enable local, on-demand production without loss of complexity? For **digital fabrication** to compete with industrial manufacturing, the threshold to production needs to be lowered to the point of it being better than the alternative.

To understand the concept of **Digital Fabrication** go to page 22

Thanks to the **maker movement**, some machines are now broadly accessible. For example, 3D printers are cheap, easier to use and more widely available than ever before. However, one type of machine cannot meet the

To understand the concept of **Maker Movement** go to page 27

needs of all kinds of production. Complex goods, such as computational, analytical or personal devices require multiple processes strung together in workflows.

We cannot expect decentralised production to happen with centralised machines. We need to distribute the development and production of manufacturing, hence machines too.

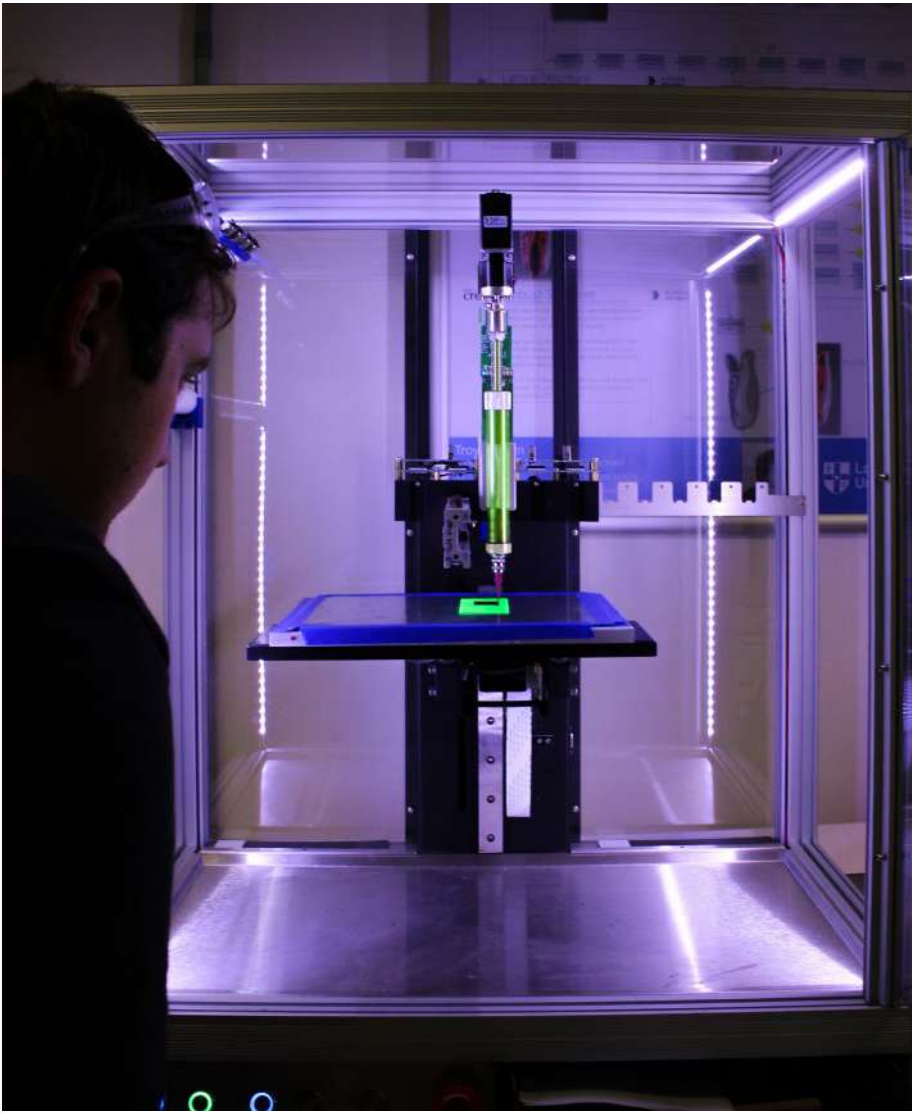


Figure 1 Human ponders machine. Photo from Rob Wingate

A QUALITY LABEL – CERTIFYING OUR VALUES

By Kate Armstrong

Something exciting is happening at the convergence of the **maker movement** and digital design field. A shared set of values is emerging as we see designers and makers prioritising the four core **Distributed Design** Values: Supportive, Ecosystemic, Open and Regenerative.

To understand the concept of **Maker Movement** go to page 27

To understand the concept of **Distributed Design** go to page 20

By allowing these principles to guide practice, creators can unite with like-minded others – as more and more people work to shift the production and consumption paradigm with an aligned mindset. As explored in this book, alliances with small and medium-sized enterprises (SMEs), industry, policymakers, educators, producers, manufactures and consumers are helping to advance the benefits of distributed design beyond design and making, to enable a much larger social impact.

The Distributed Design platform is advancing research into the possibility of making these alliances visible through a certification process: the Distributed Design Quality Label (DDQL)[28]. The starting point is for it to be a Europe-wide quality label that certifies and promotes the work of talented makers and designers. It could support practicing distributed designers in identifying potential collaborators, manufacturers and customers in a rapidly changing marketplace. The DDQL label would identify a designer's approach and, importantly, the values that could accelerate the social impact of distributed design.

How to get labelled under the DDQL

Recognising the efforts of designers through awards is crucial to developing leaders and role models to advance the culture of DD. In the field of design and creative arts, recognition through achievement is common; fashion weeks, design weeks and architectural awards are key to pushing design into the public sphere.

Figure 1 DD project manager Kate Armstrong delivers a workshop during re:publica Festival, Berlin 2019

One way of identifying the talented creators who are pioneering quality in the DD field is through the annual Distributed Design Award.

One way of identifying the talented creators who are pioneering quality in the DD field is through the annual Distributed Design Award[29]. In 2018 we collaborated with the Danish Design Award[30], and with INDEX Project[31]: Design to Improve Life in 2019. Finalists and Awardees were recognised for the level to which they reflected the values of DD determined by the platform members and the Advisory Board of Distributed Design. The winning projects were in the fields of urban agriculture (Nextfood[32], 2018) and architecture (vivihouse[33], 2019). Designers delivered high-quality DD projects which reflected its values through aesthetically-pleasing products. Winners and finalists of the DD Award are obvious recipients of a possible quality label.

When it comes to building a new production paradigm, it's a case of the more the merrier. It's important that the process for being labelled under the DDQL is wide and inclusive to have maximum impact and can be attainable for any designer looking to champion the DD values in their practice. The fact that the biennial Index Award is the world's biggest design awards will help the growth of the DD Award in the coming years. Meanwhile, local awards hosted in Vienna and Iceland help to ensure a European reach.

In this book you will read a lot about **open source**, shifting social values and commons. We will discuss the multiple actors of the growing Distributed Design network: from manufacturers, designers and prosumers to machines, designs and **digital fabrication** laboratories. In this new and complex DD field, we are not only speaking about the importance of new approaches to design but also new approaches to how we interact with new technologies, materials and protocols to build a new production system. In exploring the practicalities of a DDQL in this emergent space, we must also question the practicalities of a quality label:

To understand the concept of **Open Source** go to page 29

To understand the concept of **Digital Fabrication** go to page 22

01. What is labelled? The designer, a design, the processes used or all of the above?
02. How to go about it? Would the DD Awards serve as the only way to achieve quality in DD?
03. Legalities: Who owns the label, who manages it and how is it governed?

The place of certification in the world of Distributed Design

In the cultural field, labels have long been used to certify quality in hand-made production. 'Maker's Marks' catalogue a product and communicate the maker and a set of values to a potential consumer. In the case of 'Goldsmithing', a Hallmark[34] is administered by a third party to also qualify the provenance and quality of the precious metal used. This modern labelling was accelerated by industrial practices to enable customers to navigate a mass-produced product market; labels

morphed into brands to distinguish quality and reconstruct human values, and trust was lost to product sameness. Thanks to globalisation, even labelling products for consumer protection or material provenance has become overwhelmingly complex, with non-transparent international supply and production chains hidden inside a single 'country of origin.'

In the case of DD, we need to ask what certification looks like in the post-industrial context we imagine; one built on values, commons and **transparency**. How can we use a DDQL to ensure all aspects of a distributed and transparent supply chain are accounted for in communicating a product's values to a potential buyer? And how can we ensure design practices are not restricted by fixed parameters imposed by international standards that stem from industrialisation and economic globalisation? DDQL can be an alternative, attainable benchmark that encourages all designers to work toward more environmentally and socially aware practices.

To understand the concept of **Transparency** go to page 31

This book will discuss the approaches that the DD Platform is taking towards opening, empowering and articulating distributed design practice – including collaborative events, new business models and a platform ecosystem. The chapter on 'Fabchain' proposes technological approaches in blockchain that could provide the infrastructure for the implementation of such a label in the form of smart contracts. In this technical context the label could act as a certification of quality or standards for designs to be interoperable for distributed manufacture. In addition, there are certifications arising in the shift away from industrialisation that can feed our enquiry. B Corp[35] is successfully managing an accreditation system for social, environmental and cultural business impact in a transparent manner across all aspects of a business, whilst Copyleft[36] is challenging the regulations of copyright from within the legal framework of intellectual property (IP).

As a global platform of practitioners, we will continue to explore the possible articulations of a Distributed Design Quality Label in correlation with the Distributed Design Award; with the understanding that this nascent field of design is emerging in response to the shared values that are propelling us towards a more sustainable, open, regenerative and supportive future in design, and beyond.

"Digital fabrication embodies the promise of a radically different ecosystem of production. With only changes in code, people can produce locally, on demand, just in time."

Nadya Peek, Making Machines that Make, page 54.

DISTRIBUTED DESIGN IN PRACTICE

A collection of case studies from DD platform members and associated members that explore the emergence of distributed design practices across four distinct fields. You can explore each field through a lead article and illustrative case studies.

02
CHAPTER

01 – The World Around Us

02 – Our Wellness

03 – Speak Business, Money Talks

04 – Collaborating and Make Together

01.

DISTRIBUTED DESIGN IN PRACTICE

THE WORLD AROUND US

Introduction: Cosmo-Local Work

Case 01: Tzoumakers

Case 02: Grouu

Case 03: vivihouse

COSMO-LOCAL WORK – COMMONS-BASED PEER PRODUCTION

By Chris Giotitsas, Nikos Exarchopoulos, Alex Pazaitis and Vasilis Kostakis

01.

Empowered by modern information and communication technologies, individuals and communities around the globe have engaged in activity that exceeds traditional forms of activism.

Rising inequality and an unprecedented environmental degradation may be the most pressing issues of our times. That's why, empowered by modern information and communication technologies, individuals and communities all around the globe have been engaging in activity that exceeds traditional forms of activism. People are devising novel configurations of working and producing together; within a framework of openness, equity and sustainability. This type of production comes under the term 'commons-based peer production' and the organisational model is 'Design Global - Manufacture Local'.

This section explores three cases of communities that illustrate distributed design ideas in action, all driven by the same values: Tzoumakers[37], GROUU[38] and vivihouse[39]. This is not a comprehensive guide on how to do things. Instead it offers a critical insight stemming from distinct projects that have a similar ethos and overarching goals. All three utilise their respective local dynamics, as well as globally produced knowledge and resources, with an activity that is unique both in organisational configuration and the artefacts produced.

What is commons-based peer production?

To understand the concept of **Commons-based peer production** go to page 22

Commons-based peer production (CBPP) describes a production system powered by information and communication technologies, in which individuals are free to co-operate and co-create. Their creative output is a 'commons', meaning that communal resources are administered by users, based on mutually agreed upon regulations and customs.

The commons could potentially be considered 'rivalrous goods', like fisheries, which cannot be attained by more than one person at a time, or '**non-rival goods**', where use may be simultaneous by multiple individuals without

To understand the concept of **Non-rival goods** go to page 29

any value depletion. In fact, value is increased. For instance, with open source software, code is improved upon by multiple users. Here, the focus is placed primarily on the latter category as creative output of the cases presented is primarily digital commons.

There is a growing ecosystem of CBPP initiatives, from free encyclopedia Wikipedia[40] to **open source** software projects and open hardware communities that produce a range of products – including low cost 3D printed prosthetic arms; agricultural tools and machines; and small-scale wind and hydroelectric power generators. While the term was originally introduced to describe internet-based intellectual work, it has greatly expanded in scope over the years. Only one of the cases presented next engages in this sort of activity specifically. The rest produce predominantly (but not exclusively) open source hardware. This illustrates the adaptability of this model of production through various configurations.

To understand the concept of **Open Source** go to page 29

What is Design Global - Manufacture Local?

Design Global - Manufacture Local (DG-ML) is an organisational and production configuration that encapsulates the common features identified in all CBPP initiatives. These features are briefly mentioned in its name. Contrary to the industrial logic of limiting intellectual property and transnational supply chains that enable massive economies of scale, it promotes global access to industrial knowledge and localised physical construction. This means that the design of technologies and products may take place collaboratively, with the assistance of information and small-scale fabrication technologies (both precision tools like 3D printers and laser cutters, and traditional low tech equipment). This happens on a global scale, while at the same time being adapted for local manufacturing, according to specific needs and preferences.

This type of configuration is complementary to the concept of circular economies as it makes smaller, regional cycles or production, repair and recycling possible. Furthermore, it rejects the decontextualisation of inputs-outputs in the industrial process and their related externalities, which may harm communities and the environment alike, as it is geared towards sustainability and wellbeing, rather than financial growth.

Figure 1 Image from COSMOLOCALISM, a project funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant Agreement No. 802512)

DG-ML illustrates the various innovative ways that initiatives geared towards the commons and social good manage to navigate the often hostile environment in the markets. To be sure, these tactics are highly attuned to the regional and national socio-economic context of either case. But, if we peel away some of the contextual layers, we can pinpoint certain core elements that are compatible with CBPP. Commons based peer production as a production mode – and DG-ML as an organisational framework – presents an optimistic vision in a seemingly desperate time. It is not only a different mode of economic relations with regards to resource allocation but also, potentially, a radically different way to exist as a society. For this to happen, however, novel tactics for the transition from the destructive capitalist mode need to be devised. This section hopefully offers a glimpse on how these might proliferate[41].

Ioannina, Greece
39.6650° N, 20.8537° E

TZOUMAKERS – CO-CREATING SOLUTIONS FOR AGRICULTURE

By Cristina Priavolou

Maker culture can often be observed in cities, where events, ideas and talented designers abound. However, it is in less developed areas that the need to use advanced technologies is higher, since more severe issues need to be addressed.

Take agriculture as an example. Agricultural production is a key activity in the peripheral and less developed regions of the EU. There are rural places, plentiful of cultural and natural resources, where the locals rely on small-scale activities to earn a living. In such places, investments are low or scant, urging communities of farmers to look for alternative ways of using technology for sustainable agriculture.

Instead of adapting their techniques to the logic of established market channels, scattered communities of farmers globally work in a distributed, but interconnected, way to produce the machines they need. By sharing and reflecting on their common concerns and aspirations, farmers strive to reduce acquisition and maintenance costs of their machines on a local level, while seeking appropriate tools to serve their everyday needs.

At the same time, the importance of linking together agricultural communities becomes evident. Technical infrastructure for development can be provided and supported through the use of Information and Communication Technologies (ICT) via existing hubs (for example, Fab Labs). As a result, resilient communities could be created locally to overcome barriers through open source web tools, knowledge diffusion and collaboration for mutual benefit. Further, synergies could be created between alternative agriculture (like ecovillages) and business communities (such as micro-enterprises), while feedback loops could be facilitated among makers, designers and farmers.

Figure 1 The "bed weeder" tool created by Farm Hack

Synergies could be created between alternative agriculture and business communities.

Farm Hack[42] and L'Atelier Paysan[43] are two collaborative efforts by small-scale farmers who have gathered together to produce agricultural technologies. The former began with simple meetups in the USA, where farmers discussed ideas for tools and machinery that could facilitate their production. The latter, a French-speaking cooperative, has been aspiring to develop a toolbox for agricultural practices and achieve self-sufficiency, with regard to tools for organic farming. The designs of the produced technologies by both communities are available for free on their websites, enabling other farmers to replicate or adjust these solutions to their own needs. The designs are also provided in the form of printed guide books for constructing agricultural tools and sold to support future activities of the communities.

In the same vein, the P2P Lab is a Greek research collective that focuses on the commons. It aims to create awareness and promote an emerging collaborative productive model in agriculture. Based on the conjunction of open sharing of knowledge and ideas, it's all about localised manufacturing and distributed design.

Specifically, the model described as 'Design Global - Manufacture Local' asserts that local communities can produce technologies adapted to their own needs and context – empowered by designs, methods and knowledge, then shared globally by similar communities. In an attempt to overcome the fragmentation of the existing diverse **open source** agricultural projects, the P2P Lab works towards the replication, sharing and improvement of such solutions to create new communication channels and synergies.

To understand the concept of **Open Source** go to page 29

The P2P Lab's activities take place in a small mountainous village called Kalentzi in the Epirus region of northwestern Greece. It is situated in the village cluster of Tzoumerka, a mountainous area where the economy is largely focused on the primary sector. By linking Tzoumerka with the maker culture, a community-driven agricultural makerspace emerged – named Tzoumakers[44].

The local population in Kalentzi mostly depends on small-scale activities, including arboreal cultivation, beekeeping and husbandry, while investment opportunities for farmers are rare. Given the high acquisition and maintenance costs of machinery, together with the increasing focus of market channels on flatlands, Greek farmers decided to come to the fore. Starting with gatherings to brainstorm, the farmers identified common challenges. Soon the meetups were followed by tools that were built together. A tool for hammering fence posts into the ground was the first tool that they built to serve certain needs of the community. It should be noted that the farmers' engagement and passion was proven when, after drafting designs, they brought their own machines in to start building a prototype immediately.

Figure 2 The first tool built by the Tzoumakers community

Figure 3 The L'Atelier Paysan agricultural community

The story of Tzoumakers has just begun. It is growing into a fully functional makerspace, equipped with metal and wood processing machinery and desktop manufacturing tools. Building upon collective work, human creativity and sharing, it's an open space where everyone can participate. The community of farmers, makers and enthusiasts coalesce around common needs and values, as well as a collective vision for the area. By creating innovations on demand at a local level, Tzoumakers strive to collect, document and disseminate their solutions so as to benefit others with similar issues. Therefore, their solutions are also shareable at a global level, strengthening the maker movement worldwide.

As in the case of other agricultural communities, such as Farm Hack and L'Atelier Paysan, each solution is unique and should be adapted to other contexts. Thus, Tzoumakers do not claim to produce unified ready-made blueprints for agricultural solutions that could be replicated elsewhere. What is common, however, in all these endeavours is the process of collaboration, connection and enhancement of human capacities. Design Global - Manufacture Local summarises this process and vision for communities that are locally based and sovereign, but connected and concerned about global concerns.

Lisbon, Portugal
38.7223° N, 9.1393° W

GROUU – AN OPEN SOURCE AGRICULTURAL COMMUNITY

By André Rocha

An old lady heads outside to tend to her thriving garden. Every day she knows precisely how to look after her plants, when to water, feed or crop at the best times. Although she can't explain to you why she's doing what she is, she grows the juiciest tomatoes; intuitively navigating weather conditions, soil quality and plagues. So, how can we learn from her?

A network of sensors could help us learn from her green-fingered gardening skills. We could all benefit from fully automated balcony tomato planters that use similar conditions taken from the old woman's tacit knowledge.

GROUU[45] is a precision agriculture sensor network and Irrigation and fertilisation system, but it's also more than that. It's a knowledge transfer system that connects systems and humans. The aim? To democratise technology for agriculture by being open, modular and parametric.

Whether applied to indoor hydroponics or traditional agriculture in an urban or rural context, GROUU sensors and modules can be used together, adapted, remixed and distributed, depending on the needs of agricultural contexts and communities. As a research through design process, it is aimed at understanding the role of tacit knowledge in an open agriculture context, so it relies on a culture of knowledge sharing and a collaborative culture.

The open source modular system is formed by a set of sensors and actuators that automate agricultural tasks like fertilising and watering, and optimises them by recognising success patterns from sensor and user-generated data. Optimisation is directly related to the amount and diversity of data and users.

Figure 1 GROUU Greenhouse, 2014

Optimisation is directly related to the amount and diversity of data and users.

The research project explores the hypothetical formation of digitised tacit knowledge through a diverse implementation of open agriculture, assuming that some of the sensor data recorded throughout the process is formed by practical actions of the farmer over its surrounding environment (the farm), and therefore by tacit knowledge.

GROUU is divided into three stages:

- The first focuses on GROUU's adoption by diverse users and tries to understand it by testing different dissemination strategies.
- Secondly, it addresses the engagement of users in the design process. Open source is fundamental, but what about the participation of actual users? Apart from **makers** and motivated designers, how can farmers and farming communities get involved in developing open agriculture?
- The last step is about the possible implications and applications of tacit knowledge in open agriculture on a

To understand the concept of **Maker** go to page 27

technical level, to digitise and integrate it into open agriculture – and on a design level, to generate new open data streams between different agricultural contexts and communities. Can agricultural tacit knowledge become open agricultural knowledge? So, therefore, a 'common'?

By envisioning a contribution to global knowledge and best agricultural practices ecosystem – open agriculture – the GROUU design process anticipates inclusion and co-design. The same would not be possible if not a part of a broader open knowledge ecosystem, where designs, hardware and software are free and documented. These freely available resources are then fed and improved by initiatives such as GROUU, by its failures and successes, workshops, actions and releases.

Figure 2 Sensor Box Prototype at Cultimake, Habibi.Works, 2017

GROUU currently creates mostly design and DIY **prototyping** explorations, such as the ones detailed below, while searching for an engaging and inclusive formula, a model that can be quickly adopted, documented and disseminated for research purposes.

To understand the concept of **Prototyping** go to page 30

A fully automated greenhouse on wheels, the GROUU Greenhouse combines several sensing and automation strategies for horticulture using Arduino[46], the open source platform used for building electronics projects. This costly strategy was a crucial learning stage. It enabled GROUU to understand the level of complexity, calibration issues and diversity of agricultural variables. More recently, the modularisation of design has led to different developments and actions.

As we mapped GROUU as a scalable, modular, and expandable system, we started testing development in particular contexts. Some of these were enabled by Distributed Design **platform** actions, led by the P2P lab in two different workshops.

To understand the concept of **Platform** go to page 30

The CultiMake workshop took place at Habibi. Works[47], a makerspace dedicated to the local refugee community. Here, the engagement

To understand the concept of **Arduino** go to page 20

highlight was an introduction to **Arduino** and GROUU workshop for younger attendees. The ongoing development attracted some curious members of the community, but language barriers and the complexity of the theme acted as big constraints.

At Tzoumakers, the workshop allowed better results in terms of engaging local actors, even getting them onboard with the project. By forming a small team, we were able to exchange ideas, co-design, adapt and plan future work together. A GROUU nursery for seedlings acted as a comprehensive synthesis of how the system can be formed and evolve. We also got excellent feedback about alternative usages and alternative technologies that can be used for the same purpose.

In conclusion, as a Distributed Design process, GROUU is inevitably meaningless if no local actors adopt the system and participate in its development. All GROUU technologies already exist. They are just brought to different research contexts depending on its acceptance as part of a knowledge-sharing ecosystem, which is also dependent on trust and proximity. If nobody in a particular community builds trust over its usage or helps to make it comprehensible and accepted, the research process is interrupted. Exploring different strategies and implementations is also about pushing Distributed Design forward.

Figure 3 GROUU Nursery while experimenting at Tzoumakers, 2018

Vienna, Austria
48.2082° N, 16.3738° E

VIVIHOUSE – A STORY ABOUT STOREYS

by Nikolas Kichler, Mikka Fürst, Paul Adrian Schulz and Dilay Türe

This is the 'storey' of a building system that focuses on inclusion and environmental protection: vivihouse[48] are multi storey buildings that show how everyone can create healthy and vibrant urban settlements using an open approach. And straw.

The rapid pace of urbanisation has created considerable environmental risks and restricted the participation of citizens. With the increasing size and complexity of construction projects, legal requirements become more demanding and the circle of people who are actually capable of taking action dwindles.

In order to enable everyone to contribute to the creation of ecological and attractive urban living environments, a group of architects initiated the vivihouse project in 2017. Financed by the Austrian Climate and Energy Fund and supported by the Vienna University of Technology[49], it brought together civil engineers, mechanical engineers, building technicians and straw bale experts.

Vivivihouse is based on a modular timber skeleton structure that is optimised for the use of ecological materials, like straw bales for insulation, timber frames or lime and clay plasters. It's an inclusive project on three levels. It is DIY-friendly for makers, openly licensed for designers and based on a column grid optimised for the changing needs of its users across the storeys. The number of components requiring professionals is reduced to a minimum, so that major parts such as exterior walls and ceiling elements can be created by inexperienced participants.

In addition, most of these elements enable extensive adaptations depending on local needs, tastes, available materials, climates and modes of production.

Figure 1 The first vivihouse prototype, comfortably snowed in. Lower Austria, 2018

Since these parts are openly licensed, but the interfaces remain identical, all kinds of approaches can coexist, so that a high variety of needs can be fulfilled. All building elements are prefabricated in a safe and weatherproof environment at ground level and subsequently get joined together by cranes.

So how high to go? According to the Austrian Fire Protection Directive, six storeys still permits the visibility of natural materials, which is why this was chosen as the maximum height for vivihouse structures. The 90-minute fire load is carried by the columns in order to free the non-load-bearing exterior walls from this requirement. To date, all existing vivihouses have been insulated by 36cm straw bales, a locally available agricultural waste material, to create healthy and energy-efficient interior spaces. Future generations will be able to maintain, reuse and transform building parts as circumstances change, keeping resources in circular ecosystems. Maximum flexibility is ensured as all components are demountable, transportable and reusable.

In 2018, the first single-storey prototype was assembled in Lower Austria. This provided insights into the transportability of the parts, the adequate tolerances and the experimental use of timber nodes. In November 2019, the dismantling of this first building means the materials could be reused and combined with new parts to build a three-storey building in Vienna by the end of the year.

Onwards and upwards.

02.

DISTRIBUTED DESIGN IN PRACTICE

OUR WELLNESS

Introduction: Distributed Design for Distributed Care

Case 01: Next Steps

Case 02: From Lorenzo's Bike to Everyone's Bike

Case 03: Digitally Speaking

Case 04: Fabcare Challenge

DISTRIBUTED DESIGN FOR DISTRIBUTED CARE –

HOW IS DISTRIBUTED DESIGN BEING USED TO ENHACE THE PERFORMANCE OF PRODUCTS THAT HAVE A DIRECT EFFECT ON OUR HEALTH AND WELLBEING?

By Massimo Bianchini, Stefano Maffei and Patrizia Bolzan

Distributed design is enhancing the performance of products that have a direct effect on our health and wellbeing. It might seem surprising that an initiative that promotes the creativity of designers, makers and Fab Labs[50] can be concerned with health and wellbeing. Yet, over the past decade, a growing number of creators in Europe have been using **open** and distributed design-driven innovation to create solutions that really care.

To understand the value of **Open** go to page 34

Distributed design requires people to question themselves, to overcome their limitations and to experiment with new ways of making and doing things. Creators and innovators make use of digital-enabling technologies as digital fabrication platforms, **prototyping** spaces and community-based labs to make tools and tech accessible. Solutions are created on demand and on site, and are then shared with others. When it comes to using distributed design for health, wellbeing, prevention and lifestyle education, open source solutions directly involve medical-scientific research specialists and the health system, alongside users or patients.

To understand the concept of **Prototyping** go to page 30

Digital transformation increases innovation in designers. When that innovation is mission-oriented and mindful, it can support the autonomy and quality of life of elderly people, those affected by chronic and rare diseases or disabilities, as well as their families and caregivers. Prostheses, aids and tools can assist with eating, sleeping, walking, washing, working, hobbies, sports and therapeutic activities related to psychophysical wellbeing.

To understand the concept of **Digital Transformation** go to page 23

As well as spurring independent patient innovation and user-driven healthcare, today's digital transformation allows patients to access and exchange data and information; create a dialogue with health services and ministries; organise and participate in associations, and raise funds to develop scientific research. The health system is becoming increasingly advanced when it comes to monitoring the

body and its physical performance, with biometric data collected by interactive personal and environmental devices.

The development of eHealth and the spread of technologies, such as **3D printing** in hospitals or prosthetic centres, can offer new opportunities for creative professionals to design products and services. In parallel, the growth of spaces such as Fab Labs offers designers and makers an opportunity to independently realise solutions to improve quality of life, or reduce physical and cognitive gaps. This also defines a new field of opportunity, not only for users and patients, designers and makers, but for service and manufacturing companies, public bodies and institutions. '**Distributed agency**' between humans, machines and programs allows new communities to develop, as well as new potential markets.

To understand the concept of **3D printing** go to page 20

To understand the concept of **Distributed Agency** go to page 23

Nowadays, there is a growing demand for smart and personalised healthcare products. User innovation in health and wellbeing is a more complex process than mass-customisation, on-demand manufacturing based on biometric data, or digital participation through apps or social media. If not standardised, some solutions need alternative resources and facilities to be designed, prototyped and distributed. That's where open knowledge and design, open software and hardware, digital fabrication and co-creation processes come in.

Innovation processes are mostly driven by personal motivations, collective missions and social initiatives, either because the solution does not yet exist in the market, or is not economically accessible. The development of open source solutions for health and wellbeing is almost never linear, often characterised by the aggregation of people with creative and technical skills coming together with organisations such as patient, cultural and sporting associations, healthcare specialists and technicians.

What all this means is that solutions are becoming more personal, customisable and wearable. Prostheses, orthoses and aids can embed new functions or digital enhancements within fashionable garments and accessories, hybridise everyday objects or become add-ons. 'Augmented' tableware, furniture and furnishing accessories, sporting equipment and walking aids integrate prosthetic or auxiliary components – or 'parasitic' elements that hack existing objects – increasing its usability. Analogue and digital tools can be used for personal or environmental monitoring, prevention and health education, and specialised objects can be created

Figure 1 Render of personalised walking stick TWISTR from Next Steps 2019

to reduce physical or cognitive gaps, or stimulate training and rehabilitation.

For example, Next Steps[51] is a collection of open source walking aids and functional add-ons for crutches; **Internet of Things** (IoT) devices that augment the mobility of a rollator; and personal 3D printed walking sticks. Lorenzo's Bike[52] uses digital fabrication to create a personal object – a

To understand the concept of **Internet of Things** go to page 27

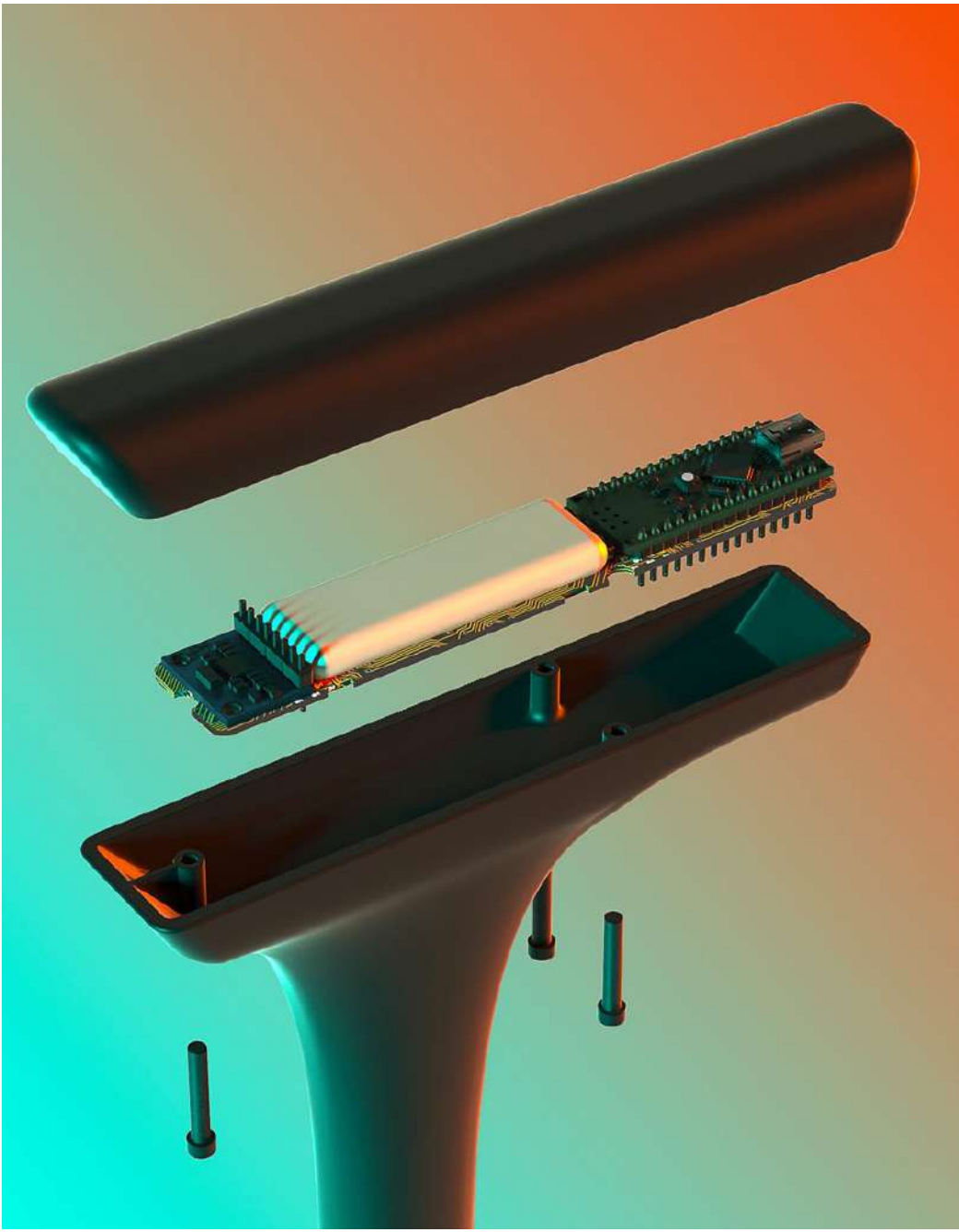


Figure 2 Render of personalised walking stick TWISTR from Next Steps 2019

bike – that supports rehabilitation. Mole Mapper[53] is what it sounds like, a small tool that monitors skin health. Digitally Speaking[54] is smart underwear equipped with safety tech to address the issue of women's safety across the globe. More about these later.

So, what can we learn from this promising direction in the innovation of distributed design for care and wellbeing?

— **Not only medical devices:** Distributed design promotes and stimulates a biodiversity of solutions, exploring the theme of prosthetics, orthosis, medical devices and a new generation of personal objects. Many solutions – especially in the field of healthcare – are influenced by the regulatory system, which is fundamental to protect users and patients. This is a bottleneck for distributed design, but it is also an opportunity. The development of non-medical devices can be complementary to medical ones. Distributed design can support users and innovators to create solutions that demonstrate how existing rules, standards and market barriers could be reconsidered.

— **Not only functional solutions:** Many solutions are designed following functional and technical requirements, but their aesthetic dimensions can be as important. Healthcare objects and aids tend to become physical extensions of people. Aesthetic personalisation is important, because it characterises the identity of objects and establishes a personal or familiarity for users.

— **Not only complex and expensive solutions:** Many objects and devices are complex and expensive. Distributed design can design solutions that can be adapted from objects already available on the market, taking into consideration open hardware and low cost technologies that are easily accessible for the everyday user and disadvantaged or vulnerable people.

— **Not only new products:** Many objects are unique and irreplaceable owing to a relationship that is established with their users and owners. Distributed design perfectly fits with hacking, repairing and upgrading practices and is compatible with remanufacturing and refurbishing processes.

So what's next? We could be at the beginning of an augmented concept of 'care' where people can develop a distributed awareness, responsibility and participation in the design of innovative open source solutions that work to take care not only of people, but also other living beings and the environment.

Milan, Italy
45.4642° N, 9.1900° E

NEXT STEPS – CO-DESIGNING OPEN-SOURCE WALKING AIDS

By Massimo Bianchini and Stefano Maffei

Next Steps[54] is an experimental initiative to develop a collection of open source walking aids, co-created by patients with designers and makers from the **makerspace** Polifactory[55] with Sanofi Genzyme[56] and Associazione Italiana Glicogenosi (AIG)[57]. The team researched the use of walking aids to understand needs, and then held a co-creation workshop with designers and patient innovators to come up with creative solutions.

To understand the concept of **Makerspace** go to page 28

These four projects were presented for the first time at European Maker Faire Rome 2019[58]:

— **Crutch Skins** are removable socks, skins and covers for all kinds of medical crutches, that can be easily personalised using **3D printing**, laser cutting and recycled textile scraps.

To understand the concept of **3D printing** go to page 20

— **The Augmented Rollator** is an **Internet of Things** (IoT) device that can improve the control and mobility of walkers. Once installed on a roller's wheels, it can be activated to facilitate the overcoming of small obstacles, to push uphill, increase braking capacity downhill, and receive basic feedback on obstacles or unevenness of the ground.

To understand the concept of **Internet of things** go to page 27

Figure 1 & 2 Selection of pictures from the design stage of Next Steps, 2019

To understand the concept of **Open Source** go to page 29

— **Crutch Add-ons** are small functional **open source** components, tools and joints that allow patients to use their walking aids in many ways.

— **Parametric Stick** uses digital design and fabrication to create personalised walking sticks sticks with a 3D printed geometrical structure.

Milan, Italy
45.4642° N, 9.1900° E

FROM LORENZO'S BIKE TO EVERYONE'S BIKE –

A CUSTOMISED BICYCLE CO-DESIGNED BY MAKERS, DESIGNERS, THERAPISTIS, LORENZO AND HIS FAMILY

By Federica Mandelli

"I pointed to the bicycle with the book of symbols that I use to communicate, speak, ask and complain. 'No Lorenzo, not today, it's cold, you have a cough, we aren't going out on the bicycle', they told me. I pointed to the bicycle again and touched my chest. The bicycle, then me. My parents looked at me with surprise and with tears in their eyes. They realised what I was trying to say: I wanted my own bicycle as a birthday present."

That was how the story started, back in 2015, when Lorenzo asked his parents for a bicycle for his fourth birthday. Said like this, it sounds like a story like many others. The only difference is that Lorenzo is affected by a complex neurological disease that makes most routine activities very difficult – and riding a bicycle is one of them.
Nevertheless, his parents began looking for the perfect bicycle for him on the internet, in catalogues, in sports shops and in specialist stores selling

Figure 1 Lorenzo on his first ride on the bike, Milan 2016

orthopedic goods. They finally found the perfect bike. It was beautiful, comfortable and seemed perfect. The only problem was that it was as expensive as a car and Lorenzo's parents couldn't afford it. They began searching again. But this time, their friends, Lorenzo's physiotherapist, doctors and TOG Foundation[59] all got involved.

"Just like in my favourite stories, where chance meetings change things, fate stepped in to help me. I was five years old. TOG met and started working with OpenDot[60], a laboratory where people invent and then build things that currently do not exist in the shops. Together, they began thinking about me and my bicycle. We would always sit around a table, there was always coffee and measuring tools. After a number of enjoyable meetings, I started testing strange bicycles that were always unique."

Lorenzo could not have described it better. There was a table and a lot of people from different backgrounds around him – **makers**, designers, therapists, a caregiver and his family. (And lots of coffee.)

To understand the concept of **Makers** go to page 27

Together, OpenDot and TOG Foundation developed a method of co-design for healthcare based on eight principles to 'design with, not for people with disabilities', by facilitating processes and stimulating creativity in order to create new solutions that improve lives and generate innovation. A combination of a participatory and inclusive approach, technical skills, **digital fabrication** and agile prototyping have made the production of the bicycle possible. When Lorenzo was six he finally received what he wanted, and now... he rides fast.

To understand the concept of **Digital Fabrication** go to page 22

The bicycle, designed and produced in the Milanese **Fab Lab** OpenDot, is a three-wheeler. The components were adapted from some standard elements, but it has small cranks (arms), an ergonomic saddle, back support and adjustable handlebars. The 3D model was customised for Lorenzo, but can be rapidly adapted to the needs of other children with different disabilities, thanks to parametric design files.

To understand the concept of **Fab Lab** go to page 24

With three-dimensional **parametric modelling**, components are interlinked, which means that they automatically change their features with others. The designer only needs to edit one parameter in an equation for the others to get adjusted automatically.

To understand the concept of **Parametric Modelling** go to page 30

Thanks to the parametric design of Lorenzo's bike[61], now Viola, Shaig and many more children with disabilities could have their own customised wooden bicycle. This is a great example of distributed design: a made-to-measure, reasonably priced, customised bike to suit personal requirements, that can be realised everywhere in the world – thanks to digital fabrication.

Developed a method of co-design for healthcare based on 8 principles to design with, not for people with disabilities.

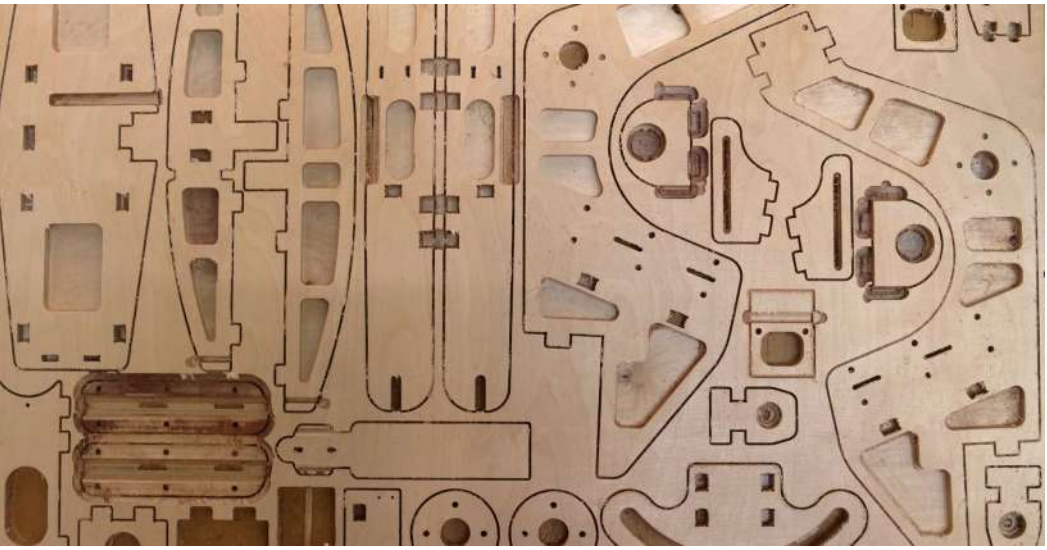


Figure 2 All the pieces of the bike's frame in one piece of CNC milled plywood, OpenDot Fab Lab, 2018

Figure 3 From the pharametric file of Lorenzo's bike, OpenDot and TOG co-designed a new bike for Viola, Milan 2018

New Delhi, India
28.6139° N, 77.2090° E

DIGITALLY SPEAKING – SMART UNDERWEAR FOR THE SAFETY OF WOMEN

By Nidhi Mittal and Avik Dhupar

On the evening of 16 December 2012, New Delhi was wrapped in a sheet of pain, sorrow, anger, tears, shame and disgust when the shocking news of a girl being gang raped on a moving bus in the capital of India broke out. Protests were held, prayers were offered, tears were shared and after fighting vigorously for a couple of days, the brave soul passed on. That day, something changed inside the young 18-year-old me, but nothing changed in society.

Security is a major issue for women in India, and across the globe. Every single day, young girls, mothers and women from all walks of life are being assaulted, molested and violated. According to statistics, 93 women are raped in India every day[62]. Women often feel unsafe just walking down the streets. In fact, rape is so serious that it is being called a 'culture' now. The data speaks for itself. The sad reality is that we live in an increasingly violent society, in which the fear of crime is often present. Personal safety has become an issue of importance for everyone, but especially for women.

Concerned about this state of affairs, we started working on Digitally Speaking[63] – a wearable tech project for the safety of women. The initial prototypes had a bold and sharp structure. The garments were embedded with a camera, screen, GPS tracker and other safety features. The designs were made to spark conversation and debate and ask the men in society: “Is this how you want us to live, breathe and walk on the streets now?”

The above designs created awareness among people. Moving on, we started working on smart underwear equipped with safety technologies.

Figure 1 Smart underwear equipped with safety technologies

In moments of distress, a user can do a specific muscle movement that will trigger an emergency alarm and send a distress message, along with the user's GPS location, to five saved numbers of family and friends and a police helpline number. Once the information is shared with the saved numbers, the user can then be tracked down based on the shared location. The underwear can also raise a loud alarm to make people nearby aware and record the sounds that are happening in the surrounding area, which can later be used as proof or evidence.

To avoid false alarms, the user can press a button located on the waistband within 15 seconds, which will cancel the whole process and won't trigger the emergency alert. The idea is to make it as unobtrusive as possible and a part of life. To put it on and off shouldn't be complicated, it should be as simple as putting on underwear. We strongly believe that safety is a fundamental right and shouldn't be considered a luxury.

The above designs created awareness among people. Moving on, we started working on smart underwear equipped with safety technologies.

Figure 2 Presenting Digitally Speaking and talking about it's features at re:publica Berlin[64] 2017

Figure 3 Close up of the safety technologies of Digitally Speaking

Milan, Italy
45.4642° N, 9.1900° E

FABCARE CHALLENGE – OPEN SOURCE HEALTHCARE

By Massimo Bianchini, Stefano Maffei and Patrizia Bolzan

Launched in spring 2018, the FABCARE challenge[65] demonstrates how designers, **makers** and independent innovators can design, produce and distribute open source healthcare solutions – like aids and prostheses with real market potential – by working alongside patients, caregivers and their associations. Then they can be created in **Fab Labs**, combining makers' skills with digital manufacturing technologies.

To understand the concept of **Makers** go to page 27

To understand the concept of **Fab Lab** go to page 24

To understand the concept of **Makerspace** go to page 28

Developed within the Distributed Design platform by the **makerspace** Polifactory[66], and technically supported by Centro Medico Santagostino[67], the challenge first ran from from July to October 2018. A group of over 60 designers presented 21 product ideas. Five of these were selected from an evaluation panel composed of healthcare experts, fab labs, designers and policymakers, in order to be prototyped, then presented at the European Maker Faire Rome[68] and released on distributeddesign.eu. These included medical devices, as well as solutions that provide support and help with prevention or monitoring activities.

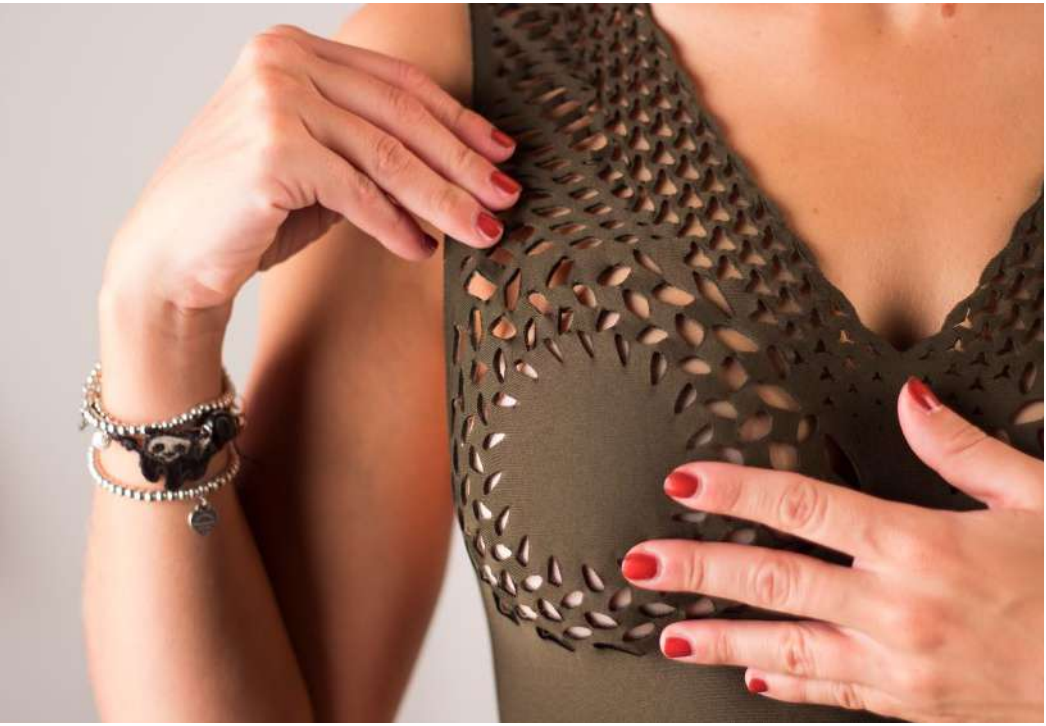


Figure 1 & 2 Photo from Polifactory, Project Palpatine, by Francesca Poli and Daniel Sanchez

Figure 3 Photo from Polifactory, Project Dermap, by Mariana Accorsi, Giulia Sala and Giuseppe Valentino

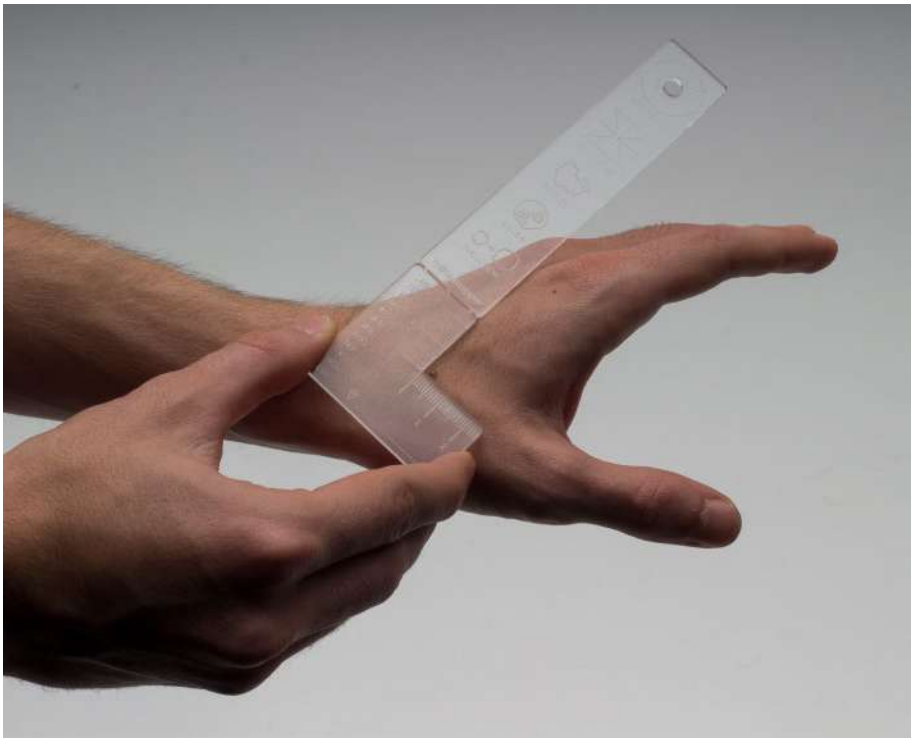


Figure 4 Photo from Polifactory, Project Mole Mapper, by Ilaria Vitali, Mila Stepanovic and Patrizia Bolzan

One of the five selected projects was Mole Mapper[69], a small tool that monitors skin health for skin cancer prevention. It was designed by Ilaria Vitali, Mila Stepanovic and Patrizia Bolzan, three young researchers in design from Politecnico di Milano[70]. Self-exams can help people to identify potential skin cancers early, when they can almost always be completely cured. It is important to identify moles that look or feel different than the others on your body, and to routinely visit a dermatologist. Mole Mapper looks for warning signs, what physicians call 'the ABCDE of melanoma', to help spot changes in all types of moles on the body, in particular if they are asymmetrical and bigger than 6 millimetres. It reminds users to look out for changes in moles, like their borders, colour and growth over time.

Mole Mapper can be fabricated in 30 seconds with a laser cut using PMMA (acrylic) scraps. Costing only one euro, it offers an inexpensive, tangible way to promote awareness about melanoma prevention, and can be distributed in 'alternative' (non-medical) places such as beauty centres and tattoo studios. For these reasons, this small object has been shortlisted for the Distributed Design Award 2019[71].

03.

DISTRIBUTED DESIGN IN PRACTICE

SPEAK BUSINESS, MONEY TALKS

Introduction: Why We Need to Strengthen the Business Muscle of Distributed Design

Case 01: REMODEL

Case 02: Fab City Store

Case 03: Version_01 Lamp

WHY WE NEED TO STRENGTHEN THE BUSINESS MUSCLE OF DISTRIBUTED DESIGN –

THE CASE FOR WHY AMBITIOUS DISTRIBUTED DESIGN PRACTITIONERS NEED TO FOCUS ON BUSINESS DEVELOPMENT ALONGSIDE THE CREATIVE PROCESS IN ORDER TO MAXIMIZE GLOBAL TRANSFORMATIVE IMPACT

By Christian Villum

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."
Buckminster Fuller, American architect, inventor and futurist[72]

To understand the concept of **Maker** go to page 27

For many people, the curiosity of exploring the potential of distributed design often takes its origin in the idealistic end of the motivational spectrum. Whether you are a **maker** craft person or designer, the idea of opening up your design for others to contribute to can often be ascribed ideological reasons. Distributed design is deeply rooted in values such as sustainability, circularity and social equality, for starters. The idea of taking the distributed, collaborative approach in most cases couples the initial desire to improve the design – by allowing others to contribute their creative input – but, just as importantly, to have the design contribute a positive impact on the world, by empowering peers and adding value to the global digital commons. The medium is most definitely part of the message, and many practitioners of distributed design have only little or even no interest in receiving financial rewards for their labour, by developing their distributed design practice as a business. And even if they do, they only rarely take a systematic approach towards realising such a vision of creating a model for economic compensation in exchange for their work – something that a more conventional entrepreneur would put front and centre in their creative process.

Distributed design is deeply rooted in values such as sustainability, circularity and social equality, for starters.

This is not to say that idealistic distributed design practitioners are not ambitious. On the contrary: some of the world's most fundamentally revolutionary ideas and designs (and products) come out of such idealism and would never have materialised if it wasn't for their originators' mix of grand vision, hard work and a non-selfish (or even benevolent) lack of pursuit of money. Examples that come to mind include free encyclopedia Wikipedia[73] or

popular **open source** operating system Linux[74], to name just a couple. But when distributed design ideas actually do develop into a business idea, it is often relatively far down the line in the evolution of the design, and sometimes even by coincidence, because a business-oriented approach often sits rather uncomfortably with the kind of compassionate community structures dominating grassroots hubs like **Fab Labs**, maker spaces and online open source communities. Only very rarely is a business approach the point of departure for initiating a distributed design process.

To understand the concept of **Open Source** go to page 29

To understand the concept of **Fab Lab** go to page 24

However if we, as a digital, distributed, sustainable, open source manufacturing movement, are to really make a dent in the world and contribute to (or even become a defining factor in) a massive, global transformation – to transition the world towards a more sustainable production and consumption paradigm as outlined, for instance, in the Fab City Global[75] vision – then we need to think much more strategically about how we onboard more conventional business thinking into our practice. Massive scaling of world-transforming ideas have a much higher chance of success if they can trigger the colossal business muscle that drives our society today. Like American architect, inventor and futurist Richard Buckminster Fuller[76] famously said: “You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete.” This is where need to take distributed design and why we need to "speak business" to truly have a shot at leveraging our ideas towards global impact.

Distributed design-driven business is, luckily, already happening in many places. Companies large and small around the world are experimenting with new ways of engaging their user bases. Building communities that stimulate users’ contributions, instead of their consumption, allows them to become co-creators, and the companies to do well by doing good. This approach makes it possible to innovate faster, scale quicker and save development costs internally, while also stimulating economic growth across the entire community of contributors. This community can also build business off of shared design assets, thereby initiating a ripple effect of multi-bottom line value creation – economically, sustainably and socially.

Examples include Silicon Valley bigwigs like IBM and Microsoft, who recently acquired American software company Red Hat[77] and GitHub[78] respectively, to tap into existing communities. However, startups and small to medium-sized companies (SMEs) all over the world are also

creating new and exciting open source-based physical products that allow anyone to build on existing designs. 3D Robotics[79], Arduino and the British furniture company Opendesk[80], which is creating open design furniture in collaboration with 600 furniture creators all over the world, are just a few examples of how open source – and thereby distributed design – has become the foundation of some of the most innovative and interesting business models of our time.

The trend is part of the even bigger global narrative of technological disruption and digitisation that is challenging old regimes and is currently top of mind for many, if not all, companies. In other words, the time is ripe for these groundbreaking ideas. The advent of the internet inspires not only a move from building business on both atoms and bits, but, more importantly, a reframing of how value is being created – as well as how to monetise that in sustainable ways. Going open might even present bigger scaling opportunities than staying proprietary. The math is simple: losing the exclusive right to a design in return of a massive scaling opportunity, as well as a rapid acceleration of innovation, might be a valuable tradeoff and create an opportunity to step into brand new economies of scale built on sustainable values.

This section of the book presents a couple of strong cases from the Distributed Design Market Platform ecosystem that exemplify some of these perspectives. In addition we introduce a brand new toolkit that allows any company to use strategic design to experiment with finding the specific distributed, open source market strategy and business model for their product and industry.

Figure 1 Makers at Danish Design Centre. Image by Agnete Schlichtkrull under a Creative Commons BY-NC license

Copenhagen, Denmark
55.6761° N, 12.5683° E

REMODEL – ONE-STOP SHOP FOR DESIGNING OPEN SOURCE HARDWARE BUSINESS MODELS

By Christian Villum

REMODEL[82] helps manufacturing companies develop new business models based on open source and distributed design principles. You can do it too.

The concept of open source collaboration – a distributed design practice – is booming globally and increasingly provides a foundation for innovative business in all corners of the world, especially in the field of virtual products and software. Hardware, however – in the broadest sense of the word – is one of the newest frontiers for the open source mindset, and perhaps represents the biggest potential paradigm shift for how we design, manufacture and consume products. Over the last two years in Danish Design Centre[82], we have looked with curiosity towards the future to see how open source principles can be brought into the realm of physical product manufacturing on a massive mainstream scale.

Challenging the nature of manufacturing physical products

The nature of creating physical products (atoms) is, of course, very different than that of virtual products (bits), because of the innate costs of its physicality. It requires acquiring materials, handling logistics, investing in machinery, setting up distribution, upkeeping shelf space and, of course, the actual fabrication of the goods – as opposed to the intangible essence of a virtual product. This is why opening the design for reappropriation by potential competitors seems so counterproductive. Why would you add more

Figure 1 REMODEL tools in action. Image by Agnete Schlichtkrull under a Creative Commons BY-NC license

REMODEL helps manufacturing companies develop new business models based on open source and distributed design principles.

risk to the already gargantuan gamble you have taken on? The answer is, of course, that the rights might be overly outweighed by the possible gains. As this book outlines, the innovation excellence, scalability and pace by which designs can evolve when successfully open sourced and distributed among a large community of competent co-creators presents, potentially, a brand new kind of business case – the idea of the open source, distributed strategy and business model.

Still some hesitation

More and more open source hardware companies are emerging, and we are already seeing some successful business ventures in this realm on the international stage (both in big tech, but also among digitally native upstarts). Still, in general, there is a widespread hesitation towards experimenting with opening IP rights for physical products. Mainly this is because the very concept radically contradicts the convention of using copyrights and patents to control supply and demand market mechanisms, protect investments in manufacturing infrastructure and to stay competitive. But one need not dive very deep in the success stories to see the potential.

The question really is: what are the tools and methods needed to build a new, open and distributed business strategy for your product? Here is a stab at answering that question.

Experimenting with strategic design approaches

In the spring of 2018, ten Danish manufacturing companies[83] took part in the REMODEL programme, launched by Danish Design Centre and co-designed with an international expert panel (which included several familiar faces from the Distributed Design Market Platform project consortium)[84].

The cohort of companies ranged from large corporations like enzyme mastodon Novozymes[85] and the world's biggest water pump manufacturer Grundfos[86] to small and medium sized companies, like industrial tool manufacturer Thürmer Tools[87], electronics innovators Tekpartner[88] and furniture company Stykka[89].

Over the course of three months, these companies went through a custom-made, self-directed design sprint, in which they worked for half a day per week and went from having very little knowledge about the very concept of open source towards emerging as proficient open source innovators in their specific industry domain. Moreover, the process guided them through drafting a strategy for one of their existing products.

Introducing the REMODEL toolkit

The process they went through served as prototype testing of the REMODEL toolkit: a design-sprint toolbox that enables any company to harness the power of open source principles to build new business strategies and business models around new or existing products.

Figure 2 Midway through a REMODEL design-sprint. Image by Agnete Schlichtkrull under a Creative Commons BY-NC license

Manufacturers of hardware (physical products), especially, can take advantage of this new resource to radically rethink how they innovate and scale their business through open source and distributed design practices.

The free and ready-to-use toolkit contains guides, video tutorials and a peer-to-peer support forum that allows a company to not only ignite and self-direct their own transformation journey, but also to find inspiration and proof of concept in the write-ups of business cases from the ten companies that went through the original REMODEL program.

In addition, for those interested in taking a deeper look under the hood of the process that shaped the toolkit, they can simply dive into the learning repository.

An open source toolkit for further appropriation

The entire toolkit itself is, of course, open source: it is published under one of the most open and liberal licenses available, namely the Creative Commons Attribution-ShareAlike (CC BY-SA) license[90]. In other words, it comes with an invitation for further re-appropriation and asks practitioners, facilitators, designers and innovation agents to take what we've made and make it your own, build on it, share it, sell it – do whatever you want with it. We would love to hear what you come up with.

Note: some time after the launch of the REMODEL toolkit we also got the opportunity to convert it into a simpler, more lightweight online course[91] on the CanopyLAB learning **platform**. This version takes aim at individuals, whereas the toolkit is directed at company teams.

To understand the concept of **Platform** go to page 30

Copenhagen, Denmark
55.6761° N, 12.5683° E

FAB CITY STORE – MORE THAN A STORE

By Michael Araujo, Arnaud Delente, Pauline Distel, Sarah Goldberg, Virginie de Labarre, Soumaya Nader, Lenaïk Née, Quentin Perchais and Aruna Ratnayake

Despite its name, the Fab City Store is not a physical store. It's a support network for designers, craftsmen and makers who want to make the city of tomorrow more sustainable, open and social – whether they are upcycling our waste, producing locally, rethinking our current system of production and consumption, or combining local manufacturing and global cooperation. Or all of the above.

The Fab City Store gathers makers and consumers around a more sustainable production system sharing common values:

— **Hyper-local production:** Looking for products fabricated as close to the place of consumption as possible to avoid unnecessary transportation and energy expenses.

— **Responsible materials:** Valuing the use of sustainable and sourced materials from reuse, recycling or upcycling.

— **Distributable:** Open collaboration for a better distribution of knowledge and resources and more efficient designs.

Figure 1 The fab Fab City Store team. Photo from the Fab City Store at Re:Publica 2019

More 'Stores'

The aim is to transfer the knowledge and good practices discovered around Paris to other urban places.

The aim is for Fab City Store to become a global and shareable knowledge platform to develop local networks specific to the characteristics of each fabric, metropolis, region or community in which it's applied. Originally built from an initiative by Parisian makerspaces and fabrication spaces to help and support their creators, in May 2019, the Fab City Store participated in re:publica 2019[92], a digital society conference in Berlin, as an opportunity to think about ways to replicate the Fab City Store Grand Paris in other cities around the world.

The aim is to transfer the knowledge and good practices discovered around Paris to other urban places – to build bridges between the makers communities across borders; to be able to move towards more sustainable consumption models; and to limit the transport of materials in favour of information, ideas and models of operation.

The workshop created for re:publica2019 aimed to map Berlin's manufacturing ecosystem through crowdsourcing, and to open the ethical charter to the problems within the city's fabric. The 'charter'[93] and 'map' became two artefacts that shared the principles and ideas of the Store, in the hope of creating a local initiative to support the various creators and responsible manufacturers.

Create and sell

To reach this objective, it is necessary to be integrated with creators, manufacturers and users, in order to help everyone to improve their work ethic and consumption.

The goal is not to only offer ethical products to consumers. Actions are two-fold: help designers create and then sell their products. Through knowledge of the Parisian local fabric, Fab City Store builds an ecosystem that helps creators design and make their products as easily as possible. They also help by setting up meetups and workshops on topics such as communication or business development.

The goal is not to only offer ethical products to consumers. Actions are two-fold: help designers create and then sell their products.

To help creators sell their wares, **Fab City** Store participates in a wide array of events, to find the best context for promoting designs – from B2C pop up stores (business-to-consumer) to B2B museum shop exhibits (business-to-business). Through the network of architects and designers, the team create relationships between products businesses and creators. Finally, the goal is also to get the public used to the values that Fab City Store holds dear... and encourage them to make a committed purchase.

To understand the concept of **Fab City** go to page 24

Figure 2 Mapping the Berlin maker community. Photo from the Fab City Store workshop at Re:Publica 2019

To create a real sense of community and engagement, designers and creators pay a membership fee to take part in the store's different activities, like pop up stores and workshops. Relying heavily on volunteer work from the team and subsidies, Fab City Store takes a fee on sales made. That means that there are no upfront costs and incentives can be shared between the designers and the team.

Copenhagen, Denmark
55.6761° N, 12.5683° E

VERSION_01 LAMP– MAKE YOUR OWN LAMP

By Nat Hunter, Gareth Owen Lloyd and Milo McLoughlin-Greening

"In 25 years, what people buy will be mostly stories, legends, emotion and lifestyle." – Rolf Jensen, Danish researcher

Europe's biggest export is air; empty shipping containers 'deadheading' their way across the ocean to be filled again with flat pack furniture, tech and toys. Held during London Design Festival 2018[94], we created the Distributed Design Lamp Challenge[95] to generate – and shine a light on – new products that could disrupt this wasteful system.

London collective Other Today[96] works with makerspaces and community spaces to create a sustainable community that has real impact on people. We don't just focus on tools, but bring the values, culture and clarity that is so often overlooked. For this challenge, we invited seven designers to the Machines Room Fab Lab[97], aptly located in two converted shipping containers in East London. The brief was to create a lamp, using bulbs and fittings from British lighting brand Tala[98], that was simultaneously distributable and (importantly) desirable.

Industry experts chose Milo McLoughlin-Greening's Light_00[99] (the project which would later lead into Version_01) as the overall winner. It showed a simplicity that made it quick for anybody to grasp the concept of distributed design. Made with two 3D printed hubs, people could construct a lamp with any number of available materials – from locally purchased broom handles to coppiced wood, making an object that is unique to them and their surroundings.

There is a huge difference between an object that could be made in a distributed fashion and the realities of an actual product that can be bought and sold. After the challenge we formed a collaboration to see what could happen if this lamp was real. The first test was

Figure 1 The lamp in September 2016

It is a support network for designers to contribute and build towards more sustainable consumption and production methods.

to confirm if it could be made anywhere by anyone. Milo made the files and instructions available on thingiverse.com, and the project was promoted as part of Greenpeace's #makesmthg week. Makers in Barcelona, Paris and Vienna all created their own versions of the lamp, adapting the designs for their local needs. Next, we partnered with Anna Lowe from the MakerNet Alliance[100], a network of people and organisations designing the digital infrastructure for an open internet of decentralised manufacturing that works for small producers in the Global South. She wanted to see if makers in in those regions could start their own business manufacturing the lamps. Anna connected us with three Fab Labs – Winam Fab Lab Kenya[101], Kumasi

Hive Ghana[102] and Nepal Communitere[103] – and we asked them to make their own versions of the lamp and to document the process.

The **makers** successfully produced their own lamps using poles normally used as scaffolding in the building trade, adding their own character to the process by lathe turning poles and laser cutting shades. In addition to these collaborations, we were continually finding out about new places where Light_00 was being produced without our involvement, from being used as a starting point for a workshop at Fab Lab Budapest[104] to being taught on a University course at Escola Superior de Educação de Lisboa[105].

To understand the concept of **Maker** go at page 27

Although we were happy that the lamp was being shared and remade without our knowledge, we felt that we had lost control of the outcome – some of the prints were breaking and makers had to hack the design to get it to work. This is a common challenge with open source design and we needed to find ways that we could ensure quality so that we can get the lamp into the hands of regular people, not just makers.
We decided to shift from the open source approach to a distributed manufacturing model and have partnered with a **3D printing** micro factory Batch.works in the neighbouring shipping container in the Machines Room **makerspace**. To print with Batch.works, the hubs have been optimised so they can be made with a single 1.2mm plastic extrusion, dramatically saving time and materials. This design-for-print is very different to simply sharing a file online and distinguishes open source from distributed manufacturing.

To understand the concept of **3D printing** go at page 20

In July 2019, we held a sprint with a new group of designers. Together we refined and prototyped a packaged product with clear instructions ready to test on the open market. Our plan is that the customer orders the set of hubs on Batch.works, which are then printed and posted on demand. They can then use the

instructions and the shopping list on wikifactory.com and build the rest themselves. The cost to the customer of this is around £45, which is comparable to buying a similar mass produced lamp.

Breaking down the numbers, the Batch.works platform shares 6% of the online retail price with designers. To make £1 per pair of hubs, we would need to retail at £16.50. With £3.50 for shipping, the customer would be paying £20 for the 3D prints. The rest of the components if bought new (and we do encourage using found parts) could be purchased for about £15-25. In this model, the designer is getting 2% of the final price, which is similar to the cut they would get as a royalty for a mass manufactured product licensed by a company like Joseph Joseph or OXO.

To be a viable business, however, we would need to sell thousands of hubs, but then do we risk becoming as bad as the system we are trying to replace? From the outset, this project has been about changing mindsets, rather than selling a new product. When someone orders our hubs, they are not buying a lamp, but purchasing permission to pick up a saw, a drill, to wire a plug and to create an object that will bring them joy through making.

In 1996, Danish researcher Rolf Jensen wrote: "In 25 years, what people buy will be mostly stories, legends, emotion and lifestyle." Jenson was referring to what is now known as the ‘Experience Economy’. Perhaps this is the business model for version_01 – to sell workshop experiences where people can come together to make their own lamps? Makers around the world are already selling crafting activities like bookmaking or spoon carving on disruptive platforms such as AirBnb Experiences and Meetup. Perhaps soon, makers around the world will also be teaching people how to make their own version_01 lamps – the value not being as a commodity, but in being able to say, “I made that!”

Figure 2 Winam Fablab used sticks normally used in the building trade to create the lamp structure.

Figure 3 The prototype packaging to be sold for retail

04.

DISTRIBUTED DESIGN IN PRACTICE

COLLABO-RATE & MAKE TOGETHER

Introduction: Underbroen

Case 01: Gameboks

Case 02: Testbed for a Better Future

Case 03: Plastic for Good Challenge

UNDERBROEN – CREATING MICROFACTORIES OF EXPERTS

By Stine Broen Christensen and Asger Nørregård Rasmussen

As the capital of Denmark, Copenhagen is an epicenter of experimental and innovative design practice. Like most capitals and major cities, it has created a 'scene' amongst the Danish craft, design and engineering schools, which hatch a substantial amount of creatives within architecture, fashion, arts and engineering every year. The city's great amount of **makerspaces**, shared workshops and fab labs are, compared to Copenhagen's population, plentiful – offering its maker community access to shared equipment.

To understand the concept of **Makerspace** go to page 28

This innovative context creates fruitful potential for experimentation, collaboration and **distributed design** activities in the local creative industries, which currently amount to 6% of the total businesses and employment in Copenhagen[106]. New local policy strategies have been initiated to increase this substantial number in the coming years.

To understand the concept of **Distributed Design** go to page 20

In Europe, over 800 fab labs and makerspaces (an average of 30 for each of the 28 EU countries[107]) show that this new creative paradigm focused on collaboration, connectedness and access has come to stay. Working in a nonprofit association like Maker, we witness the growth and growing mobility of this European movement on a daily basis. One in eight makers and co-creators of our annual Copenhagen Maker Festival are from countries outside of Denmark, some of which travel to the event, others settling in Copenhagen and finding a natural starting point for their enterprises in one of the region's ten or so spaces.

Maker was founded in 2015 around the goal to develop and promote talent, knowledge and methods from the growing local and global maker and design communities. As a nonprofit association, we do this through open and holistic approaches that engage local talent and industry, professionals and private citizens in collaborative activities and shared experiences that foster a local ecosystem from zero-to-maker-to-market, and experiment with unfolding the full potential of creative design and maker practices – with Copenhagen as our playground.

In 2016 we opened Underbroen[108] – a shared workshop and collaborative space for creative talent in the design and maker communities – to meet the need for a professional, semi-industrial productive space for Copenhagen. The space is a hybrid entity itself, as it is managed by Maker and the private company BetaLab[109]. BetaLab are running two other makerspaces, BetaFactory, which is a 2,000 square metre flexible factory, and a makerspace for artisans in Helsingør.

Underbroen has been running as a prototype and prefabrication facility in the field of urban and local production ever since. It is a fully furnished workshop with tools for digital and more traditional hardware production currently shared by 40 members. Most are micro-entrepreneurs and startups in the fields of architecture, furniture, art, light, and leather design, creative engineering and interaction design. Some are fresh out of school, some still students, some recently quit their full time job while others have been running their own design and production businesses for years. This group of multidisciplinary creatives typically work as independent makers or small companies. During the lifespan of Underbroen, more and more members are beginning to make a living from local and **digital fabrication** and design. It is all about professionalising the maker community.

It is a fully furnished workshop with tools for digital and more traditional hardware production currently shared by 40 members.

To understand the concept of **Digital Fabrication** go to page 22

When one workshop becomes a micro-factory with 40 experts: fab labs as platforms for distributed labour

When money talks, necessity is the mother of all collaboration. Workshops as Underbroen are hubs designed for distributed labour, cooperation and improvised collaboration. The business potential of sharing access to production facilities and tools for digital fabrication has led to the foundation of local fab labs and makerspaces. The members at Underbroen, and in most other shared workshops around the world, do not have the necessary resources to own and run their own workshops. Instead they crowdsource an abundance of technologies and tools that they, on their own, could only dream of using. When time is scarce, learning, research and development turn into knowledge-sharing – locally at a workshop-level and globally on online platforms. When every expertise is available in your workshop community, you can start developing business models around ad hoc engagements and distributed labour.

To understand the concept of **Prototyping** go to page 30

Underbroen is designed to work as a **prototyping** and prefabrication facility. There are no fees for machine usage or booking systems, except the CNC mill, and a small 'Makershop' offers common prototyping materials at cost prices. Members use the machines when they need to, jumping from one workstation to another in often improvised ways, doing quick experiments and fast prototyping. Being in the same physical space, working side by side helps valuable shared learning, sparring and tutoring and creates a fruitful learning environment, both for longtime members and newcomers.

Being in the same physical space, working side by side helps valuable shared learning, sparring and tutoring and creates a fruitful learning environment, both for longtime members and newcomers.

Underbroen is shared by startups, independent makers and SME owners with backgrounds in different fields and disciplines – enabling the combined experience of a large design business department. In many ways, Underbroen has developed both informal and formal structures of a co-operated design studio, with 40 highly skilled experts in design, business and production models in house (ones you would pay hundreds of euros for just a few hours of R&D consultancy elsewhere). And the best part is: they love to work on each other's projects. This flexibility is an important asset in spaces like Underbroen.

Furthermore, the model functions as a continuing education and skills development system where new, lesser-skilled members are taken under the wings of the more experienced, who get paid for their apprenticeship as they learn by observing how others run their businesses, organise productions and handle customers.

We truly believe in the distributed model we have developed over the past three years and experiences from the Distributed Design Market Platform project has made us even better at understanding what our members and community want and need, and has equipped us to better support the growth of new collaborative business models. At the time of writing this, we are taking the first steps to co-create a joint collaborative platform with all fab labs and makerspaces in the

capital. It will acknowledge that we all need and dream of the same things, whether technology, getting more knowledge or the good company of fellow makers – even if we are working in different fields of interest.

Designing for collaboration

So what makes these distributed labour models work?

— **Proximity:** The existence of a physical space with shared production facilities creates a community of practice around the values of openness, sharing, working and learning together, eventually employing others to work as experts on one another's projects. This proximity is also found in the form of open source communities where knowledge sharing and 'working out loud' are key activities.

— **Connectivity:** The connectivity (of both atoms and bits), interconnectedness and lab network provide the keys to success when talking about distributed labour and design. Many professional independent designers and makers are hardworking bees who make a living from design and production. Therefore, guidance, gatekeeping and matchmaking are often fostered by managers or other staff within such labs, which benefit both the makers, the projects and the lab as a vibrant space.

— **Multidisciplinarity and a vibrant space:** In relation to connectivity, multidisciplinarity is a key to the success of distributed labour in Fab Labs and makerspaces. As in traditional companies, various levels of competence, interests and knowledge are present in labs. This enables a perfect opportunity to utilise and invest in other people from the community on projects, by learning from the interconnectedness, networking and matchmaking.
The result is a highly flexible, skilled and appreciated way of working on projects, product development and production. This is the modern way of working with apprenticeships, where people of all experiences can gain valuable knowledge and help.

— **Continuous training & skills development:** In order to maintain a vibrant and innovative working environment, it is important to continuously offer courses and events that enhance skills and knowledge within the community.

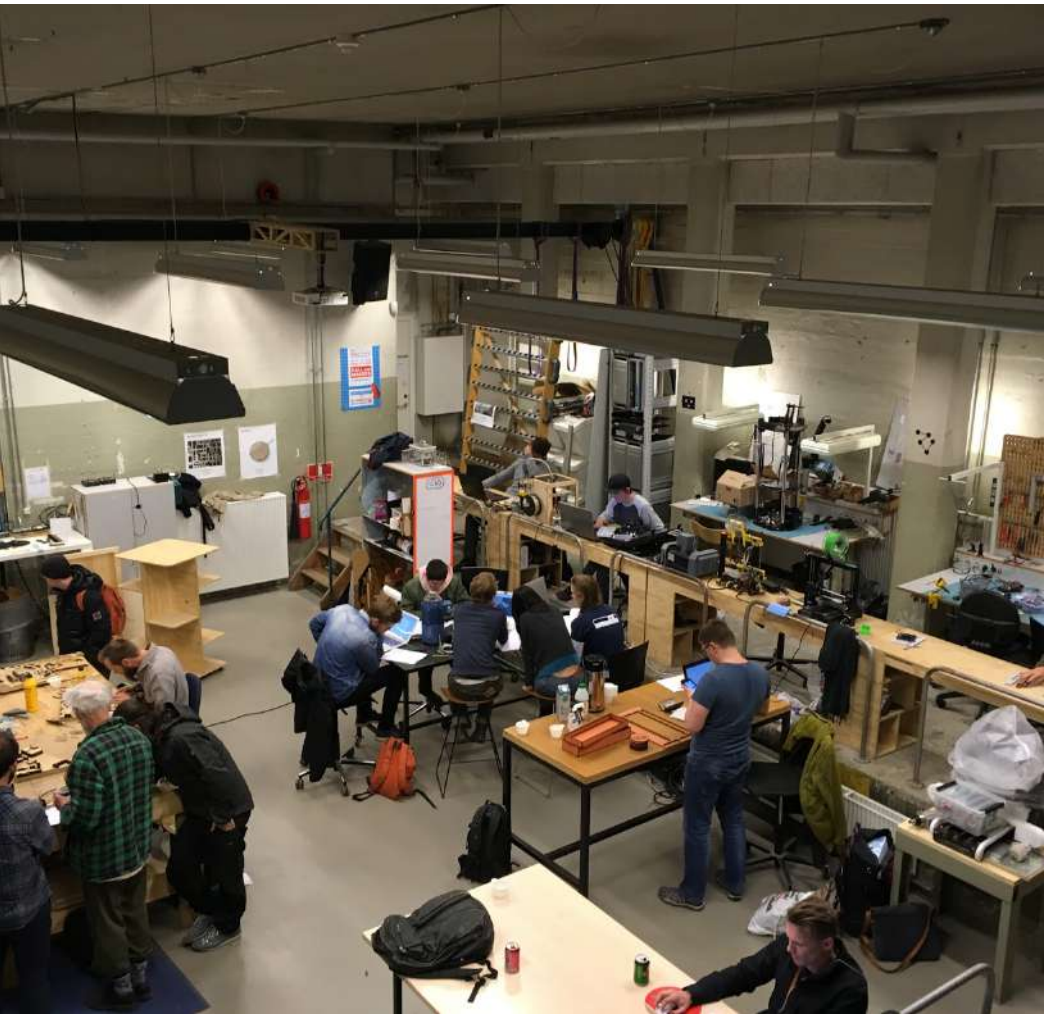


Figure 1 Photo of Underbroen workspace

— **Trust and transparency:** From a management point of view, it is important to continually understand the actual needs and interests from the community, in order to provide the best possible services and facilities. This also plays an important role in how the community will interact with the space and create ownership.

In Underbroen, we try to limit the amount of rules and bureaucratic systems, as we believe in a transparent system that relies on trust and collective responsibility.

Copenhagen, Denmark
55.6761° N, 12.5683° E

GAMEBOKS – GO-TO PORTABLE GAMING

By Stine Broen Christensen and Asger Nørregård Rasmussen

GameBoks[110] is a portable gaming station made from high-quality wood from sustainable sources in Copenhagen. Capturing the essence of Danish minimalistic design, it is compatible with the majority of gaming consoles and allows social gamers to freely take their gear with them anywhere at any time. The young, fast-paced startup began its journey with a Distributed Design residency at Underbroen[111] in the summer of 2018 – a brilliant idea that evolved into a massive success over just 12 months.

Besides being educated in carpentry and product design, one of GameBoks' founders, Christian Alves, is a major gamer. He became increasingly frustrated with the impracticality of bringing his console, monitor and other gaming gear to his friends' houses. Meanwhile, he discovered how friends distanced themselves from each other as they started gaming more. He decided to find a solution to the problem, by building a simple case of spare wood to put his TV inside. It worked and solved his problem.

Friends and co-founders Anthon Schrader and Steffen Pedersen, who have experience in marketing and logistics, quickly saw the potential and founded GameBoks in May 2018 with the goal of launching a Kickstarter campaign in September, while showcasing it at Copenhagen Maker Festival[112]. From here, GameBoks launched to an eventful year. They were 100% funded in eight hours: the first 300 units had to be produced!

Over the next six months, the GameBoks design was refined at Underbroen. The four team members spent all day and night making prototypes and sometimes slept on the couch (or not at all). Often found sparring with other members more experienced in production on product details, they slowly started pushing out the first 300 units.

Figure 1 Christian Alves adding leaf gold details to a GameBoks (Credit: GameBoks)

From there, a masterful marketing strategy – involving social media and professional football players from Barcelona FC, West Ham United and Arsenal – catapulted them to the stars with orders of 1000+ units.

From the moment they joined Underbroen, Gameboks have had an urgent need to increase their production capacity in order to keep both Kickstarter backers and customers happy. They have done this by improvised employment of other members at Underbroen on an ad hoc basis, based on the current needs they had. **Through their initial development and prototyping process, they had the opportunity to scout and work with members who are experts in electronics, painting methods, woodworking and digital manufacturing on an ad hoc basis based on the urgent needs they had.** One example is a series of VIP orders with inserted plate gold where they engaged a light designer experienced in this exact material, and employed her to work on the units. Throughout their first year at Underbroen, GameBoks has engaged a dozen individual members in their R&D and initial manufacturing activities. Now they have set up a storage space outside the workshop, since their production need exceeds the facilities of the prototype lab, but have on-boarded a loosely engaged satellite team of members who have been part of the prototyping and production process – simply by being around – who they engage when new units have to be produced.

The GameBoks case is a good example of the distributed business and production models employed by professionals in maker communities.

The GameBoks case is a good example of the distributed business and production models employed by professionals in maker communities. Like GameBoks, many emerging design and manufacturing businesses would not have been able to catapult their product and grow their productive capacity in such a pace if it had not been for the multidisciplinary group of available members at Underbroen, or similar spaces.

Bilbao, Spain
43.2630° N, 2.9350° W

Vienna, Austria
48.2082° N, 16.3738° E

TESTBED FOR A BETTER FUTURE – SIX SUCCESS STORIES

By Karim Asry & Leyla Jafarmadar

We can't predict the future, but if there's one thing that's certain, it's that to stay sharp and competitive and survive in the 21st century markets, we need to learn, unlearn and relearn. Today schools, training programmes and informal networks like Fab Labs, **hackerspaces** and makerspaces are forming networks of open source communities and distributed design – to share new digital knowledge, tools and expertise. This enables social entrepreneurs, artists and designers to come up with innovative, original and creative projects that sell. Now we want to share some of them with you:

To understand the concept of **Hackerspace** go to page 26

Let's go back to the year 2006, a time when 3D printers and drones were only accessible to a privileged few. The **Internet of Things** was a thing of science fiction. That year, a Spanish telecommunications engineer named David Cuartielles gave a conference in his hometown, Zaragoza, to a total audience of eight people, about **Arduino**[113]; the new open source electronics platform he had co-founded. Arduino is today one of the building blocks of maker culture, a tool that allows millions to create projects, products and services with electronics.

To understand the concept of **Internet of Things** go to page 27

To understand the concept of **Arduino** go to page 20

Figure 1 Photo from HappyLab Viena, Project Kairoz by Julia Fischer

Two students who showed at the conference, Alicia Sin and David Gascón, immediately started using Arduino to build their own startup, Libelium[114]. Today, it's an award-winning spanish SME that sells its IOT sensors to several Fortune 500 companies. Early access matters, especially when technology moves fast. 3D printers and drones no longer cost several tens of thousands of euros, but just a few hundred per unit, thanks to the work of Arduino, which now has around one hundred employees, with millions of contributors on the platform worldwide.

Josef Prusa is an early star of the Arduino online community. He used the open source platform to make low-cost 3D printers from other 3D printers. The RepRap[115] project is considered to have started the open source 3D printer revolution and is the most widely used 3D printer among the global members of the maker community. Once a young economics student from Czech Republic, Josef is now the CEO of Prusa Research[116], one of the fastest growing tech companies in Central Europe, according to Deloitte. Even though the company shares all its design online as open source, it

has 250 employees sells 6,000 3D printers every month worldwide. Communities can create a better competitive advantage than patents – and often a product cycle can end faster than the time spent on patent paperwork.

But let's not focus only on the big stories. The rise of distributed design, fab labs and **open source** communities has created plenty of smaller success cases all over Europe. In 2006, Karim Jafarmadar and Roland Stelzer were in Vienna trying to figure out their own robotic autonomous sailing system. They needed machines to achieve their prototypes. As soon as they realised the huge potential of having a workshop where you could make almost anything, doors opened. The first person to show up was an artist in need of a laser cutter. That project would later evolve into Happylab[117], a member of the **Fab Lab** Network, with three locations spread between Vienna, Salzburg and Berlin, ten employees and 2,000 members, who all pay between 9-49 euros per month to have access to a collective workshop that has seen many entrepreneurs flourish.

To understand the concept of **Open Source** go at page 29

To understand the concept of **Fab Lab** go at page 24

At Happylab, Johannes Kurz and his wife, a violin maker, developed a foldable CNC-milled stand for wooden stringed instrument. He called it Kajoku[118]: "We had the opportunity to implement our ideas and we even got a patent on the instrument stand. We now have a wholesaler for our instrument stands and spiked boards, who delivers to 60 countries worldwide and our own online shop. What I learned is that it is important to believe in your ideas and try to implement them," Kurz explains.

It is a support network for designers to contribute and build towards more sustainable consumption and production methods.

Magdalena Muszyska, also from Vienna, is a fashion designer who went to Happylab with a precise idea that she assumed would use a 3D printer. "I did a bootcamp there and used mostly laser cutting in the end," she recalls. "This technology is seriously underestimated in fashion at the moment. It opens new possibilities to experiment and play with textiles. It has inspired me to develop a laser cutter and self-assembled fashion line and an open source database to apply laser for textile manipulation."

Figure 2 Photo from Distributed Design presentation at Maker Faire Bilbao, 2018

Event-based learning is a hard-to-measure reality, but that doesn't make it less real or less important than other things that are necessary for Europe to keep its central role as a testbed for better futures. Workshops change lives; DIY events and festivals like Maker Faire[119] connect technology, design and people with emerging vocational possibilities. Our challenge for the years to come is to find ways to track these meaningful stories and highlight the importance of maker culture, Fab Labs, open source communities and distributed design when it comes to creating economic-related success stories.

Eindhoven, Netherlands
51.4416° N, 5.4697° E

PLASTIC FOR GOOD CHALLENGE– REDESIGNING THE FUTURE OF PLASTIC

By Lisa Goldapple

Backpacks with integrated school desks; modular tiles and twisty joints; pop up recycling trailers; and even a child's rocker – it's amazing what new, useful things you can create out of recycled plastic, with a little bit of imagination and some cool tools.

The Plastic for Good Challenge[120] is a campaign that brings creatives together with one mission – fighting the global plastic problem. Shredding, extruding, injecting, moulding; this is DIY plastic recycling at its most fun. Co-funded by Creative Europe, the crafty challenge is a collaboration between Distributed Design Market Platform and Precious Plastic[121]. It brings together 15 creative minds from all over the world to showcase the possibilities of recycled plastic as a valuable resource that allows designers and makers to create meaningful products.

Today, plastic poses one of the greatest challenges to society. Once it has served its productive life, it is not just useless, but also destructive to the environment and people. The products we buy are often assembled in super-sized factories out of materials that often have to travel long distances. Mass produced, highly standardised products leave no room for individual customer needs or the use of local resources. What if we could change this system?

Figure 1 Team work makes the dream work.
Plastic for Good Challenge, Eindhoven 2019

To understand the concept of **Open Source** go to page 29

Precious Plastic is a global **open source** movement with a community that works towards a solution to plastic pollution. Started in 2013 by Dutch designer Dave Hakkens[122], their mission is to let people in every corner of the world know that they can start their own local little plastic recycling workshop: “We develop machines to recycle plastic and share the blueprints open source for free so that everyone in the world can download and build them.”

The global online community of over 76,000 people relies on interacting and sharing. The network now includes over 350 people who have built machines – and a new one is popping up every week. Meanwhile, the Distributed Design fosters the role of emerging creative players, makers, designers, artists, architects and scientists within our new digitised world.

For the first design challenge, the Precious Plastic community welcomed 15 Distributed Design creatives into their Eindhoven 'Basekamp' in the Netherlands in June 2019. Coders, designers and **makers** from all over the world came together with one objective: to produce a product out of recycled plastic to improve lives in one week.

To understand the concept of **Maker** go at page 27

The five groups worked with the latest Precious Plastic machines to bring their imaginative designs to life. "Part of the magic of the process is that the recycled plastic sheets and beams have an attractiveness and a feel of high quality to them," explains creative director Marcel Rodríguez. "At their best, the colourful, marbled plastics can emulate the look of stone, ceramics or even glass, when transparent."

For Marcel, the most exciting part was seeing how 15 creative minds from very different backgrounds and fields managed to conceptualise, design and manufacture meaningful products in just one week, "from understanding how to work with new materials and tools, to overcoming a heatwave!" Next, the Plastic for Good Challenge team wants to encourage local communities of makers and designers to replicate the campaign in as many places as possible to address local problems using recycled plastic. Because only good can come from that.

Part of the magic of the process is that the recycled plastic sheets and beams have an attractiveness and a feel of high quality to them.

All products from the 2019 challenge are fully open source and can be downloaded from Wikifactory[123] for everyone to be able to make, improve or adapt them to their local needs – whether created in a lab, or at home with Precious Plastic machines.

Figure 2 & 3 Work in progress and the final result. Plastic for Good Challenge, Eindhoven 2019

"Our challenge for the years to come is to find ways to track these meaningful stories and highlight the importance of maker culture, Fab Labs, open source communities and distributed design when it comes to creating economic-related success stories."

Karym Asry and Leyla Jafarmadar,
Testbed for a Better Future, page 130.

PLATFORM ECOSYSTEM

Design in the digital era affords us the capability to collaborate at scale. In order to develop a distributed design paradigm, many platforms need to co-exist and cooperate. We are developing a menu of platforms that give us a glimpse into the potential of design in a distributed ecosystem that is enhanced by the connectivity of distributed ledger technologies.

04 CHAPTER

Platform Ecosystem

01 – FabLabs.io

02 – Precious Plastic

03 – Wikifactory

04 – Make.Works

05 – Materiom

06 – Faberin

07 – Fabchain

PLATFORM ECOSYSTEM – THE TECHNICAL BACKBONE OF DISTRIBUTED DESIGN

By Tomas Diez, with contributions by Emily Whyman and Kate Armstrong

To understand the concept of **Open Source** go to page 20

It's been quite a journey since **Distributed Design** was created in 2018. Growing annually, the Europe-wide network deploys strategies to engage organisations at a local level, and at large through a distributed digital network of knowledge and data sharing. The first year comprised of brand development and communication with partnerships, organisations and individuals. Various events such as the **Fab City** Summit[125], Maker Faires and other design festivals help expand the message. By prioritising offline cultural development with local ecosystems in member locations, Distributed Design promotes the principles of Fab City[126] and the Fab Lab network.

To understand the concept of **Fab City** go to page 24

As an ecosystem of powerful organisations and technical platforms started congregating around the concept of Distributed Design, fablabs.io was launched as the technical backbone to advance the articulation and enable this digital exchange.

The network became aware that the potential of Distributed Design is not only to articulate the benefits of new models of production and consumption, but also to configure these interactions with pragmatic tools. Highly reputable organisations and powerful existing platforms began to plan integrations to increase Distributed Design's capabilities and audience. Synergies became practical in 2019, when a white-label was created between fablabs.io and Wikifactory, who were finalists of the DD Award 2018. This feature gave Wikifactory the opportunity to host projects on their site and allowed fablabs.io users a previously unmatched level of distributed collaboration (more about this later).

What's next? The further development and articulation of the platform ecosystem includes taking key steps with existing like-minded platforms that both practice the values of distributed design and provide practical tools for makers and designers to develop their distributed design practice. An alliance of innovative platforms is already gathering under the thinking of Distributed Design, to connect, share and articulate the circular, ecosystemic, distributed systems we invisage. Some are outlined in the following chapters.

FABLABS.IO – FAB EXCHANGE PLATFORM

By Tomas Diez

Figure 1 Fab lab locations inspired by Fablabs.io map

Fab lab (noun)
A local fabrication laboratory which aims to democratise access to personal and collaborative invention using digital technologies to make almost anything.

Started (almost) accidentally as an outreach programme at MIT's Centre for Bits and Atoms in 2002, Fab Labs have since become an emergent network of digital fabrication laboratories. First established in the South End Community Center in Boston as a joint collaboration between the

'Part of the magic of the process is that the recycled plastic sheets and beams have an attractiveness and a feel of high quality to them.'

National Science Foundation[126] and MIT's Center for Bits and Atoms[127], you can now find 2,000 of them dotted all around the world, from Bolivia to Ethiopia.

Using digital fabrication as the main focus, Fab Labs promote the idea of distributed manufacturing. Designs can be sent to the other side of the planet, and using CNC machines, laser cutters, 3D printers and other simple tools, citizens can create nearly any object, big or small. The informal network has been growing exponentially during the last ten years, doubling every 24 months, similar to the rate established in the Moore's Law for microprocessors speed and cost.

The labs have the potential to impact profoundly how we live, work and play. However, they need better governance, validation and value exchange tools to incentivise the impact within the network and in the places where they are located.

The main Fab Lab community values and mission are simplified in the Fab Charter[128] (updated in October 2012 for the last time):

To understand the concept of **Fab Lab** go to page 24

— **Collaborative community:** For the last ten years, the **Fab Lab** network has gathered in a different country every year for an annual Fab Conference. Taking advantage of tools that aid global collaboration – such as GitLab[129], GitHub[130], fablabs.io, Whatsapp[131] and Slack[132] – Fab Labs are organised in regional networks, with the most consolidated examples being in Latin America, Asia and Europe. Networks collaborate on educational programs such Fab Academy[133], Textile Academy[134] and Bio Academy[135].

— **Open source philosophy:** Thanks to digital fabrication technologies, the open source movement from is moving from software

to hardware as Fab Labs exchange code, files and instructions to design and produce things anywhere in the world, without the need to ship any materials. Because of its very nature, open source software lacks incentive mechanisms, but this is not the case when it comes to hardware. All the content of the Fab Lab network is publicly available online – the inventory[136], educational program curriculums, video lessons, project designs, platform source codes and online tools.

— **Circular economy and open innovation:** The ultimate goal of Fab Labs is to build the vision of the **Fab City** project. Under this mission, it is data, not things, which is shipped globally, enabling objects to be made locally. The **circular economy** is not based in the management of materials, but in the creation of value from waste, and its ability to be reinserted in the supply chain at the local scale. This ambitious goal requires open innovation at its core – a fundamental value of the Fab Lab network.

To understand the concept of **Fab City** go to page 24

To understand the concept of **Circular Economy** go to page 21

— **Social impact:** Neil Gershenfeld, Director of MIT's Center for Bits and Atoms, claimed back in 2005 that the network's intention was to "encourage hands-on activities and invention by bringing 'science and technology' to peripheral and marginalised communities". Today we are seeing that in action as people in Fab Labs all around the world are challenged to get out of the comfort zone of the empowered and self-satisfied geek, and to use their knowledge to help their local community, and then measure and document impact. Digital fabrication has the potential to provide solutions for specific needs anywhere in the world, especially impacting communities with a lack of access to water, energy or communications. An

Because of its very nature, open source software lacks incentive mechanisms, but this is not the case when it comes to hardware.

Figure 2 The collaborative folk at Fab Lab Barcelona, 2018

example of this is the Vigyam Ashram Fab Lab[137] in rural India, which has implemented successful solutions such as an LED lighting solution, precision agriculture control devices and a sanitary incinerator. Fab Labs are physical spaces which hold the potential for social inclusion; to empower like-minded people (individual and collective agency); and to enable their capabilities. Digital empowerment takes another dimension when bits and atoms are connected, and people and communities can satisfy their local needs through access to new means of production.

— **Access to digital fabrication tools:** The core objective of the Fab Lab network is to democratise access to digital fabrication tools through the development of educational programs and facilities for communities worldwide. There are a growing number of Fab Labs being promoted by public and private sectors that provide free access to spaces and machines for their use. However, this access is not limited to machines: the aim is to give citizens the knowledge and tools to expand the network's potential around the world.

— **Development of educational programs:** Individual Fab Labs, regional networks and the global community have been developing and implementing new educational programs around the world, including certified programs such as the Fab Academy or Bio Academy, as well as STEAM school programs (Science, Technology, Engineering, Arts and Mathematics). These new educational programs teach the next generation skill sets needed in today's digital economy that are requested by large companies, startups and innovation organisations when hiring new personnel. Fab educational programs stimulate entrepreneurship, with a large number of Fab Labs started by alumni as new businesses, as well as the development and creation of new products.

— **Development of new economic model based on new urban industries:** Fab Labs support the Fab City vision, which aims to transform the urban dynamics and space with an industrialisation based on clean technologies, demand production, circular economy and citizen innovation. Fab Labs have the potential to become the articulators of a transition towards a new productive model in cities – able to provide access to tools; build a new set of skills; and deliver a new type of services and products that will challenge the 150 year old industrial model.

— **Catalyst for a new model of distributed production:** Fab Labs won't replace industry, but will accelerate the transition to a new model of manufacturing on various scales within cities and regions. They can help provide the services and products needed in cities without compromising the planet resources or exploiting workers. Fab Labs are the places where ideas are turned into reality; prototypes are designed and tested with users, and business models are developed, while connected with larger manufacturing ecosystems at the city and region scales. For example, the approach of open access factory finder Make Works is complementary within the Fab Lab network worldwide, since it registers the manufacturers and suppliers at industrial scale in cities and regions.

Introducing Fablabs.io

The distributed nature of the Fab Lab network means it needs a tool to officially recognise and list all of the world's Fab Labs. Online social network Fablabs.io connects the international community, which shares the same principles, tools and philosophy around the future of technology and its role in society

The exchange platform is a way for the people, labs, projects, machines, events and groups that operate around the network to communicate.

The exchange platform is a way for the people, labs, projects, machines, events and groups that operate around the network to communicate, share developments and collaborate online. Fablabs.io fosters interactions between designers, makers and users, and aims to engage discussions about matters of concerns of the wider public in which Fab Labs are embedded in cities and remote areas of the world.

Created initially as a spin off project from Fab Lab Barcelona by its director, Tomas Diez, and John Rees in XXXX, today Fablabs.io has approximately 2,000 Fab Labs around the world registered – expanding the global scale of this community.

Fablabs.io is not intended to replace existing platforms that are widely used by makers, **hackers** and technologists to document and share open source developments – such as Facebook or GitHub. In fact, when adding a project to the Fablabs.io repository, it is possible to include links to **GitHub** repositories.

To understand the concept of **Hacker** go to page 26

To understand the concept of **GitHub** go to page 25

More recently, both the Fablabs.io and Wikifactory platforms have partnered in order to integrate some of each other's key features. By adding new features and integrating existing platforms, Fablabs.io facilitates distributed collaborations across participants in different Fab Labs, and embeds their creations in the specific ecosystems of the maker community.

The integration of Wikifactory has improved search functionality for people, projects and capabilities. On top of this, the new Fab Labs approval process is based on issue trackers; there is a badge system for users, labs and organisations; and the personal user homepage includes updates from the labs in the network.

Scan it to visit Fablabs.io

PRECIOUS PLASTIC – DIY PLASTIC RECYCLING WORKSHOPS

by Joseph Klatt

Figure 1 Precious Plastics and Distributed Design teams: Plastic for Good Challenge

Our mission is to (re)valorise plastic so we can eliminate its waste altogether, creating local circular economies.

Precious Plastic[138] is an open source project that aims to boost plastic recycling. We design plastic recycling machines, techniques and digital tools and share the blueprints for free, so that anyone can start their own plastic recycling workspace anywhere in the world.

Our mission is to reevaluate the value of plastic, which is where the 'Precious' part comes in. We can eliminate plastic waste altogether, educate people about the problem and create local circular economies. While traditional centralised recycling systems require massive investments and access to high tech machinery that's inaccessible for much of the world, we provide DIY recycling machines, techniques and knowledge to turn plastic waste into new valuable products using universal materials and basic tools. The blueprints of our designs are published for free, **open source**, online and come with a detailed set of 40 instruction videos, guidebooks and all the necessary knowledge for anyone to be able to create a fully functional plastic recycling workspace – including plastic types, collection, product design, product creation and finishing techniques.

To understand the concept of **Open Source** go to page 29

Our machines and methodologies provide a production system that starkly contrasts with the mass production of virgin plastic and its associated environmental degradation. Through local collection and low-volume craft production, participants witness their plastic waste transformed into beautiful new products, which rejects detached consumption and disposal in favour of a participatory act of creating an alternative future – without waste.

Our Community

Since the project's inception in 2013, the community has grown to more than 350 known Precious Plastic workspaces globally, using Precious Plastic machines to recycle plastic waste locally. Our online discussion forum has 76,000+ members contributing questions, hacks, tips and resources related to running a plastic recycling workspace. Our online map has more than 12,000 pins from people offering their skills, hoping to collaborate with others. This community, on and offline, is the key to our success.

Figure 2 The Precious Plastic machines

We chose to invest heavily in creating a community around Precious Plastic, because plastic waste is everywhere, and the benefit of open source projects is that everyone can start working on a problem together and share successes and failures. The plastic waste problem isn't going to be solved with just one solution – every setting is different, every country is different and every culture is different. Open source communities create the best solutions through local ways of customisation, hacks or plug-ins, and help you get close to the problem in a quick, scalable way. You also build a strong foundation of people collaborating together, which is more sustainable in the long run, rather than relying on one centralised organisation to develop solutions.

There are two main ways that the Precious Plastic community collaborates with one another – online forums and the 'Precious Plastic Map'. Our online forum allows people from all over the world ask questions to the community, share their experiences, and lead new areas of research and development. The map allows people to find and connect with others locally so that they can start a local group or new Precious Plastic workspace. Connecting locally is the key to empowering people to find local solutions.

One of the toughest challenges for open source projects, especially hardware projects, is working out how you share back high quality information (new designs, techniques, learnings) from the community in an organised way.

Within our community we've experienced people wanting and willing to share information that they've developed locally, but we don't have a clear channel or place for it. That's why we are working on developing a documentation tool that will enable community members to upload specific products, machines, techniques or other 'how tos' so that other people can utilise them. This will serve as a repository of information from both the Precious Plastic core team and workspaces from around the world.

What's next?

We've built a huge community and infrastructure around solutions to the plastic waste problem, but many of the Precious Plastic projects around the world are geared towards educational initiatives or small community projects. Precious Plastic Version 4 has a focus on scaling our network up in impact through three new 'semi-industrial' machines – a shredder, extrusion and sheet press. These machines will enable Precious Plastic workspaces to significantly increase the amount of material they are recycling. Along with our new digital tools and business models, this will help people to more easily start a small plastic recycling business and sustain themselves financially.

We envision a robust regional or city network of small businesses working together to recycle plastic and produce new valuable products. Each Precious Plastic workspace within the network will specialise in one part of the process, whether collection, shredding, production or sales – with each adding value. This model contrasts to previous versions of Precious Plastic, which focused on having an all-in-one workspace. The shift in design occurred as a result of learning from the most successful workspaces in our community.

Figure 3 Some of the vibrant Precious Plastic Community

Scan it to visit Precious Plastic

WIKIFACTORY – SOCIAL PLATFORM FOR COLLABORATIVE PRODUCT DEVELOPMENT

By Christina Rebel

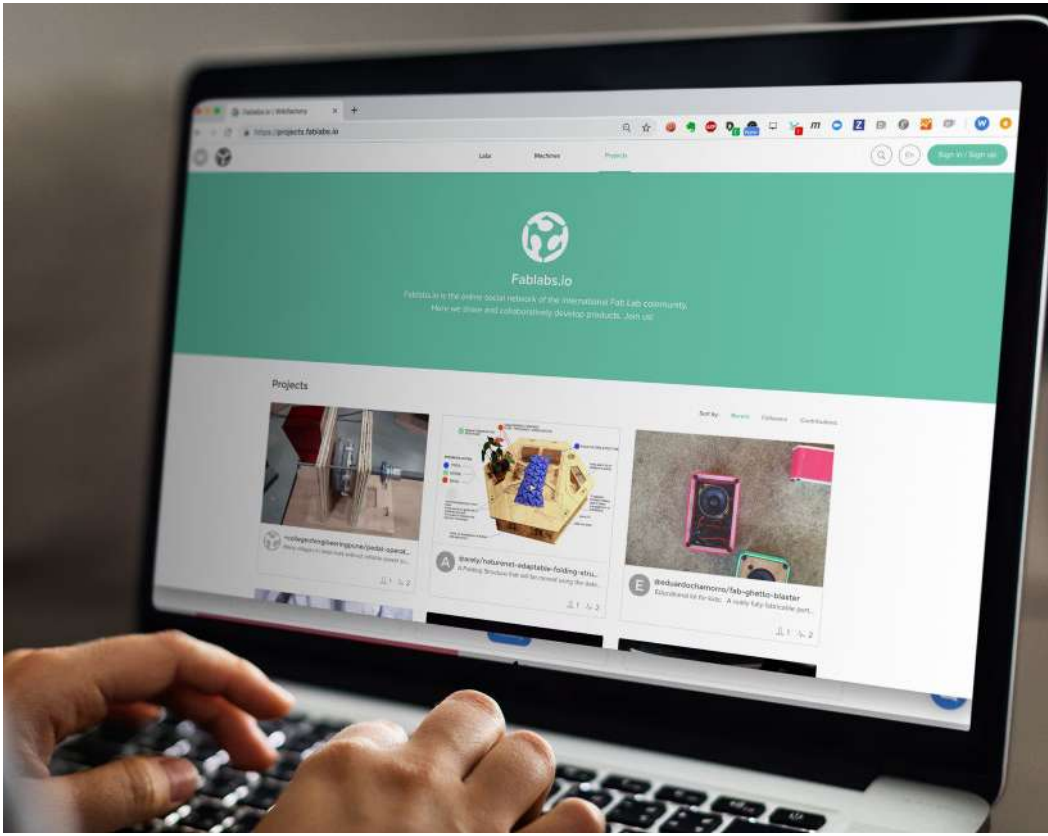


Figure 1 Live on projects.fablabs.io

Manufacturing conjures up an image of a global community sharing their ideas with little more than an internet connection.

Wikifactory[139] shares the importance of looking at what is necessary to make it possible to distribute design – and bring more local, circular models of design to production.

Increasingly, manufacturing conjures up an image of a global community sharing their ideas with little more than an internet connection. Just like video or music, new digital tools for design and production are making it easier to turn product ideas into reality. From our perspective at Wikifactory, the greatest learnings from online content can be found in the lines of code contributed by the software community.

Budding developers can be humbled by the sheer amount of knowledge and information that has been openly shared by the software developer community. We rely immensely on open source software for pretty much every single app and online that we use. Developers build on the 'shoulders of giants', realising an incredible scale of contribution brought about by a highly skilled community of software developers.

What underpins that collaboration in the first place? How do distributed online communities and teams develop software together? These are the core questions that Wikifactory asked as a team when we came together in 2016. Around us in London and China, we saw an open source and **maker movement** emerge that inspired us to ask these questions in the first place. Within this context and as technologists, we looked to GitHub[140], GitLab[141] or BitBucket[142] and how these online platforms have served to organise the efforts of the software development community through a key set of collaboration tools.

To understand the concept of **Maker Movement** go to page 27

These tools include repositories capable of **version control**, a markdown editor for documentation and an issue tracker to manage the iterative cycle of improvements and bug resolutions – as well as the permission systems to enable a distributed team to work together; and, better yet, the ability to '**fork**' a repository

To understand the concept of **Version Control** go to page 31

To understand the concept of **Fork** go to page 24

and enable a global community to freely build on the work, whilst offering a way to 'merge' these changes, if needed.

Whilst Wikifactory would turn to these best practices of open source software development as a starting point, we knew that we'd have to guide our development through incremental and iterative feedback from the community that inspired us too. While engaging product developers, we realised they were already sharing their content online, albeit that they would rely on many services put together, as a kind of online project management system: mixing a file-sharing tool from one service; a documentation editor from another; and a task management tool, with a handful of others in the toolbox.

Indeed, there are plenty of online listing sites where product developers can share their Yoda heads and fidget spinners as **.STL files**. However, there is nothing like a solid equivalent of GitLab or GitHub for software developers to host their projects and engage a community online. When the rest of our workflows are going social, it's as if product development hadn't had its online social and collaborative moment.

To understand the concept of **.STL files** go to page 31

In that process of validating our value proposition with the community, it became clear to us that we had to build Wikifactory for the needs of product and hardware development from the ground up as well. We'd do so in providing, for example, a version controlled drive that can host and view over 30 CAD formats without needing plug-ins, and would be viewable on mobile; or a markdown documentation editor with a user experience closer to that of a blog, for those unfamiliar with the .md syntax (a lightweight markup language with plain text formatting syntax).

We also assessed our collaboration tools in relation to the professional product lifecycle management (PLM) and product data management (PDM) tools that underpin product innovation processes at large companies. At least for the budding product or industrial designer, we found that these expensive licenses of more professional product development tools are out of reach. These tools are not designed for online collaboration, as they are usually desktop software that leads to information loss at organisational boundaries.

Wikifactory therefore saw the opportunity to become an online infrastructure that can serve as an alternative: providing a collaboration infrastructure – for free – for open source projects, and an affordable subscription for private project collaboration. We aim to strengthen existing communities and projects with our collaboration tools where possible. For this reason, we built our social collaboration platform on top of an extendible web infrastructure that can be part of a platform ecosystem. We do believe that developing software is in an important aspect, inherently different to developing hardware or products. Whilst products exist in the physical space, the process of design to production to market is increasingly entirely digital. It's an exciting time for digital fabrication as it is already possible to distribute digital designs through a network of near on-demand fabrication services. We want to help bring the end-to-end process of design to production increasingly online. This book captures the incredible learnings of what it takes to make that distribution possible.

We hope our contribution can draw attention to the need to be able to share not only 3D designs online, but the data from design to production. We hope to make it possible for creators and collaborators of distributed design projects to share not only 3D designs and documentation, but, increasingly, the design to production data to streamline the replication of their designs elsewhere.

This brings about a great deal of potential further research and development on what it takes to have a 'minimum viable process' of distributing design so that it can be replicable across locations. At Wikifactory, we seek to identify and respond to the gaps in the online digital toolchain that are needed for a fully seamless online process from 3D design to physical product. In doing so, we hope to continue providing initiatives like those highlighted in this book with the advanced collaboration tools that can support their incredible efforts to distribute designs of (almost) anything to (almost) anywhere.

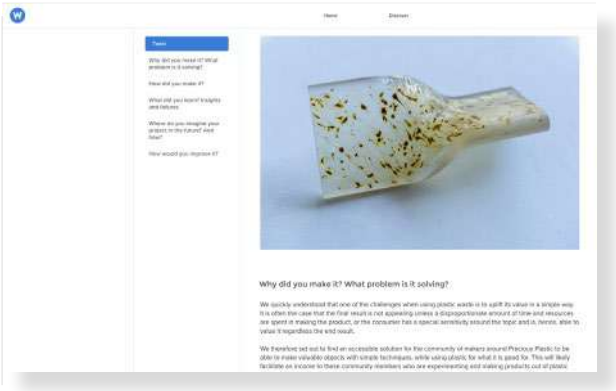


Figure 2 TWIST from Plastic for Good Challenge on projects.fablabs.io

Scan it to visit Wikifactory

MAKE.WORKS – MAPPING LOCAL FACTORIES

By Alessandra Schmidt and Helen Voce

Figure 1 Gordon Ellis & Co, Derby. Photo from Make.Works webpage.

Make Works[143] is on a mission to make local manufacturing openly accessible. An open access factory finder, we source manufacturers, makers, material suppliers and workshops. The online platform allows designers, makers, artists, engineers, entrepreneurs and micro-businesses (essentially, everyone who wants to) search listings in their local area, so they can find someone who can assist them to create, build or repair physical things.

An open access factory finder, we source manufacturers, makers, material suppliers and workshops.

We want to support small scale, local manufacturing – distributed manufacturing – as an alternative to the consumption of mass manufactured products. We think that the information we are gathering should be open and accessible, connecting people directly to making and repairing things, democratising access to production and investing in local economies, skills and community.

Local manufacturing is better for the environment, sustains local economies and supports communities. We have found that the makers, manufacturers, technicians, craftsmen and factory owners on Make Works are some of the most incredibly skilled and passionate people we have ever met. Yet, it is really difficult to find these hidden local industries online.

Make Works offers a solution to this and is a big step in the right direction when it comes to building small scale production networks to help us develop environmentally sustainable systems for the future – from distributed production reducing the carbon emissions released in transportation and shipping; supporting local, resilient economies; through to providing communities with access to tools and skills needed to repair existing things. Make Works assists with local manufacturing, creating skilled local employment and supporting other small business networks. On a practical level, everyone can simply source local manufacturers, craftspeople, workshops and materials, as well as create accessible information about manufacturers to inspire people to make, build, create and repair things in the world.

The platform gives citizens access to information about manufacturing means, so that they can make more conscious decisions about their consumption habits. People can easily visit and meet manufacturers. Meanwhile, craftspeople and suppliers are able to meet face to face to discuss projects, and build human relationships
The idea is to improve the quality and integrity of what can be designed and made, through an understanding of the materials and production processes. Businesses can take more responsibility for working conditions and the environment that any manufacturing that they commission locally affects.

Scan it to visit Make Works

Make Works: Story 01

OUR MAKE WORKS STORY: DERBY AND DERBYSHIRE

By Laura Dudley

At Make Works Derby and Derbyshire[144], filmmaker Andy Taylor-Smith works with students to provide a professional content creation experience, developing the wealth of content included in a Make Works listing. This has opened the eyes of the students to opportunities available in the creative industries.

Make Works Derby and Derbyshire is coordinated by Derby Museums as part of the delivery programme for the Museum of Making[145] at Derby Silk Mill. It was designed with an ethos of co-production in November 2017, in collaboration with the University of Derby and Derby College.

Make Works has three primary functions at Derby Museums:

01. To provide a volunteer training programme, working with students to utilise the processes of being listed on Make Works. This offers valuable professional experience and introduces students to the breadth of making happening in their region.

02. To contribute to a growing database of 'makers' working in our region, of all disciplines and scales, who offer a bespoke service.

03. To highlight and tell the continued story of making that started with the Silk Mill as the site of the world's first factory and continues today.

The three key benefits we see of working in this way with Make Works are:

— **Volunteer co-produced:** When creating new listings, we go through the processes of recruiting volunteers, running an intensive and thoughtful training programme at Derby Museum and Art Gallery, site visits, post production and evaluation. These are all done with volunteers, collecting feedback and responding to this throughout to enhance our programme for mutual benefits.

— **Database of makers:** In developing this public database, we are expanding understanding of the full breadth of making in our region. Make Works allows us to meet the people behind a company and showcase them proactively.

— **Ongoing story of making:** By working with the team at Make Works Scotland[146] we have played a role in developing the taxonomies which tailor search results on the site. A selection of these are now being applied to the Museum of Making at Derby Silk Mill, where Derby Museums' Make Works films will represent part of the contemporary manufacturing landscape in this region.

Make Works has supported us in understanding how we can highlight and facilitate opportunities for collaboration with students and industry, giving companies the confidence and knowledge to work with volunteers and create spaces for active learning within their companies.

Figure 1 Green Door, Derby. Photo from Make. Works webpage.

Make Works: Story 02

OUR MAKE WORKS STORY: UNITED ARAB EMIRATES

By Jumana Taha

The Make Works UAE[147] directory of factories, makers and material suppliers makes manufacturing accessible and gives visibility to those hidden among a labyrinth of warehouses in industrial estates. The Tashkeel[148] initiative was launched at Dubai Design Week in 2017[149].

Established in Dubai in 2008 by Lateefa bint Maktoum, Tashkeel provides a nurturing environment for the growth of contemporary art and design practice rooted in the United Arab Emirates (UAE). It supports the UAE's creative and cultural industries through studio facilities, training and residencies alongside exhibitions, events and workshops. Tashkeel's other design-focused initiatives include the Tanween Design Programme[150] and the Van Cleef & Arpels Middle East Emergent Designer Prize.

Figure 1 A visit to Rasheed Al Hallak marble factory in Sharjah, UAE

By providing the tools to help bring ideas to life, Make Works UAE allows creatives to understand the different manufacturing processes available in the country, and form meaningful relationships with manufacturers. There are already case studies of challenging collaborations between local factories and makers, with many adjusting the regular functionality of machines to fabricate limited edition or one-off designed products.

The Make Works UAE website is also an advocate of UAE traditional crafts, such as Sadu (geometrical embroidery) fabric weaving and Khoos (handwoven) palm frond weaving. By connecting creatives to talented craftspeople, the knowledge of the material process is shared and passed on, and the crafts themselves have the opportunity to be reinvented, often integrated within contemporary design concepts.

Tashkeel aims to grow the Make Works UAE network to include manufacturers from all seven Emirates, and deliver a wide range of workshops for practitioners, youth and the community exploring the processes, practices and technologies used by members of Make Works UAE.

Figure 2 Al Fakher Pottery factory, one of the last remaining communities of traditional potters in the UAE

MATERIOM – NATURE'S RECIPE BOOK OF THE FUTURE

By Pilar Bolumburu and Zoë Powell

Figure 1 Cork/Agar-starch, Image by Antonia Bañados, Maquinario, Fab Lab Santiago, from Materiom.org

All you need to create alternative ceramics, planet-friendly plastics and fermented fabric is a cup of old coffee grounds, a handful of mussel shells or a dash of green tea.

Materiom[151] are the circular design experts sharing recipes for materials that are useful, natural and simple. The open source recipes use locally abundant natural ingredients and data on materials made from abundant sources of natural ingredients – to create plastics and composites you can cook on the stove, laser cut and 3D print.

Materiom are the circular design experts sharing recipes for materials that are useful, natural and simple.

Our mission? As a team of material scientists, researchers and creatives, we want to enable everyone, everywhere to participate in the next generation of materials. We work with companies, cities and communities in creating and selecting materials sourced from locally abundant biomass that are part of the local ecologies to promote a regenerative circular economy.
How do we do it? Our three pillars are a core foundation of knowledge sharing:

— **Responsible material development:** Our library features open source recipes for materials made from abundant biomass that can be locally sourced. Recipes use life-friendly chemistry methods and nutrients such as sugars, proteins, fats and common minerals, making them biodegradable by design.

— **Open data:** The properties of our materials are measured in laboratories so that they can be compared to materials on the market. Data can be used to identify sustainable alternatives for product design.

— **Community:** Recipes are contributed by our international community of designers, scientists, engineers and artists. They are licensed as open source to encourage rapid advancement and widespread use. Materiom Hubs are centres of regional expertise, creating a feedback loop between local sourcing and market application, and our international network for materials R&D.

The growth that matters

Since 2018's book 'Fab City: The Mass Distribution of (Almost) Everything', Materiom's network has grown to include many more biomaterial researchers who are building upon the groundwork of founders Alysia Garmulewicz and Liz Corbin. The core team has grown and now includes researchers with a background in chemistry, circular economy, material science and design. We all share the distributed design ethos from the Fab Lab network. Two of our new team members are designers: Pilar Bolumburu, who is a graduate from the Fab Academy in Santiago, Chile and Zoë Powell, who is a graduate from the Fabricademy in Barcelona, Catalunya.

Materiom now works from London, Santiago, Amsterdam and Boston with the focus on building communities in these cities and beyond. We focus on hands-on learning via biomaterial workshops with communities and businesses at events across the UK, Spain, France, Denmark, Chile and the USA.

What will materialise next?

We are developing several core Materiom Hubs, which will focus their research on waste resources and biomass, developing new recipes for bioplastics, biocomposites, binders and coatings. We are also partnering with universities, scientists and engineers who are testing the properties of these innovative materials such as rate of degradation, mechanical strength, elasticity, and gas and water barrier properties . This promises to bring locally developed biomaterials into the realm of industry and open up conversations within business.

This work will be supported by a new approach for mapping material flows of abundant sources of waste and biomass within municipalities, cities and ecoregions. Our focus is on the systems and solutions needed to develop a regenerative circular materials economy that everyone can participate in.

Figure 1 Gelatin / ochre bio-'leather' by Antonia Bañados

Materiom: Recipe 01

Do you want to try making your own bioplastic? This is one of the most straightforward recipes on the Materiom website.

Agar bioplastic (heated)

Made by Alysia Garmulewicz1[52], who sourced the recipe from Green Plastics, by E.S. Stevens.

Collection: Seaweed recipes
Process: Cast, Cooked, Air Dried.
License: CC BY-SA 4.0
Difficulty: 1 of 5

Tools:

- Cooker/stove
- Teaspoon
- Measuring Cup
- Cooking pot
- Scale
- Thermometer
- Stirring spoon
- Flat surface

Composition:

- 4 grams Agar Agar
- 2.5 ml Glycerol
- 430 ml Water

Properties:

- Tensile Strength, Ultimate 4.58 E-06 MPa
- Tensile Strength, Yield 3.17 E-06 MPa
- Modulus of Elasticity (Young's) 5.42 E-05 MPa

Method:

Step one: Mix all of the ingredients in a pot in the amounts above, and stir until agar and glycerol dissolve in the water.
Step two: Put the pot on the stove and heat the mixture to 95C or to just below boiling. Keep stirring the whole time. When it reaches 95C (or begins to froth), remove from the heat. Keep stirring and skim off any of the froth from the top with a spoon. Any froth left on the surface will cause air bubbles in your plastic sheet.
Step three: Pour liquid onto a flat surface or mould. A silicon sheet works well with a frame (you can cut this from scrap wood), or lay a silicone sheet on a baking tray with edges. Let dry for 1-2 days, depending on temperature and humidity levels.

Scan it to visit Materiom

FABERIN – ORIGINAL DESIGNS MADE FOR YOU

By Vicente Cánovas

Figure 1 Kenny design by Juanny Barcelo

Faberin[153] believes that talent should be rewarded. As the world's largest platform of product designers and makers, the mission is to connect three communities: designers, local manufacturers and consumers from all over the world. The aim is to create products for its customers by converting a design into a product for sale in just three clicks. The vision is to digitalise the process of creation and manufacture of any product.

Transformation and death of the massive industry

The death and transformation of the industry began in 2001 with the creation of the first Fab Lab. Everything started there.
If we analyse the manufacturing model that emerged as a result of the First Industrial Revolution, we see large factories accumulating large investments

Have we reached the point of no return – or are we in time to change this dynamic?

to make large product runs. Economies of scale, logical supply chains, large distribution centres and marketing chains allow the consumer to get products at affordable prices; triggering even more consumption. This model generated a vicious circle of resource consumption, which meant that the only way to continue progressing was to continue destroying the planet.

Have we reached the point of no return – or are we in time to change this dynamic?

Opportunity for new manufacturing models

If we analyse the traditional industry value chain, we see that more than 50% of the value accumulates in the tasks of the marketing department. Product creation, distribution and promotion make up most of the costs. Supply, manufacturing and general costs do not create a differential value in companies.

The platform business model that has emerged in recent years uses technology to connect manufacturers of goods and services with consumers, disrupting the value chain and creating new sources of value that can be distributed. This leads us to ask ourselves: will we move from platforms for the exchange of goods and services to platforms for the creation of goods and services – from exchange to creation?

To understand the concept of **Moore's Law** go to page 29

Moore's Law is evident in the Fab Lab environment; the number of digital manufacturing workshops doubles every year and a half, which means that in 10 years its figure will be in the millions, in 20 years, billions and in 30, trillions.
The boom of product design programs, facilitating access to a growing community, helps this transformation. Within 20 years, the crossover of the volume of local manufacturing with mass manufacturing is inevitable.

The power of design

Faberin believes in valuing skills and creativity. Design is a source of value and designers are interpreters of an increasingly urban and technological consumer; able to respond to needs in a sustainable and appropriate way when it comes to the consumption of resources. In the coming decades, artisans and makers will become the protagonists of commerce.

We believe in an environmentally-conscious model that is sustainable, where the consumption of resources is appropriate; reducing the consumption of logistics and raw materials, cutting stocks and making noble materials that are recyclable and biodegradable. And above all, we believe in people. We believe in the talent that, connected to a network of local manufacturers, craftsmen and makers who will produce exponential results – thanks to technology.

Lonelamp[154] represents the Faberin values and beliefs in one design. Inspired by the life of a refugee who seeks his place in the world, designer and manufacturer Javier Mañas collaborated with the NGO Open Arms[155] to illuminate our lives.

How does Faberin work?

We don't believe in open source design[156]. Furniture and decor does not result in binary options, such as ‘it works’ or ‘it does not work’. Its design is open to discussion, opinion and assessment. Having spoken directly and exchanged information with over 500 product designers and creators so far, most of them (99%) reject open design.

To sell a product on Faberin, local designers, manufacturers, craftsmen and makers just upload their designs, add a price and delivery time. Consumers get access to a catalogue of exclusive designs, which gets added to daily. They can choose the design and the maker who will make it, depending on the proximity and other specific needs.

Here we have the example of ‘Kenny’, designed by Juanny Barcelo, and put on sale by 3D Cheese in just 48 hour[157].

What does Distributed Design contribute?

DD contributes local manufacture and made on demand. These two concepts are so simple and modest, yet involve the transformation of the entire

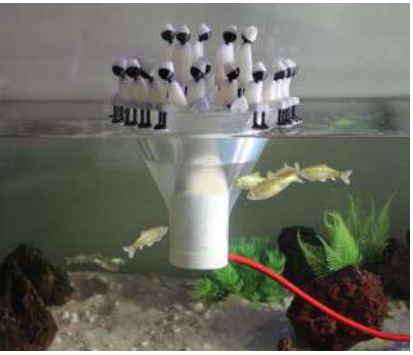


Figure 2 Lonelamp by Javier Mañas for collaboration with OpenArms

economic model that was developed over the last 100 years; the only things that are carried over are the economic costs, not the environmental costs.

What makes us different from other platforms is that the communities of local designers and manufacturers – all connected thanks to technology – can achieve exponential results. It will allow us to create the largest catalogue of products of exclusive designs, manufactured on demand, efficiently consuming the least amount of resources seen so far.

How do we envision the future?

We see Faberin as a connection point for new technologies, serving a community of designers, local manufacturers and consumers. **Blockchain** will create a secure and reliable means of transaction, which will allow us to guarantee the royalties of our designers, the industrial property of designs and traceability of products; the authentication of raw materials and components, allowing guarantees; waste evaluation, and more. We see virtual reality and augmented reality as tools for manufacturers and consumers; facilitating the visualisation of designs and finished products; and locating components and finished products. Meanwhile, the **Internet of Things**, by means of the necessary electronic components, will be able to convert each of the manufactured products into a connected product.

To understand the concept of **Blockchain** go to page 21

To understand the concept of **Internet of Things** go to page 27

We hope to create a community of connected products.
We believe in a more efficient production model, with better use of resources and a better balance of wealth.
Faberin is ready.

Scan it to visit Faberin

FABCHAIN – BLOCKCHAIN'S FAB NEW LOCAL VALUE EXCHANGE

Extract from the Whitepaper draft[158] by Tomas Diez and Primavera de Filippi, with contributions by James Tooze, Liz Corbin, Mara Balestrini, and others

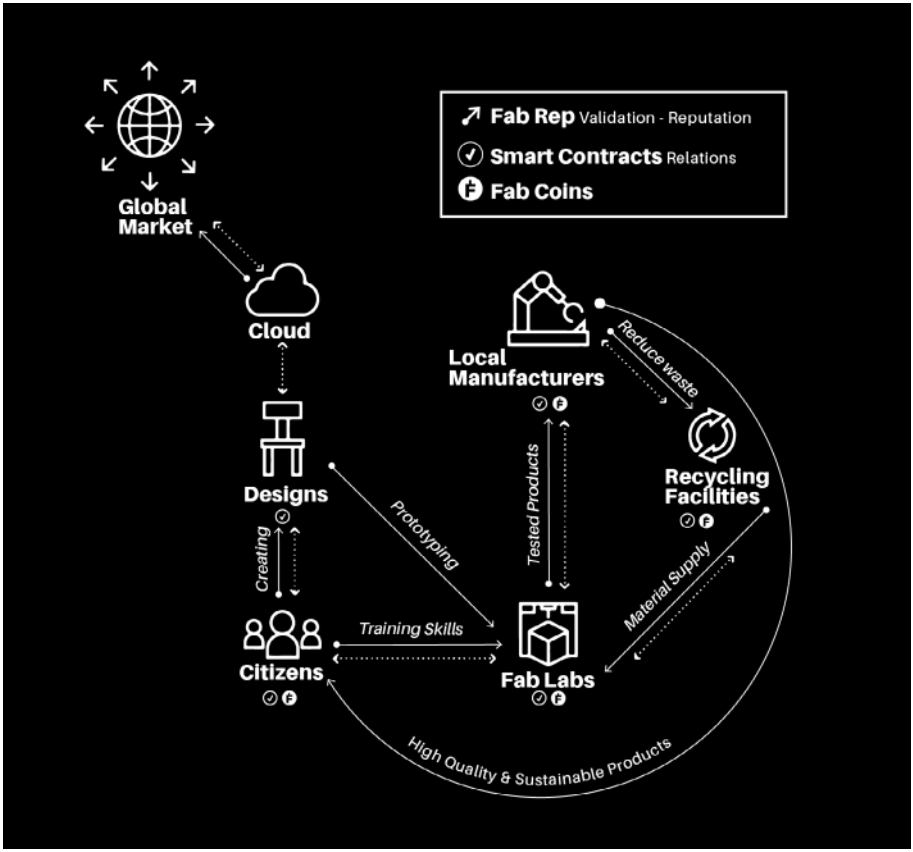


Figure 1 Fabchain ecosystem. Tomas Diez

During the last few decades, the development of new open source hardware and software tools has fostered new modes of learning, designing, manufacturing and collaborating. Maker communities have been building new technologies, tools and communication channels to increase the impact of these new forms of innovation – through the rise of a new creative class in both urban and rural environments. Today, millions of people connected to the internet are using open source software and digital fabrication tools (including **3D printing**) to build the largest distributed design and manufacturing ecosystem in the world. However, various parts of that ecosystem are not closely tied with one another, and currently lack the tools to exchange value and resources between them, or to connect with complementary communities.

To understand the concept of **3D printing** go to page 20

Fab Labs and makerspaces have become widespread worldwide.

Over the last ten years, Fab Labs and makerspaces have become widespread worldwide. They offer a new type of 'third space' that uses digital tools to enable new forms of innovation, learning and production – mainly in cities, but also in rural areas. The maker movement has been growing exponentially, reaching mainstream media and political agendas, being inserted into major educational programs in schools and higher education, as well in the world of industry and corporations.

In the Fab Lab network, we focus on being a key part of the maker movement; a curated and consolidated network of digital fabrication laboratories implementing projects and programs such as the Fab Academy[159] and Academany[160] (distributed education) or Fab City[161] (new urban model for sustainable cities). Our goal is to support the growth of the maker movement as a community and scale its impact in society, by enabling the 'Fabchain'. The **blockchain** technology layer will create incentives for contribution between peers through the platform ecosystem proposed by Distributed Design – with reputation tools for designs, labs, machine and people; certification

To understand the concept of **Blockchain** go to page 21

of skills to build professional profiles; and support for the economic sustainability of the organisations running Fab Labs around the world.

Given the distributed nature of the Fab Lab global network of makerspaces and businesses, industries and communities – and the emergence of new productive models promoted by it – there is a need to create a new mechanism of value exchange and certification. Fablabs.io hosts approximately 2,000 Fab Labs (and counting) and some 15,000 users. Existing platforms like Fab City, which currently has 34 official members, could also make use of the Fabchain, as well as educational programs offered by the Academany (1,200 students have graduated from ten editions so far).

Blockchain-enabled smart contracts, distributed ledgers and immutable cryptographic records are poised to enable communities of designers and makers to reduce cities' carbon footprints by optimising production costs; driving greater operational efficiencies; and unleashing new business opportunities for manufacturers worldwide.

Enabling local processes of production to reduce the impact of the current industrial globalisation is crucial, but enabling mechanisms to incentivise, accelerate and scale this process is fundamental and urgent. This is where we propose the use of a local blockchain, which could be articulated between stakeholders in cities that are already contributing to a paradigm shift in terms of recycling, reuse, relocalisation of supply chains, and other practices that reduce the impact of the linear economy. This local approach will be globally synchronised and confederated with other cities that are part of Fab City project, and other follower cities.

Introducing Fab smart contracts and tokens

Under the Fabchain model, the makerspace or Fab Lab could make the machines that are not being used available under specific conditions dictated by a smart contract. The makerspace could decide, for instance, to exchange machine use for space use, or to trade the use of its own machines with the use of other machines or services provided by other players within the ecosystem; it could exchange the use of the machines with access to a particular set of expertise, or perhaps simply exchange it for a particular amount of meals in the restaurant. When the two parties agree, they can code the terms in a smart contract to establish a public, anonymous and protected execution of a commercial relationship. The smart contract can establish the conditions of the commercial agreement in the blockchain, to ensure the automatic execution of the terms without the need for any third party enforcement authority.
Apart from the automation and guarantees provided by the blockchain, such a system would remain similar to a traditional barter system. It

Figure 2 Tomas Diez presents Fabchain at Blockchain for Distributed Design & Manufacturing Presentation, Estonia, 2019

requires the actors to foresee, in advance, what they need at a particular point in time; plus it creates a system of direct exchange and competition where each party tries to increase the value of its own service over that of the other. By introducing blockchain-based tokens that can be used interchangeably for different products and services within the ecosystem, we create a positive feedback loop, a form of 'coopetition' whereby everyone has an incentive to promote and contribute to the ecosystem, because the higher the value of the products or services it provides, the higher the value of these tokens will be.

> **Coopetition (noun)**
> Cooperative competition. Groups of organisations or citizens work together for common, mutual benefit, as opposed to working in competition for selfish benefit.

Fabchain proposes to explore the use of blockchain technology to promote collaboration between multiple fab labs at the local and global level. The goal is to facilitate the transfer of skills and knowledge between multiple centers; test circular economy models for tangible outcomes and local

material flows; and enable better and more transparent supply chains in order to support the transition from PITO (Product in - Trash Out) to DIDO (Data in - Data Out).
The Fabchain model will come with two different tokens: a non-transferable reputation token (FabRep) and a transferable token (FabCoin). In addition, the system will implement a series of ad-hoc certification tokens, that will be used to describe: (a) people's competences and personal skills; (b) Fab Lab's certifications, with regard to quality and security, as well as concerning their services as learning centres; (c) design quality and certifications, which can be issued by specific institutions; and (d) machines and other tools or apparatus. The blockchain will also be used to provide proper attribution to the designers and their creations, with a possible link to the Distributed Design Quality Label.

Introducing FabRep

The FabRep represents the value of an entity's contribution to a particular ecosystem. There can be as many FabReps as there are Fab Labs, makerspaces or other third spaces. Each will reward their contributors with a particular amount of reputation whenever they provide value to the local ecosystem. Each Fab Lab or makerspace will itself act as an entity within a larger ecosystem, and will therefore be assigned reputation depending on the contribution the entity provides to that ecosystem. Reputation works transitively, so that if one individual has a lot of reputation within a local Fab Lab, which has a high reputation within the global Fab Lab community, the individual's reputation with regard to the global community will also be high. The model can be expanded indefinitely in a fractal fashion to outer circles – from the individual to the Fab Lab to the Fab City to the Fab Region, up to the global ecosystem.

The assignment of FabRep is done according to the rules defined within each local community, which is free to establish its own system of rules to determine what constitutes a valuable contribution, or not. Reputation within a local community can provide people with more decision-making power, as well as with a series of privileges – such as priority for accessing machines, access to specific training programmes and discounts for materials, which are themselves defined at the local level by the local community.

Introducing FabCoin

The FabCoin token is designed to be transferable from one entity to another, in order to enable and promote a circular economy within the global ecosystem of third spaces.

In order to avoid excessive deflationary dynamics, the supply of FabCoins will not be fixed, as in Bitcoin[162], but will grow over time at a particular inflation rate, as in global, decentralised platform Ethereum[163]. An initial amount of tokens will be issued at the time of the initial coin offering. Any tokens that have not sold will be distributed to the strategic partners in the ecosystem – like Fab Labs and **makerspaces**. Over time, the smart contract will generate new tokens at a fixed rate over time. These tokens will be made available for purchase at a predefined price. This price will act as a lower ceiling price that will be such as to excessive speculation on the secondary market. If the market price is higher than the smart contract price, people will purchase directly from the latter.

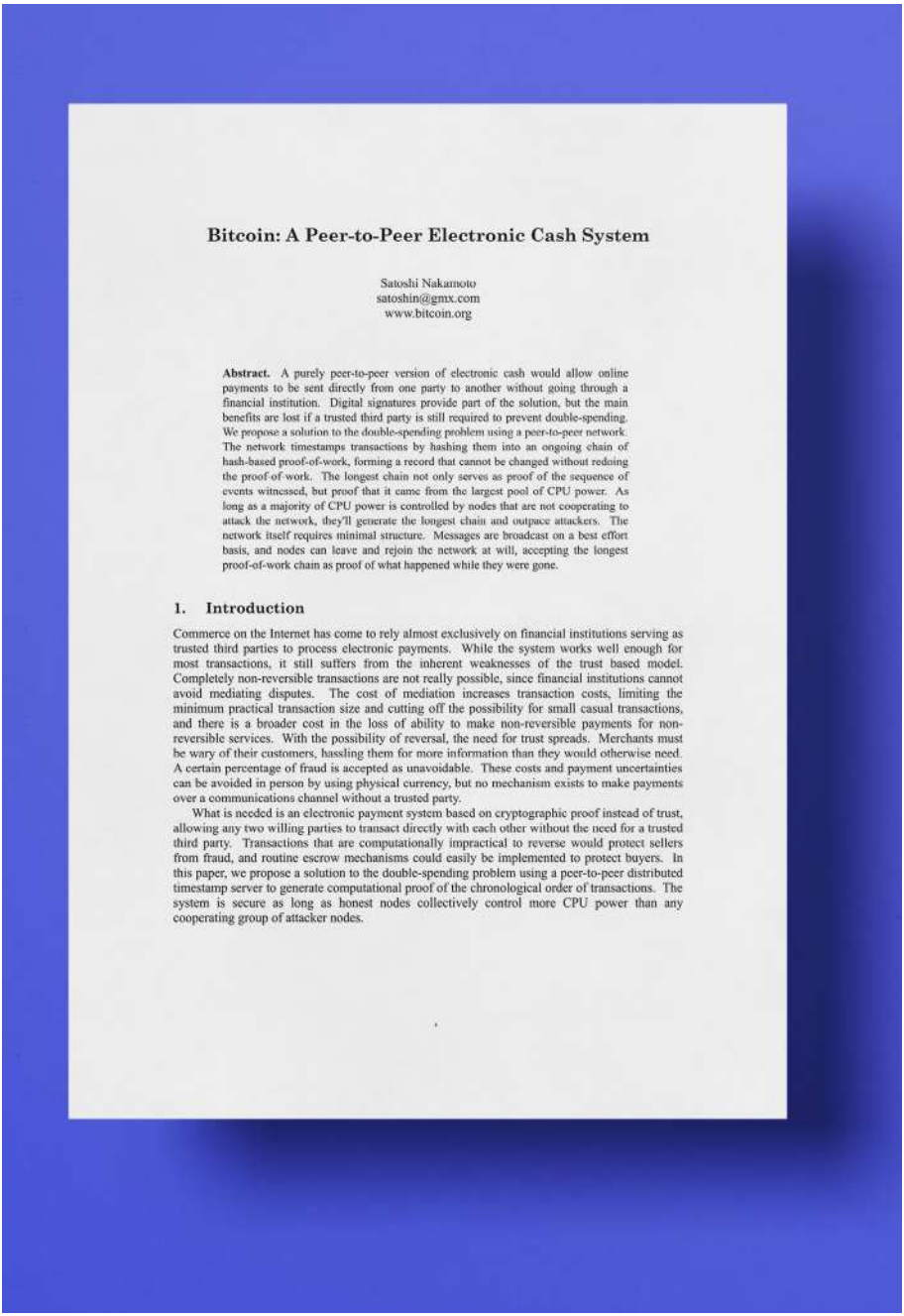
To understand the concept of **Makerspace** go to page 28

The utility of the FabCoin will depend on the number of actors that recognise the tokens as a valuable mechanism of reciprocity.

The utility of the FabCoin will depend on the number of actors that recognise the tokens as a valuable mechanism of reciprocity. Different actors might provide different products or services in exchange of FabCoins or fiat currency. (Fiat money is a government-issued currency without intrinsic value, like paper, that is not backed by a physical commodity, like gold or silver.)

The value of FabCoins will be the aggregate value that can be extracted from the use of these tokens within the local and global ecosystem. For instance, depending on the use cases, FabCoins might be required in order to pay to:

- Register a design on the Fabchain platform
- Get a design certified/evaluated by others
- Promote a design within the Fabchain platform (possibly becoming a stakeholder in the design via a mechanism of tokenisation/securitisation)
- Use resources (machines and raw materials) from a Fab Lab or makerspace participate in training or skill-share workshops
- Invest in a particular design and get a share of the payment when the design is being printed/produced in a local shop



Bitcoin: A Peer-to-Peer Electronic Cash System

Satoshi Nakamoto
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www.bitcoin.org

Abstract. A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution. Digital signatures provide part of the solution, but the main benefits are lost if a trusted third party is still required to prevent double-spending. We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work. The longest chain not only serves as proof of the sequence of events witnessed, but proof that it came from the largest pool of CPU power. As long as a majority of CPU power is controlled by nodes that are not cooperating to attack the network, they'll generate the longest chain and outpace attackers. The network itself requires minimal structure. Messages are broadcast on a best effort basis, and nodes can leave and rejoin the network at will, accepting the longest proof-of-work chain as proof of what happened while they were gone.

1. Introduction

Commerce on the Internet has come to rely almost exclusively on financial institutions serving as trusted third parties to process electronic payments. While the system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust based model. Completely non-reversible transactions are not really possible, since financial institutions cannot avoid mediating disputes. The cost of mediation increases transaction costs, limiting the minimum practical transaction size and cutting off the possibility for small casual transactions, and there is a broader cost in the loss of ability to make non-reversible payments for non-reversible services. With the possibility of reversal, the need for trust spreads. Merchants must be wary of their customers, hassling them for more information than they would otherwise need. A certain percentage of fraud is accepted as unavoidable. These costs and payment uncertainties can be avoided in person by using physical currency, but no mechanism exists to make payments over a communications channel without a trusted party.

What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse would protect sellers from fraud, and routine escrow mechanisms could easily be implemented to protect buyers. In this paper, we propose a solution to the double-spending problem using a peer-to-peer distributed timestamp server to generate computational proof of the chronological order of transactions. The system is secure as long as honest nodes collectively control more CPU power than any cooperating group of attacker nodes.

Figure 3 The *legendary* Bitcoin Whitepaper, 2008

At the same time, each entity within the FabChain ecosystem will be able to use these tokens in order to incentivise certain behaviours. Different actors might decide to reward people for different activities and contributions, depending on what they need and, or what they consider to be the most valuable. As a general rule, the tokens represent a mechanism to overcome the problem of under-contribution in the context of common-pool resources, by retributing people for the work they are sharing into the commons. Specifically, within the FabChain ecosystem, FabCoins could be used as a reward to encourage people to act in a way that is supporting the commons (by contributing time, skills, raw materials, machines, tools, venues or other), to promote localised production (as opposed to globalised) and to encourage collaboration between different actors in the space, who all have an incentive to promote the value of the overall system.

Here are some ways in which you might earn FabCoins:

- Contribute resources – machines, tools, infrastructures or materials – to a local fab lab or makerspace
- Create open designs or contributing to collections of open or remixable designs
- Contribute a design that later gets printed or produced locally in a Fab Lab
- Evaluate or certify the designs of others, according to their quality or integrity
- Teach people how to make a design or use machines
- 'Invest' in certain designs that later get produced (and receiving shares of the profits every time they are manufactured)
- Engage in recycling and upcycling

While FabCoin is generally distributed from a third space to an individual or another third space, individuals can also use it to encourage sharing and reciprocity on a peer-to-peer basis. For example, people could engage in skill-sharing workshops, tool-sharing, or even neighbouring micro-payments and value exchange (smart grids) through the trading of FabCoins. In theory, people could even agree to provide their work in exchange of FabCoins, to the extent that they can later rely on these tokens to benefit from the services of the global FabChain community, or – if needed – sell them on the secondary market for fiat currency.

We want the fragmented ecosystems that are not connected to each other to interact in order to enable local production in cities, and to reduce the environmental and social impact of industrialisation. Fabchain is a research project by the Fab City Foundation[164], in collaboration with its partners.

"Enabling local processes of production to reduce the impact of the current industrial globalisation is crucial, but enabling mechanisms to incentivise, accelerate and scale this process is fundamental and urgent."

Tomas Diez, Fabchain, page 172.

OUTRO –
DESIGNING 'EMERGENT FUTURES'

By Tomas Diez, with contributions from James Tooze, Oscar Tomico and Mara Balestrini

'Design' can give us the power to shape the environment and the imagination to create a desired reality. We need the support of technology and the skills it can enable.

It has been suggested that humans have become the most important geologic agents on planet Earth; more profoundly destructive than volcanoes, earthquakes or hurricanes. By controlling certain natural systems, we have changed global interactions, producing unanticipated consequences in climate, ecosystems and infrastructures.

Designing emergent futures[165] is not about looking for moonshots or massive solutions. Instead, it proposes the creation of learning environments to experiment and speculate with new narratives around desired futures. It calls for the design of small-scale interventions to approach large-scale challenges; to dissolve wicked problems at multiple scales, instead of solving them with single solutions.

Today, the biosphere, financial markets, family structures and business models in product development – not forgetting society in general – are being challenged in one of the most important transition periods of human history. While the industrial revolution produced innumerable benefits to society, we are now confronted with a plethora of complex and interconnected problems that challenge our productive model: climate change, social disenfranchisement and the centralisation of wealth and power. The moment is now for us to formulate new questions for technology and to redefine its role in society, to create promising and viable emergent futures for humanity to thrive, not just survive.

“Technology is the answer, but what was the question?” –
Cedric Price, English architect

Our economic, environmental and social paradigms are challenging the status quo of a 200-year-old industrial society. The role of design has changed significantly during this last quarter of a century. In medieval villages, the artisans who used to work and live in the same place saw how machines dramatically transformed production processes, hence the design practice itself. It took some time to digest the influence of industrial production on design. Around a century later, within the industrial revolution, the Bauhaus revolutionised the relation between arts, design, industry and society. We have since celebrated 100 years of the single most influential modernist art school of the 20th century. Not just a school, it was a movement in which the arts, design, expression, architecture and performance met industry and technology.

The beginning of the 20th century brought fundamental transformations, which can help to understand how we live today. We saw the birth of wireless communications, oil as a source of energy and raw materials, automation as a production process, and many new forms of organising our economy and society. Every moment of convergence in technology and socioeconomic systemic change is built out of historical transformations that took place centuries ago. Most recently, these are taking place in even shorter periods of time. Decades become years, years become months; change is happening rapidly, yet operates paradoxically inside the previous layers of transformations.

We are in a period of convergence: of technologies and of crisis. The still ongoing transformations in the industry are happening under a new production paradigm supported by advanced manufacturing. New forms of synthetic intelligence, new material science and connected systems are opening up endless opportunities to re-calibrate the negative effects of the human-centered activities on planet Earth. Some of these emergent technologies – digital fabrication, synthetic biology, artificial intelligence and blockchain, to name a few – are already disrupting the established mechanisms under which our productive model operates, and are producing massive cultural transformations in society. If the Machine Era aimed to shape the human habitat by creating interfaces with natural resources, through science and technology, the ubiquitous nature of digital technologies will demand articulation and rapid synchronisation of systems at different scales, both biological and synthetic. At the same time, the emergence of such new tools and technologies is demanding us to create different outputs from the ones we already know and to design possible

futures for life (human and non-human) on this planet.
The world used to be more predictable, as were the behaviour of markets, the demand for products and services, and human behaviour itself. On the contrary, today's modern world seems to be more and more fluid, or 'liquid' – and our reality consists of getting to grip with what we would have called fiction, or science fiction, some years or decades ago.

"What has been cut apart cannot be glued back together. Abandon all hope of totality, future as well as past, you who enter the world of fluid modernity." – Zygmunt Bauman, 'Liquid Modernity' (2000)

A good algorithm can make you president of the most powerful country in the world. Could it be possible for anyone to become a designer with the support of algorithms or machines? What if these designs can be materialised and fabricated immediately thanks to the access to the means of production? Will distributed design make more difficult to predict the many entangled realities being created at the same time?

This is why is so important to consider:

— **Context:** What is the world in which we live today? Consider that is ever-changing, and all people, institutions, organisations and living beings. There are more worlds than people; we might live in one planet, but each of us creates our own world.

— **Technology convergence:** What are the tools shaping design? As in many times in history, we are in a massive moment of convergence, ideal to rethink fundamental questions around how we organise society and our economy.

— **Access:** How will access to computing power, instant global communication and production tools shape the design practice; enabling new processes of learning, innovating and creating our own reality? Wikipedia has made an entire encyclopedia obsolete (Encyclopaedia Britannica). Can we make 'Made in China' obsolete?

— **Learning:** What kind of learning environment do we want to foster in the coming years? How can we design places in which students, faculty, machines, algorithms, local impact and global collaboration become one collective effort to address the most difficult problems locally?

— **Innovation:** How can innovation happen as a networked process, outside labs and companies, involving as many stakeholders as possible? Innovation is not an option in a fluid, constantly changing reality. We are not talking about innovation that creates the next smartphone, but micro-innovation at a personal level, connected with peers and communities physically (local) and digitally (global).

— **Design:** Can design be more distributed, circular and ecosystemic? Of course it can, as long as it disconnects from the industrial paradigm of efficiency, ego and economic growth. A more holistic design approach needs to be developed; hence the need to create learning environments and spaces for convergence between cultures, narratives and philosophical understandings of the world.

— **Cities:** How will cities supply the demands of a growing population? Cities need to transform dramatically the way they have access to the world's resources needed to satisfy the demands of the urban populations. We have to keep atoms in the cities – and move bits globally.

One of the challenges for designers today is how to embrace non-linear strategies in a world of complexity and chaos. The complexity of the current transition period is leading to more problems. Solutions can create even more, so problems need to be addressed from a multidisciplinary and collaborative perspective.

Designing emergent futures means to de-objectify and de-colonise design, and to focus on designing interventions in the present, to create new narratives about possible, desirable futures that we cannot anticipate – but we can play with, and learn from.

The future is an idea of the past, welcome to many emergent futures.

DESIGN REMIX SHARE REPEAT – HOW CAN YOU BE PART OF DISTRIBUTED DESIGN?

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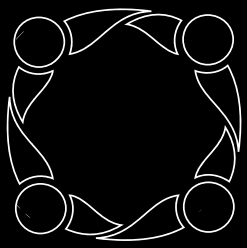
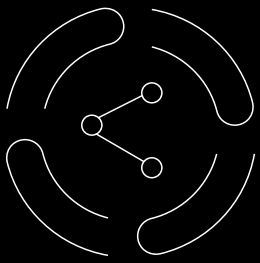


Contribute

Get in touch with our communities and find synergies for collaboration



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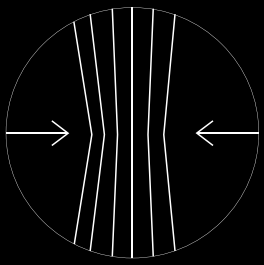

Adapt

Remix, transform, and build upon the material for any purpose, even commercially.[167]

You could probably add to it, improve it, suggest changes or add additional case studies.

This book was created with GitBook and will continue to live there.
This way, you can contribute your knowledge to our book and join the Distributed Design community.

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The world used to be more predictable, as were the behaviour of markets, the demand for products and services, and human behaviour itself. On the contrary, today's world seems to be more and more fluid, or 'liquid' – and our reality consists of getting to grip with what we would have called fiction, or science fiction, some years ago.

Distributed Design is a phenomenon that integrates design skills and the 'making' approach to enable the development of new entrepreneurial types of professional producers. On one hand, designers acquire more technological and practical skills. On the other, makers evolve their design attitude and capabilities. This convergence is generating new markets, which require new business models and distribution models. In turn, this breeds new ways of working, thinking and valuing, which are explored in the observations, research and cases presented in this book. These accounts come from members and associated members of the Distributed Design platform, who gather from cultural organisations, industry and educational institutions to advocate for Distributed Design, and foster the role of European creatives in actively shaping this emerging field which is shaping the way we view design in our liquid reality.

Distributed Design Market Platform

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