Co-creating social and sustainable innovation in Makerspaces and Fab Labs. Lessons learnt from the SISCODE European project

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Abstract

"Making" and the Fourth Industrial Revolution have been extensively investigated in the last few years. Several pieces of research have been carried out on the topic of fab lab networks and makers movements; in many cases, these studies highlighted problems of their economic sustainability, stressing -however- their cultural-related role.

Nowadays, it is evident that Makerspaces and Fab Labs do not only produce physical goods, but they also develop knowledge and relationships, which are expressed through physical productions and activities.

The European Union has been particularly interested in the study and development of innovative ecosystems, which might serve as levers for sustainable growth, because of their focus on co-creation and the involvement of different groups of stakeholders. SISCODE Horizon 2020 project was developed according to this European requirement. Within the SISCODE project, a co-creation methodology for societal challenges was proposed and tested throughout ten pilot projects carried out by Living Labs, Science Museums and Makerspaces, and Fab Labs.

In this paper, we are going to present the three pilot projects developed by three Makerspaces and Fab Labs (Polifactory (Milan), Maker (Copenhagen), and Fab Lab Barcelona) and discuss main insights on co-creation practices.

Keywords

Sustainability, Co-creation, Makerspaces, Fab Labs, Responsible Research and Innovation

1 The European perspective to co-creation ecosystems

The European Commission, already in 2001, proposed "opening up the policy-making process to get more people and organisations involved in shaping and delivering EU policy" promoting "greater openness, accountability and responsibility for all those involved." (EU, 2001: 1). Citizens need to become subjects and not (only) objects of the policy development processes. Their participation is very relevant because they own important local knowledge and skills (Dalton, 2008). More recently, the attention to participation has been enlarged towards innovation processes including science and research as fields which should involve different stakeholders and in particular citizens and civil society. This would improve

the research results and help identify preferable solutions for social problems (Eckhardt et al., 2021; Deserti et al., 2020).

In particular, in 2009, the Lund Declaration included scientific research and development in the realm where the involvement of citizens has to be taken into consideration to address grand societal challenges and ethical issues. This led to the discourse and emphasis on Responsible Innovation (RI) and Responsible Research and Innovation (RRI), defined as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products" (Von Schomberg, 2012, p. 50). The European Community included in the remaining period of the 7th Framework Programme (FP7) and into Horizon 2020 the funding of a program of research and coordination support actions on RRI; in fact, "RRI was a useful umbrella term to help reposition the action lines of the Science in Society programme within the Horizon 2020 initiative" (Owen and Pansera, 2019: 37). In 2021, the great relevance of RRI for the European Community has been made explicit by its integration in Horizon Europe as a transversal principle to the different funding programs (Robinson et al., 2020).

Within RRI general framework "*Co-creation has been a recurrent approach [...] sometimes labelled as co-construction or co-production, and intended to be applied in public engagement, policy deliberations and participatory research agenda setting and, citizen science*" (Robinson et al., 2020: 2). Co-creation activities are based on a nonlinear, open-ended, and iterative process and it enables mutual learning and knowledge sharing among all the stakeholders involved.

The European Union has been particularly interested in the study and development of innovative ecosystems, which might serve as levers for sustainable growth because of their focus on co-creation and the involvement of different groups of stakeholders. In particular, the concept of ecosystem derives from the natural sciences and it is aligned with what has been already presented since it provides a framework for understanding and studying the interaction of various actors, institutions, and contexts in society (Kumari et al. 2019; Eckhardt et al., 2021). As Eckhardt et al. (2021) stressed, different typologies of ecosystems have been identified and analyzed in the literature. In particular, there has been a transition from business ecosystems to innovation ecosystems, which differ according to the value of co-creation practices. In the first case (business ecosystems) these are more oriented to value capture, while in the second (innovation ecosystems) are more oriented to value creation (De Vasconcelos Gomes et al., 2018).

Makerspaces and Fab Labs are places and spaces where to experiment and carry out Responsible Research and Innovation and give shape to innovation ecosystems; as we are going to discuss in the following paragraph, Makerspaces and Fab Labs, through tangible manifestations of production and prototyping, are able to involve different stakeholders in co-creation processes especially oriented towards sustainable and social innovation. As we will discuss later, SISCODE Horizon2020 project was developed according to the European goals and requirements, which we presented in this section.

2 The cultural role of Makerspaces and Fab Labs

Grassroots Innovation and co-creation processes need places where networking between different stakeholders is facilitated, where knowledge is shared, where experimentation is easily performed. Makerspaces and Fab Labs own these characteristics and are actors of a socio-technical system, where social, economic, and environmental sustainability can be pursued thanks to the adoption of processes of collaborative, open and distributed production, even if "the need to ensure economic sustainability easily comes into conflict with other values espoused in Makerspaces: open access, free sharing, suspicion of mass manufacturing, and the like" (Kohtala and Bosqué, 2014).

Making together can positively impact the creation of more economical, social, and ecological sustainable futures; indeed, as Sanders and Simon highlighted (2009) "The social value of co-creation is fueled by aspirations for longer term, humanistic, and more sustainable ways of living. It supports the exploration of open-ended questions". Several pieces of research carried out on the topic of fab lab networks and makers movements highlighted problems of their economic sustainability, stressing -however- their

culture-related role (Wang et al., 2015; Bianchini et al., 2015; Taylor et al., 2016; van Holm, 2017; Sedini, 2019). Nowadays, it is evident that Makerspaces and Fab Labs do not only produce physical goods, but they also develop knowledge and relationships, which are expressed through physical productions and activities.

As Troxler (2017) highlights, Makerspaces and Fab Labs' contribution to economic sustainability depend on their capability to develop value propositions and to become economically self-sufficient. The capacity to pursue social innovation relies not only on various stakeholder engagements but also on fragile populations' empowerment; as Fleischmann et al. (2016: 127) stress, "People could therefore influence the production process towards sustainable design and co-creation ideas". At the same time, ecological (environmental) sustainability has mainly to do with energy and material consumption and waste generation. However, Troxler is mainly focused on Makerspaces and Fab Labs for their own sustainability. Instead, Makerspaces and Fab Labs, through the use of tangible artifacts and co-creation processes, can favor the experimentation and diffusion of more sustainable behaviors (Mersand, 2020). Starting from the interconnection between economical, social and environmental sustainability (Davico, 2004), it is possible to point out how the creation of networks composed by several stakeholders could be at the basis of the development of circular economy processes (Real et al., 2020), of mass consumption alternatives (Kohtala, 2017), of bottom-up innovation processes (Sedini et al., forthcoming). The engagement and empowerment of diverse and multiple stakeholders through prototyping and distributed infrastructures are at the core of the community of makers. The creation of networks and alliances, which we can define as ecosystems, are very important to activate, implement and scale innovative and sustainable solutions. Indeed, "Being able to translate social and environmental aspects into sustainable design concepts is as important as to have the technical knowhow when trying to utilise the labs as spaces for social and environmental goals" (Fleischmann et al., 2016: 128).

Projects such as SISCODE, which we will discuss in the following section, and initiatives like Distributed Design [1] and the Fab City agenda [2], focused on citizen science, deeply influenced the practices of engagement and empowerment. They show how co-creation on a global scale within makerspace and fab lab networks holds the strength to connect local capacities with global ecosystems and cross-pollinate knowledge, best practices, and solutions. In this matter, co-creation can transform cities and global networks to connected and ecosystemic entities for experimentation, social and sustainable innovation and democratization of policy making and urban development.

3 SISCODE: Makerspaces and Fab Labs pilot projects

Within the SISCODE project, a co-creation methodology for social challenges was proposed and tested throughout ten pilot projects carried out by Living Labs, Science Museums and Makerspaces, and Fab Labs (Rizzo et al., 2018; Real et al., 2019).

This paper presents the three pilot projects developed by three Makerspaces and Fab Labs: Polifactory, Fab Lab Barcelona and Maker.

The three case-studies are synthesized in the following paragraphs in three tables describing the core elements of the co-creation journey (challenges, stakeholders involved, processes, prototypes, scenario) and the respective social changes that facilitators of the processes and authors of the paper identified. Those changes are described following a simplified classification of the co-creation ecosystem model developed in the project (Maylandt et al., 2020; Eckhardt et al., 2020) and consists of three levels:

- *Macro-level*: how does the knowledge, perceptions of the macro context have evolved during the co-creation process and how its activities have influenced the dynamics and overall strategies of both the local policy and the global fab lab ecosystem?

[1] https://distributeddesign.eu/

[2] https://fab.city/

- *Meso-level*: How has the culture of design and co-creation evolved and diffused in the internal lab organization? What are the lessons learned and good practices for better managing/facilitating co-creation at the lab level?
- *Micro-level:* What was the learning from a co-creation project perspective? What were the dynamics in terms of stakeholder engagement and management and co-design and co-production practices? What transformations and actions were needed to scale out, deep and up the prototype?

A deeper understanding of the cases is described in the project deliverables (Real et al., 2020) and Deserti et al. (2021).

3.1 Polifactory (Milan)

Polifactory worked on Patient Innovation, collaborating with the patient association FightTheStroke, which deals with young stroke survivors and their caregivers.

Case: BODYSOUND		Description
Story	**Challenge**	Co-create innovative solutions to improve the movement of children with cerebral palsy
	Stakeholders	Kids and Families of FightTheStroke (Patient Association), Therapists, Experts, Policymakers
	Process	The co-creation process behind the BODYSOUND solution started in May 2019, involving different stakeholders (kids, caregivers, therapists, experts, policymakers) during the analysis, ideation, prototyping, development, test, and iteration phases. We started the analysis phase with a survey dedicated to caregivers of FightTheStroke association: thanks to the survey and the initial encounter that we had with the patient association, we could reframe our challenge. We conducted three co-creation/co-design and experimental workshops during the ideation phase to validate some intuitions, refine the needs, and better identify the various stakeholder groups' problems to transform them into design opportunities. The last co-design workshop included policymakers who were already informed of the project and involved in face-to-face interviews. Polifactory' researchers refined and systematized the ideas that emerged during debrief moments, originating one singular idea: BODYSOUND. Subsequently, we carried out BODYSOUND development cycles in a recursive manner, testing with the children and refining the solution. Because of COVID-19, the solution replaced the Kinect-based body-tracking technology with a more accessible webcam-based technology so that development and testing could also proceed remotely. Observations, diaries-voting, post-tasks interviews were used as data collection methods to evaluate children's interaction with tangible and intangible, analog and digital prototypes.
	Prototypes	BODYSOUND is a multi-platform system to perform gross-motor exercises through music and play to improve motor (re)activation, coordination, and balance. The system provides users visual movement guides to follow through a virtual avatar to produce sound melodies, gain points, and access new levels. The service is aimed at pediatric psychomotricity and motor

		rehabilitation specialists to supplement and support sessions designed to facilitate the continuity of training in the youngest patients and track their progress.
	Future Scenario	BODYSOUND has many possibilities for development and scalability in different areas. First of all, it can be useful for different types of patients (from children to the elderly), but also can be used for various purposes, such as sports training and in disciplines such as yoga and dance, but not only.
Social changes	**Macro**	Systematize the co-creation processes and the new knowledge learned to be shared and applied in other European projects such as Distributed Design, T-Factor, Reflow. Relations and contamination with Fab Labs and Makerspaces applying co-creation processes. Europe-wide expansion of knowledge about projects and processes that support the phenomenon of Patient Innovation until now mapped only at the Italian level through the platform-observatory "Design Healthcare Innovation".
	Meso	● Increasing co-design skills within the organization. ● Creating opportunities to scale up collaborations with patients, specialists, and patient associations for other projects.
	Micro	**Stakeholder engagement:** ● Opportunity to define potentials and criticalities of the relationship with patient associations within EU pilot projects. Fablab gives the idea of obtaining "ready-to-use" solutions, but this is not always the case. ● Polifatory improved its experience in application and deepened its knowledge on engagement practices. What is crucial here is that Polifactory mobilized all the skills and experiences in the field of service. ● Design to engage external and unusual stakeholders (i.e. children) for performing a co-creation process close to the needs of the potential future users of the solution. **Process:** ● Experimentation with boundary objects as support for co-design with children and parents. ● Acquiring skills regarding the possibility of remote stakeholder involvement, turning the covid challenge into an opportunity for the solution. **Outcomes:** ● BODYSOUND software and configurator to be used as a system demonstrator. ● Enlargement of BODYSOUND scale and pool of users. ● Conversations and cooperation with professionals and institutions for the improvement and diffusion of BODYSOUND.

3.2 Fab Lab Barcelona

Fab Lab Barcelona explored the topic of food circularity in the neighborhood of Poblenou and created an ecosystem designing and crafting with food waste (Real and Calvo, 2019; Pistofidou et al., 2020).

Case: Remix El Barrio		Description
Story	**Challenge**	Fab Lab Barcelona identified the challenge of finding creative solutions to improve food circularity at the district level, identifying Poblenou in Barcelona as the pilot district.
	Stakeholders	The pilot project engaged mainly the local makers/designers, restaurants and cafés, and local associations.
	Process	The co-design phase has started with the development of a stakeholder mapping of local food cycles based on the team participation in policy-making events and 35 informal interviews with 50 local actors. It was followed by developing six co-creation and learning community events, from a synergy soup to a workshop on biomaterial making. The co-production phase was framed in two main iterations: the first loop consisted of a set of fuzzy explorative projects (cargo bike design, eggshells material exploration, food waste campaign). The second loop focused on running a structured incubation program for creating a real mix of materials, people, and knowledge for crafting and micro-producing with food waste.
	Prototypes	Solutions have been envisioned at the material, product, service and ecosystem level. Remix El Barrio has developed learning ecosystems for the crafting and micro-fabrication with food waste at a neighborhood scale. 9 projects have created a range of products from olive and avocado pits, eggshells, orange peels, coffee skins. They have been exhibited in two places in Barcelona.
	Future Scenario	"What about if in the following years, food waste has become our new treasures? Inspired by Remix The Barrio, Poblenou has shaped a circular ecosystem with restaurants, citizens and new fabrication community places. Restaurants and citizens are much more informed and caring about their waste and their neighbors; they separate their organic waste in jars; we see the type of waste (peels, pits, …) Community places of co-fabrication - spaces where we imagine- co-create serie of useful products with citizen, urban garden of my neighborhood and learn on how to make things How does it work? It is simple… The circular system starts from collecting waste from restaurants - transporting it via cargo bike, pre-processing waste, micro-manufacturing of products, re-distributing them in local market places, urban gardens… In 2050, this practice has inspired many other places… Each neighborhood functions as a point of transformation of waste into biomaterials, as a place of meeting and cooperation between designers and artisans, building knowledge and products. From the other barrios of Barcelona to all cities and places in the world where recipes and knowledge are shared." (script from the video)
Social changes	**Macro**	Cooperation cross pollination of knowledge within the wider Fab Lab ecosystems like Fabricademy, Distributed Design, Fab City. Remix El Barrio has won the Starts prize, a European recognition on collaborative innovation that has a strong potential for inspiration and future

		practices. Diffusion of co-creation practices in the global network. (blogpost)
	Meso	Maturation of co-creation and circular design skills in the organisation. New organizations in the lab and synergies with local communities. More internal dialogues and interests in structuring how to foster trustful relationships with local stakeholders. Alignment between emergent co-creation project and inter-organizational strategies
	Micro	**Stakeholder engagement:** ● Value-oriented process about radical ecology visions guided by craft-innovative learning mindset. ● Diversity of mapping the stakeholder network. ● Agility in addressing stakeholders' expectations, being more explorative at the initial stage to more structural/contractual when maturing. **Process:** ● Dialogic mindset (short/long term, individual/collective, economic/social/environment, theory/practice, Left/Right IP… ● Respect of knowledge exchange and mentoring. ● Open spaces to experiment together (virtual/onsite), outside living experience with tools and meta-design methodologies. ● Support for circular communities and textile and material networks. **Outcomes:** ● Remix el Barrio as a collective of designers sharing values, projects and practices. ● 10 projects, 1 catalogues, video tutorials, 2 exhibitions. ● Cooperation with many glocal stakeholders.

3.3 Maker (Copenhagen)

Maker has worked to enable a local ecosystem and prototype model for developing, educating, and promoting a community of plastic recyclers, designers, and producers in Copenhagen (Denmark).

Case: PIPO "Plastic-In Plastic-Out"		**Description**
Story	**Challenge**	Makers and designers in Copenhagen local community have a demand for locally sourced, recycled plastic materials to use in their productions and projects. During the prototyping of PIPO (Plastic-In Plastic-Out), we realized that having a small-scale prototype of our plastic processing solution also generated a lot of interest from further micro-entrepreneurs and local designers. PIPO has also turned into a knowledge-sharing platform and training facility for local stakeholders with a wish to become more circular.
	Stakeholders	Local makers, engineers and designers, small scale plastic recyclers, students, companies, civil servants.
	Process	The co-creation and co-design activities have played an important role in all collaborative processes throughout PIPO. The role of co-creation in relation to prototyping has undertaken an approach that relates both to validation

		and exploration, focusing mainly on community workshops, learning activities and prototyping. Developing and prototyping the PIPO concept have gone through several iterations. The core team from Maker has worked closely with the industry and innovation community to prototype recycled plastic sheets and local cases on the physical prototype scale. This work has matured more than nine case solutions and run educational activities for the community to engage in plastic recycling and ensure knowledge transfer.
	Prototypes	PIPO (Plastic-In Plastic-Out) is a community-based ecosystem for plastic recycling and circular economy initiatives in Copenhagen (DK). PIPO started with the wish to incubate the Fab City agenda in the city of Copenhagen. It envisioned the development of circular systems by adopting an ecosystemic approach for small-scale systems of designers, recyclers and producers. By co-designing the PIPO-ecosystem Maker has been empowering and supporting local communities to re-circulate materials and engage in the circular economy through a distributed ecosystemic approach. *A focus on local plastic recycling ecosystem* The key objective was to meet the local need for inquiring about locally produced recycled plastic sheets. This need was established due to a growing interest in designing and manufacturing with recycled plastics. Maker's local challenge addresses the lack of local and economically accessible facilities, technologies to, as well as incitement and know-how on, local recycling of plastic waste in Copenhagen. The challenge meets a need for circular systemic innovation and holistic production models for recycling plastics that take the whole model chain - from local generators of waste plastic to end-buyers of locally produced goods - into consideration in a way that is economically viable and scalable. The casework and prototypes have been disseminated as a digital exhibition and as part of a large exhibition in Vejle.
	Future Scenario	The future vision building on top of PIPO and learnings from the SISCODE-project is to establish a Fab City test area in Copenhagen, focusing on experimenting with, developing, and testing community-led solutions to a circular economy, social innovation, and democratic urban development. The PIPO ecosystem serves as a community prototype for working with multiple stakeholders on circular economy and sustainable innovation initiatives in Copenhagen. PIPO seeks to inspire, empower and influence others to embed circular design, co-creation and recirculation of materials when designing and producing for the future. (script from the video)
Social changes	**Macro**	Connecting and sharing learnings with the broader fab lab and makerspace network. Cross-pollinating with other initiatives to scale collaboration and to contribute to a global capacity building of community-led circular initiatives. Utilizing knowledge, resources and know-how in other projects such as Distributed Design, CIRCuIT and Open_Next.

	Meso	Creating new synergies in the City of Copenhagen and Denmark to expand the PIPO ecosystem with more materials and other communities. The work during the SISCODE project has empowered Maker, as an association, to focus more on circular initiatives and to support a growing ecosystem of physical entrepreneurs in Denmark.
	Micro	As part of the project, Maker's base of members and community of physical entrepreneurs have shown a growing interest and desire to learn more about responsible design and circular design. This will be a continuous process focusing on open resources, community capacity building and learning activities. Plastic recycling on a small scale might seem like a drop in the ocean; however, projects like PIPO (as well as front-runner initiatives like the Precious Plastic Community) are important from an educational, empowerment, and change-making perspective

4 Discussion and final remarks

In the following pages, we will discuss the pilot projects presented above in a comparative way, looking mainly at the approaches towards sustainability. Then we will present some final remarks with specific attention to the roles of Makerspaces and Fab Labs in the co-creation ecosystems, their capability of fostering a co-creation culture focused on sustainability and the recurrent difficulties they encountered.

Discussing the sustainability of the three pilot projects

As said in the previous pages, analyzing sustainability means paying attention to the different areas that concern this concept. At the same time, when we talk of Makerspaces and Fab Labs' sustainability, we can look at them as overall subjects; or, as in this case, we can pay attention to specific projects they carried out and their extroverted impacts on the different sustainability areas: environmental, social and economic. Due to the overall topic of the SISCODE European project, all the labs participating in it had to focus on sustainability, addressing societal change and considering their own maintenance, scalability, and replication based on citizen/stakeholders' engagement, exchange of expertise, and initiatives. This also means to foresee possible societal change embedding co-creation into the socio-cultural, organizational/structural/systemic levels of the ecosystem for which it was developed.

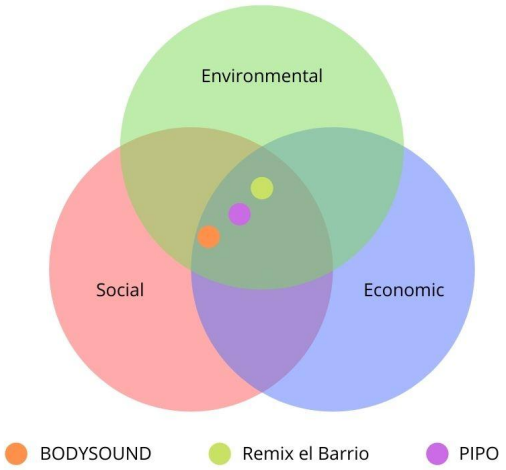

Figure 1: Pilot projects positioning according to the three components of sustainability

We now will briefly compare the three pilot projects according to the area of sustainability that was the starting point of their experimentation with specific attention to their targets. Then tools and technologies will be taken into consideration to talk of sharing and open innovation, looking at the economic sustainability of the developed solutions.

IAAC “Remix el Barrio” and Maker “PIPO” promoted a circular economy model of production and consumption. They put environmental sustainability at their core since they faced issues connected with food and plastic waste, which they also overcame through micro-fabrication processes involving citizens at large. Instead, Polifactory “BODYSOUND” had social sustainability at its core, focusing on the healthcare domain and involving a specific target of users: children affected by cerebral palsy and their families.

“Remix el Barrio” used accessible resources and tools to avoid and reuse food waste and promoted convivial modes of logistics and production that could be used at home or in small collective spaces. Ideas and knowledge were cross pollinating; craft techniques and low technological tools were shared to create original biomaterials that thus consented to a higher replication of solutions and the development of a glocal food waste material-making community and a more self-sufficient circular model at the neighborhood level.

“PIPO”, by focusing on plastic recycling, transformed plastic waste through the use of semi-industrial machines that citizens do not own but which they could potentially use since it is shared and available in the makespace. In this case, the mediation role of Maker maintained its importance not only for pieces of machinery but also to be a platform of relationships.

“BODYSOUND” focused on a different sustainable development goal (good health and wellbeing), promoting and favoring the so-called Patient Innovation. BODYSOUND considered both the economic and environmental sustainability by selecting digital tools that could be affordable (e.g. personal computer) and shared thanks to the inclusion of school and medical institutions among the stakeholders. Even if “BODYSOUND” experimentation started from the involvement of a little group of users already in the project lifespan, the solution was scaled involving entire classes of a primary school.

Beyond their core purposes, the three cases are still facing difficulties finding the proper governance model and an economic balance to sustain their practices. Based on open-source principles, different business models have been imagined and tested based on examples such as distributed platforms, cooperatives at the core of the sharing and “common” economy. Sustaining those initiatives required revisiting the shared value between stakeholders, most of the time adding third parties. Those examples also questioned the intermediary role of the labs in supporting cooperation between civil society, industry and the public sphere. Beyond supporting the emergence of projects and creating safe spaces for learning and knowledge cross-pollination, labs can offer a series of services and customized forms of cooperation from ecosocial cooperatives to developers of healthcare devices.

Specificities of Makerspaces and Fab Labs in co-creation ecosystems

From the recent practices of the SISCODE project, we can highlight some specificities of the culture of Makerspaces and Fab Labs. Through mutualization, their experiences for collaboration and knowledge sharing are part of their DNA and facilitate co-creation within responsible research and innovation (RRI). However, it is difficult to conclude clear and standardized notions since all spaces and organizations are different. Makerspaces and Fab Labs rely on digital empowerment, community engagement, shared infrastructure, information access, knowledge sharing, open-source philosophy, peer2peer production, and learning by doing. All the projects of digital fabrication spaces, citizen science projects and distributed network developments presented here were guided by the use of tangible artifacts and the intent to better appropriate fabrication technologies to citizens. Prototyping and distributed infrastructures are at the core of the community of makers and their main strength to succeed in engaging with a wide variety of stakeholders. Compared to the 7 other labs of SISCODE (Science Museums and Living Labs networks), the three projects here presented based their intervention and support on physical or digital prototypes and solutions, using artifacts to generate learning and interactions. Even if Remix El Barrio and Pipo created new services based on circular ecosystems, one of the core activities was making "stuff"

(materials, and products). BODYSOUND was the only co-creation project that effectively developed a software and used it as a test and demonstrator to discuss the user experiences, the devices' ergonomics and identify soft signals to improve comfort, wellbeing and patient interactions.
SISCODE's co-creation practitioners could experience that Fab Labs are pro-active stakeholders in the global ecosystem to support the integration of society in Science and Innovation and benefit from cooperating with other labs and networks, in this particular case Living labs and Science museums.

Fostering the culture of co-creation in Makerspaces and Fab Labs

Making practices and learning-by-doing approaches are important assets for co-creation coming from Makerspaces and Fab Labs. Value-driven communities are both motors and outcomes of makers' community activities and skills.
In SISCODE, co-creation has been practiced through various prisms; the diversity of visions and representations was a source of inspiration for the ecosystem of Fab Labs. The partners have observed factors and their interdependencies to foster and hinder co-creation *(see Figure 2).*

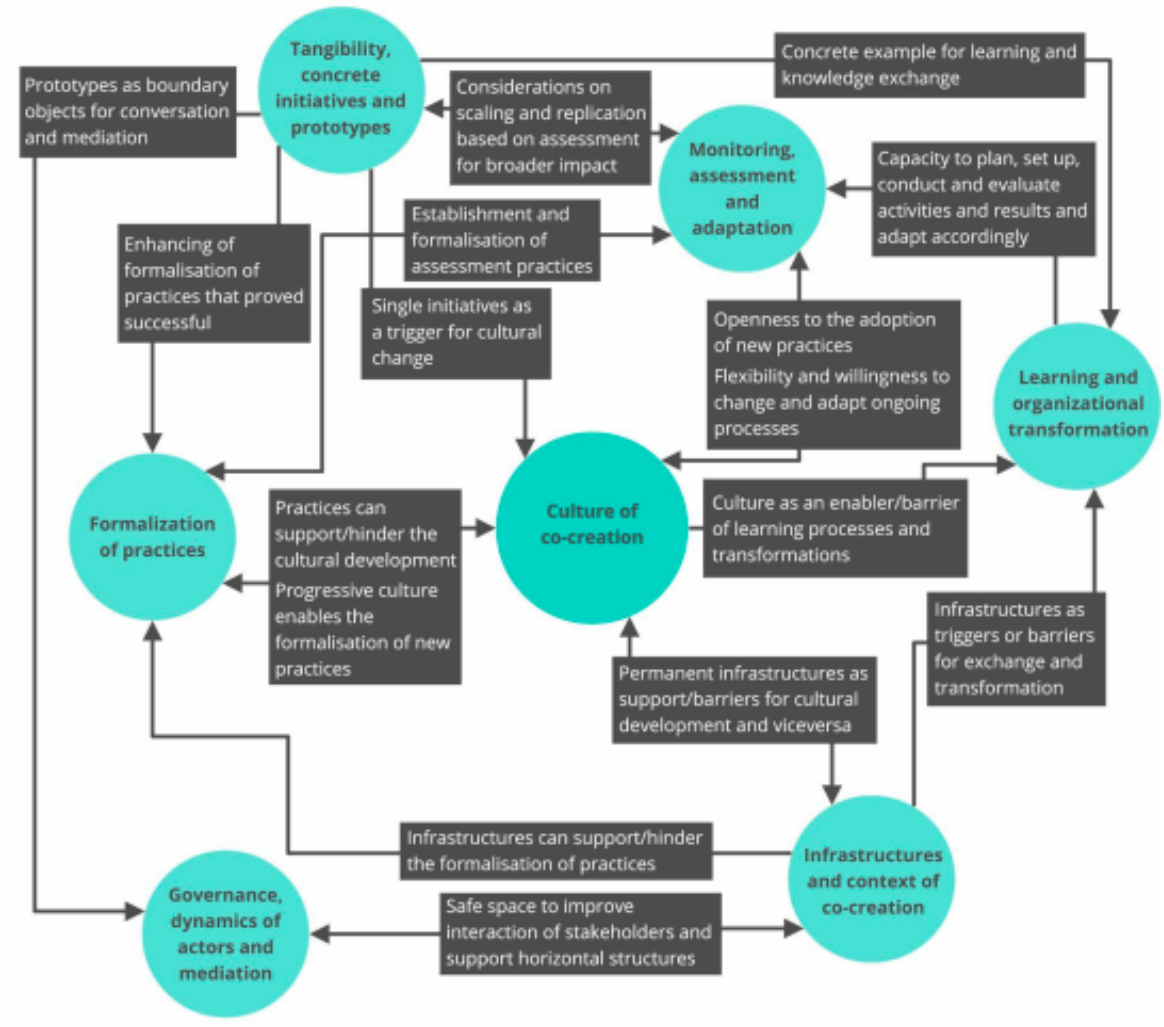

Figure 2: How to observe and create a culture of co-creation (Deserti et al, 2021)

In the project's final conference, the partners have emphasized four angles of co-creation: "*it goes beyond tools: it is an organizational culture. It is about using empathy and letting go of power, and thinking and living as an ecosystem*". Beyond the experiences and knowledge created, those angles can be perceived as new pledges and leitmotivs in our community to expand, test, and better apprehend the complexity of co-creation.

- Co-creation can be applied or utilized in different ways - both informal and formal. These two co-creation mechanisms can be argued to be equally important since informal co-creation holds

the great strength of day-to-day sharing of knowledge, resources, and facilities in labs. In contrast, formal co-creation is excellent for structural and systemic processes. When working with cross-sector innovation and multiple stakeholders from many fields, the formal approach to co-creation is a great tool for guiding the process.

- Stakeholder engagement and management appeared as one of the essential elements of co-creation. Beyond tools and methods, the way to foster the emergence of interactions, trust and maintain cooperative relationships through time came crucial. It is not just about sharing one-to-one information but building the trust in people's self for making, but attracting people with more diversity, and enabling cohesion in groups, engagement through time.

In conclusion, the SISCODE project has illustrated that Fab Labs have a complex and determinant social role in their localities. Co-creation methods need to be accompanied by relevant attitudes and behaviors adapted to the principles of sustainability and inclusivity, especially when working with citizens and vulnerable people. Co-creation is going beyond "tooling" moments of sharing and needs to be practiced in its full complexity as a multi-layered ecosystemic approach that can help Fab labs to frame their internal strategies for stakeholder engagement, dissemination, and design knowledge sharing.

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